Progress Report, 1945-1949

Southeast Oklahoma
PASTURE-FERTILITY
Research Station

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Summary

Experimental studies to measure the effect of soil treatment on forage and beef production have been conducted since 1945 on the Southeast Pasture-Fertility Research Station about 6 miles northeast of Coalgate, Oklahoma. These experiments have been conducted on four soils which are typical of a large percentage of the pasture land in southeast Oklahoma.

Abandoned upland prairie soil planted to Bermuda grass, lespedeza and big hop clover has produced an average of 75 pounds of beef per acre annually over a four-year period. Lime applied to this soil increased beef production to 98 pounds per acre. Lime and superphosphate further increased beef production to 129 pounds per acre.

On a branch bottomland pasture, superphosphate applied to a limed soil has increased annual beef production from 175 to 203 pounds per acre.

Eroded timber soil treated with lime, superphosphate and potash and planted to Bermuda grass, big hop clover and lespedeza produced 113 pounds of beef per acre.

Eroded timber soil planted in weeping lovegrass without fertilizer produced 60 pounds of beef per acre. Lime plus 0-14-7 fertilizer produced a vigorous growth of lespedeza and big hop clover on this soil, and the average annual beef production for 1947 to 1949 was 116 pounds per acre. The stand of weeping lovegrass has decreased rapidly under continuous heavy grazing.

The cost of fertilizer, which is applied every third year, has been about 2½ cents for each additional pound of beef produced. Fertilizer cost per pound of increase in beef gains has been about the same in all pastures.

The winter feed cost for Hereford steer calves was $14.12 per head in 1946-47 and $13.15 per head in 1949-50. The average gain per calf was .61 pounds per day during the winter feeding period in 1949-50. The winter feed cost for yearling steers was $17.30 in 1947-48; and for two-year-old steers it was $23.72 in 1948-49.

The stocking rates for different pastures have varied with the character of the soil, age of the steers, season of the year as it affects the growth of forage, and soil treatment. About 30% more acreage was needed for a two-year-old steer than for a yearling steer on a similar pasture. About 30% more acreage was needed for a three-year-old steer than for a two-year-old steer. Three acres of improved upland pasture has provided good grazing for one two-year-old steer for 200 days.

Three-year-old steers gained 3.24 pounds per day for 81 days in the spring of 1949 on big hop clover and Bermuda grass pasture on prairie upland soil that was limed and fertilized with superphosphate, as compared with 2.26 pounds per day on unfertilized pasture. Gains on eroded forested soil were 2.54 pounds per day on fertilized and

1.67 pounds per day on unfertilized land. Three-year-old steers can be fattened by grazing for 70 to 80 days on big hop clover in April, May and June, if they are in good condition at the beginning of the grazing season.

Superphosphate drilled in rows 14 inches apart at the rate of 200 pounds per acre has produced a higher yield of big hop clover and lespedeza hay than rock phosphate applied in a similar manner at the rate of 300 pounds per acre.

Big hop clover and Korean lespedeza are more compatible in a pasture mixture on low organic matter upland soil than a mixture of big hop clover, Bermuda grass and Korean lespedeza.

Korean lespedeza planted twice on fertilized prairie upland and branch bottomland pastures has not survived in competition with big hop clover and Bermuda grass.

White clover (Ladino) has made a good growth with Berumda grass on the branch bottomland pasture, but has not survived to any extent on the prairie upland or eroded forest soil.

Protein production was doubled by planting big hop clover with Bermuda grass on upland prairie soil which had been limed and fertilized with superphosphate applied at the rate of 200 pounds per acre.

A comparison of beef gains with the protein content of the forage indicates that about two pounds of protein in the forage produced one pound of beef, in pastures which were not overgrazed. An undergrazed condition normally occurred in the spring with some overgrazing in the fall months.

Both legumes and grasses contained enough nitrogen and phosphorus for maximum beef production in the spring grazing periods, except for low total phosphorus in the forage grown on eroded timber soil without fertilization. During the summer grazing period, the nitrogen in the forage was below the optimum except where white clover and lespedeza were growing. The forage was also deficient in phosphorus, except in those pastures where phosphate had been applied to the soil. In the fall, nitrogen was deficient in the forage of all pastures except on the phosphated bottomland, and all pastures produced forage low to very low in total phosphorus.

The calcium content of pasture herbage was adequate for satisfactory production of beef cattle in all pastures at all seasons of the year.

Killing perennial ragweeds in an overgrazed pasture by spraying with 2,4-D in June produced three times as much lespedeza and grass the following season as was obtained on unsprayed land. Both areas were planted to lespedeza and treated with 200 pounds of superphosphate per acre.

Persimmon sprouts were killed by painting or spraying the lower part of the trunks with 2,4,5-T in kerosene or diesel fuel.

Black jack oak and other upland timber were killed by treating axe-cuts with 2,4,5-T dissolved in kerosene or diesel fuel.

Sodium arsenite was a very effective and inexpensive poison for killing bottomland timber.

Branch bottomland cleared of timber, planted in Bermuda grass, Ladino and big hop clover, treated with lime and fertilized with superphosphate, has produced 203 pounds of beef per acre over a four-year period.

Back furrowing at intervals of about 75 feet before planting Bermuda grass on claypan soil has greatly improved surface drainage conditions for plant development on nearly level areas of land.

Ammonium nitrate with mineral fertilization has not provided any earlier grazing on big hop clover-Bermuda grass pastures than mineral treatment without nitrogen.

Potash fertilization did not increase the forage yield of lespedeza or big hop clover on the prairie upland soils.

When summer moisture was favorable, a mixture of Kobe and Korean lespedeza produced a higher yield of hay than big hop clover on fertilized land. During dry summers more forage was obtained from the big hop clover than from the lespedeza.

Spring rainfall in southeast Oklahoma is normally favorable for high forage production when soil conditions are favorable for plant development. About one half of the summer and fall seasons are too dry to produce high forage yields.

PROGRESS REPORT, 1945-1949:

Southeast Oklahoma Pasture-Fertility Research Station

By HORACE J. HARPER, W. C. ELDER, *and* O. B. ROSS*

The Pasture Problem in Southeast Oklahoma

Climatic conditions in southeastern Oklahoma are favorable for the growth of many grasses and legumes, but a high percentage of the pastures have a very low grazing value because of a phosphorus deficiency in the soil. Pasture improvement is the key to a successful livestock enterprise in this area. High yields of beef or milk cannot be obtained without an abundant supply of high quality forage.

Most of the pasture soils in southeast Oklahoma are too low in available phosphorus to produce maximum yields of legume crops. Many of the soils are moderately to strongly acid, and some are deficient in exchangeable potassium. A large acreage of land formerly used for the production of cotton and corn has been abandoned for cultivation. Much of this land is low in organic matter in addition to being low in available phosphorus, exchangeable potassium, and other plant nutrients. Triple awn and sedge grasses make up a high percentage of the vegetation in many of these abandoned fields.

Most of the native pastures in southeast Oklahoma have been overgrazed. The stands of bluestems and other tall grasses have been greatly reduced or completely destroyed. In many pastures, perennial ragweeds are abundant, along with other less desirable grasses. A large acreage of land occurring in small branch bottoms is not cultivated because of occasional or frequent overflow during the spring months; and most of this acreage is covered with worthless timber or brush. The woody cover prevents the growth of desirable grasses and legumes because of excessive shading and competition for soil moisture.

Pasture improvement is needed to increase farm income on the smaller farms in southeast Oklahoma, where both yields and acreage of soil depleting crops have declined as a result of low soil productivity. Soils must be fertilized to produce satisfactory yields of cultivated or pasture crops, and legumes must be grown to improve or maintain the nitrogen and organic matter content of a soil. Under those conditions, cost of soil improvement is much lower under a livestock system of farming. In a pasture improvement program, legumes are grown with the grasses for two reasons: (1) To produce

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forage with a higher protein and mineral content; and (2) to add nitrogen to the soil, thus stimulating the growth of succeeding grass crops. Since there are many different kinds of winter and summer legumes and grasses, information is needed concerning the compatibility between various legumes and grasses, both from the standpoint of yield and also from the standpoint of quality of forage produced.

One of the most important problems to be solved in a pasture improvement program is the relation between costs and benefits. Previous studies have shown that legume yields can be increased by fertilizing land which is low in available plant nutrient content. The work reported in this publication was planned to determine the relative cost of increasing beef production on fertilized pastures as compared with similarly treated areas of unfertilized land.

Soil Conditions and Pasture Locations

The Southeast Oklahoma Pasture-Fertility Research Station is located about six miles northeast of Coalgate, on 220 acres of land typical of approximately two million acres of pasture land in that part of the State. Post oak, black jack oak and hickory were growing on approximately one half of this farm under virgin conditions, and the other half was covered with prairie grass. A small branch bottom divides the prairie land from the forested area. Some of the prairie land had been cultivated for sixty years. It had not suffered severely from erosion, but it was very low in natural productivity. Most of the land had been previously used for the production of cultivated crops, and had been abandoned for periods ranging from six to twenty years.

Four different soils were present on this area: (1) Sloping prairie upland with a permeable subsoil. This soil developed principally on sandy shales. (2) Nearly level prairie upland with a compact, impervious subsoil (commonly called a claypan). This soil has developed on shale and internal drainage is very poor on this type of land. (3) Forested soil developed on sandstone, and shallow under virgin conditions. Opportunity for improvement appeared far less promising on this type of land than on the prairie areas. Gully erosion had removed both surface and subsoil in a few areas. (4) Branch bottom land developed on sediments washed from the adjacent uplands, principally under the influence of grass. A considerable portion of this area was covered with trees and brush. About one-fourth of the bottomland area had been used previously for the production of cultivated crops.

A detailed soils map was made of the area and used as a guide in locating the boundaries of the nine pastures as shown in Figure 1. Three of these pastures, each with an area of 18 acres, were located on the permeable upland prairie soil. One 8-acre pasture was located on the nearly level upland claypan area, and two 10-acre pastures were located on the branch bottomland. These six pastures were established in the spring of 1945. Three pastures on the formerly cultivated forested upland soil were established in the spring of 1946.

