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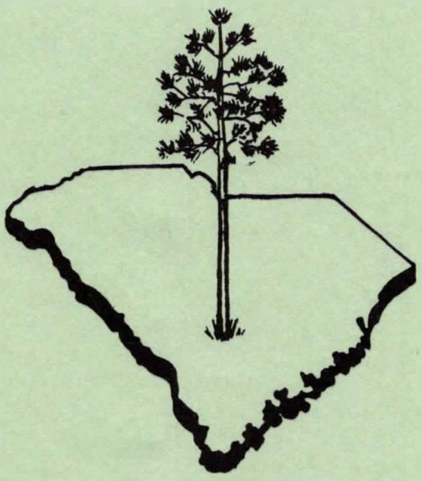
Pelleted Silvicides--Their Use in Controlling Unwanted Hardwoods in South Carolina

R. D. Shipman



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This publication, i.e., Research Series No. 11, is a progress report pertaining to results obtained as of May 1963 with fenuron pellets used as a means of controlling undesirable hardwoods in pine stands. While the testing involved was done on a scientific basis, the time period elapsed between the initiation of tests and the description of results is rather short; this is especially true of plots established on Piedmont sites in April 1962 and evaluated one year later.

Additional studies and observations are necessary before any recommendations are made. It is with this understanding that this publication is made available to interested readers.

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ACKNOWLEDGEMENTS

The author wishes to express his appreciation to H. R. Scott, C. Crosby Rice, Randolph B. Lee and R. W. McCombs of the South Carolina State Commission of Forestry, who assisted in the original field and operational trials with pelleted silvicides.

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Pelleted Silvicides--Their Use in Controlling Unwanted Hardwoods in South Carolina

R. D. Shipman[1]

Introduction

This paper attempts to describe some of the many ways in which chemical pellets may be used as a supplemental tool in a forest management program. The idea of a silvicide in pelleted or "pill" form to control woody species is not entirely new. However, the actual registration and manufacture of fenuron pellets as a weed and brush killer did not occur until 1957. The following described field and operational experiments represent three years of testing pelleted silvicides, primarily in the Sandhill and Piedmont Regions of South Carolina.

The silvicidal material used in these investigations contains fenuron, manufactured as a cylindrical pellet approximately 1/8-inch in diameter and varying in length from 1/8- to 1/4-inch. Chemically, fenuron is one of the substituted urea compounds (known as 3-phenyl-1,1-dimethylurea). According to the manufacturer's specifications, it is non-corrosive, non-flammable, non-volatile, and possesses a low order of toxicity to man and animals. Pellets used in these trials contained 25 per cent active fenuron.

Early Trials with Pelleted and Granular Silvicides

Some of the earliest trials with fenuron pellets dealt with the control of post oak in pastures. These investigators concluded that pellets were superior to other methods of application. As a result of this work, utility companies began to apply pellets beneath telephone lines and on right-of-ways to control woody brush (2). In 1955, CMU was tested in the sand-hills of west Florida to deaden worthless scrub oaks (13). Five years later, Ditman and Chappell reported their success in the use of granular fenuron for establishment and release of white pine in Virginia (3). In 1961, Herron and Newman described the use of fenuron at different rates to control undesirable species for purposes of seeding and planting after treatment (4). Rogers experimented with monuron, which he applied to hard-wood trees in bands and at the base of trees. All treated stems 1 inch and larger had died within two years (5). In 1961, the writer demonstrated how scrub oak lands in the Carolina Sandhills could be prepared for planting by using fenuron pellets (9).

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Mode of Action

Perhaps one of the most valuable basic findings associated with hardwood control in forestry was the recent discovery of the role of light in photosynthesis by Arnon and his associates (1). This brilliant work indicated that chloroplasts could convert light energy into chemical energy without oxygen. The mechanism for blocking the oxidation of water by certain classes of chemical compounds has been explained by Van Overbeek (12). One of these compounds is fenuron, the major subject of this paper, manufactured and applied in dry, pelleted forms. This herbicidal material blocks the oxidation of water and thus prevents the return flow of electrons to the chloroplasts. Besides fenuron, other substituted methyl urea compounds such as diuron, monuron, and neburon cause the death of plants in a similar fashion. The question now becomes, what is the most efficient manner in which these pelleted materials can be employed as a potential tool in forest management practices?

Methods of Pellet Application

Pelleted materials are generally applied in two ways. One is by broadcasting, which can be done by hand, cyclone seeder, ground equipment, or by aircraft. These techniques are best adapted to areas which contain numerous small-diameter stems of a single susceptible species, or to clumps of brush. A second method, requiring no tools other than a teaspoon and container, is to simply scatter the pellets around the base of individual living trees or around cut stumps which have sprouted. This method is particularly adapted to selective control of unwanted trees on upland sites containing a great variety of species (Figure 1).

There are modifications in applying pellets which attest to their versatility. For example, pellets can be broadcast in alternate strips or bands spaced at varying intervals, perhaps 4 to 6 feet apart. On areas of a single species group such as scrub oak, recent trials indicated that satisfactory control was possible by "stripping" at one-third the cost of full broadcasting. Pellets can also be applied in a grid or checkerboard pattern where ground conditions warrant.

Pellets are particularly adapted to an artificial regeneration program. As described in our 1961 trials, we have achieved a 95 per cent scrub oak control on light sandy soils, with pellets applied one month <u>after</u> planting, at the rate of 7.5 pounds per acre active material (9).

One of the most promising and effective ways to use pelleted materials in a regeneration program is to treat the competing vegetation which remains between furrows of planted seedlings. Generally, furrows are 6 to 8 feet apart while the furrow itself may be 3 feet wide and free of vegetation. In numerous trials we have controlled 96 per cent of the remaining scrub oak vegetation at rates as low as 6 pounds active material per acre. Virtually no discoloration or deadening of planted or directly seeded pine seedlings has been caused by pellets used in this manner.

In choosing a method of application, and depending on application rates, the forest landowner will need to consider his principal objectives of management. Whether the objective is to release desirable species from competing hardwoods, to prepare a site for planting through reduction of

Figure 1. Pelleted silvicides can be broadcast by aircraft or scattered around the base of individual cull trees. These methods can be modified to fit the landowner's objectives of forest management.

competition, to remove undesirable "wolf" trees, or to eliminate competition between rows of sown or planted seedlings, the amount and method of applying pellets will be dictated by a knowledge of the present stand, species, susceptibility rating, and site conditions. An assessment of the above factors for a given stand will enable the owner to estimate costs per acre or per treated tree in advance of a silvicultural investment.

