VERN L. MARBLE

FERTILIZED RANGE CAN PAY DIVIDENDS

SECOND PROGRESS REPORT

RESULTS OF TEN GRAZING TESTS ON ANNUAL RANGE 1954 - 1955 SEASON

using animal gains as a measure of results

W. E. MARTIN and L. J. BERRY

IN COOPERATION WITH FARM ADVISORS OF ALAMEDA, GLENN, MADERA, MARIN, NAPA, SACRAMENTO, SAN MATEO, SANTA CLARA, AND SOLANO COUNTIES

UNIVERSITY OF CALIFORNIA AGRICULTURAL EXTENSION SERVICE

this report tells about ★ ★ ★

PROBLEMS OF RANGE FORAGE PRODUCTION

★ ★ ★ where fertilizers may help!

THE TWO METHODS OF USING FERTILIZERS ON RANGE

★ ★ ★ to build up clovers with phosphorus and sulfur
★ ★ ★ to fertilize grasses directly with nitrogen

HOW FERTILIZER MAKES GRASS GROW IN THE WINTER

★ ★ ★ when it usually doesn't want to!

SECOND SEASON'S RESULTS OF "U. OF C." FERTILIZER TESTS

★ ★ ★ applying nitrogen and "NP" materials on annual range and using ANIMAL GAINS to MEASURE RESULTS

10 TESTS in 9 counties with 1110 animals on 1879 acres showed even in a "cold dry" winter and spring

1. ANNUAL RANGE FERTILIZED WITH NITROGEN plus Phosphorus and Sulphur if needed

★ ★ ★ *made earlier winter growth with less "frost bite"*
★ ★ ★ *produced more forage with higher crude PROTEIN and higher PHOSPHORUS content*

2. ANIMALS GRAZING ON FERTILIZED FIELDS

★ ★ ★ *"needed less acres" average carrying capacity was doubled*
★ ★ ★ *"did better" gained more per day in many cases especially in winter months*
★ ★ ★ *"produced more meat per acre" meat yields increased an average of 125 pounds per acre*
★ ★ ★ *"made enough EXTRA meat to" pay for fertilizer and show a profit in 7 of 10 tests "break even" on fertilizer cost in 3 others*

RANGE FERTILIZATION CAN PAY DIVIDENDS

Results of 10 Field Tests Comprising Second Year's Program on Range Fertilization

W. E. Martin and L. J. Berry

I. INTRODUCTION

Actual meat production by cattle or sheep on typical range will decide whether or not range fertilization can be economically feasible. Only by this means may we find out whether dollars spent for fertilization have returned value enough to justify the expense.

This report covers the results from ten field-scale cooperative tests laid out by the University of California Agricultural Extension Service on typical winter range in northern and central California. At three locations treatments were a second-season "follow-up" of treatments made in 1953-54, while seven were at entirely new locations. The tests represent as nearly as possible normal operations under actual range conditions. Gains in weight of 1,110 animals on 893 fertilized and 986 unfertilized acres measure the effectiveness of nitrogen and nitrogen-phosphorus treatments. Before discussing the results of these tests, it may be well to outline some of the problems of range forage production and to review some of the fertilizer work already done on California rangeland.

II. THE PROBLEM

California range makes up somewhat over a third of the area of the state. It includes about ten million acres of open treeless range, plus about 25 million acres of oak-grass woodland and brushy areas used primarily for grazing. Much of this rangeland has been grazed by cattle or sheep for at least a century. Practically none has ever been fertilized. Present forage is composed principally of annual grasses, clovers, and alfilaria.

Most of the open range and low-lying portions of the oak-grass woodland are used for the production of green winter feed. At higher elevations and along the coast where rains continue longer, the range provides green spring and early summer feed. Late summer and fall feed is from the dry grasses and legumes produced during the spring months.

There are several problems of range forage production that may be improved by proper fertilization:

First, there is usually a shortage of green feed in the early part of the winter grazing season. Annual grasses and legumes grow slowly during the winter months, even through adequate soil moisture is present. The major production of forage comes in a great flush in the spring when soil and air temperatures have increased and soil moisture is still adequate. Feed dries up quickly in late spring as soon as the rains cease. This uneven seasonal growth makes for a feast or famine situation. Quickly available nitrogen or nitrogen plus phosphorous fertilizers greatly speed up growth of grasses during the cool winter months.

Second, total feed production is poor in many areas. Here the soils appear infertile and little forage is produced even when temperature and moisture conditions are favorable. Many such soils are known to be acutely deficient in phosphorous, sulfur, and nitrogen. Some soils are severely compacted from years of grazing and neither water nor plant roots penetrate readily. Growth is poor.

