of the hills, the clearness of our mountain streams, the privilege of enjoying the wild game and seeing the animals in their native habitat, and the value of what all these things contribute to our American way of life.

I wish to make an observation on the value of research. It is amazing how many people know so little about so much. Of all the phases of the range management program research is one of the most important. We need more coordination between the technical and the practical.

One final observation: We, as grassland managers, have a responsibility to humanity. Let us not permit people to lose sight of the importance of our basic resource, which is grass. If I may paraphrase using the famous Biblical quotation, "It will profit us nothing if we win the war against Communism and lose our own top soil."

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**Aerial Chemical Reduction of Hardwood Brush as a Range Improvement Practice in Arkansas**

**HURLON C. RAY, Range Conservationist, Soil Conservation Service, U. S. Department of Agriculture, Fayetteville, Arkansas**

The first treatment of brush by aerial application of chemicals in the State of Arkansas took place in 1951. Since then, many thousands of acres of brushland and potential pine land have been treated with chemicals and restored to high productive use. The use of airplanes for application of chemicals for hardwood control has progressed rapidly in Arkansas during the past seven years. The need for controlling much of Arkansas' undesirable hardwoods on rangeland created a demand for a quick, practical and economical method of treating the unwanted hardwoods and brush. The advent of chemicals that could be applied from airplanes and helicopters met this need and chemical brush control has become an important improvement practice on Arkansas agricultural land.

The objectives of the landowners have varied. Some have treated undesirable hardwoods for release of native grass for forage. Others have treated undesirable hardwoods in pine lands for pine release, while other landowners treated to eradicate the hardwoods for pasture or cropland development.

**General Information on the Herbicides Used**

The herbicides which are useful in aerial application must be effective in small quantities and must be adaptable to low-volume applications. Both the high-volatile and low-volatile esters of 2,4,5-T, 2,4-D and 2,4,5-TP have been used. The invert formulations of 2,4,5-T are now being used on a trial basis. The high-volatile esters used are methyl, ethyl, propyl, butyl, and pentyl. The low-volatile esters used are isooctyl, butoxy, ethyl, tetrahydrofurfuryl, butoxy propyl, butoxy ethoxy propyl, ethoxy ethoxy propyl, propylene glycol, and butyl ether ester. With favorable conditions the 2,4,5-T amine appears to be almost equal to 2,4,5-T ester. However, 2,4,5-T amine does not appear to be as consistent as 2,4,5-T ester.

The plant growth regulators that have been used by farmers in Arkansas are shown in Table 1. The term hormone growth regulators is often used for these substances, but actually this is somewhat misleading, because hormones are generally recog-

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**Table 1.** Quantity of chemical used per acre in aerial spraying calculated as acid equivalent. All chemicals applied with enough diesel oil to make a 5 gallon mixture per acre, compared with 1 gallon diesel and water to make a 5 gallon mixture per acre. The 2,4,5-T amine was applied with water to make a 5 gallon mixture per acre.

<table>
<thead>
<tr>
<th>2,4-D</th>
<th>2,4-D Amine</th>
<th>2,4,5-T Esters</th>
<th>2,4,5-T TP Esters</th>
<th>2,4,5-T Amine Emulsion*</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.4</td>
<td>2.4,5-T Esters 50-50 Mixture</td>
<td>2.4,5-T Amine</td>
<td>2.4,5-T Amine Emulsion*</td>
<td></td>
</tr>
<tr>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.0</td>
<td>1.5</td>
</tr>
<tr>
<td>1.5</td>
<td>2.0</td>
<td>1.5</td>
<td>1.5</td>
<td>2.0</td>
</tr>
<tr>
<td>2.0</td>
<td>2.5</td>
<td>2.0</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>2.5</td>
<td>3.0</td>
<td>2.5</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>3.0</td>
<td>4.0</td>
<td>3.0</td>
<td>4.0</td>
<td>4.0</td>
</tr>
</tbody>
</table>

*Special formulations have been developed for aerial spraying, which makes it possible to apply 1 to 4 pounds of acid equivalent in 5 to 10 gallons of spray per acre. The invert formulations require specially designed equivalent on the airplanes.