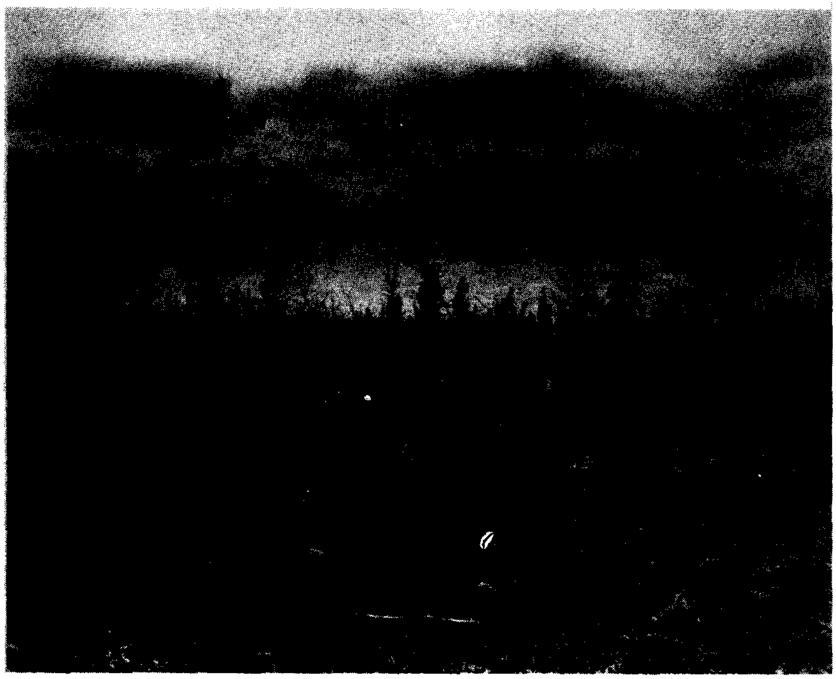
Recently, in a cooperative demonstration-research operation, pellets were broadcast from the air with a helicopter on a series of plots at the Sand Hills and Manchester State Forests in South Carolina. Prior to application, the merchantable timber was removed from a 140-acre sandy site. In this instance, the management objective is to regenerate these areas with slash and longleaf pines by planting or seeding directly. To accomplish this objective will require the control of thousands of small-diameter scrub oaks whose roots compete with the planted pines for soil moisture and nutrients. By burning half of the treated area before the pellets were broadcast, it was possible to determine the effects of ground cover, pine tops and litter on the aerial and ground distribution of pellets. In addition, both slash and longleaf pine seedlings were planted in advance of pelleting on portions of the burned and unburned areas. The remaining land will be planted with the same species after treatment.

The pelleted silvicides were applied in March 1963 at rates of 10, 15, and 20 pounds per acre from the air with a helicopter owned and operated by Inland Air Lines, Myrtle Beach, South Carolina. Under Sandhill conditions, when applied to predominately susceptible species, past research indicates that 15-20 pounds of the chemical should be distributed per acre. Two hoppers were constructed and attached to the sides of the aircraft, each containing 350 pounds of the pelleted material. The herbicide was scattered from a height of 35-40 feet in swaths of 50 feet. The rate of pelleting was manually controlled by the operator from the cockpit. Including loading and reloading time, a total of 140 acres was treated in approximately 45 minutes at an estimated operational cost of about $1-2 per acre (Figure 2).

Close examination of the pellets on the ground indicated that distribution of the assigned experimental rates was satisfactory. Approximately 7,700 pellets are contained in a pound of the pelleted silvicide. This weight equivalent provides a helpful guide for checking the ground distribution of pellets. Thus, 10 pounds distributed uniformly per acre would result in two, 30 pounds in six pellets per square foot.....and so on. Visual results of these aerial trials should be possible by July 1963.

Pellets for Scrub Oak Control

The timber grower who owns land in the deep, sandy soils of the South Carolina Sandhills knows that successful planting and future growth of pine requires the control of competing scrub oak during the early life of a plantation. He is also aware that the major hardwood competitor for soil moisture and nutrients is turkey oak (*Quercus laevis*). This undesirable species is a prolific sprouter, and unless the root systems are controlled by mechanical or chemical means, a second and possibly a third release operation may be necessary during the life of a plantation, usually 25 years in this locality.



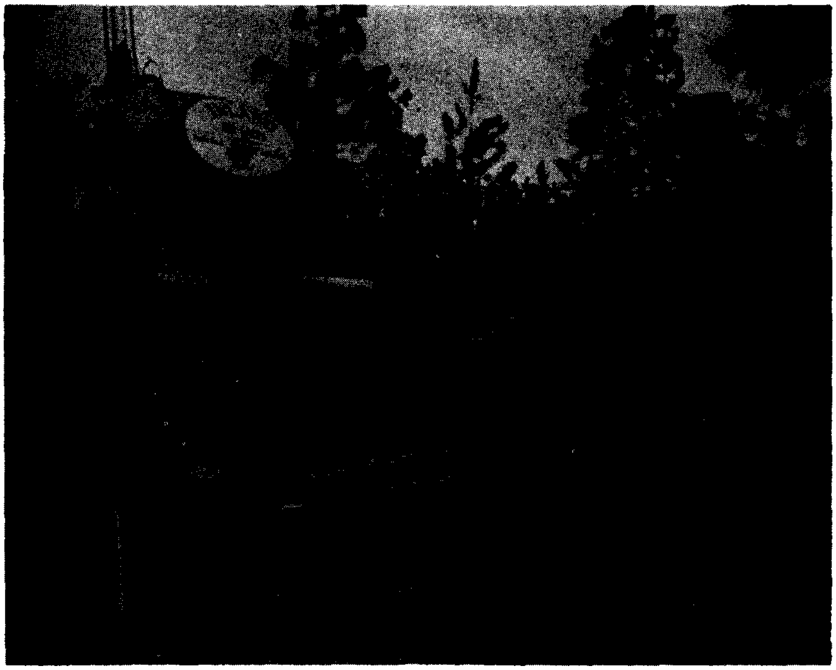


Figure 2. On March 12, 1963, the first operational trials in the application of pelleted silvicides was carried out on scrub oak lands of the South Carolina State Commission of Forestry. Merchantable timber has been logged (upper) and the area was treated from the air with fenuron pellets. The author and Mr. Randolph B. Lee examine the pellet "hoppers" attached to a helicopter (lower).