Third, forage quality is often poor for animal use. Winter and spring-growing annual grasses make good feed while green or approaching maturity. Most of these same species are of low nutritive quality and some are unpalatable and even injurious when mature and dry. Fertilizer treatments that increase the growth of legumes and desirable annual grasses, along with proper livestock management, will improve the quality of dry feed for summer and fall use. In some areas, annual grasses and legumes fail to extract the available moisture from the soil, allowing non-palatable summer weeds, such as star thistle and tarweed to become established. This further reduces the over-all quality of the dry feed. In some cases the growth of summer weeds seems related to low soil fertility. Fertilization of desirable annual grasses and legumes has, in some cases, stimulated enough early growth to reduce the summer weeds.

III. WHAT HAS AIREADY BEEN DONE?

Two different approaches have been made to the problems of range improvement through fertilization. The first has been to stimulate native or introduced legumes by fertilization with phosphorous, sulfur, and other materials. The second has been the direct fertilization of grasses and other non-leguminous plants with nitrogen-bearing fertilizers. Both methods have much merit but achieve different results.

Previous Work on Range Improvement Through Legume Fertilization:

The aim of legume fertilization has been, first, to improve current feed supplies and, second, to help build up soil fertility. A large number of small exploratory range tests have been set up throughout the state by the Agricultural Extension Service, in cooperation with Dr. John Conrad of the Department of Agronomy. These tests included phosphorous, sulfur, potassium, lime, and other materials. At many locations, phosphorous or sulfur-bearing fertilizers, alone or in combination, greatly increased growth of native or introduced clovers. In these areas, effective range improvement was achieved at low cost. The amount of spring forage was increased. The quality of feed, both green and dry, was improved by the greater proportion of high protein legume vegetation. A residue of organic nitrogen was left in the soil which stimulated grass growth the following season.

Legume fertilization, though often effective in increasing spring feed, has serious limitations. First, it does not provide the early feed needed on many winter ranges. Second, in many areas, soils are well enough supplied with phosphorous and sulfur so that added fertilizers cause no growth increases. Third, some seasons, known as poor clover years, have temperature and rainfall conditions such that little legume growth is made regardless of fertilizer applications.

Previous Work on Range Improvement Through Nitrogen Fertilization of Grasses:

The aim in using nitrogen fertilizers has been to fertilize the grasses directly and thus increase forage production. Nitrogen treatments were included in many of the legume range fertilizer tests carried out by the Agricultural Extension Service and Department of Agronomy. In nearly every test, the grasses present responded to nitrogen. In a few cases, clovers responded.

In this series of exploratory tests, several patterns of nitrogen response on grasses appeared. On soils well supplied with phosphorous, nitrogen treatments alone made as good early and total growth as did nitrogen-phosphorous combinations. On soils acutely deficient in phosphorous, little benefit at any season was obtained

unless phosphorous was used with the nitrogen applied. Many soils showed a seasonal or winter deficiency in phosphorous. On these soils, nitrogen-phosphorous treatments gave large increases in winter and early spring growth. Here straight nitrogen applications showed little result in the winter, but produced good grass growth in the spring after soil temperatures had increased. On some sulfur-deficient soils, ammonium sulfate applications made for better grass growth than equal nitrogen from ammonium nitrate.

A series of range fertilizer clipping plots has recently been carried out both by the Soil Conservation Service and by the University of California Agronomy Department. The plots of the Soil Conservation Service Sunol Nursery near Pleasanton, showed for six successive years, an average increase of production of 2,879 pounds per acre over the control as a result of annual applications of 200 pounds of 16-20 ammonium phosphate sulfate. At current fertilizer prices, the extra feed was obtained at a cost of $5.64 per ton of dried forage.

Similar plots by the University of California Agronomy Department at the Brown Ranch in Sacramento County on a phosphorous-deficient soil showed that over a two-year period 6,775 pounds of extra forage was produced from a single application of 1,600 pounds of 16-20. 82% of the gain came during the first season. The total gain was achieved at a fertilizer cost of $7.25 per ton. More recently, at the University of California Hopland Range in Mendocino County, fertilizer strips were laid out on seeded legume-perennial grass pasture, where there is little winter growth, although rainfall is adequate. In the winter of 1953-54, feed production to March 30 was increased from 540 pounds per acre on the control to 3,944 pounds with 400 pounds of ammonium sulfate, and to 6,349 pounds with 519 pounds of 16-20. Here, the out-of-season winter feed was produced at a fertilizer cost of $6.60 to $7.40 per ton.