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1Paper presented at the 58th annual meeting of the Society of American Foresters, Salt Lake City, Utah, October 1, 1958.
NAMES OF FARMERS

1. Lee Nichdr
2. Lewis Oawdy
3. Ola Farwell
4. Roy Griffith
5. J. F. Bell
6. W. T. Thompson
7. Jay Smith
8. Jim Huntley
9. C. L. Kirkey
10. H. A. Burns
11. Sam Powell
12. T. J. McCabe
13. Floyd Hawkins
14. Jack Humphries
15. Floyd Lunn
16. Jack Reed
17. Henry Walker
18. Ralph DoweIl
19. Roy Murr
20. Tom Hargis
21. Ross Packer
22. Ralph Shannon
23. Houston Hinkle
24. Luther Decker
25. J. D. Dugan
26. Robert Stroud
27. Lawrence Mash
28. Raymond Griffin
29. Martha McIee
30. C. O. Long
31. H. E. Flannagan
32. L. H. King
33. H. F. Hardgrave
34. L. J. Churchell
35. Dudley Brown
36. Stone Ranch
37. Clyde Hatt
38. O. C. Moore
39. Rusty Johns
40. Garlend Cuthn
41. Green Brothers
42. Phillip Richardson
43. Lynn Wilson
44. Paul VanDaliun
45. Stenses Foresen
46. Robert Gierow
47. Stones Forwoods
48. Marceln Keith
49. Albert Stephens
50. W. B. Ridgeway
51. George Pige
52. J. L. Brownrants
53. Ruben Brooks
54. Searcy Stofl
55. D. P. Leonard
56. Claude Lee
57. Phillip Allan
58. Bernard Frazier
59. Jack Marion
60. Jack Gilson

LEGEND

AV ARKANSAS VALLEY Sandy loam soils. Shale valleys and flat top mountains.
BL BLACKLAND PRAIRIES Clay soils. Rolling land. Houston, Wilsoh, Sumter, 122, 8k Acres
BM BOSTON MOUNTAINS Sandy stone soils. Deep, narrow valleys. High, steep mountains. Hector, Pottsville, Muskogun, Wellington. 23.3k Acres
BO BOTTOMLANDS Sand, silt and clay soils. Nearly level land. Sharkey, Dunn, Clark, Perry, Portland, Pulaski. 12.9k Acres
CP CHEROKEE PRAIRIES Clay pan soils. Shale valleys. Taloka, Parsons. 12.6k Acres
FC FORESTED COASTAL PLAIN Sandy soils. Rolling land. Phoea, Ruston, Savannah. 13.8k Acres
GS GRANITE SOILS Silt loam soils. Moderately deep to shallow. Rough topography. 13.9k Acres
LM LOESSIAL HILLS Deep silt loam soils. Strongly rolling. Leroy, Grenada. 13.6k Acres
LT LOESSIAL TERRACES Silt loam soils. Level land. Calhoun, Crawley, Richland, Olivier. 13.5k Acres
OM OUACHITA MOUNTAINS Gravely silt loam and sandy loam soils. Mountains and narrow valleys. Glenoan, Merrow, Georgiow. 13.5k Acres
ZH OZARK HIGHLANDS - Chert and Limeclay Cherty silt loam and silt loam soils. Limestone hills and valleys. Cedar, Bona, Talbol, Gasoan. 13.5k Acres
ZH A OZARK HIGHLANDS - Prairie Silt loam soils. Gently rolling land. Newton, Caddo, scrap. 13.5k Acres
ZHB OZARK HIGHLANDS - Sandstone, Limestone and Shale Sandy loam to clay soils. Rough topography. Boone, Iread, Talbot, Calhoun. 13.5k Acres