Unless scrub oak sprouting is eliminated, the grower can anticipate an additional \$5 to \$10 per acre investment in release work, assuming a successfully established pine plantation (Figure 3).

Within the past 15 years mechanical eradication of scrub oak and control by individual stem treatments have been attempted in the Carolina Sandhills. These techniques have varied in complexity from the construction of single, furrowed lanes in scrub oak to the more elaborate measures of complete eradication employing undercutters and bull-dozing equipment (7).

Silvicides have also been tested for deadening small-diameter scrub oak. However, their use has been restricted primarily to the early release of established pine from re-sprouted scrub oak stems. The commercial chemicals, 2,4,5-T and ammate, have been applied on Sandhill lands as stump and basal sprays, in basal cups and V-notches, and by tree injectors with varying degrees of success (8). However, the possibility of extensive control of scrub oak using dry or granular silvicides in the South Carolina Sandhills has not been investigated until recently.

Pellets for Upland Hardwood Control

Upland Piedmont sites contain trees of many different species, densities and sizes. This situation is unlike that of the Sandhill area where pellets can be used effectively on a single highly susceptible species growing on light sandy soils. In general, upland soils possess greater amounts of partially decomposed litter which may render pellets less effective. On these sites, soils are heavy clays and loams, and higher rates of pellets per acre may be required to effectively control a large per cent of the total species composition. The question naturally arises, should one broadcast or treat cull stems individually? To partially answer this question, we have broadcast pellets experimentally on a wide variety of Piedmont soil and site conditions.

Some of the results to be expected in treating upland oak sites with pelleted silvicides are presented in the Appendix, Tables 1 and 2. Both of these plots were broadcast by hand in April 1962, at the rate of 20 pounds of fenuron pellets per acre. In the first situation (Table 1) the objective was to reduce and control the sprouts arising from cut stumps following a logging operation. A second plot (Table 2) was treated with the intent of releasing four-year-old planted loblolly pine from hardwood competitors. Some advanced naturally regenerated shortleaf and Virginia pines were also present on these plots.

The results of these trials indicate the broad range of species susceptibility when fenuron pellets are broadcast on upland sites. In the case of pellets applied broadcast on areas containing cut stumps, an average of 67 per cent of the total sprouts present was completely controlled. Of the eight hardwood species represented, black oak sprouts were most susceptible, whereas pellets applied to cut stumps of scarlet oak and blackgum gave the least effective sprout control.

Figure 3. Pelleted silvicides can be used in converting thousands of acres of small-diameter scrub oaks (upper) to valuable stands of timber (lower) in the South Carolina Sandhills.

In contrast to the foregoing stump applications, standing trees of scarlet oak and blackgum were highly susceptible to fenuron as indicated in Table 2. Of the 16 hardwood species growing on these plots, an average 60 per cent were completely controlled. Among the three species of pine regeneration, the planted loblolly was less affected by the pellets than was the naturally occurring shortleaf and Virginia pine reproduction.

At this stage of our investigations on upland hardwood sites, it appears that a prescribed burn to reduce the ground litter in advance of pelleting may be required to obtain maximum benefits if pellets are broadcast (Figure 4). Based upon observations after one year, it appears that approximately 75 to 80 per cent of the total species composition can be controlled by broadcast methods when a light prescribed fire is used in advance of pelleting. As an aid to the landowner in determining the effects of applying pellets at varied rates, susceptibility rankings of the more important tree and brush species encountered in the Southeast are given in the Appendix, Table 3. These ratings include data obtained from a variety of sites and at different dosages per tree. They should be revised from time to time in accordance with the reported experience of pellet users.

Rate of Pellet Application

The present stand conditions and objectives of management will determine the rate of pelleting. In most cases, the forester will know something about the average size of tree to be treated, and the composition of his stands by species and density. If this prior knowledge is not available to the owner, a number of sample inventory plots can be taken before pellet application.

In applying fenuron pellets both broadcast and to individual stems for the past three years on scrub oak sites and after one year on Piedmont areas, we have found the following measures and their approximate equivalents useful in making quantity and cost estimates:

Weight

1 lb. = 7,700 pellets, approximately = 453 grams
1 gm. = 17 pellets (1/8-inch diameter, 25% active)
1 heaping teaspoon pellets = 10 grams
1 level teaspoon of pellets = 8 grams

Chemical cost--1963

1 teaspoon = $0.03 worth of pellets (retail)
1 lb. = $1.40 (under 500 pound lots) in 50 lb. bags
1 lb. = $1.20 (over 500 pound lots) in 50 lb. bags
1 lb. = $1.05 (truck load) in 50 lb. bags

General recommended rates of application

Individual stem:
1. Apply 0.5 to 1.0 gram (active material) per inch of tree diameter, or
2. Apply 1/4 teaspoon per 2 inches of tree diameter (by weight).