Five field-scale grazing tests were carried out by the Agricultural Extension Service and cooperating ranchers in 1953-54. In these tests, meat production by grazing animals was used to evaluate results. In every case, earlier winter feed was produced on the fertilized fields. Meat production per acre was increased two to fourfold by fertilization. The value of the meat produced equalled or exceeded the cost of fertilizer in all three of the tests involving cattle. In the one sheep test, of short duration, only the cost of nitrogen in nitrogen-phosphorous fertilizers was recovered, although meat production was increased over $3\frac{1}{2}$-fold, and production of early winter feed greatly hastened.

A similar series of demonstrations, sponsored by Balfour-Guthrie, Ltd., and carried out in cooperation with a number of Soil Conservation districts, showed similar results in that production of winter feed was greatly hastened, and profits, as measured by meat production, achieved in most cases.

IV. RELATION OF CLIMATE AND FERTILITY TO WINTER FORAGE PRODUCTION

The most striking and consistent results in the entire series of range fertilizer plots and demonstrations have been the fact that supplemental nitrogen fertilizers stimulate early and continued winter and early spring growth of annual grasses. These responses have occurred during the cold season when little growth would normally be expected. Nitrogen appears to be the key to early growth, but was effective only if adequate phosphorous and sulfur were present or were applied in the fertilizers used.

How Fertilizers Stimulate "Out-of-Season" Feed:

Three factors - moisture, temperature, and nutrient supply govern the growth of range plants. Throughout California, rainfall usually comes during the winter months when temperatures are at their lowest. The bulk of the feed production does not come until the spring when soil temperatures have increased and moisture is still adequate. The warming up of the soil as spring approaches permits the liberation of nitrogen from organic reserves and crop residues in the soil. This increases the nutrient supply and causes the range forage to grow in a great flush of spring growth, which slows to a stop as rains cease and the dry summer approaches.

It is ironic that the most favorable growing temperatures occur when there is little rain, and that good moisture conditions occur when soil temperatures are usually too low for natural growth of range plants. Winter temperatures are apparently too low for soil bacterial processes which bring about decomposition and mineralization of organic matter and legume and crop residues. The same winter temperatures, however, are not too low for grass and alfilaria and other forage plant if adequate nutrients (principally nitrogen and phosphorous) are present in available form.

As a result, it is perfectly possible to provide nitrogen and phosphorous, where necessary, out of the fertilizer sack to make up the deficit induced by cold winter and spring temperatures. Thus, it is possible for grasses to grow in much of our winter range area at the season when they do not do so normally.

The relationship of winter temperature, rainfall, and fertility, to winter forage growth may be shown graphically in Figure 1 from the data taken in the Santa Clara County test in 1954. This soil was deficient in both nitrogen and phosphorous. Clippings were made at monthly intervals from exclosures in fertilized and control fields. These yields of forage are plotted along with the corresponding temperature and rainfall records.

It is clear that the yields of unfertilized forage occurred only when temperatures were rising, rainfall decreasing but adequate, and moisture was still present. The yields decreased rapidly as spring rains ceased.