LOCATIONS AND NAMES OF FARMERS
BY COUNTIES AND MAJOR SOIL AREAS OF ARKANSAS
WHERE STUDIES WERE MADE ON AERIAL APPLICATION
OF CHEMICALS FOR HARDWOOD CONTROL

Prepared by Hurlon C. Ray, Range Conservationist,
Soil Conservation Service, Fayetteville, Arkansas.
nized as being a growth regulating substance that is produced in plant or animal tissues. Also, the term tree poison is misleading. The compounds used for brush control are active in small quantities and move through the plant by travelling through the phloem. These selective herbicidal chemicals are non-poisonous, non-staining and non-inflammable.

Of all the applications made by farmers in Arkansas, 2 pounds of 2,4,5-T low volatile esters of active acid per acre was found to be the most economic and efficient. This dosage has been determined more or less as standard for one application, and all other treatments are compared with it. However, the early results with 2,4,5-T invert emulsions are encouraging. The invert emulsions have a low drift characteristic which is good. Special formulations of this emulsion can be successfully applied by airplane using a special spray device.

**Purpose of Investigation and Methods of Study**

The purpose of this investigation was to determine from experiences by many Soil Conservation District cooperators in Arkansas the best methods of aerial application of chemicals for hardwood reduction, pine release, and forage production. Such information is needed for conservation planning on farms and ranches in Arkansas, where approximately 80 percent of the woodland owned by farmers and ranchers is grazed by domestic livestock at some time during the year. The promising results in hardwood control with chemicals have increased the interest in grassland management and pine release.

The investigations were made in 33 of Arkansas’ 75 counties. The aim was to obtain a representative cross section of the different vegetative types, soil types, and different seasons of application of chemicals. A total of 60 farms were studied where detailed records are available on the aerial application of chemicals. The accompanying figure shows the locations of farms studied. These studies began in the summer of 1952.

Three types of studies have been in progress on farms since 1952. One was set up to observe the effectiveness of chemicals for hardwood control on different soil types. The investigation of soil types, site index, and effectiveness of the chemicals was made on a total of 35 soil types selected by random sampling throughout the state.

The second study was set up to evaluate the increase of native grasses following aerial application of chemicals for hardwood suppression. Six major soil groups having different soil productivity were chosen for these investigations. The field investigations of soil types and other site factors with site indexes aided greatly in grouping the soil types into groups having similar productivity. The study included investigations of forage production as influenced by forest type and timber stands.

The third study was set up to test the effectiveness of the chemicals applied at different times of the year. Applications were studied from April 17 to October 4 on soils having similar site indexes or soil productivity.

**Control by Soil Types**

From observations it has been noted that hardwood reaction to chemicals varies from area to area. Excellent control has been obtained on some areas, while very poor control has been obtained on other areas, with the same chemical, same flying service, same weather conditions, and same time of year for applications. It has been known for some time that age and kinds of hardwoods do influence the percent of kill. However, little attention has been paid to the soil types.

In July 1958, 19 soil types were selected that could be located on soil maps of farms that were treated in 1957. All areas were treated from May 24 to June 14, 1957, which appears to be the best time of the year for aerial application of chemicals for hardwood control. The same flying service was used on all applications.

In evaluating, analyzing, and presenting the data from the different soil types, the 19 soils were listed in order of site index productivity for shortleaf pine. Fifty, one-tenth-acre plots were laid out across each soil type and measurements were made on all stems 1” d.b.h and larger. The soil types according to site index rate for shortleaf pine and effectiveness of aerial application of chemicals for hardwood control are summarized in Table 2. The type of soil seems to influence the percent of control of hardwoods. The studies further show that the higher the site index, the less effective the application of 2 pounds of 2,4,5-T acid per acre on the hardwoods. Percent control of hardwoods was found to be higher on upper slopes and ridges as compared to lower slopes and bottomland. Also, the percent control of hardwoods was found to be higher on south and west exposures as compared to north and east exposures.