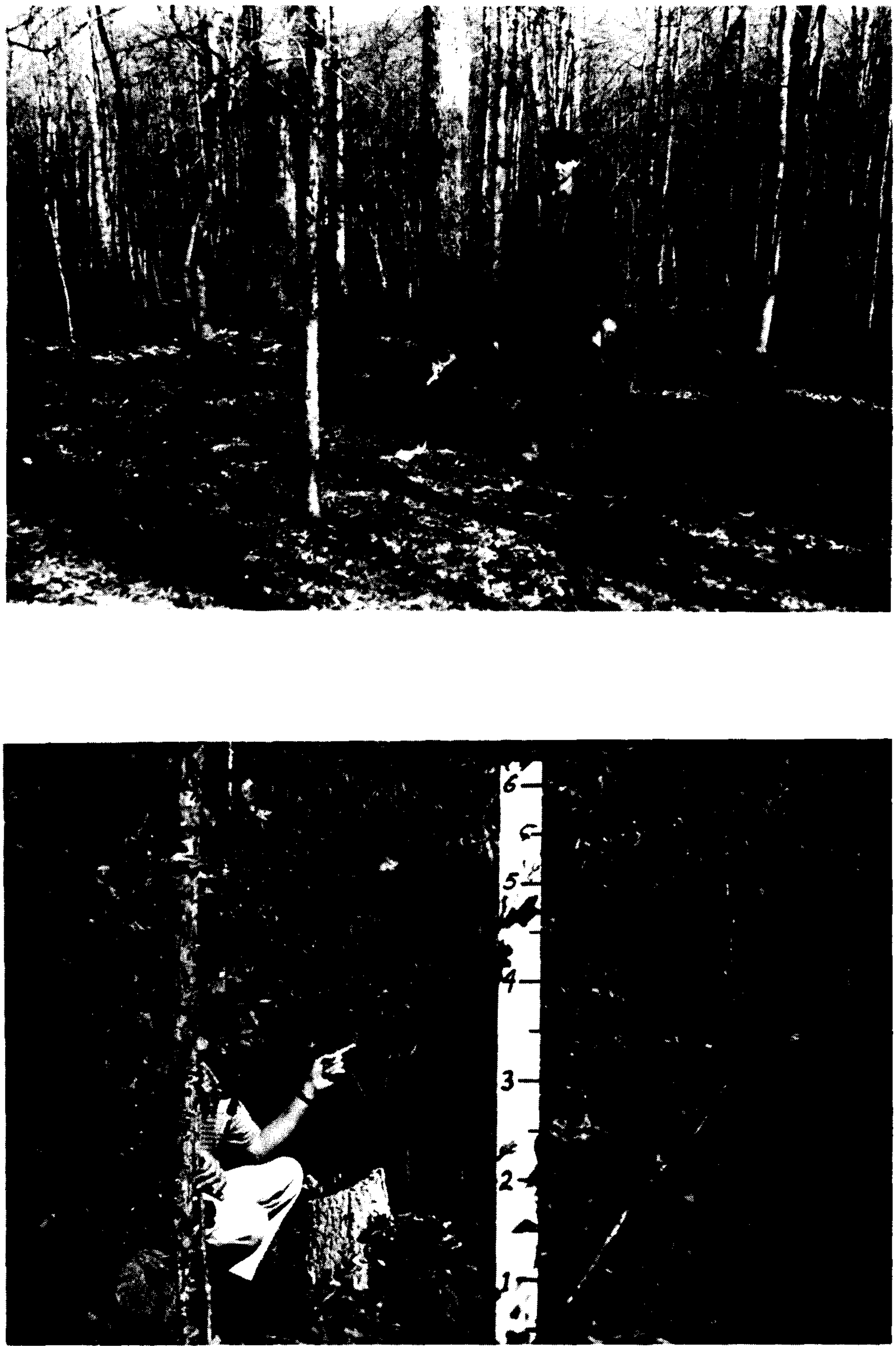


Figure 4. Above, an upland Piedmont site is prescribed burned in advance of broadcast pelleting to reduce excess litter. An effective way to control sprouts from cut hardwood stems is to scatter pellets around the base of individual stumps (lower).

Broadcast: 1. 20 lbs. per acre (by weight) on sandy soils with a single susceptible species.
2. 30-40 lbs. per acre (by weight) on heavy clay soils with a variety of species.

Perhaps the most difficult decision the potential user of pellets will have to make is whether to broadcast or to treat stems individually on any given tract. The comparative cost data as shown in Appendix, Table 4 was obtained from fourteen 1/2-acre plots located on the Savannah River Project near Aiken, South Carolina. Approximately 90 to 95 per cent of the monetary investment for broadcast treating scrub oak trees is in the cost of silvicide. Where small-diameter stems are treated individually on similar sites, the labor costs can be 20 per cent of the application investment. The total percentage control (with no re-sprouts) on the scrub oak plots averaged about 95 per cent irrespective of the rate of pellets used. Thus, an application of 20 pounds per acre appears to be as efficient as a 60-pound per acre rate and at a cost of about one-third of the highest rate attempted. On one plot, a 10-pound per acre rate was exceptionally good on these sites. The "break even point" in costs per acre where an operator must decide either to broadcast or treat individual stems is not precisely known. However, broadcasting is probably the most economical method where stems are small and numerous. Table 5 (Appendix) is presented as an aid in determining the minimum number of stems required per acre to give equivalent rates for broadcast and individual tree treatments. For example, 113 trees averaging 1 inch in diameter will require the same amount of pellets as if they were broadcast at 1 pound per acre. The assumed rate per tree given in Table 5 is 1 teaspoon per 2 inches of stem diameter. These rates may be modified in light of future findings on other species. Similar tables can be constructed for any given rate of broadcasting or by changing the rate applied per inch of diameter. A general formula applicable to a change in rates is also presented. These equivalents should be useful in estimating the time and labor charges for cull tree removal.

Season of Pellet Application

The time at which fenuron pellets are applied will vary with the climatic and soil conditions for a particular locality. In the Carolina Sandhills area, we have conducted numerous trials aimed at determining the optimum season for best results. These tests indicate that late winter or early spring applications (March-April) give best results on light, sandy soils in South Carolina. On these soil types, early season treatments receive the benefit of improved soil moisture resulting from late winter rains which generally occur in January and February. In 1957, Upchurch (10) found similar results in Florida and his data are as follows:

Silvicide	Pounds per acre	Time of Treatment: August	February	May
		-----Per cent kill-----		
Fenuron	0	5	5	0
	4	15	25	35
	8	30	40	80
	16	70	65	95
	32	95	95	100

Good results have also been achieved with mid-summer applications in the Piedmont region, where pellets were applied around the base of cut stumps to control sprouting or to individual standing trees. In January 1963, a series of monthly applications at rates of 5, 10 and 15 pounds per acre was begun at the Sand Hills State Forest in South Carolina. Results from these trials will be reported at a later date.

For broadcasting pellets, application is easiest in months when leaves are off the trees. Leafless crowns offer less mechanical obstruction and the chances of pellets falling close to the base of cull trees is improved.