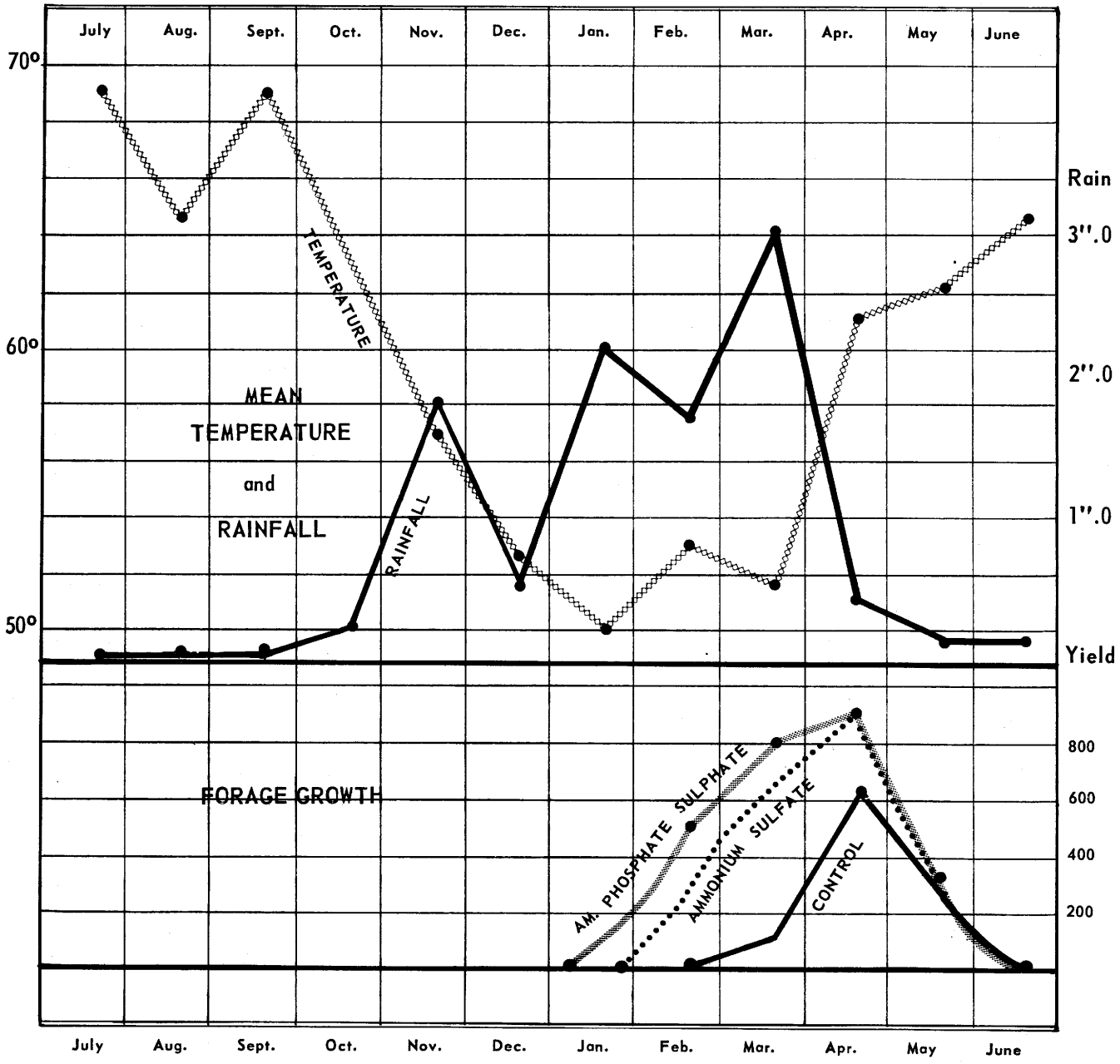
On the ammonium sulfate treated field, growth was hastened, and took place well in advance of that on the control, but not nearly as rapidly as where both nitrogen and phosphorous were applied to this seasonally phosphorous-deficient soil.

Both early and total forage production were increased and the grazing season hastened by supplying the nutrients, nitrogen and phosphorous, at the time of year when conditions for growth were favorable, but soil-supplied nutrients insufficient.

This chart illustrates the potential we have in much of our range area for making plants grow during the winter to take advantage of the rainfall which normally occurs during these months. With perennial grasses, it may be possible to make the forage production curve follow the annual rainfall. With annual grasses there is inevitably a lag for the seeds to sprout, but growth can be greatly increased during the winter period if needed nutrients are provided.

SEASONAL GROWTH OF ANNUAL RANGE AS RELATED TO FERTILIZATION, RAINFALL AND TEMPERATURE

Santa Clara County, 1953-54



V. LAYOUT OF RANGE FERTILIZER GRAZING TESTS

Site Selection and Size of Experimental Fields:

Animal grazing tests on fertilized range were set up in ten counties in the fall of 1954. They were set up for the specific purpose of finding out how much nitrogen-phosphorous fertilizer could be used most profitably on winter range. Meat production during the grazing period was used as a measure of success. Tests were in Alameda, Glenn, Marin, Madera, Napa, Sacramento, San Mateo, Santa Clara, and Solano counties. All were field-scale trials carried out on lands selected as typical of extensive areas in each county. Some tests were on good productive range. Others were on poorer range, depleted by years of heavy grazing, or areas of low initial capacity on rocky terrain recently cleared of brush and seeded to improved range species. Some were in areas known to be deficient in phosphorous or sulfur, while others were on soils well supplied with these nutrients.

The size of experimental fields was, of necessity, large, in order to get a fair cross-section of rangeland and to accommodate sufficient animals to obtain reliable results. Field size was also dictated by the size of suitable fenced fields that might be divided for treatment and also by the location of stock waterholes. In every test the rancher cooperator had to build considerable new fence to provide suitable fields for treatment. Fertilized fields were approximately the same size in each test - usually 10 to 60 acres - while control fields were often somewhat larger. In the Glenn County test the terrain was such that much larger areas were required. The total acreage in all ten tests was 1880 acres, of which 986 were fertilized.

Fertilizer Treatments of Experimental Fields:

The basic plan of these field-scale range fertilizer tests was to have a control field and one or more adjacent fields fertilized with various nitrogen and nitrogen-phosphate treatments. Tests in eight of the ten counties involved multiple treatment. In three counties plots were planned in such a way that all fertilized fields were to receive equal nitrogen but varying amounts of phosphorous. In two counties, fertilized fields received equal amounts of phosphorous but differing nitrogen rates. In one county on a high phosphorous soil, two rates of nitrogen were compared. In one county a nitrogen source comparison was set up, comparing ammoniacal with nitrate nitrogen, both applied in split applications at equal nitrogen per acre.