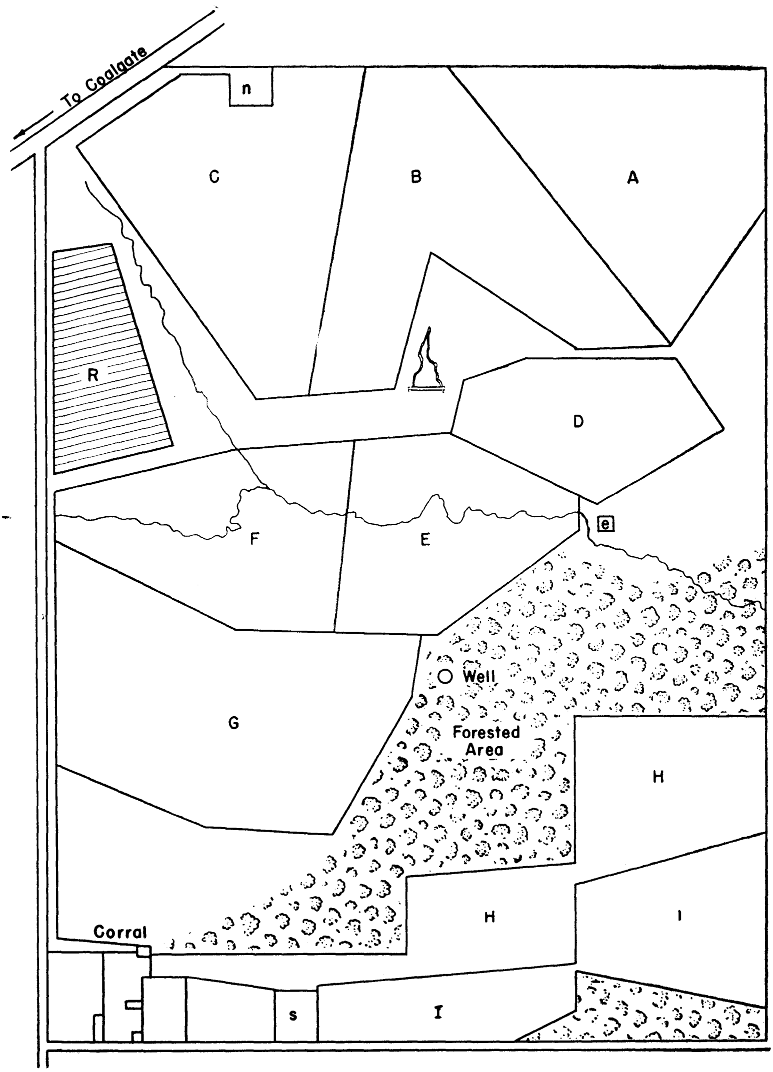

Fig. 1 — Map Showing Location of Pastures and Experimental Plots on the Southeast Pasture-Fertility Research Station.

Pastures A, B and C are on deep, medium textured, moderately to slowly permeable upland prairie soils. Pasture D is on a medium textured, very slowly permeable (claypan) prairie soil. Pastures E and F are on deep, medium textured, moderately to slowly permeable creek bottom soils. Pastures G, H and I are on formerly cultivated, shallow, medium textured, moderately permeable forest soil.

Areas marked (n), (s) and (e) are nursery plots to study the effect of different fertilizer treatment on the production of various legumes and grasses. Thirty-six fertilizer plots 25 feet wide and of variable length are in the reserve pasture, R.

The area in each pasture is given in Table I. The pastures are irregular in shape because it was necessary to follow soil boundary lines as nearly as possible, so that the results obtained could be applied to a particular soil type. Pastures H and I are very irregular because the two fields on which these pastures were located were not abandoned at the same time and more organic matter had accumulated in the surface soil on the east part of this area.

The Pasture Improvement Program

Table I shows the fertilizer treatment given each of the pastures. Soil tests indicated that lime and phosphorus would be important limiting factors in the production of legumes on the prairie soil area, and that lime, phosphorus, and potash would be needed to produce maximum yields of legumes on the forested land. Although the bottomland was high in organic matter where it had not been cultivated, it was also too acid and too low in available phosphorus to produce a maximum yield of legumes.

Bermuda grass was selected as the most desirable grass to plant on Pastures A to G, inclusive, because it is not as easily injured by heavy grazing as native grasses such as the bluestems. Some undesirable perennial grasses were present on a part of the land which had been out of cultivation for several years; consequently, the land was plowed to destroy these grasses and retard the development of persimmon sprouts. All of the land on the north half of the farm was plowed in the spring of 1945, and finely ground limestone was applied

TABLE I. — Soil Condition, Acreage, and Fertilizer Treatment on the Experimental Pastures.

Pasture	Soil condition	Acreage	Fertilizer treatment	Pounds per acre
A	Permeable upland prairie soil	18.1	None	——
B	Permeable upland prairie soil	18.1	Limestone	4000
C	Permeable upland prairie soil	18.1	Limestone Superphosphate	4000 150
D	Claypan upland prairie soil	8.0	Limestone Superphosphate	4000 150
E	Branch bottom land	10.0	Limestone	4000
F	Branch bottom land	10.0	Limestone Superphosphate	4000 150
G	Eroded timber soil	22.0	Limestone 0-14-7	3000 200
H	Eroded timber soil	11.3	None	——
I	Eroded timber soil	11.3	Limestone 0-14-7	3000 200

Limestone applied once in ten years, at rate shown. Fertilizers applied once every three years at rate shown, drilled in 14-inch rows.

Pastures A to G inclusive were planted in Bermuda grass. Pastures H and I were planted in weeping lovegrass.

Winter legumes survived winter heaving from freezing and thawing only on the areas where superphosphate was drilled in rows 14 inches apart. February planting is recommended over fall planting on a seedbed which has little or no organic residue on the surface to provide protection for the young legume seedlings.

to Pastures B, C, D and F, at the rate of 2 tons per acre. The soil was double disked to mix the limestone into the surface layer, and Bermuda grass roots were planted in rows 28 inches apart with a three-row planter built on a tool bar carrier. The furrows were opened with 10-inch lister points, and roots were dropped through sprouts into the furrows and covered with disc coverers. The soil was pressed firmly around the roots with a packer wheel. Most of the Bermuda grass roots were planted in May and June. The area was lightly grazed in the summer of 1945 to reduce the competition between the annual grasses and the young Bermuda grass.

Ryegrass was drilled in rows 14 inches apart in the fall of 1945 on the area which had been planted to Bermuda grass the previous spring. The seeding began on October 18 and the rate was 10 pounds per acre. Two pounds of a winter legume seed mixture was inoculated with the proper bacteria and dropped between the ryegrass rows to provide a more favorable environment for the growth of the legume seedlings. This legume mixture contained 19% each of White Dutch and Ladino clover; 12% each of big hop clover, little hop clover, Black Medic, and Persian clover; 6% of Alsike clover; 2% of subterranean clover and the remaining 6% was composed of birdsfoot trefoil, button, little bur, Tift bur and California bur clovers. A combination fertilizer grain drill with grass seed attachment was used to plant the ryegrass and legume seed. Superphosphate was drilled in 14-inch rows* at the rate of 150 pounds per acre on pastures C, D and F and the legume seeds were dropped above the phosphated zone. Most of the legume seedlings which started to grow in the fall were destroyed by heaving in January. A sufficient number of seedlings appeared in February and survived to produce enough seed to reseed the areas. Good stands of big hop clover were obtained on the fertilized pastures in 1947. This legume supplied enough forage so that the disappearance of the ryegrass, which provided excellent grazing in the spring of 1946, did not interfere with the pasture improvement program. Korean lespedeza was broadcast on these pastures in March, 1946, at the rate of 10 pounds per acre. The seed was covered lightly by pulling a disc with the blades set nearly straight over the pastures, to provide a more favorable condition for the development of the lespedeza seedlings. The lespedeza survived on A pasture, which was not fertilized, and on B pasture, which received lime; but it was quickly crowded out by the hop clover and Bermuda grass on the other areas. Reseeding these pastures by drilling a 50-50 mixture of Kobe and Korean lespedeza at the rate of 15 pounds in March, 1948, did not improve the stand of this legume on Pastures C, D, E and F.

Bermuda grass was planted in Pasture G, which is on a forested upland soil, in the spring of 1946, using a 3-disc plow. A platform was constructed on the plow frame and Bermuda grass roots were dropped through a metal spout behind the first disc so that they would fall on moist soil and be covered with soil from the second disc. This land was limed at the rate of 1½ tons per acre after the Bermuda grass was planted. The use of a disc plow is recommended for planting Bermuda grass roots on land where stumps or stones would interfere with the operation of a lister, a mold board plow, or a shovel type furrow opener. When early spring planting is practiced, or if the perennial vegetation is not dense, the land can be plowed and the Bermuda grass roots planted in one operation. Under unfavorable soil conditions, dropping small chunks of Bermuda sod with soil attached at intervals of 8 or 10 feet in a furrow may be more effective in securing a good stand of Bermuda grass than dropping bare roots at closer intervals.

Weeping lovegrass was planted in the spring of 1946 on Pastures H and I, which are on soil very similar to that in Pasture G. Before planting, the land was plowed and 1½ tons of limestone per acre applied to Pasture I. In the fall of 1946, a mixture of legume seed similar to that planted in the fall of 1945 was planted on the three forested upland pastures. Ryegrass was planted in 14-inch rows in Pasture G and the legume seeds were dropped between the ryegrass rows above a fertilized zone which received 200 pounds of 0-14-7 per acre. The legume seeds were planted in 14-inch rows without the ryegrass on H and I pasture at right angles to the lovegrass rows, and 200 pounds of 0-14-7 per acre was drilled in 14-inch rows and

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*If the fertilizer is not drilled in rows the rate of application should be increased about 50% to provide a more favorable condition for the growth of the legume seedlings.