Pellets and Rainfall

Soil moisture conditions existing at the time of, and following, pellet application probably play an extremely important role in fenuron uptake and subsequent deadening of trees. Considerable information is available about the physical and chemical action of this material. For example, it is known that pellets (containing 25 per cent active fenuron) are generally stable toward oxidation and moisture under conventional conditions. Pellets melt at 262° F, and their solubility is about 2,900 ppm. in distilled water at 74.5° F. Both elevated temperatures and more acid or alkaline conditions appreciably increase their rate of hydrolysis. The highest activity and solubility per unit of silvicide, particularly for the substituted urea compounds, is directly related to soil type, moisture content, organic matter, soil acidity and temperature (6).

The level of scrub oak control obtained in the Carolina Sandhills on dry, sandy soils, deficient in organic matter and highly acid in reaction, suggest that high rainfall and other climatic factors may be closely associated with the degree of fenuron uptake by roots. In view of these assumptions, the average monthly precipitation records during the ten-month period taken on the original 1961 scrub oak plots is presented (11):

Monthly Rainfall and Departure from Long Term Means
(Inches)

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Total for period
1.64	6.53	4.75	5.46	4.41	6.23	4.89	7.00	1.00	0.28	42.19
-1.62	+3.28	+0.80	+1.66	+1.09	+2.37	-0.51	+1.64	-3.34	-2.18	+3.39

Although the foregoing precipitation data represent a single ten-month period during 1961, it is worth noting that above average amounts of rainfall (6.53 and 5.46 inches) occurred in February and April, one month preceding and following pellet application respectively. If one considers the period February through June as the "effective period of soil moisture conditions in relation to deadening," 65 per cent of the total rainfall of 42 inches fell during this interval. A closer examination of the recorded precipitation in the experimental area at the time of a March application showed that 4.07 and 5.95 inches of rain had fallen three weeks prior to and three weeks after pelleting respectively. Further investigations on the relationships between the degree of kill and the rainfall pattern are needed.

Pellets and Soil Moisture

In some of our more basic trials, we have followed the soil moisture regimen throughout the growing season on a variety of pellet-treated Sandhill sites. In 1962, twelve soil moisture installations were established on lands of the Savannah River Project near Aiken, South Carolina. Bouyoucos soil moisture blocks were embedded in soils at depths of 3, 7, and 14 inches on scrub oak plots treated on March 27 with fenuron pellets at varying rates. Available soil moisture readings were obtained from the described depths plus controls at approximately three-day intervals from March 28 through September 16, 1962. The soil moisture regimens at soil depths of 3 and 14 inches were plotted against the rainfall occurring in the same localities, as shown in Figures 5 and 6. Each of the plotted points represent individual measurements taken at one installation for any given pellet treatment.

The increased available moisture resulting from the control of scrub oak with pellets under these conditions is apparent at the time of leaf defoliation, which occurred in the latter part of May or early June. In these trials, the trend of soil moisture throughout the growing season followed the rainfall pattern fairly well at all depths tested. The data illustrate how pellets, through their ability to completely cut off the transpiration stream from deadened trees, prevent the further use of soil moisture. In interpreting the results shown in Figures 5 and 6, one can, with a high degree of precision (due to the completeness of plant kill), estimate the quantitative amounts of available soil moisture conserved by a pelleting treatment applied at different rates. It is significant to note that the greatest amounts of moisture were conserved at the 14-inch depth, which is within the effective root zone of planted seedlings.

Further research along these lines should enable the user of pelleted silvicides to predict in advance the approximate quantities of available moisture he can expect to conserve by treating at definite rates and methods of application for a given locality. The added effects of increased growth in seedlings resulting from improved moisture relations and the removal of competing stems free of sprouting, attest to the indirect biological advantages of pellet treatments. Similar results in soil moisture conservation can be achieved by other methods of hardwood control, provided the "water-using" vegetation is satisfactorily eliminated.

Fenuron Residues and Planting Time

The question of residual chemical activity following treatment is a logical one asked by many landowners. On sandy sites, in our first-year trials, pine seedlings were interplanted among scrub oak trees one month in advance of a 40-pound per acre pellet application. Virtually no effect was observed one year after treatment. In a second trial, where pellets were applied at the rate of 20 pounds to upland hardwoods on heavy clay soils, no chemical residue was apparent five months after treatment. On soil samples extracted from these pelleted areas, oats and loblolly pine seeds were sown in pots with appropriate controls. Oats were used because of their extreme sensitivity to fenuron residues. Both of these indicator plants developed satisfactorily and growth was essentially the same on soils obtained from treated and untreated (control) plots (Figure 7).

FIG. 5—THE SOIL MOISTURE REGIMEN AT A 3-INCH DEPTH (1962)