Airplane application was used in one half of the field tests. This means of application was very satisfactory in rapidly and uniformly spreading materials on lands too rough for ground equipment. Even on level terrain, the airplane offers advantages when time is short and insufficient labor and ground equipment available.

Costs of application by plane in these tests varied from 60¢ to $1.00 per cwt., or from $1.50 to $3.00 an acre. These costs are higher than by ground rig on accessible terrain and with good equipment. Landing strips close to the fields to be fertilized, and use of high analysis materials will keep costs down. It was also found practical and efficient to mix materials in the field while being placed in the hopper of the plane. With large acreages, lower plane costs may be expected.

Stocking of Experimental Fields:

Grazing was carried out as close to normal ranch operations as possible. In the cattle tests, young animals, weighing from 400 to 600 lbs., were used. In some cases all animals were heifers, while in other tests all steers were employed. Where young steers and heifers were used together, the same proportions of the two were placed in each test field. Animals were weighed into the field when green feed had reached a height of four to five inches on the fertilized areas.

Untreated fields were stocked on the same date at rates selected by the rancher as the normal carrying capacity of the range. Fertilized fields were stocked more heavily at rates estimated as proper for the available feed. Animals were added, as needed, to utilize increased feed in spring months. Because of the drought prevailing at some locations, it was necessary to remove animals so as to keep stocking in proportion to the available feed. In two of the tests, winter and spring drought was so severe that cattle numbers had to be drastically reduced. In two tests, it was also necessary to provide supplemental feed.

All animals were removed and the test terminated by mutual agreement with the rancher when nearly all of the green feed had been utilized, thus leaving enough growth to provide dry feed for normal fall use. Every effort was made to graze the fields so as to utilize the available feed but not to over-graze any of the treatments. The control and the fertilized fields were grazed during the same period.

All animals were weighed when placed in the fields and again when removed. Test weighings were made during the season to determine progress. At these times, stocking rates were changed if the condition of the range indicated it. By using this method of weighing and stocking, it has been possible to express results first as total grazing days per acre; second, as average daily gains per animal; and, finally, as pounds of meat per acre.

Forage Samples for Chemical Analysis:

Samples of forage were taken from the experimental fields in seven of the tests. They were collected as clippings from ungrazed, fenced exclosures. These samples were taken to determine the effect of fertilizer treatment upon the chemical composition of forage.

Analysis of all samples was made in the Central Agricultural Extension Service Laboratory in Berkeley.

VI. METHOD OF EVALUATION

The dollar value of meat actually produced on the experimental fields is used as the principal basis of evaluation. In the eight tests involving beef cattle, great gains during the grazing period have been evaluated at a standard rate of 20¢ per lb. Where dairy heifer or lamb and ewe gains were measured, prices approximating market values were used. In cases where supplemental feed was provided, meat equal to costs of supplement was deducted prior to recording the meat yield from the pastures alone.

Meat attributable to fertilization has been calculated by subtracting the meat yields of the control fields from the yields of fertilized fields during the same grazing period.

Gross profit per acre from fertilization was calculated by subtracting the cost of fertilizer materials from the extra meat produced on the fertilized fields. Fertilized costs were net cash prices of September 1955 for materials in car- or truckload lots.

Fertilizer application costs are recorded for each test, and are actual costs of application by plane, or a standard value of $1.00 per acre covered by ground applicator.

VII. SUMMARY OF RESULTS

The results obtained from the ten field-scale fertilizer tests are summarized in Table I. In spite of an unfavorable growing season with prolonged winter drought and unusual cold, all tests were carried to completion. In only two tests was supplemental feed required. In two tests, cattle numbers had to be reduced because of drought conditions. In one test, supplemental feed was supplied in all fields as part of the usual ranch operations.

I. Field Observations on areas fertilized with nitrogen alone, or in combination with sulfur or phosphorous where necessary, showed:

1. Earlier winter growth
2. Less frost damage
3. Better growth during winter drought
4. Better quality winter feed, as measured by chemical composition
   a. Higher protein content of nitrogen-fertilized forage
   b. Higher phosphorous content where nitrogen-phosphorous fertilizers were applied to phosphorous-deficient soils.

II. Grazing Results by Test Animals showed:

1. Carrying capacity increased in every test by fertilization:

   Unfertilized range 11-74 grazing days/acre (av. 40.0)

   Best treatment in each test - 62-138 grazing days/acre (av. 102.4)

2. Better gains of test animals on fertilized feed were observed in many cases. Even though stocked at higher rates, animals on fertilized fields often gained more per day than did animals on the control areas. These differences were most striking during the winter months, and were particularly striking in the Madera, Napa, and Sacramento tests.