Ladino clover growing with Bermuda grass on a small branch bottom pasture provides a longer grazing period than big hop clover.

the legume seed dropped above the fertilized zone in Pasture I. These seeds were planted on September 20, when soil moisture conditions appeared favorable for the growth of the legume seedlings, but a high percentage of these seedlings died because of drought during October and November. A sufficient number of the seeds germinated in February, 1947, to reseed these areas in the fall of 1948 and excellent stands of legumes were obtained on Pastures G and I. Korean lespedeza was planted in the spring of 1947 and a good stand has been maintained on Pasture I, which supplies excellent summer grazing following the disappearance of big hop clover. On Pasture G, where Korean lespedeza had been planted prior to 1945 and a good stand of this legume was present in 1947 and 1948, the lespedeza is being crowded out on the areas where the Bermuda grass has developed a dense sod. Big hop clover grows much better than lespedeza with the Bermuda grass, because the hop clover makes most of its growth during that part of the year when Bermuda grass is dormant.

Big hop clover has developed as the dominant winter legume on these pastures, partly because of its ability to produce seed from plants which germinate in February and March. Persian clover has survived in the high fertility pastures which have been fertilized and limed, but it has disappeared from the check pastures or pastures receiving lime but no phosphate. Although Black Medic has done very well on limed and phosphated soils in the south nursery, it has not survived in competition with big hop clover on the forested upland pastures. An occasional plant of Ladino and White Dutch clover will be found on the limed and phosphated upland pastures; but the best growth of these legumes has occurred in Pasture F, an area of branch bottomland which was fertilized with phosphate and received two tons of limestone per acre in the spring of 1945 to correct soil acidity.

Effect of Pasture Improvement on Gains and Market Grade of Steers

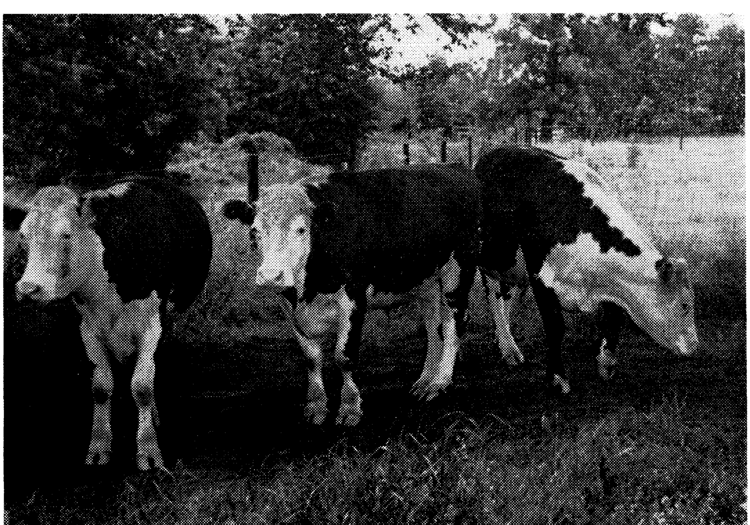
Sixty Hereford steer calves were allotted to the nine pastures in the spring of 1947. Twenty-eight head were selected as "permanent" steers to be placed in the same pasture each year during the grazing season for three years. The carrying capacity of the different experimental pastures for three-year-old steers was not known when the experiment was started; consequently, the number of steers selected for some of the pastures was lower than those pastures could have carried. Data on the permanent steers during the three grazing seasons are given in Table II. Since the grazing value of the fertilized pastures has gradually improved during the four-year period, the number of acres per steer and the total gain in pounds per acre for the spring grazing season, April 11 to July 1, 1949, is also presented. It will be observed that three-year-old steers on pastures receiving lime and phosphate and/or potash gained about one pound more per day in 1949 than steers on unfertilized pastures, due principally to the more abundant growth of big hop clover. The acre gain for the spring grazing season was more than two and one-half times that of unfertilized pastures. This difference was reflected in the stocking

Three-year-old steers on unfertilized forested upland soil weighed 855 pounds after gaining 440 pounds in three grazing seasons. They were wintered on corn gluten meal and prairie hay.

rate of number of acres per steer. Pasture C, which is on a permeable upland prairie soil and was fertilized with lime and superphosphate, carried one three-year-old steer per two acres from April 11 until July 1, 1949, and an abundance of forage was present in this pasture when the steers were marketed. The eroded timber soils have been grazed more closely than the prairie type soils in this experiment, but the annual legumes which have provided most of the forage in these pastures can be grazed heavily, the only problem being seed production to replace the plants the following season.

All of the data reported in Table II were obtained on steers fed prairie hay and corn gluten meal as a protein supplement during the winter feeding periods of 1947, '8 and '9, except the averages for the steers in Pasture G and the column showing total gains per acre from April 11 to July 1, 1949. All other steers were wintered on prairie hay and cottonseed cake, and the effect of a low and a high phosphorus ration on blood phosphorus and calcium was studied during the three grazing seasons. The plasma phosphorus level of the steers grazing in pastures fertilized with superphosphate during the 1949 grazing season was significantly higher than the plasma phosphorus of steers grazing in pastures treated with limestone or those receiving no treatment.

It will be observed that the average weights of the permanent steers in the different pastures were very similar except in Pasture H where the protein and mineral content of the forage was much poorer than in the other pastures. The slightly higher gains of the steers in Pastures E and G were probably due to individual differences in the



Three-year-old steers on fertilized forested upland soil weighed 1,115 pounds. The one steer that was kept in this pasture for three years and was wintered on corn gluten meal and prairie hay gained 672 pounds.

TABLE II. — Effect of Pasture Improvement on Gain and Market Grade of Three-year-old Steers.

Pasture	Av. daily gain (pounds) 4/11 to 7/1/49	Total gain per acre* (pounds) 4/11 to 7/1/49	Acres per steer	Av. wt. of steers (pounds) 7/1/49	Av. gain in pounds 4/14/47 to 7/1/49	No. of steers graded as: Slaughter	No. of steers graded as: Feeder	Appraised Value Slaughter	Appraised Value Feeder
A	2.26	40	4.5	1020	606	0	4	....	$19.75
B	2.06	52	3.0	1030	614	0	4	....	21.50
C	3.24	113	2.0	1060	646	2	2	$22.50	21.50
D	2.75	107	2.0	1040	625	3	0	22.67	....
E	2.62	104	2.0	1120	707	1	3	23.50	20.67
F	3.14	150	1.4	1070	636	2	2	22.00	21.50
G	2.50**	64	2.4	1130	754**	8**	1**	23.00	19.50
H	1.67	24	5.7	850	439	0	2	....	20.50
I	2.54	67	2.8	1070	672	0	1†	....	21.00

* All steers were included in these calculations.

** Only two of the steers in Pasture G were in that pasture for the three grazing seasons and all of these steers were fed cotton seed cake each winter. All other steers were fed corn gluten meal each winter.

† One of the permanent steers in Pasture I broke a leg in the winter of 1948-49.

animals rather than differences in the quality of the forage. Theoretically, steers in a pasture experiment should gain at about the same rate, and the number should be varied depending upon the carrying capacity of the pasture. When fertilizer treatments influence the vegetative composition as well as the quality and quantity of the forage, some differences in growth rate and gains of steers in different pastures would be expected.

Cost of Increased Production Through Soil Improvement

One of the important reasons why many farmers have not been fertilizing and liming their pastures may be the initial investment required and the lack of definite knowledge as to the benefits which may be obtained from such an investment. Two of the objectives of the southeast Oklahoma pasture study are (1) to determine how much beef could be produced per acre on different soils by fertilization, and (2) how much it would cost to produce beef on fertilized as compared with unfertilized land. The relation between beef production and soil treatment on the nine pastures (representing four different soils) at the Southeast Pasture-Fertility Station are given in Table III.

If a farmer planted Bermuda grass, rye grass, winter legumes and lespedeza on a permeable upland prairie soil, beef production over a period of years would be similar to that obtained from Pasture A (73 pounds per acre) which received no fertilizer treatment. The two

TABLE III. — Pounds of Beef Produced Per Acre on Different Pastures, 1946 to 1949.

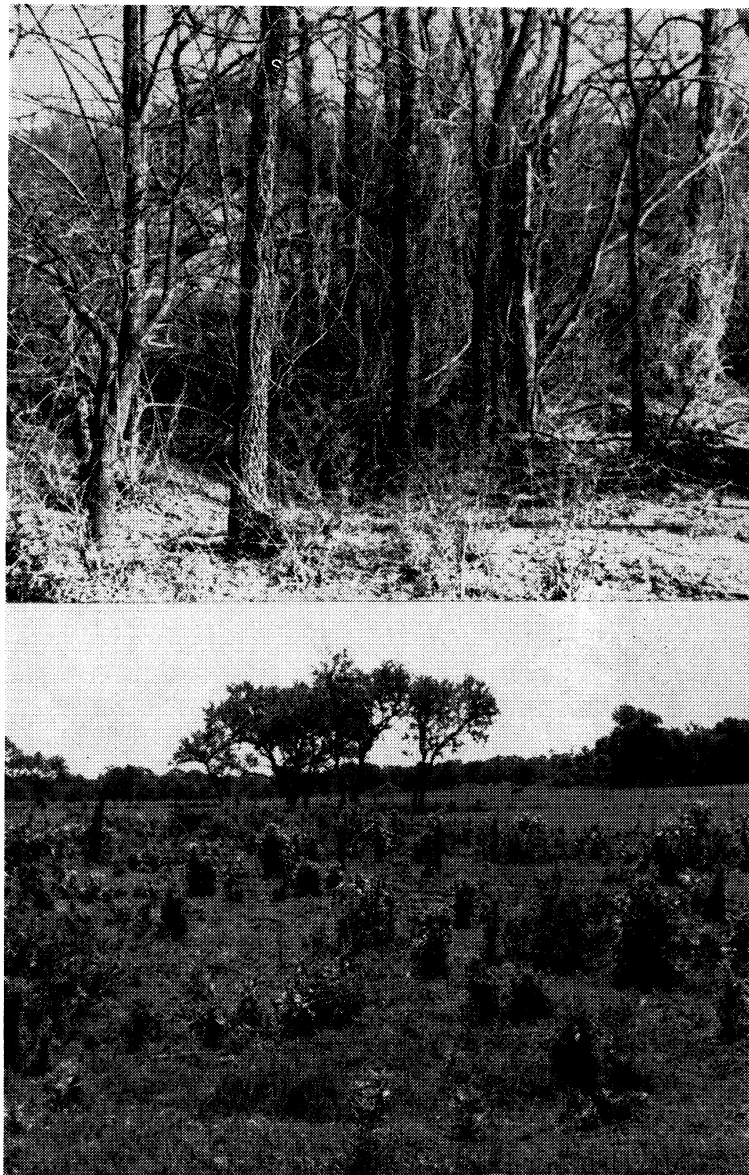
Pasture	Soil condition	Fertilizer treatment	Pounds of beef produced per acre 1946	1947	1948	1949	Av.
A	Permeable prairie upland	None	65	68	67	91	73
B	Permeable prairie upland	Limestone	82	96	99	115	98
C	Permeable prairie upland	L and SP	108	130	88*	189	129
D	Claypan prairie upland	L and SP	103	122	95	167	122
E	Branch bottom land	Limestone	140	185	183	192	175
F	Branch bottom land	L and SP	140	218	197	255	203
G	Eroded timber soil	L, SP & K	......	101	96	142	113
H	Eroded timber soil	None	......	58	62	61	60
I	Eroded timber soil	L, SP & K	......	92	107	149	116