On many farms it has been necessary to respray the area the second or third year. When a good initial application is obtained, best results are obtained if the second treatment is delayed until the second year. This would make the hardwood control program extend over a three year period instead of two years. On Hector, Pottsville, and Muskingum soils sprayed in 1952 with one application of 2 pounds of 2,4,5-T acid per acre, a re-spray was necessary in 1958. The time interval required between
Table 2. Effectiveness on hardwoods of aerial application of a low volatile ester of 2,4,5-T applied at the rate of 2 pounds of acid with 1 gallon of diesel oil and 3½ gallons of water per acre on different soil types. Results in percent are accumulated from stem counts made in July 1958. All areas were treated from May 24 to June 9, 1957.

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Average Site Index</th>
<th>Average Kill</th>
<th>Average Feathered</th>
<th>Average Alive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hector fine sandy loam</td>
<td>20</td>
<td>87</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Pottsville fine sandy loam</td>
<td>24</td>
<td>85</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>Muskingum fine sandy loam</td>
<td>25</td>
<td>84</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Gasconade silty clay</td>
<td>27</td>
<td>83</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Nixa cherty silt loam</td>
<td>34</td>
<td>82</td>
<td>11</td>
<td>7</td>
</tr>
<tr>
<td>Bodine cherty silt loam</td>
<td>36</td>
<td>81</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>Talbot cherty silt loam</td>
<td>40</td>
<td>80</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>Enders fine sandy loam</td>
<td>53</td>
<td>78</td>
<td>15</td>
<td>7</td>
</tr>
<tr>
<td>Linker fine sandy loam</td>
<td>55</td>
<td>73</td>
<td>16</td>
<td>11</td>
</tr>
<tr>
<td>Izard loamy fine sand</td>
<td>60</td>
<td>70</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>Baxter cherty silt loam</td>
<td>65</td>
<td>69</td>
<td>20</td>
<td>11</td>
</tr>
<tr>
<td>Decatur silt loam</td>
<td>67</td>
<td>68</td>
<td>22</td>
<td>10</td>
</tr>
<tr>
<td>Almont fine sandy loam</td>
<td>72</td>
<td>66</td>
<td>23</td>
<td>11</td>
</tr>
<tr>
<td>Boswell fine sandy loam</td>
<td>74</td>
<td>65</td>
<td>24</td>
<td>11</td>
</tr>
<tr>
<td>Ruston fine sandy loam</td>
<td>75</td>
<td>63</td>
<td>25</td>
<td>12</td>
</tr>
<tr>
<td>Eustis loamy fine sand</td>
<td>77</td>
<td>62</td>
<td>25</td>
<td>13</td>
</tr>
<tr>
<td>Tilden fine sandy loam</td>
<td>81</td>
<td>61</td>
<td>27</td>
<td>12</td>
</tr>
<tr>
<td>Bowie fine sandy loam</td>
<td>85</td>
<td>57</td>
<td>30</td>
<td>13</td>
</tr>
<tr>
<td>Iuka very fine sandy loam, silt loam, and fine sandy loam</td>
<td>90</td>
<td>52</td>
<td>32</td>
<td>16</td>
</tr>
</tbody>
</table>

1 National Cooperative Soil Survey, USDA, Soil Conservation Service.  
3 Calculated from fifty one-tenth acre plots laid out on line transects across each soil type. All stems 1” d.b.h. and larger were tallied.  
4 Trees that have leaves growing out of the stem and out of limbs. Usually abnormal in size. Many of these trees often die the second and third years after treatment.

Resprays seems to vary with the soil types as well as age, species, and amount of hardwoods at time of initial application.