3. Meat production per acre was increased in every test by fertilization:

   Unfertilized range 15.2 - 148.0 lbs meat/acre (Av. 71.5)

   Best treatment in each test - 97.5 - 395.5 lbs meat/acre (Av. 193.2)

4. The value of the extra meat exceeded the fertilizer cost and application in seven of the ten tests. In these seven, the average gross profit was almost $15.00 per acre. In the other three tests, the value of the gain was about equal to the cost of the fertilizer, but not enough to pay for the cost of its application.

5. Carryover effects of 40-50 lbs. of nitrogen applied in 1953-54 were measured at two locations. In the Glenn County test, 18 pounds more meat were produced than on the control. In the Solano test, 14 pounds less meat were produced.

SUMMARY OF UNIVERSITY OF CALIFORNIA FERTILIZER GRAZING TESTS - 1954-55

County and Ranch	Fertilizer Treatment	Grazing Days/ Acre	Meat Production: Av. Daily Gain lbs.	Meat Production: Meat from Pasture lbs/ac.	Meat Production: Gain from Fertilizer lbs/acre	Evaluation: Value of extra meat @ 20¢	Evaluation: Cost of fertilizer material/ acre	Evaluation: Gross Profit per acre
1. ALAMEDA								
Mulqueeney	None	45	1.59	72				
135 days	N_{50}	89	1.61	143	71	$14.28	$ 6.71	$ 7.57
cattle	N_{100}	103	1.45	149	78	15.52	13.42	2.10
2. GLENN*								
Sevier	None	18	1.68	29*				
161 days	N_{60}	54	1.68	69	41	$ 8.16	$ 8.45	$ -.29
cattle	Carryover	42	1.53	47	18	3.68	--	(3.69)
3. MADERA								
Urrutia	None	37	1.21	44				
128 days	N_{80}	127	1.63	207	163	$32.60	$10.71	$21.89
cattle								
4. MARIN**								
Lawson	None	203	.73	147		@17¢		
125 days	$N_{64}P_{20}$	362	.76	277	130	$17.65	$12.92	$ 4.73
sheep	$N_{64}P_{40}$	362	.76	278	131	17.17	14.54	2.63
5. MARIN								
Wheelwright	None	11	1.43	15				
100 days	$N_{48}P_{60}$	37	1.87	70	55	$10.96	$12.35	$-1.39
cattle	$N_{93}P_{60}$	62	1.86	116	101	20.24	18.85	1.39
6. NAPA*								
Alexander	None	173	1.18	67*				
183 days	$N_{48}P_{60}$	167	1.36	132	65	$13.04	$11.48	$ 1.55
cattle	$N_{93}P_{60}$	280	1.74	253	185	37.08	19.99	17.11
7. SACRAMENTO								
Van Vleck	None	40	1.40	57				
173 days	N_{73}	88	1.53	135	78	$15.54	$10.25	$ 5.29
cattle	$N_{73}P_{49}$	123	1.80	221	164	32.82	14.74	18.08
	$N_{59}P_{79}$	107	1.43	152	95	19.06	15.56	3.50
8. SAN MATEO								
Skyway	None	47	2.69	127		@15¢		
148 days	N_{144}	75	2.35	176	49	$ 7.32	$21.44	- $14.12
dairy heifers	$N_{144}P_{64}$	138	2.88	396	269	40.28	27.06	13.22
	$N_{72}P_{64}$	117	3.17	369	242	36.30	16.32	19.98
9. SANTA CLARA								
Nettles	None	18	.96	17				
91 days	$N_{64}P_{20}$	69	1.41	98	80	$16.02	$12.92	$ 3.44
cattle	$N_{64}P_{40}$	69	1.15	80	62	12.42	14.54	- 1.68
	$N_{64}P_{80}$	69	1.38	96	78	15.62	16.46	- .51
10. SOLANO								
Lawler	None	74	1.99	148				
127 days	N_{100}Am.S.	107	2.03	216	68	$13.60	$13.52	$ .08
cattle	N_{100}Ca.N.	108	1.97	213	65	13.00	18.00	-5.00
	Carryover	74	1.81	134	- 14			(-2.80)

*Meat from Pasture after deducting meat equal to cost of supplement fed.
**Evaluation includes Lamb gains @ 17¢, Ewe gains @ 5¢, and Wool @ 60¢ per lb.