* Severely overgrazed in the fall of 1947; and severe drought in March and April 1948 prevented hop clover development.

tons of lime per acre applied to Pasture B in 1945 cost about six dollars. This treatment will last approximately ten years, and the future lime requirement of this land will probably be one ton per acre every ten years. The cost of limestone spread on the land in southeast Oklahoma counties will vary from three to four dollars per ton. Figuring the cost of limestone at 60 cents per year, which does not include PMA* payments, the cost of the increase in beef production on a permeable upland soil which was limed at the rate of two tons per acre has been 2.4 cents per pound. When two tons of limestone and 150 pounds of 20% superphosphate per acre were applied to similar soil in Pasture C, the average annual cost of fertilization per acre will be about 60 cents for lime and 75 cents for the superphosphate which will be applied every third year. Increasing beef production 56 pounds per acre with an annual investment of $1.35 per acre for fertilizer and lime would make the cost of beef gains about 2.5 cents per pound. The cost of increased beef production on the branch bottomland pasture where superphosphate was applied to the limed area has been approximately 2.7 cents per pound.

On the forested upland pasture where lime, superphosphate and potash were used to produce a maximum growth of legumes, the annual cost of fertilizer and lime per acre has been 45 cents for lime, 75 cents for superphosphate, and 25 cents for potash. This investment of $1.45 per acre produced 52 pounds of beef at a cost of 2.6 cents per pound.

*Production and Marketing Administration of the United States Department of Agriculture. Farmers co-operating in the agricultural conservation program of the PMA can obtain lime at a cost of $1.50 to $2.00 per ton and superphosphate at a cost of 60 to 70 cents per 100 pounds. A portion of the cost of planting Bermuda grass, rye grass and winter legumes also will be paid by the PMA.



Top: Branch bottom land occupied by a thick growth of worthless timber and undergrowth in March 1945, had no grazing value.

Bottom: The same branch bottomland with trees and brush removed and pasture established. A few perennial weeds need to be killed by spraying with 2,4-D. This pasture produced 255 pounds of beef per acre in 1949.

Only one pasture was established on claypan soil because of the limited area of this type of land. The cost of beef gains on fertilized claypan soil would not be much different than on permeable upland prairie soil, although the effect of summer drought is normally more severe on this type of land.

It is quite evident from this study that branch bottomland has the highest potential grazing value. However, the cost of increasing beef production by fertilization and liming has been about the same as on the prairie upland and eroded timber soil. Clearing brush and trees from small branch bottoms and planting these areas to adapted grasses and legumes will produce more beef for the money and labor invested than any other type of pasture improvement.

Bermuda grass, big hop clover and Korean lespedeza on eroded timber land have produced about the same amount of beef per acre as a mixture of weeping lovegrass, big hop clover, and Korean lespedeza.

One of the big problems in the optimum utilization of the forage produced on an improved pasture is good management. When the same number of animals are to be grazed on a pasture during the entire season, some of the excess forage produced during the spring months should be cut for hay. If livestock numbers are available to utilize the large quantity of forage produced during the spring and early summer, animals that are ready for market in late June or early July should be sold, since the carrying capacity of an improved pasture is much lower in summer and fall than during the spring grazing period.

WINTER FEEDING DATA—Winter feeding data have been obtained during the past four years. In 1946, sixty steer calves were fed weeping lovegrass hay and cottonseed cake. In 1947, steers which had been assigned to the different pastures for the duration of the experiment were separated from the "other" steers during the winters of 1947-48 and 1948-49, and were fed prairie hay and corn gluten meal to study the effect of a low phosphorus ration on metabolism. The "other" steers were fed prairie hay and cotton seed cake. Data on quantity of hay and protein supplement consumed, length of the winter feeding period, average gain or loss per steer and relative cost of feed for the four winter seasons are given in Tables IV and V.

Stocking Rates as Affected by Age of Steers and Season

Proper stocking of a pasture is an important factor in optimum beef production. Rainfall is normally high during the spring months in Southeastern Oklahoma, and the carrying capacity of an improved pasture will be much higher than in summer when high temperatures and lower rainfall make less favorable conditions for the growth of the grass. When a pasture is stocked for normal summer rainfall, the pasture will be overgrazed if drought occurs. When a tall grass pasture is stocked lightly in the spring, a high percentage of the forage will have a low protein value during the summer months. If an undergrazed pasture can be mowed, clipping early and removing a hay crop will greatly improve the quality of the forage for summer and fall grazing.

TABLE IV. — Quantity of Prairie Hay and Protein Supplement Fed per Steer During Three Winters, and Gain or Loss per Day

Age of steers	Length of winter feeding period (days)	Pounds of Feed per day			Pounds Gain or Loss per Day	
		Hay	Cotton-seed Cake	Corn gluten meal	Cotton-seed cake	Corn gluten meal
Calves (1946-47) (9 to 12 mo.)	135	8*	1.38	......	......	......
Yearlings (1947-48) (21 to 23 mo.)	149	14	1.17	1.22	+.27	+.005
Two years (1948-49) (33 to 36 mo.)	161	17	1.53	1.55	—.02	—.08
Calves (1949-50) (9 to 12 mo.)	135	9	1.33	......	+.61	......

* Weeping lovegrass hay was fed the first winter.

Spring grazing can be doubled in most southeast Oklahoma pastures as a result of a pasture improvement program. But summer and fall grazing on low organic matter soils will not be improved until the residual effect of the winter legumes can build up enough nitrogen and organic matter in the soil to stimulate the growth of Bermuda, or other summer or fall grasses. When pastures are stocked to take advantage of the abundant production of spring forage which results from the use of fertilizer and the planting of winter legumes, it will be necessary to decrease the number of animal units about July 1, because the carrying capacity of an improved pasture will be lower in summer and fall than in the spring.

In some grazing experiments, steers are removed, or added to different pastures, depending on the condition of the pastures. In this experiment an attempt was made to stock the pasture so that the same number of animals could be kept in the pasture for the entire grazing period.

The data presented in Table VI show the number of acres for

TABLE V. — Cost of Winter Feed per Steer.

Year	Hay and cotton-seed cake	Hay and corn gluten meal
1946-47 (calves)	$14.12	......
1947-48 (yearlings)	17.30	$19.47
1948-49 (2 yr. olds)	23.72	27.28
1949-50 (calves)	13.15	......

Cotton seed cake cost $100 per ton in 1946-47, $94.00 in 1947-48, $71.00 in 1948-49, and $66 to $70 per ton in 1949-50. Corn gluten meal cost $100 per ton in 1947-48 and $85.34 per ton in 1948-49. The prairie hay cost $12.00 per ton. The value of the weeping lovegrass hay was calculated at $9.00 per ton.

one-, two-, and three-year-old steers which were grazed on the nine pastures at the Southeast Pasture-Fertility Station during the four-year period, 1946-1949. It will be observed that the improved pastures have carried from one and one-half to two times as many steers as were grazed on the same acreage of unfertilized pasture. The soil on the unfertilized timber pasture (H) was too poor to grow very much big hop clover and lespedeza. Consequently, the grazing value of this pasture remains low because very little nitrogen has been added to the soil to improve the grazing value of the weeping lovegrass.

Bermuda grass has spread slowly on much of Pasture A, located on permeable upland prairie soil, even though the soil contains a good supply of organic matter. The high acidity and low mineral phosphate availability in this soil is largely responsible for this condition. The stand of hop clover and lespedeza has gradually increased in this pasture, but the plants are always small and the grazing value will never approach that of a fertilized pasture.

The vigorous growth of big hop clover combined with overgrazing retarded the spread of Bermuda grass in Pasture C during the second and third year. The number of one-year-old steers placed in this pasture in the spring of 1947 was too great for the amount of Bermuda grass produced during the summer and fall, because of limited rainfall. The steers lost weight during the latter part of the grazing

TABLE VI. — Number of Acres per Steer and Age of Animals Allotted to Different Pastures, 1946 to 1949.

Pasture	Fertilizer treatment	Acres of grass per steer, by years				
		1946	1947	1948	1949	
					4/11 to 7/1	7/1 to 10/21
A	None	4.5	3.0	3.6	4.5	3.6
B	Limestone	3.6	2.0	2.6	3.0	2.6
C	L. and superphosphate	3.0	1.3	2.6*	2.0	2.0
D	L. and superphosphate	2.7	1.3	2.7	2.0	2.0
E	Limestone	2.5	1.0	1.3	2.0	1.7
F	L. and superphosphate	2.5	.6**	1.0†	1.4	1.3
G	L. and 0-14-7	.....	2.4	2.8	2.4	2.4
H	None	.....	1.9	2.8	5.7	3.8
I	L. and 0-14-7	.....	1.6	2.3	2.8	2.3

* Stocked lightly to permit pasture to recover from overgrazing in the fall of 1947 and severe damage to big hop clover from spring drought in 1948.
** Five steers removed on September 1 because of drought and limited forage.
† Two steers removed from F pasture because Bermuda grass was the principal source of forage in the summer and fall of 1948.

Age of steers:
1946 — Two-year-olds.
1947 — Yearlings.
1948 — Two-year-olds.
1949, 4/11 to 7/1 — Three-year-olds.
1949, 7/1 to 10/21 — Two-year-olds.