Two and one-half pounds of 2,4,5-T acid were applied on the Leonard farm in May 1957 (farm 55 on the figure). The soils on this farm have high site index ratings. A respray of 2 pounds of 2,4,5-T acid per acre was applied in May 1958. Counts made in August 1958 indicated a 93 percent control of the hardwoods of all diameter sizes. On other farms having soils of lower site index ratings, two and three treatments, of one and one-half pounds of 2,4,5-T acid per acre, have given controls of 98 percent of hardwoods of all diameters. On all soil types, ash, maple, hawthorn, and persimmon have shown a high resistance to aerial applications.

The exact treatment, and success of treatment will vary with the objectives of the individual landowners. For example, the percent control of hardwoods on Tilden, Bowie, Iuka, Ruston, Norfolk, Amite, and other soil types having similar site index classes may be 50 percent or less and still be a successful chemical pine release program. While 50 percent control of hardwood brush for release of native grasses on Hector, Pottsville and Muskingum soils would be considered a poor control. Each application involves a different set of circumstances and the prescription must meet the conditions. The efficiency of the application is the most important factor in getting the desired results.

Forage Production on Treated Areas

Both native grazing lands and forest lands in Arkansas face practically all the problems known to range management. These two types of lands are a very important source of grazing for cattle. Successful utilization of this native grazing resource is dependent upon a knowledge of the capabilities of the soil as well as the characteristics of the forage. This study reports some findings on increased forage following aerial application of chemicals for brush control.

Production of native grasses was inventoried in September 1957, on six different groups of soils. Each of the six soil groups studied had a different climax plant community, and each group is different in terms of potential vegetative productivity. The yields of forage were measured on each group of soils for both treated and untreated areas. A total of thirty-six 3.1-square-foot plots were laid out along line transects across each of the soil groups. The increased production of native grasses, as shown in Table 3, varied with the different soil groups. This study shows that prairie and savannah types of vegetation produce much more forage than do soils that have high site index for timber production. However, the tree stand and litter must be considered. In areas of good pine land, the increase of native grasses following chemical application varies with the class of the stand at time of treatment, such as open or newly cutover, seedling sapling, young pole, and mature trees, or stands approaching the fully stocked stage. The percent shade of the pine timber for these stand classes is different. The quantity of forage produced varies with the density of the shade. Forage production decreases quite rapidly as the stand of pine approaches a fully stocked condi-
Table 3. Increase of native grass two years following aerial application of a low volatile ester of 2,4,5-T on different types of soils and vegetation.1

<table>
<thead>
<tr>
<th>Soil Type2</th>
<th>Type of Trees or Brush</th>
<th>Percent Kill of Hardwoods Average3</th>
<th>Percent Increase</th>
<th>Average Annual Forage Production lbs.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taloka silt loam</td>
<td>Mostly prairie vegetation, winged elm, hawthorn, post oak, persimmon</td>
<td>80</td>
<td>400</td>
<td>5,000</td>
</tr>
<tr>
<td>Parsons silt loam</td>
<td>Post oak, blackjack oak, hickory, elm, red oak, and some shortleaf pine</td>
<td>85</td>
<td>525</td>
<td>3,500</td>
</tr>
<tr>
<td>Pottsville stony sandy loam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hector stony sandy loam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muskingum stony sandy loam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boone sandy loam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gasconade stony clay loam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bodine cherty silt loam</td>
<td>Blackjack oak, black oak, chinquapin, post oak, hickory, maple and some shortleaf pine</td>
<td>75</td>
<td>300</td>
<td>4,000</td>
</tr>
<tr>
<td>Talbot cherty silt loam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nixa cherty silt loam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Colbert cherty silt loam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wrightsville silt loam</td>
<td>Shortleaf pine, red oak, white oak, post oak, gum and maple</td>
<td>65</td>
<td>275</td>
<td>2,200</td>
</tr>
<tr>
<td>Boswell gravelly fine sandy loam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gadde very fine sandy loam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Susquehanna very fine sandy loam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shubuta fine sandy loam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ruston fine sandy loam</td>
<td>Shortleaf pine, loblolly pine, white oak, red oak, gum, maple and elm</td>
<td>60</td>
<td>244</td>
<td>2,000</td>
</tr>
<tr>
<td>Norfolk fine sandy loam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sawyer very fine sandy loam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Savannah fine sandy loam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shubuta fine sandy loam</td>
<td>Shortleaf pine and mixed hardwoods. Pine pole and mature size.</td>
<td>50</td>
<td>174</td>
<td>1,400</td>
</tr>
<tr>
<td>Iuka silt loam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mantachie fine sandy loam</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Two pounds of 2,4,5-T acid, 1 gallon diesel oil and 3½ gallons of water per acre. All results were determined from studies made on areas treated in late May 1955 and measurements made September 1957.
2 National Cooperative Soil Survey, Soil Conservation Service, USDA.
3 Calculated from 36 ¼ acre plots made on line transects across each group of soil types. All stems 2 inches d.b.h and larger were counted.
4 Calculated from 3.1 square ft. plots on line transects across treated areas compared to measurements made on untreated areas of same soil type and same type of vegetation. Average forage production is on treated areas, and is measured as air dry forage per acre.