6. Most efficient fertilizer rates depended upon rainfall, and phosphorous and sulfur status of the soil. Nitrogen was clearly shown to be the nutrient key to increasing grass production, but must be accompanied by phosphorous and sulfur where soils are deficient in these nutrients.

   a. Straight Nitrogen Treatment on phosphorous deficient soils in both Sacramento and San Mateo counties made virtually no winter growth, produced far less spring growth, and less total meat per acre than did equal nitrogen with phosphorous added.

   b. Nitrogen Rate Comparisons at Equal Phosphorous were made at five locations. Under low spring rainfall conditions in eastern Alameda County, 50 pounds of nitrogen were more profitable than 100. With more favorable spring rainfall in Sacramento County, 73 pounds of nitrogen were more profitable than 59. With more nearly adequate spring rainfall in Marin and Napa counties, 100 pounds of nitrogen were more profitable than 50. In San Mateo County, 144 pounds of nitrogen produced considerably more meat but were less profitable than 72 pounds.

   c. Phosphorous Rate Comparisons were made at three locations. Two tests on soils only slightly deficient in phosphorous in Marin and Santa Clara counties, showed as good results with 20 pounds P_2O_5 per acre as with higher amounts, all plots receiving equal nitrogen. In Sacramento County, on soil acutely deficient in phosphorous, 50 pounds P_2O_5 per acre with 73 nitrogen produced as good winter growth and more meat per acre than did 79 pounds P_2O_5 with 59 pounds of nitrogen per acre.

7. Costs of fertilizer materials used in range fertilization are important, but only in relation to the results obtained. Whether fertilization of range can be justified will depend upon the cost of the extra meat produced in relation to prevailing cattle prices.

Table 2 shows the cost of material for the most efficient treatment in each of the nine range plots with cattle. Along with it are listed the amount of extra meat produced per acre by the treatment and, finally, the fertilizer cost for each pound of additional meat.

COST OF EXTRA MEAT BY RANGE FERTILIZATION

	"Best" Fertilizer Treatment	Cost of Fertilizer Mat'l./ac.	Pounds "Extra Meat" Produced/ac.	Fertilizer Cost per pound of Extra Meat
Alameda	N_{50}	$ 6.71	71.4 lbs.	9.4¢
Glenn	N_{60}	8.45	40.8	20.7¢
Madera	N_{80}	10.71	163.0	6.6¢
Marin	$N_{93}P_{60}$	18.85	101.2	18.6¢
Napa	$N_{100}P_{60}$	19.95	185.4	10.8¢
Sacramento	$N_{73}P_{49}$	14.17	164.1	9.0¢
San Mateo	$N_{72}P_{64}$	16.32	242.0	7.6¢
Santa Clara	$N_{64}P_{20}$	12.92	80.1	16.1¢
Solano	N_{100}	13.56	68.0	19.2¢

ACKNOWLEDGMENTS

We wish to acknowledge the splendid cooperation of the ranchers who provided the animals and, at extra expense, provided the weighing facilities and specially fenced fields for these tests.

Grateful acknowledgment is also made to the companies whose gifts of fertilizers made most of these tests possible. A total of 94 tons of materials was furnished by the following companies:

Badische-Aniline, Germany (through Atkins, Kroll)	Urea
Best Fertilizers Company	Ammonium phosphates
E.I. duPont de Nemours	Urea
Norsk Hydro, Norway (through Wilson & Geo. Meyer & Co.)	Urea and calcium nitrate
Shell Chemical Corporation	Ammonium sulfate
Western Phosphates	Treble superphosphate

In addition, 34 tons of fertilizer were purchased by the ranchers themselves, providing all, or part, of the fertilizer materials in four of the tests.

MULQUEENEY TEST - Alameda County
by Earl Warren, Jr., Farm Advisor

This test was a follow-up of one on the same fields the previous season. The area was near the village of Midway nine miles west of Tracy on the eastern edge of the Altamont Hills. Materials were applied by plane in November to two fields fertilized the previous year. Ammonium sulfate was used to provide 50 and 100 lbs. of nitrogen per acre, with the same control field as in 1953.

Fall rains came early and the fields were stocked on December 16 with yearling Hereford heifers, using three acres per animal on the control, 1½ acres per animal on the 50 nitrogen field and 1 1/3 acres per animal where 100 nitrogen was applied.

Test weighings were made on Jan. 21 after five weeks. The fertilized fields, apparently, had been slightly overstocked, since the average daily gains for this initial period were less than in the control field.

During the cold period in February animals on both fertilized fields tended to bloat, though few clovers were present. At this time all of the old dry feed had been eaten and the new green feed on fertilized fields appeared "washy." Analysis of green forage showed a higher water content and less dry matter than that from the unfertilized field. Later, as weather warmed up, the fertilized feed "strengthened," and animals gained rapidly. From Jan. 22 to April 28 when the test was terminated the heifers gained 1.7 lbs. per day on the control and 1.7 to 1.9 lbs. per day on fertilized fields with double the stocking rate.