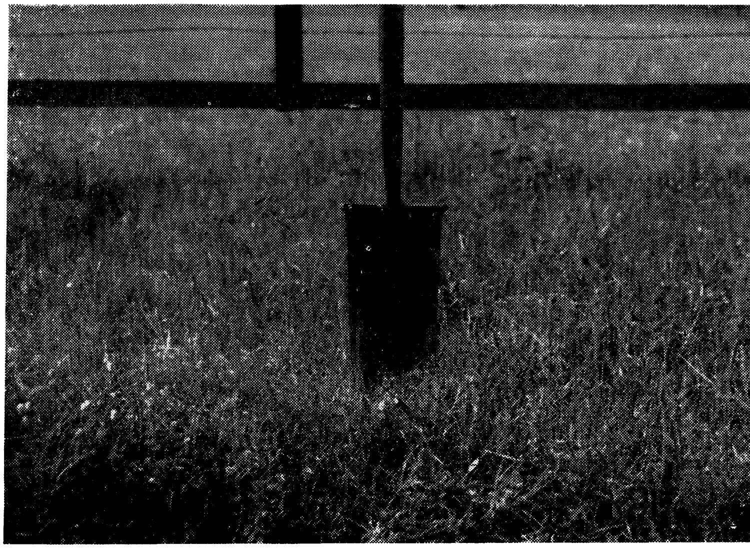
season, partly due to the fact that a good stand of Bermuda grass had not yet developed. Some winter injury occurred to the Bermuda grass as a result of close fall grazing, and this reduced the vegetative cover far below what should be left on a pasture to protect the shallower Bermuda roots from freezing and to provide a more favorable environment for the growth of winter legumes. Dry weather in April, 1948, killed several stands of big hop clover which appeared on this pasture because of a lack of vegetative cover needed to protect the young seedlings during their early stage of development. Consequently, the stocking rate in 1948 had to be reduced because of limited forage production. This pasture recovered quickly in 1948 and produced 188 pounds of beef per acre in 1949. Overgrazing was prevented in Pasture F during the summer and fall of 1947 by removing five of the sixteen yearling steers on this 10-acre pasture on September 1 because of a limited feed supply.

Where a sufficient number of animals are not available to utilize the large quantity of hop clover produced during the spring grazing season, a portion of a pasture could be cut for hay, although curing may be a problem during some seasons. Big hop clover which is not utilized for pasture during the spring months and is not cut for hay will add organic matter and nitrogen to the soil after the plants die. This process of soil improvement will gradually improve the growth of Bermuda grass planted with the hop clover, making the Bermuda more succulent and higher in protein content when summer and fall rainfall is favorable. The beneficial effect of winter legumes on the growth of the Bermuda grass will eventually increase the carrying capacity of a pasture during the summer and fall, even when the soil was very low in organic matter content at the time the pasture improvement program was started.

Bermuda grass makes up the major portion of the forage in the six pastures, A to F, inclusive, after the big hop clover disappears. In 1949, three-year-old steers were grazed on these pastures until they were marketed on July 1. The same number of two-year-old steers were placed in these pastures to complete the grazing season (see Table VI). Two-year-old steers grazing on high quality Bermuda grass in Pasture C, which received lime and phosphate, gained 2.4 pounds per day during July and August as a result of the soil improving effect of the big hop clover during the previous seasons. The gains on Pasture A, which is not fertilized, were 2 pounds per day during this period. A good stand of lespedeza in Pastures G and I was largely responsible for the high carrying capacity of these pastures in the summer and fall of 1949.

Relation of Beef Production to Protein Content of Forage

Beef gains are closely related to protein production under optimum grazing conditions. Better gains are obtained when the protein content of the forage is high than when it is low. The protein content of grasses declines as the plants increase in size. Also, the grasses become less succulent as they approach maturity, and animals do not eat this type of forage readily. Legumes have a very high protein



Vegetative growth on protected area on the unfertilized permeable upland prairie soil in Pasture A. This pasture produced an average of 73 pounds of beef per acre annually from 1946 to 1949.

content when young, and the protein content remains high as the plants approach maturity; consequently, they have a high beef-producing capacity at all stages of development.

Big hop clover, white clover and Korean lespedeza have been the principal legumes in the fertilized pastures on the Southeast Pasture-Fertility Station. The protein content of these legumes has varied during the different seasons. Mature plants have been analyzed for protein content with the following results: White clover (Ladino) 15 to 20% protein; big hop clover, 13 to 17% protein; and Korean lespedeza, 11 to 15% protein. Bermuda grass in early spring will contain 12 to 14% protein, but in midsummer and fall the protein content will vary from 5 to 10%, depending upon the leaf-stem ratio and intensity of drought. Weeping lovegrass on the low organic matter soil of Pastures H and I has varied from 5 to 7% protein. This value may increase when legumes have an opportunity to increase the nitrogen and organic matter content of the soil.

The protein content of the forage in different pastures has been estimated from the yield and nitrogen content of forage samples collected from two exclosures 12 feet square placed in each of the pastures to study and measure the quantity and quality of the forage produced during the spring, summer, and fall grazing periods. These areas have been harvested three times a year to obtain data on relative yield and composition of the forage in the different pastures. Although the winter legumes are approaching maturity when harvested about June 1 each year, in many instances only a portion of the forage produced in the pastures during the spring grazing period was consumed when the forage in the exclosures was harvested. Also, legumes that are grazed do not mature as early as ungrazed plants. Consequently, more protein is available for later grazing in the pastures than the maturity of plants in the exclosures might indicate. The results presented in Table X show that a much larger quantity of protein is produced in all pastures during April and May as compared with the production during June, July and August, or September and October.

A comparison of the average protein production in relation to average livestock gains in 1947, 1948 and 1949, which is shown in Table VII, would indicate that the stocking rate on the better pastures was much too low in early spring. However, if the better pastures were stocked heavily enough in May and June to utilize all of the forage produced, there would be too many cattle in the pastures to make satisfactory gains during the summer and fall. In the spring of 1947 the ratio of pounds of protein in the forage to pounds of beef produced per acre was nearly 10 to 1 in all pastures except H and I, because of favorable rainfall. The average quantity of protein produced in April and May has varied from 5 to 9 pounds per pound of beef produced. In midsummer the ratio has varied from 1.5 to 3 pounds of protein in the forage of the exclosures per pound of beef produced in the pastures. In the fall of 1947 the ratio of protein to beef production was quite variable because of overstocking on some of the pastures which resulted in negative gains in September and October. In 1948, the ratio was approximately two pounds of protein in the forage to 1 pound of beef produced for the entire grazing season with a tendency for a narrower ratio to appear in overgrazed pastures. The data for 1949 were similar to those obtained in 1947.

TABLE VII. — Relation of Production of Protein in Forage to Production of Beef; Average, by Seasons, 1947 to 1949. (pounds per acre)

Pasture	Treatment	April & May		June, July & Aug.		Sept. & Oct.		Total	
		Protein in forage	Beef gain	Protein in forage	Beef gain	Protein in forage	Beef gain	Protein in forage	Beef gain
A	None	221	33	77	24	64	18	362	75
B	Limestone	326	42	83	40	63	21	472	103
C	L. & S. P.	604	68	100	50	76	18	780	136
D	L. & S. P.	549	59	82	47	54	20	685	126
E	Limestone	533	81	255	72	160	33	948	186
F	L. + S.P.	603	103	221	87	135	33	959	223
G	S., S.P. + K.	342	32	76*	48	50*	33	468	113
H	None	116	24	62	23	39	13	228	60
I	L., S.P. + K.	198**	45	64*	43	45*	28	307	116

* These values are too low because the method of harvesting did not accurately measure the protein contributed by the lespedeza in these pastures.

** 409 pounds of protein per acre from big hop clover in 1949.

Big hop clover growing on a protected area in a limed pasture on permeable upland prairie soil. This pasture produced an average of 98 pounds of beef per acre each year during the four-year grazing period from 1946 to 1949.

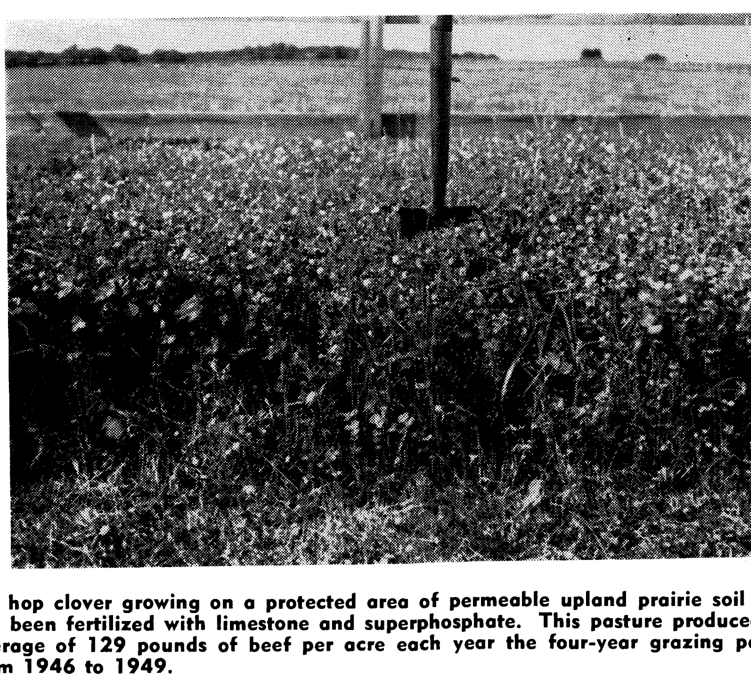
Data obtained from pasture exclosures may give an incorrect picture of the value of lespedeza in a pasture improvement program when it is grown in combination with big hop clover. When the exclosures are clipped with a lawnmower in the spring to obtain information on the yield of the winter legumes, the tops of the slender lespedeza plants are cut off and many of the plants are killed. When samples of forage obtained from grazed areas outside of the exclosures were compared with the results obtained from the forage produced within the exclosures in Pastures G and I on July 16, 1948, it was found that 44.4 pounds of protein per acre were present in the forage from the exclosures in Pasture G, whereas 51.8 pounds of protein per acre were secured from clippings collected outside of the exclosure where continuous grazing had occurred. In Pasture I, the values were 40.8 pounds of protein per acre from the forage produced within the exclosures and 48.1 pounds per acre from samples of forage collected from a grazed area. On all other comparisons the total amount of protein in the forage harvested from the protected area was much greater than in the samples of forage collected from the grazed portion of the pasture near the exclosures.