Chemical pine release results in an increase of native forage for three to twelve years, depending upon the stage of growth of the pine at the time of treatment. Cattle numbers must be kept in balance with forage production, and adjustments have to be made to prevent overuse of forage and damage to pine seedlings. There is always a problem of overgrazing on acres that have been treated for chemical pine release in open range areas. Cattle seem to have a very unusual instinct for locating the treated areas. The new forage production on treated areas is succulent and very palatable.

Application at Different Times of Year

The season of the year in which chemicals are applied by airplane has a highly important effect on the results. Identical treatments by the same flying service fifteen days apart may get quite different results. The movement of the chemical in the plant is determined largely by the growth activity of the plant at the time of application. Since the chemicals generally move with the food materials of the plant, it is important to spray when the leaves are fully developed and beginning to manufacture food materials in excess of their requirements for growth. Applications made too early will burn the leaves, but will not kill the plant. Applications later in the summer after the growth has slowed down are also less effective. However, some fall treat-
ments in 1957 gave very good results. Tree growth in 1957 was high in September and October due to plenty of moisture. September 1957 had a lot more rainfall than September 1956. Considerable variation has been noted in results of fall applications during the past seven years. Some of the 1957 fall applications burned the needles on the pine. However, observations made in July 1958 showed that all affected needles had apparently recovered and appeared to be normal. Formulations of 2,4,5-T or 2,4,5-TP amine with water appeared to get less needle burn with fall applications than when diesel oil was used in the formulation.

A survey was made on applications made from April 17 to October 4. The results determined two years after application are summarized in Table 4. From the data presented in Table 4, it appears that the best time of year for aerial applications of chemicals for hardwood control in Arkansas is between May 24 and June 14.

May applications for aerial chemical pine release will often burn the pine needles and the tender terminal shoots. However, the trees usually recover by the second year after treatment. The common coniferous species have a high resistance to the herbicide. Application of herbicides from an airplane for chemical pine release was started in the spring of 1951 on the W. T. Thompson farm. The coniferous species show little and often no adverse effects to the standard application of 2 pounds of 2,4,5-T or 2,4,5-TP acid per acre. With higher concentrations of acid or diesel oil, some contortion of needles and current growth does occur. The southern pines can be killed with an application of 4 pounds of 2,4,5-T acid per acre. In "dog hair" stands of pine, the damage is sometimes high with 2 pounds of acid. Pine seed collected from areas that had been treated with 2 pounds of 2,4,5-T per acre, May 15, 1955, had a germination of 35 percent. However, many thousand acres of treated pine land have been re-stocked to pine by natural seeding. Additional research is needed on the effects of herbicides on pine cones and pine seed. On many farms where pines have been released by aerial treatment, the pines grew 60 percent more during the second growing season than unreleased pines.