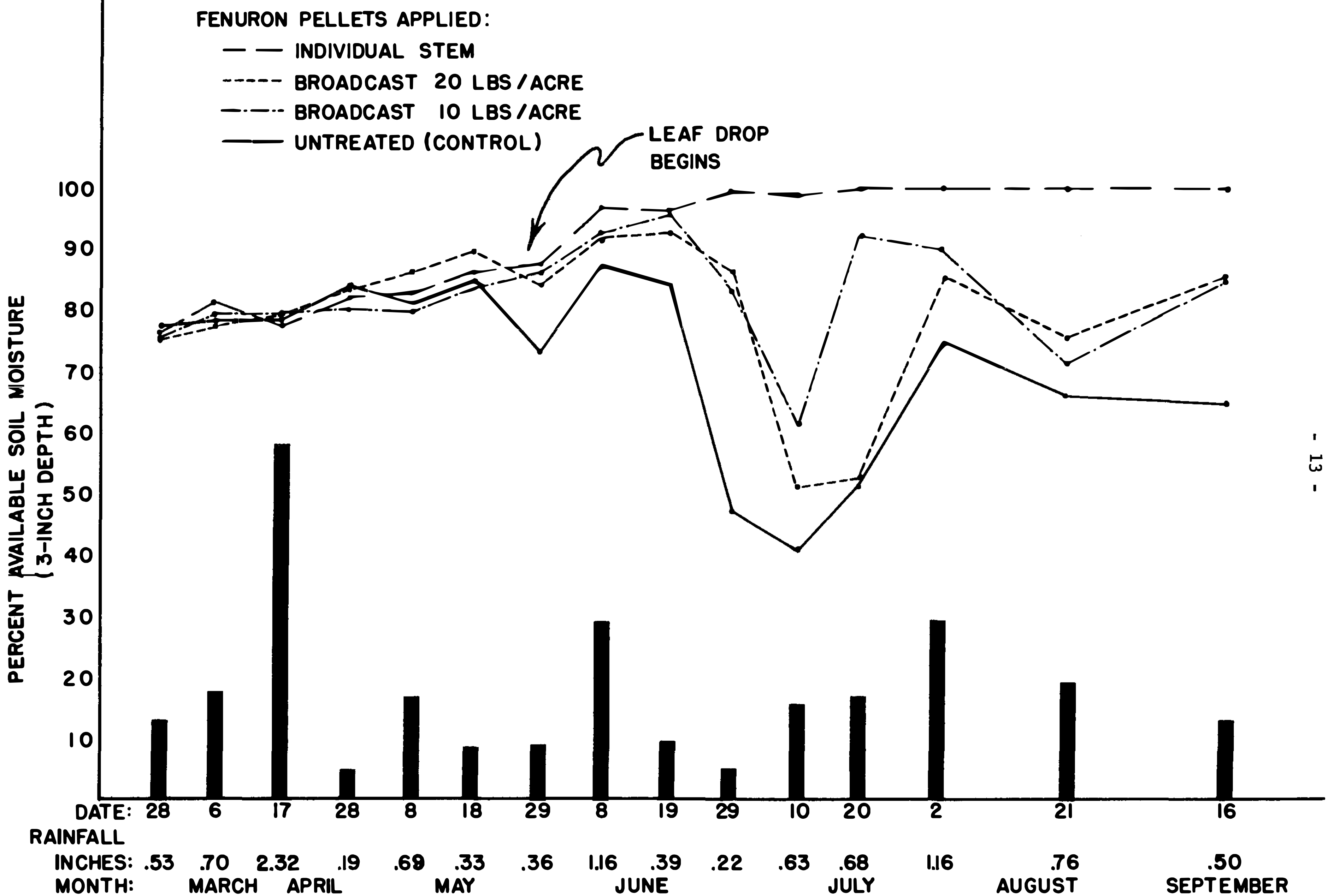


FIG. 6 – THE SOIL MOISTURE REGIMEN AT A 14-INCH DEPTH (1962)

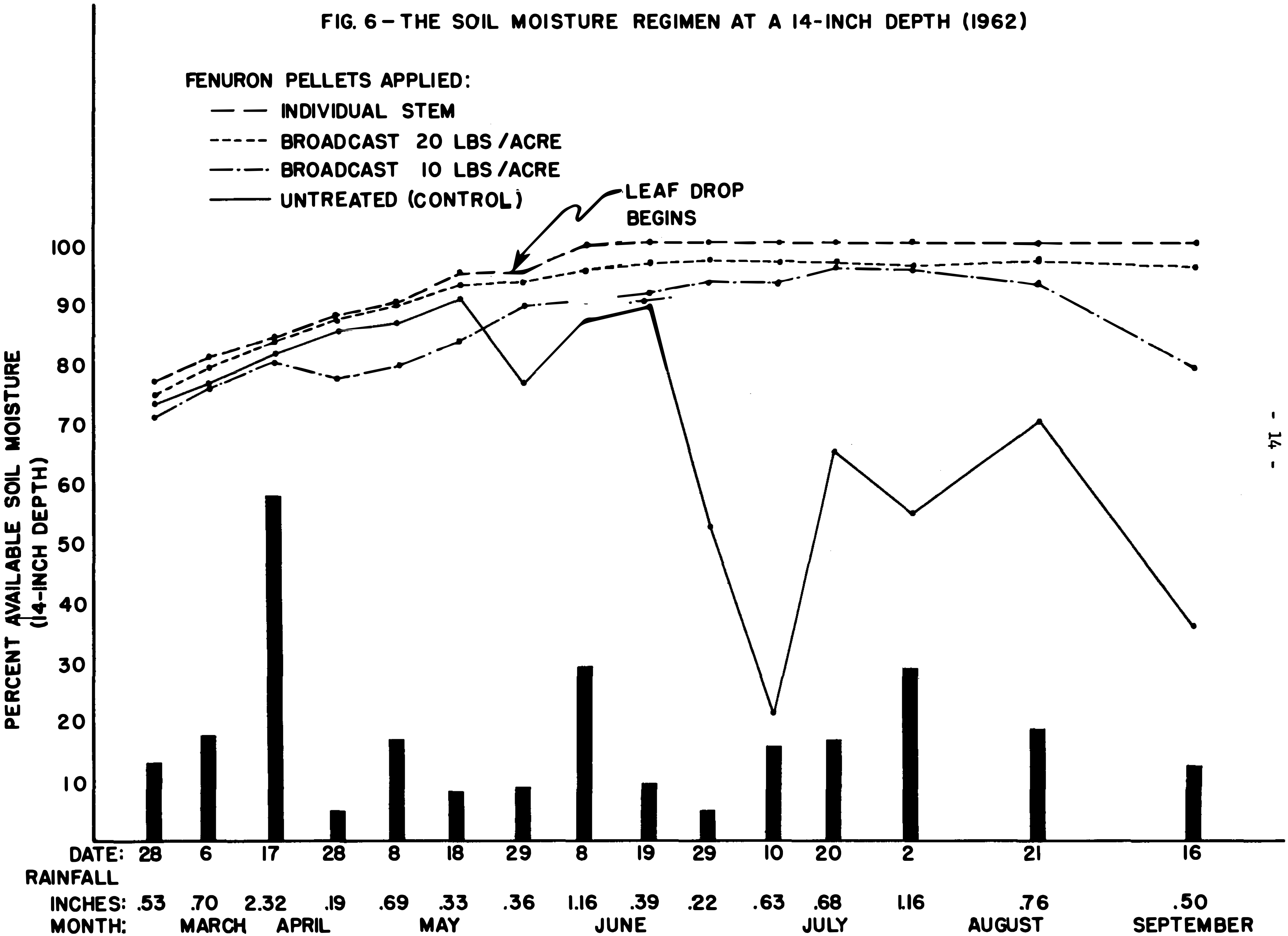


Figure 7. The development of indicator plants (oats and pine) on soil samples taken from an upland Piedmont site after broadcasting a 20-pound per acre application of fenuron pellets. The photo was taken five months after pelleting. No differences in color or growth were observed between treated and control plots.