Effect of Season, Fertilization, and Kind of Plant on the Chemical Composition of the Pasture Herbage

Forage samples obtained each year from 18 pasture exclosures about the first of June, late July or August, and in October, were dried and analyzed for nitrogen, phosphorus, calcium, and potassium content. Samples taken in June were separated to determine the percentage of grass and legumes in the pasture herbage. No separation was made of samples collected in the summer and fall. Average data on the chemical analyses of these samples for the years 1947 to 1949 are given in Table VIII.

It will be observed that mature hop clover plants were much higher in total nitrogen than young Bermuda grass or young weeping lovegrass during the spring grazing season, and that summer and fall forage was lower in total nitrogen than the legumes and grasses which grew during the spring months. The analyses given in Table VIII were all made on a dry forage basis. Dry forage should contain at least 1.28% of nitrogen (8% protein) for cattle to make maximum gains, according to a report prepared by the National Research Council Committee on Animal Nutrition. As pasture herbage matures, or when growth is restricted by drought, the protein content of grass decreases, consequently the gains of grazing animals will likewise decrease. Under such conditions a high protein feed should be fed during the fall to hold summer gains, and during the winter so that the animals will continue to grow and gain in weight. Plants which have a relatively high protein content at maturity have a much higher feeding value than low-protein forage for beef production.

Pastures E, F and G produced herbage during the summer grazing period which had a nitrogen content above 1.28% as recommended by the National Research Council Committee. All other pastures were lower than this value, and the unfertilized pastures were 12 to 16% lower in nitrogen content than pastures receiving phosphate and lime.



Big hop clover growing on a protected area of permeable upland prairie soil that has been fertilized with limestone and superphosphate. This pasture produced an average of 129 pounds of beef per acre each year the four-year grazing period from 1946 to 1949.

TABLE VIII. — Average Nitrogen*, Phosphorus, Calcium, and Potassium Content of Forage from Ungrazed Exclosures in the Pastures, 1947 to 1949.
(percent, dry matter basis)

Pasture	Nitrogen	Phosphorus	Calcium	Potassium
		Legumes, April and May		
A	2.03	.13	.83	1.92
B	1.93	.12	.97	1.85
C	2.26	.15	1.03	2.09
D	2.17	.19	.91	2.04
E	2.09	.15	1.06	2.12
F	2.16	.20	1.12	2.17
G	2.25	.15	1.36	2.05
H	1.64	.12	.88	1.58
I	2.15	.19	1.17	1.88
		Grasses, April and May		
A	1.35	.11	.47	1.77
B	1.37	.14	.51	1.94
C	1.84	.16	.64	2.10
D	1.68	.18	.45	1.81
E	1.44	.14	.40	2.17
F	1.55	.17	.49	2.17
G	1.43	.14	.64	1.98
H	.92	.06	.31	1.16
I	1.37	.13	.59	1.52
		Grasses, July and August		
A	.97	.10	.37	1.10
B	1.03	.11	.41	1.36
C	1.16	.12	.44	1.45
D	1.16	.15	.41	1.32
E	1.37	.13	.53	1.76
F	1.40	.14	.51	1.77
G	1.46	.13	.80	1.62
H	.99	.08	.46	1.04
I	1.13	.11	.53	1.15
		Grasses, September and October		
A	.99	.06	.40	.86
B	.97	.08	.40	.74
C	1.20	.07	.43	.74
D	1.11	.12	.36	.76
E	1.09	.09	.45	1.01
F	1.50	.11	.57	1.12
G	1.23	.07	.59	.95
H	1.13	.05	.29	.57
I	1.16	.06	.33	.53

* Protein content in forage is approximately 6.25 times the nitrogen content.

SPECIES—

Legumes, April and May: Principally big hop clover, with some Ladino clover in Pastures E and F.

Grasses, April and May: Principally Bermuda grass, with weeping lovegrass in Pastures H and I.

Grasses, July and August: Principally Bermuda grass, with weeping lovegrass in Pastures H and I. Includes some lespedeza in Pasture G and I.

Grasses, September and October: Bermuda grass in all pastures except Pastures H and I, which were planted in weeping lovegrass. Includes some lespedeza in Pastures G and I.

Phosphate fertilization increased the phosphorus content of big hop clover from approximately .12% on unfertilized land to .15 to .20% on phosphated soil. The phosphorus content of both Bermuda grass and weeping lovegrass was increased by fertilization. An application of lime appears to have increased the phosphorus content of Bermuda grass more than it increased the phosphorus content of big hop clover. An application of superphosphate doubled the phosphorus content of weeping lovegrass, changing it from a very low value (which is definitely phosphorus deficient for grazing animals) to a phosphorus content which is adequate for the growth and development of beef cattle. When other nutrients are adequate, the most efficient production of beef from a pasture will be obtained when the forage contains from .12% to .15% of total phosphorus. As the phosphorus content of forage drops below these levels, maximum performance cannot be expected; and if such forage is fed for a long period of time a phosphorus deficiency will be produced. All fertilized pastures produced plants that contained an adequate supply of phosphorus for grazing steers during the spring and summer months, except Pasture I, which was slightly deficient based on the samples collected from the pasture exclosures in July and August. More lespedeza was present in this pasture than was obtained from the pasture exclosures; consequently it is probable that much of the forage consumed during the summer months has not been deficient in phosphorus. The forage in all pastures, except D and F, was very low in phosphorus in September and October, due principally to fall drought. The chemical compositions of forage samples collected in the fall of 1949 were not included in the averages shown in Table VIII.

An application of agricultural limestone to these pasture soils has increased the average calcium content of both legumes and grasses. Big hop clover contained .83% of total calcium on unlimed soil and .97% where lime was applied on prairie upland soil. On the forested upland soil big hop clover contained .88% of calcium on the unlimed soil and 1.17% on the limed plots. Forage containing from .15% to .35% of total calcium is adequate for the efficient production of beef cattle. However, young cattle require more calcium than mature animals. Although most forages do not generally contain levels of calcium sufficiently low to produce gross calcium deficiency symptoms, the level of calcium in some forages may be too low to produce the most rapid growth when fed to young animals. Bone breakage is one of the most common symptoms of a severe calcium deficiency. The calcium results were somewhat erratic on the summer and fall forage samples, due to the presence of varying percentages of lespedeza or Ladino clover in the different pastures. However, these variations are not important since all forage samples contained adequate supplies of calcium for beef production.*

Although potassium is normally abundant in all forages consumed

*Although finely ground limestone is recommended in a 1-1-1 limestone-salt-bonemeal mixture, the limestone is added primarily to increase palatability rather than to supply calcium for the animals.

by livestock, an application of potassium to the forested upland soils increased the potassium content of both big hop clover and weeping lovegrass. No potassium was applied to the prairie upland soils or the branch bottomland soils, but the forages produced on these soils were high in potassium content. The potassium content of Bermuda grass was much lower in summer and fall than in the spring. Plant maturity is probably responsible for this condition.

TABLE IX. — Average Composition of 18 Forage Samples from Pasture Exclosures and from Adjacent Grazed Areas; July 16, 1948.

(Percent; dry matter basis)

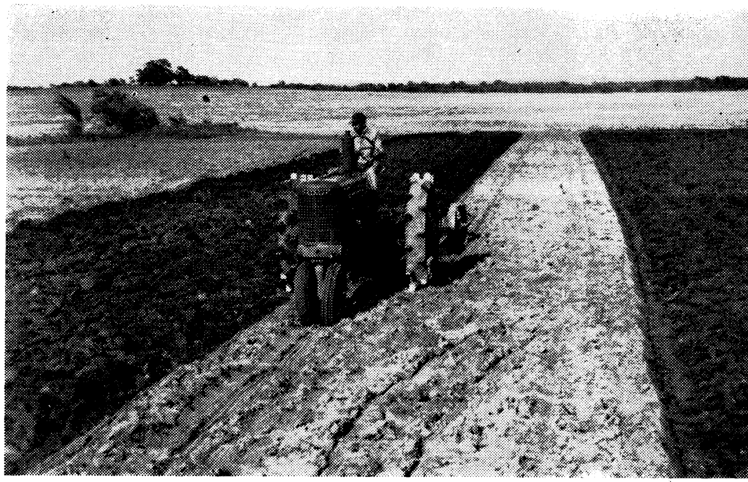
Location	Nitrogen	Phosphorus	Calcium	Potassium
Exclosures	1.42	.15	.49	1.87
Grazed areas	1.40	.15	.55	1.65

The forage obtained from the pasture exclosures contained more mature vegetation than may have been consumed by the steers in some of the pastures. Table IX shows the average chemical composition of forage clipped on July 16, 1948, from 18 exclosures and from the grazed area adjacent to each. Average nitrogen and phosphorus content was the same for both groups. In all probability, the tops of the plants as eaten by grazing cattle have a narrower ratio of stem to leaves than that portion of the plant which remains. Therefore it seems quite likely that both nitrogen and phosphorus are higher in the green forage consumed by grazing livestock than they are in clippings from a grazed area.

Spring Forage Production on Variously Treated Plots

In the spring of 1945, a portion of the reserve pasture was back-furrowed to improve surface drainage conditions. This area is very gently sloping land with a very slowly permeable (claypan) subsoil. Then a fertilizer experiment was established to study the effect of rock phosphate, superphosphate, muriate of potash, limestone, and ammonium nitrate on the spring growth of winter legumes planted in Bermuda grass. Ryegrass was the principal forage produced in the spring of 1946 and no yields were obtained. Yields of winter legumes—principally big hop clover containing some Bermuda grass—were harvested during the latter part of May in 1947, 1948 and 1949. In 1948, the forage yields were low due to severe drought in the spring. Weather conditions were favorable for the early growth of grasses and legumes in 1947 and 1949.