### Conclusions

Extensive field investigations were made on 60 farms in Arkansas where aerial application of chemicals had been used to control hardwoods. Many soil conservation district cooperators have recognized the problem of worthless hardwoods and have undertaken well-planned aerial chemical control programs to control the hardwoods on range-land, pastureland, and pine land. Studies were made on treated and untreated areas to determine the relationships between soil types and percent control of hardwoods, increase in production of native grasses, and season of year for application of chemicals.

The effectiveness of aerial application of chemicals for hardwood control was studied on 19 soil types. On soils having lower site index ratings, the control was much better with one application than on soils having high site index ratings. A definite correlation between soil-plant-water relationships and effectiveness of the chemicals on hardwoods was also found.

Each of the six soil groups had a different climax plant community and was different in terms of potential vegetative productivity, either for grass or trees. The average grass production increase on the treated soil groups varied with the individual soil groups. Native grass pro-

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**Table 4. Effectiveness of aerial application of a low volatile Ester of 2,4,5-T acid on hardwoods at different times of the year.** Rate of application was 2 pounds of acid of 2,4,5-T with 1 gallon of diesel oil and 3½ gallons of water per acre. Areas treated in 1956 and results in percent are accumulated from stem counts made in August 1958.

<table>
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<th>April</th>
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<th>June</th>
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<th>August</th>
<th>September</th>
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<tbody>
<tr>
<td>Day of month</td>
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<td>81</td>
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</table>

1 Average kill in percent determined from stem counts on 50 one-tenth acre plots for each date of application. The plots were along line transects across treated areas. All stems 2 inches d.b.h and larger were counted. Areas selected for study included Rockland, Muskingum, Hector, Colbert, Talbot, Gasconade, Nixa, and Pottsville soil types.

2 An area treated in 1957 with same treatment, had lots of rain in September. Trees in untreated adjacent area put on ½ of year's growth in September. Count made July 1958. Percent kill on hardwoods was 70. Area had a lot of shortleaf pine in stand. The 1957 fall applications produced considerable needle drop on the pine. In July 1958, all needles appeared to be normal. On October 4 application obtained a 70 percent kill on hardwoods.
A Method of Managing Sportsmen on Rangeland

G. W. PHILPOTT, W. E. HOWARD, and C. A. GRAHAM,
Formerly President, Sportsmen Council of Central California, 1278 Arthur, Fresno; Specialist, Field Station Administration, University of California, Davis; and Superintendent, San Joaquin Experimental Range, U. S. Forest Service, O'Neals, California

The bulk of our wildlife resource is no longer available to the average sportsmen, for the amount of private land in farm, forest or range includes almost three quarters of continental United States. Much of this private domain is now closed to outdoor enthusiasts because so many people seek this form of recreation that landowners are literally forced to close their land to unregulated free access. Some farmers have been invaded by so many sportsmen “friends” that they have had to close their land completely, because it becomes too involved to allocate access privileges. Also, the “opening day” stampede creates many problems.

The crux of this private-land-versus-too-many-sportsmen dilemma is in the management of sportsmen access. If methods can be developed that will create an incentive among ranchers and farmers, the principal landlords of fish and game, to open their land to sportsmen, more opportunities will then be provided for outdoorsmen as well as reducing the demands for further “opening-up” the few remaining wilderness areas (Howard and Longhurst, 1956).

Permit Card

The objectives of our study were to develop and test a more or less standard sportsmen’s access permit card, as shown in the accompanying figure, that would serve to make it easier for landowners to open up land they have been forced to close to sportsmen.

There are a number of other conditions or modifications that can be incorporated in a permit and registration card that are not apparent in the illustration. It should be small enough to be carried in a billfold (our permit and registration cards are each 2¼ x 3¾ inches). Different color combinations can be used on the cards to denote regular permit, guest permit, landowner permit, custodian or attendant permit, different dates, and other features. Holes can be punched in the permits if they are to be tied