According to our findings, it appears safe to plant or directly seed a pelleted area in the winter following a spring application of fenuron pellets. In fact, as indicated above, there is evidence to show that this interval of time can be as short as five months after applying pellets on heavy clay soils.

Vegetational Changes

From the standpoint of changes in composition of the ground vegetation, pellets indirectly affect forest management practices. These management prospects can be advantageous in some instances, depending upon the landowner objectives. For example, prescribed burning on Sandhill sites has not been extensively practiced for preparing sites in advance of planting or seeding. This situation is mainly due to the paucity of "flat" fuels and other ground vegetation capable of carrying an effective prescribed fire on these sites.

As shown in Figure 8, the removal of competing vegetation by broadcasting with fenuron pellets, increases the amount of light and available soil moisture on treated areas. As with most hardwood control measures that remove unwanted vegetation, annual and perennial weeds, broomsedge, wiregrass, and a host of other herbaceous vegetation begins to occupy the ground. A rapid buildup of ground material can become both a wildfire hazard as well as a management opportunity. Where longleaf pine is the preferred tree to regenerate such areas, a prescribed burn, properly timed, can be used to effectively control brown-spot needle disease and "trigger" longleaf pine seedlings into height growth. In our first-year trials with broadcast applications, a successful prescribed burn was carried out on a site containing a two-year buildup of ground vegetation resulting from a pellet application. Depending upon the rate of vegetative increase and composition, a landowner can choose the appropriate time to burn if such a practice is warranted. In the case of slash pine, planted one month <u>in advance</u> of pelleting on scrub oak areas, we have obtained excellent survival and early seedling growth without burning (9). In these trials, we have observed that the successional change in herbaceous vegetation following the hardwood kill, offers little competitive effect to planted seedlings--in fact, the early shade provided by the new aspect appears to assist in early establishment of slash pine seedlings by providing some degree of shading under Sandhill conditions.

From the standpoint of a wildlife habitat, the removal of undesirable vegetation with pellets and the subsequent occupancy of the site by herbaceous materials, can provide weed seeds and protective cover for certain kinds of wildlife. Species of plants appearing on these areas, presumably arising from seeds from adjacent lands or from previously dormant and stratified seeds, are establishing themselves under a new set of environmental conditions. In some cases, the indirect effects of pelleting will decrease cover and food for certain kinds of animals, while others will probably benefit from these changes.

Figure 8. Vegetational changes occurring on scrub oak sites after broadcast treatments with pelleted fenuron. Above, an area was successfully prescribed burned to control brown spot disease and to initiate the early height growth of planted longleaf pine. The lower photo shows the buildup of annual weeds, broomsedge and wiregrass resulting from the complete control of scrub oak with pellets. These habitats now provide cover and food for wildlife as well as timber production.

Conclusions

Perhaps the chief limiting factor at the present time in the widespread use of pelleted materials for control of woody stems in a forestry program, is high initial investment in the silvicide. Newness and the simplicity of the method are other factors that may cause hesitancy on the part of the average landowner in using them. However, continued research aimed at comparing the biologic and economic values of pelleting with other herbicides used for controlling hardwoods, will enable the landowner to assess their benefits. Not all of the problems have been solved in the field application of these materials, nor do they offer a panacea for every hardwood control situation. In the Sandhill regions of South Carolina, the results obtained in the use of pelleted silvicides as a weed tree control technique appear promising. Early results of pellet application on Piedmont sites are also encouraging. Based upon three years of experimental investigations in using pelleted fenuron, the following items should be considered:

Biologic:

1. Fenuron pellets are easily and rapidly applied and there is no mechanical inversion of the soil profile.
2. Fenuron pellets have a low order of toxicity to man and animals when used according to the manufacturer's recommendations.
3. Fenuron pellets have a low soil residual and no drift problems.
4. Fenuron pellets appear to have a high degree of chemical selectivity, both within and between pine and hardwood species.
5. Fenuron pellets, if properly applied, produce a high level of kill with a low level of sprouting from stems of susceptible species.

Economic:

1. Pellets can be used in many stands considered too expensive and inaccessible to control with heavy equipment.
2. A minimum of supervision and training is needed in application.
3. The method requires practically no initial capital investment in equipment; there are no depreciation or maintenance charges.
4. Pellets are applied with low labor costs in contrast to other methods.
5. Pellets require no elaborate mixing, carriers, or dosage computations.
6. Control with pellets can reduce the number and cost of intermediate release operations necessary throughout the life of a plantation.

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APPENDIX

Table 1 - Fenuron treatment to reduce sprouting from cut stumps after logging[1/]

Species	Cut Stumps: Number Stumps[2/]	Cut Stumps: Avg. diameter Inches	Total number Sprouts	Sprouts From Cut Stumps: Avg. dia. Inches	Sprouts From Cut Stumps: Avg. length Inches	Number Living	Number Dead	Sprouts Completely dead Per Cent
Post oak	2	2	6	0.62	40	1	1	50
Scarlet oak	5	3	13	1.10	69	3	2	40
White oak	6	7	47	1.16	87	1	5	84
Southern red oak	8	3	20	0.96	65	1	7	88
Blackjack oak	2	3	7	0.75	39	1	1	50
Black oak	2	6	11	0.62	42	0	2	100
Blackgum	5	2	17	0.85	94	3	2	40
Hickory	3	3	13	0.75	53	1	2	67
Total	33		134			11	22	
Mean		3.6		0.85	61			67

1/ 5 lbs. (active) per acre, broadcast application April, 1962.

2/ 1/20th acre (Upper Piedmont site).