Data on this experiment are given in Table X and represent the residual effect of fertilizer treatments applied in the fall of 1946,



Plowing narrow lands with back furrows about 75 feet apart to provide surface drainage before sodding Bermuda grass on nearly level claypan soil.

except that ammonium nitrate is applied each spring. Yields on the superphosphate plots were slightly superior to those treated with rock phosphate. The beneficial effect of lime on the growth of the legumes has not been as great as that of the phosphates. Maximum production, however, was obtained where limestone was applied with phosphate, potash and nitrogen. Muriate of potash had very little effect on the growth of winter legumes on this soil, which has a slowly permeable subsoil and contains a medium amount of exchangeable potassium. There has been a tendency for grass to replace the legumes on the plots where the ammonium nitrate was applied, whereas the phosphate fertilizers applied without nitrogen have greatly stimulated the growth of the legumes. No appreciable effect on early development of the pasture herbage has been noted from the addition of ammonium nitrate to these plots except that this fertilizer did stimulate the growth of ryegrass in 1947. The ryegrass stand has thinned out very rapidly on these plots under a system of light summer grazing. Although a very heavy seed crop of ryegrass was produced in the spring of 1946, this grass has disappeared from all of the pastures. This condition is probably due to absence of an available nitrogen supply in the soil after it has supported a vigorous growth of Bermuda grass all through the summer. Nitrogen would be lacking to stimulate the fall and winter growth of the ryegrass. This condition will tend to restrict the use of winter grasses on soils low in organic matter. However, big hop clover will supply early spring grazing after a good stand has been established (usually the second year after planting), because it can obtain nitrogen from the air through the aid of root nodule bacteria. Therefore the disappearance of the ryegrass is a benefit rather than a detriment in the development of a big hop clover and Bermuda grass pasture.

TABLE X. — Yield of Spring Forage on Variously Fertilized Plots in the Reserve Pasture, 1947 to 1949.

Plot No.	Treatment		Pounds Dry Forage Per Acre, & Date Harvested			
	Fertilizer	Pounds per acre	May 27, 1947	June 4, 1948	May 31, 1949	Average
1	Rock phosphate	300	2470	990	2730	2030
2	Rock phosphate Muriate of potash	300 100	2480	910	2500	1963
3	Superphosphate	200	2810	1055	3320	2395
4	Superphosphate Muriate of potash	200 100	2660	1085	3050	2265
5	Rock phosphate Limestone Muriate of potash	300 4000 100	3000	1405	3140	2515
6	Superphosphate Limestone Muriate of potash	200 4000 100	3170	1530	3120	2606
7	No treatment	......	1105	610	2060	1258
8	Rock phosphate Limestone Muriate of potash	600 4000 100	2790	1100	2680	2190
9	Superphosphate Limestone Muriate of potash	400 4000 100	3090	1160	2990	2413
10	Rock phosphate Ammonium nitrate	300 100	2710	665	3070	2148
11	Superphosphate Ammonium nitrate	200 100	3400	795	2960	2385
12	Rock phosphate Ammonium nitrate Muriate of potash	300 100 100	2710	615	2640	1988
13	Superphosphate Ammonium nitrate Muriate of potash	200 100 100	3320	665	2930	2305
14	No treatment	......	1995	610	2220	1608
15	Rock phosphate Limestone Muriate of potash Ammonium nitrate	300 4000 100 100	4530	1350	3730	3203
16	Superphosphate Limestone Muriate of potash Ammonium nitrate	200 4000 100 100	4520	1395	3930	3281

Effect of Different Phosphate Fertilizers and Potash on Yields of Hay

BIG HOP CLOVER—In the spring of 1948, one ton of lime per acre was applied to a moderately acid permeable upland prairie soil. Five different phosphates were drilled with and without potash on duplicate plots and big hop clover was seeded on the area. A sufficient number of plants were obtained to reseed the area, and an excellent crop of forage was produced in the spring of 1949. The results of this experiment are given in Table XI. There was very little difference in the yield of hop clover on plots fertilized with 20% superphosphate and fused tri-calcium phosphate. Calcium metaphosphate and treble

TABLE XI. — Effect of Different Phosphates and Potash on Yields of Big Hop Clover Hay and Kobe-Korean Lespedeza Hay Mixtures, 1949.

Plot No.	Treatment		Hay yield (pounds per acre)**	
	Fertilizer	Pounds per acre	Big hop clover	Lespedeza
1	None	......	1578	2720
2	Superphosphate, 20%	200	3436	4439
3	Muriate of potash, 50%	200	1801	2904
4	Superphosphate Muriate of potash	200 200	3411	4780
5	Rock phosphate, 30%	300	1780	2519
6	Rock phosphate Muriate of potash	300 200	2110	3221
7	Rock phosphate Calcium sulphate	300 100	2399	3217
8	Rock phosphate Calcium sulphate Muriate of potash	300 100 200	2314	3398
9	Fused tri-calcium phosphate	300	3383	4553
10	Fused tri-calcium phosphate Muriate of potash	300 200	3300	4975
11	Calcium meta-phosphate, 62%	64	2670	4469
12	Calcium meta-phosphate Muriate of potash	64 200	2151	5337
13	Treble superphosphate, 45%	89	2680	4586
14	Treble superphosphate Muriate of potash	89 200	2913	4861

*All phosphates were applied with a fertilizer drill in 7-inch rows. Muriate of potash was applied broadcast. The gypsum was mixed with the rock phosphate. The area was treated with one ton of lime per acre in March, 1948. All fertilizers were applied and the legumes planted on March 24, 1948. No yields were obtained in 1948.

**Average of two replicate plots.

superphosphate produced yields which were intermediate between the superphosphate and rock phosphate. Gypsum applied with rock phosphate appeared to be only slightly superior to rock phosphate applied alone, although the differences in yield between duplicate plots was rather great in some of the comparisons. Potash had only a slight effect on the growth of big hop clover on this soil. Yields of big hop clover hay were lower in this experiment than yields of lespedeza hay obtained on an adjacent plot.

An experiment was started in the spring of 1950 to study the effect of heavier applications of rock phosphate applied broadcast and disked into the soil before the big hop clover seed was planted. This experiment is the same as described for the Kobe-Korean lespedeza in the following paragraphs.

KOBE-KOREAN LESPEDEZA—Annual lespedezas have been planted extensively in eastern Oklahoma for the past fifteen years. Climatic conditions are usually quite favorable for the growth of annual lespedeza, but in many instances production is poor because of a phosphorus deficiency in the soil.

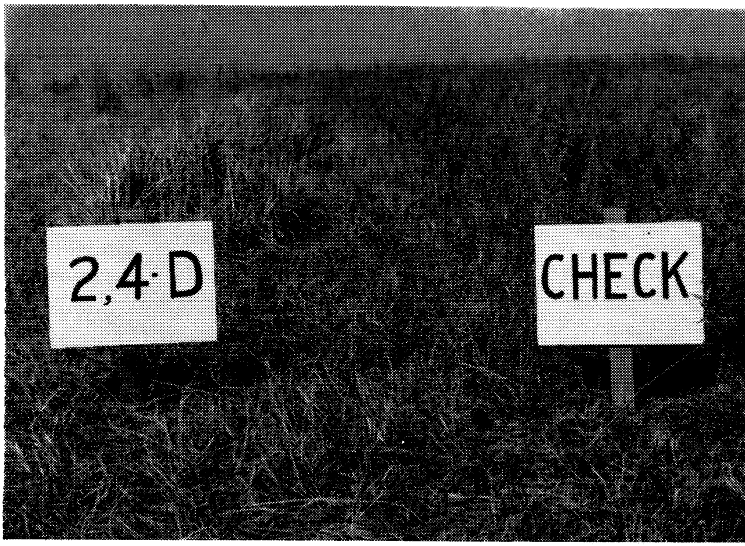
An experiment was started in March 1948, to determine the effect of various phosphates, with and without potash, on the production of Kobe-Korean lespedeza hay on a soil which, though phosphorus deficient, produced a fairly good yield of lespedeza without fertilization. One ton of limestone per acre was applied to partially neutralize the acidity in this moderately acid soil. All of the fertilizers were drilled in 14-inch rows at the time lespedeza was planted. The residual effect of the different fertilizers applied in 1948 on the production of lespedeza hay in 1949 is given in Table XI. No data were obtained in 1948 due to a relatively dry fall which caused a high percentage of the leaves to shed early.

Potash without phosphate produced very little increase in the yield of lespedeza hay. There was very little difference among the five different phosphates compared. Three hundred pounds of rock phosphate drilled in 14-inch rows produced a much lower yield of lespedeza hay even when applied with gypsum than the other phosphate fertilizers on this permeable prairie upland soil.

Heavier rates of rock phosphate (1000 pounds per acre) applied broadcast on phosphorus deficient soils have produced a good growth of Korean lespedeza in several eastern Oklahoma counties. Consequently, a second experiment was started in the spring of 1950 to study the effect of rock phosphate applied at the rate of 500, 1000, 1500 and 2000 pounds per acre as compared with 200 and 400 pounds per acre of 20% superphosphate. All of these fertilizers were broadcast and disked into the soil before the lespedeza was planted.

Perennial Ragweed Control with 2,4-D

Perennial ragweed is abundant in many overgrazed pastures in southeast Oklahoma. This plant cannot be killed economically by mowing. It can be killed by spraying with 2,4-D in late May or early



Perennial ragweeds on right have been killed by spraying with 2,4-D. Untreated ragweed on the left.

June, when the plants are six to eight inches tall. About forty acres of overgrazed upland pasture heavily infested with ragweeds was sprayed during the latter part of June, 1948, with 2,4-D, using ½ to ¾ of a pound of the "acid" in 10 gallons of water for each acre of land. This area was fertilized with 200 pounds of superphosphate in the spring of 1949 and seeded to a mixture of Korean and Kobe lespedeza. Two exclosures were placed in this pasture. One of these exclosures was located on an area which received limestone and superphosphate. The other was located on a dividing line between a plot sprayed with 2,4-D in July, 1948, and an unsprayed area.