Table 2 - Fenuron treatment to release planted and natural pines from unwanted hardwoods

Hardwood Control

Species	Number Stems 2/	Treated stems 1/ Avg. diameter Inches	Avg. height Inches	Mortality Number Living	Mortality Number Dead	Stems Completely dead Per Cent
Post oak	6	0.44	22	4	2	33
Scarlet oak	6	0.62	44	1	5	83
White oak	4	0.34	32	2	2	50
Southern red oak	20	1.50	109	6	14	70
Blackjack oak	5	0.50	28	3	2	40
Black oak	3	0.50	32	2	1	33
Northern red oak	2	0.50	39	1	1	50
Water oak	1	3.50	228	0	1	100
Blackgum	4	0.50	59	0	4	100
Hickory	8	0.78	57	5	3	38
Black cherry	3	1.41	127	2	1	33
Sumac	10	0.37	42	2	8	80
Green ash	1	2.50	180	1	0	0
Mimosa	4	0.47	68	4	0	0
Yellow poplar	1	1.50	216	1	0	0
Black locust	37	1.61	156	12	25	68
Total	115			46	69	
Mean		1.06	90			60

Pine Release

Species	Number Stems 2/	Treated stems 1/ Avg. diameter Inches	Avg. height Inches	Mortality Number Living	Mortality Number Dead	Stems Completely dead Per Cent
Pine (loblolly)	62	0.70	47	53	9	14
Pine (shortleaf)	5	3.00	192	3	2	40
Pine (Virginia)	7	0.79	46	4	3	43
Total	74			60	14	
Mean		1.49	95			19

1/ 5 lbs. (active) per acre, broadcast application April, 1962.

2/ 1/20th acre (Upper Piedmont site).

Table 3. – Susceptibility of common southeastern woody species, vines and grasses to fenuron pellets based on trials 1957-63.

Readily Susceptible 1 T/2" Stem Diameter[1/]	Susceptible 1 T/1" Stem Diameter	Intermediately Susceptible 2 T/1" Stem Diameter	Undetermined Susceptibility[2/]	Resistant
Alder	Black Gum	Ash	Acacia	Bermuda grass
Birch	Black Locust	Callicarpa	Aspen, quaking	Buckeye
Bon Elder	Elderberry	Dogwood	Bay, Magnolia	Catalpa
Elm	Hawthorne	Mimosa	Barberry	Cattail
Hackberry	Haw	Mulberry	Beech	Greenbriar (Smilax)
Hemlock	Hercules Club	Osage Orange	Button Bush	Johnson grass
Maple	Hickory	Persimmon	Cane	Mt. Laurel
Oak	Honey Locust	Privet	Chestnut	Nut grass
Pine	Hornbeam	Sassafras	Chinaberry	Palmetto
Sumac	Ironwood	Sourwood	Coffee Tree	Paulownia
	Prickly Ash	Tulip poplar	Cottonwood	Rhododendron
	Raspberry	Wax Leaf Myrtle	Cowitch (Trumpet vine)	Walnut
	Red Bud	Willow	Cypress	
	Redcedar		Honeysuckle	
	Scotch Broom		Holly	
	Sweet Gum		Pecan	
	Sycamore		Poison Oak	
	Wild Cherry		Poison Ivy	
	Wild Plum		Wild Apple	
	Wild Rose		Wild Bamboo	
			Wild Grape	
			Wild Pecan	
			Yaupon	

1/ 1 T/2" = One teaspoon at base of tree per 2 inches of stem diameter breast high.

2/ Insufficient trials and usage to ascertain definite degree of susceptibility.

Table 4. - Comparative per acre costs involved in treating small-diameter scrub oaks with pelleted and liquid silvicides[1/]

Silvicide	Method of Application	Rate of Application Per Acre	Labor cost[2/] (application) Per Acre	Chemical[3/] cost Per Acre	Equipment cost Per Acre	No. stems treated Per Acre	Avg. d.b.h. Inches	Total cost Per Acre
Fenuron pellets	Broadcast	20 lbs.	$1.00	$24.00	$.01	1320	2.3	$25.01
Fenuron pellets	Broadcast	40 lbs.	2.00	48.00	.01	2100	1.7	50.01
Fenuron pellets	Broadcast	50 lbs.	.50	60.00	.01	760	2.0	60.51
Fenuron pellets	Broadcast	10 lbs.	1.00	12.00	.01	2160	1.2	13.01
Fenuron pellets	Broadcast	30 lbs.	1.00	36.00	.01	2165	1.3	37.01
Fenuron pellets	Broadcast	30 lbs.	.75	36.00	.01	1620	1.2	36.76
Fenuron pellets	Broadcast	40 lbs.	1.00	48.00	.01	2940	1.0	49.01
Fenuron pellets	Broadcast	30 lbs.	.75	36.00	.01	3002	1.2	36.76
Fenuron pellets	Broadcast	40 lbs.	1.00	48.00	.01	2160	1.2	49.01
Fenuron pellets	Broadcast	60 lbs.	1.25	72.00	.01	1780	1.6	73.26
Fenuron pellets	Individual stem	35 lbs.	10.50	42.00	.01	840	3.0	52.51
Fenuron pellets	Individual stem	32 lbs.	12.75	38.40	.01	720	3.0	51.16
2,4,5-T	Injector	1:20	15.00	5.68	.10	1060	2.3	20.68
2,4,5-T	Injector	1:20	8.00	4.15	.10	870	2.5	12.25

1/ Costs do not include overhead, supervision, supply or transportation.

2/ Assumed $1.50/hour

3/ Assumed wholesale cost/lb. = $1.20

Table 5 - Equivalent rates of pellet application for broadcast and individual tree treatments based upon the minimum number of trees required per acre.

Avg. stand d.b.h. (Inches)	1	5	10	20	30	40
	Pounds per acre broadcast					
	------Minimum number of trees per acre-------					
1	113	566	1132	2265	3397	4530
2	57	283	566	1132 1/	1699	2265
3	38	189	377	755	1132	1510
4	28	141	283	566	849	1132
5	23	113	226	453	679	906
6	19	94	189	377	566	755
7	16	81	162	323	485	647
8	14	71	142	283	425	566
9	13	63	126	252	377	503
10	11	57	113	226	340	453

1/ General formula:

$$\frac{\text{453 gms./lb. x lbs. of pellets used}}{\text{Rate in gms./inch of diameter x Avg. d.b.h.}}$$

Example:

$$\frac{\text{453 gms. x 20 lbs.}}{\text{4 gms. x 2 inches}} = \text{1132 trees}$$

Assumed rate of pellets = 1 level teaspoon (8 grams) per 2 inches of stem diameter, or 4 grams per 1 inch of diameter.

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