Data on the production of lespedeza, grass and weeds on these two exclosure areas in 1949 are given in Table XII. The total dry weight of the ragweeds on the unsprayed area was 2,280 pounds per acre. The dry weight of the lespedeza was 384 pounds and the grass 456 pounds per acre. The production of lespedeza and grass on the sprayed area was more than three times that produced on the unsprayed plot. Where lime and superphosphate were applied, the yields of grass and lespedeza were nearly double the yields on the plot fertilized with superphosphate. Although the dry weight of annual weeds which grew from hard seed produced prior to 1948 was rather high on the two sprayed plots, these weeds did not seriously reduce the growth of desirable grasses and legumes in this experiment. Annual weeds are easily controlled by mowing before seed are produced.

Perennial ragweeds and other undesirable perennials should be destroyed in a pasture improvement program before lespedeza or winter legumes are planted. The quantity of 2,4-D to apply per acre will vary with the concentration and type of spray material used and the plant to be killed. One half pound of the ester or ⅔ pound of the amine per acre will kill the ragweed and not injure the grass. Most clover and lespedeza seedlings are injured when sprayed with 2,4-D. Mature lespedeza plants are somewhat more resistant than seedlings. Bermuda and native grasses are not injured by 2,4-D unless they are in the seedling stage of development.

A convenient boom for spraying weeds can be made from ½-inch galvanized pipe to which fan-type spray nozzles are attached at 18-inch intervals. A pump which will provide about 30 to 60 pounds of pressure should be used. A small centrifugal pump with brass gears can be operated with a gasoline motor, or from the power take-off on a small tractor. The quantity of water which will pass through the nozzles should be measured as the spray equipment moves over an area at the speed which will be used in field operations. Calculate the volume of water that will be applied per acre and mix ½ to ⅔ of a pound of the 2,4-D in that much water for each acre to be treated. The mist from adjacent spray nozzles should cross before it reaches the top of the ragweed plants.

A knapsack sprayer can be used for treating ragweeds in a small pasture. A short boom can be made from ¼-inch copper tubing. Four spray nozzles are attached to this boom, about 18 inches apart. A tee is placed in the center of the boom from which a short copper

Perennial ragweed sprayed with 2,4-D, left, and not sprayed, right. Grass which appeared after ragweed was killed has been grazed heavily by livestock. Lespedeza was seeded on the sprayed area the following year. In 1949, the unsprayed area had more than 2,200 pounds per acre of ragweed, while there was none on the area sprayed with 2,4-D.

tube equipped with a cut-off valve is connected to the spray tank wth a rubber hose. Weeds can be sprayed by walking slowly across an area, holding the boom so that the tops of all plants will be covered with mist from the spray nozzles.

Cotton plants are very susceptible to 2,4-D injury. Contact your county agent for precautions to follow in spraying pastures adjacent to cotton fields.

Poisoning Timber

BOTTOMLAND — Timber such as elm, hackberry, bois d'arc, honey locust and ash is easily killed by hacking a complete circle around the tree a few inches above the ground and placing a few drops of sodium arsenite in each axe-cut with an oil can, pressure sprayer, or other equipment. Small trees, one inch in diameter, will usually be killed by placing the poison in a deep cut on one side of the trunk near the ground. Deep axe-cuts will reduce the efficiency of the poison on large trees. The optimum depth of hacking is just deep enough to go through the bark into the edge of the white wood.

Caution: *Since arsenic is very poisonous to livestock, animals should be excluded from an area where trees have been poisoned until rain has washed any arsenic on the outside of the tree trunks into the soil.*

In many bottomland areas, small trees up to five or six inches in diameter should be killed first and the land plowed with a disc plow as soon as the trees can be removed. This is usually the third season

TABLE XII. — Forage Yields in 1949 from Ragweed-Infested Pastures Sprayed with 2,4-D on June 20, 1948.

	Plot 1 not sprayed; superphosphate	Plot 2 2,4-D superphosphate	Plot 3 2,4-D; superphosphate and lime
Forage production (lbs. per acre)			
Lespedeza	384	1490	2880
Grass	456	1415	2475
Weeds	2280	1345*	1030*
Pct. of forage in:			
Lespedeza	12.3	35.1	41.1
Grass	14.6	33.3	38.8
Weeds	73.1	31.6	16.1

*The weeds were principally annual weeds such as croton and black-eyed daisies which came from hard seed produced before 1948. Mowing for two or three seasons will eradicate these annuals. Very few ragweed seedlings were found on the sprayed area.

Fertilizer treatments applied in March, 1949 —

Plot 1: 20% superphosphate, 200 pounds per acre.
Plot 2: Same as plot 1.
Plot 3: Same as plot 1, plus 1.5 tons of limestone per acre.

2,4,5-T painted on the lower part of the trunk from the ground upward about 10 or 12 inches on March 15 killed this persimmon sprout. One part of 2,4,5-T was dissolved in 39 parts of kerosene.

after poisoning. After a good sod of Bermuda grass has been esablished on the area, the larger trees can be poisoned and removed as the tops fall and the roots decay. A small tree will usually rot so that it can be removed in about 2 seasons. The stump of a large tree may remain for 5 or 6 years.

The arsenic solution is prepared by mixing three pounds of white arsenic with two pounds of lye in a 5 gallon iron pail. Set the bucket in an open area in the yard and add two quarts of water and stir with a wood paddle. The mixture will boil vigorously and during this period keep away from the fumes. After boiling ceases, stir until the solution is clear. When cool, dilute to 3 gallons and place in glass jugs. One gallon of the arsenic solution will poison from 100 to 200 trees depending upon the size. One man can poison about 200 to 300 trees per day.

For further information, see U. S. D. A. Farmers' Bulletin No. 1526.

UPLAND — Studies on the eradication of upland trees as blackjack, post oak, persimmon and hickory indicate that 2,4,5-T is more effective than sodium aresenite for the control of this type of timber. The trees should be hacked in the manner previously described, and treated with one part 2,4,5-T dissolved in 10 parts of diesel fuel or kerosene. August and September treatments have been very effective in killing blackjack oak trees.

Young trees with a smooth bark can be killed by painting or spraying the trunk from the ground upward about 10 or 12 inches with one part of 2,4,5-T dissolved in 39 parts of kerosene or diesel fuel. This treatment will also control persimmon sprouts. March treatment has been very effective for treating the trunks of small trees or brush. Persimmons also have been killed when the trunks were painted in May and early June. Neither the best time for treatment nor the optimum concentration of the 2,4,5-T has yet been determined. More accurate information will be available when the effect of different treatments applied in 1949 have been observed, after spring growth has fully developed in 1950.

Rainfall and Soil Fertility

Rainfall data in *Climate and Man,* (U.S.D.A. Yearbook of Agriculture, 1941, pp. 1065-1074) indicate that the Southeast Pasture-Fertility Station is located in an area which received slightly less than 40 inches of average annual precipitation during the 35-year period prior to 1938. Rainfall has been measured in Coalgate, or on the Southeast Pasture-Fertility Station, since 1937; and data on monthly and total annual rainfall during the past 13 years are given in Table XIII. These data indicate that the total annual rainfall has been approximately four inches higher in the Coalgate area during the past 12 years as compared with the previous 35-year period, but the "warm season" precipitation (April to September, inclusive) for the two periods has been very similar—about 25 inches.

Spring rainfall is normally adequate for the production of a vigorous growth of vegetation on productive soil, but erratic summer rainfall affects the production of both cultivated and pasture crops. About half of the summer seasons are too dry to produce optimum yields of forage.

High winter rainfall has been largely responsible for the formation of acid soil in eastern Oklahoma. Water which is absorbed and moves downward through the soil profile dissolves and carries lime, potash and magnesia into the deeper subsoil beyond the reach of plant roots. It also gradually changes the inorganic phosphorus in the soil into compounds which are relatively unavailable to plants. Farmers in high rainfall areas must buy fertilizer and lime to increase crop production on acid land that has been severely leached by winter rainfall, whereas farmers in an arid region must pay for the water needed to grow crops on soils which normally contain an abundant supply of plant nutrients, because rainfall has not leached them into the deeper subsoil beyond the zone of root development.

TABLE XIII. — Monthly and Total Annual Rainfall Data, 1937 to 1949.*

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1937	4.17	.39	3.69	3.83	3.75	5.09	2.57	7.89	1.21	2.81	4.96	3.09	43.45
1938	1.60	9.34	5.74	3.35	3.16	3.41	6.65	1.88	1.29	.04	1.79	1.59	39.84
1939	2.18	4.44	2.75	3.28	2.99	6.53	1.88	4.65	.57	2.46	2.59	1.26	35.58
1940	.45	3.37	.08	7.32	8.50	9.48	7.46	2.79	1.54	2.19	5.14	3.31	51.73
1941	1.82	3.48	.23	8.60	3.08	3.53	3.59	5.61	1.72	14.82	1.66	1.69	49.83
1942	1.57	1.33	1.33	14.57	4.99	9.03	.87	1.99	4.25	2.48	2.45	2.66	47.52
1943	.30	.80	3.06	2.65	6.15	5.72	1.13	.00	3.24	1.24	1.26	4.27	29.82
1944	2.61	5.91	4.69	2.73	6.09	3.36	.98	3.04	.77	5.30	2.45	3.04	40.25
1945	1.30	9.00	10.74	5.13	4.00	12.48	5.64	4.14	6.20	2.10	1.60	.80	63.13
1946	2.82	5.39	2.92	3.43	6.38	3.73	.22	2.31	3.03	.48	10.33	6.79	47.83
1947	.33	.33	1.81	7.26	8.67	3.97	3.22	1.57	2.12	1.16	2.96	5.44	38.84
1948	.65	4.28	2.13	.78	7.01	5.36	4.42	1.88	1.46	2.48	.24	1.62	32.25
1949	5.19	3.07	3.75	6.39	5.84	5.39	1.60	2.13	4.95	4.67	0.00	3.42	46.40
AVG.	1.92	3.93	3.30	5.33	5.43	5.92	3.09	3.06	2.48	3.24†	2.87	2.99	43.57

*Data for 1937 to 1944, inclusive, from Coalgate, 6 miles southwest of the Pasture-Fertility Station. Data 1945 to 1949 from the Station.

†Average rainfall for October, omitting the 1941 data, is 2.28 inches.