Total meat production per acre was doubled by fertilization. Final weighings at the close of the green feed period showed the N_{50} field had produced 143 lbs. of meat per acre versus 149 on the N_{100} field and only 72 lbs. per acre on the control.

The "Extra Meat" produced on the N_{50} field, if worth 20¢/lb., would pay for the fertilizer, its application, and leave a profit of $5.90 per acre. The meat yield of the N_{100} field would pay only for the heavier fertilizer application and $2 of the $3 application cost - a net loss of $1 per acre.

The "Fertilizer Cost of the extra meat" was only 9.4¢ a lb. on the N_{50} field, but with N_{100} was 17.4¢, not including application.

Samples of forage were clipped from exclosures throughout the season; these showed slightly higher protein content in feed from the fertilized areas and high phosphorous from all fields. During the winter months there was much less frost damage on the fertilized grasses. Large proportions of early maturing grasses like foxtail were present in the fertilized fields.

Effect of Fertilizer Treatment on Yield and Composition of Forage

	Field	Fresh Weight lb/acre	Dry Weight lb/acre	% Dry Matter	% Protein	% Total Phosphorus
Jan. 27	Control	2,771	725	26	18	.36
	N_{50}	13,568	1,698	13	26	.46
	N_{100}	9,325	1,655	18	24	.41
Feb. 24	Control	1,733	430	25	19	.40
	N_{50}	8,601	1,256	15	25	.48
	N_{100}	5,790	1,116	19	27	.45
Apr. 4	Control	2,409	1,574	65	12	.32
	N_{50}	4,570	2,386	52	15	.33
	N_{100}	4,810	2,898	60	13	.32

MULQUEENEY TEST - ALAMEDA COUNTY
135 days, Dec. 16-April 29, 1955

Seasonal rainfall 10.9 inches

		A	B	C
I.	TREATMENTS			
	Nutrients/acre	--	N50	N100
	Materials/acre	--	238 Am. Sulfate	476 Am. Sulf
	Field size/acres	45	37	45
II.	STOCKING AND GRAZING			
	Acres/animal	3.00	1.50	1.33
	Grazing days/acre	45.00	88.6	102.8
III.	WEIGHT GAINS			
	Average In Weight	512 lbs.	488 lbs.	483 lbs.
	Average daily gain:			
	Dec. 16-Jan. 21	1.31	.96	.77
	Jan. 22-Apr. 29	1.70	1.87	1.71
	Entire period	1.59	1.61	1.45
	Total Meat Produced/acre	71.5 lbs.	142.9 lbs.	149.1 lbs.
	Increase from fertilizer		71.4	77.6
IV.	EVALUATION			
	Total grazing income/acre, meat @ 20¢	$14.30	$28.58	$29.82
	Less Fertilizer Cost			
	Material		6.71	13.42
	Application		1.67	3.09
	Net grazing income	$14.30	$20.21	$13.31
	Profit or loss from fertilization		$ 5.91	- .99
V.	FERTILIZER MATERIAL COST			
	Per lb. extra meat		9.4¢ per lb.	17.3¢

THE SEVIER TEST - Glenn County
by Glen P. Eidman, Farm Advisor

This test was a follow-up of a trial carried out at the same location the previous season. The experimental area was located ten miles west of Willows on rolling hills, including both open grassland and oak-grass woodland. The field fertilized the previous year was left unfertilized to study any carryover effect and the same control field of 365 acres was used. An additional field of 200 acres was fertilized by plane in November with 130 lbs. of urea to provide 60 lbs. of nitrogen per acre. All fields contained about the same amount of hill and valley land and were, of necessity, large to include a fair cross section of the range.

The fields were stocked with Angus steers on December 21st, since the fall rains had come early and feed was well advanced in the fertilized field. Following the first of the year rains ceased, and practically no rain fell from mid-January until April 17. It became necessary to provide supplemental feed for animals on all fields, with larger amounts for those on the fertilized fields because of the higher stocking rates. By April 5, the drought had become so severe that feed upon the thinner soils and south slopes had died. On that date the stocking rates were very greatly reduced. Late rains came on April 17, and feed on the deeper soils and north slopes returned and outgrew the forage needs of the remaining animals on the experimental fields.

In evaluating this test, the cost of the supplement fed per acre has had to be considered. Meat at 20¢ a lb. to pay for the supplement has been deducted from the total meat produced in each field. This gives a figure which may or may not accurately reflect the meat from pasture alone.

The value of the fertilizer gain in this test was $8.15 per acre. The cost of fertilizer materials was $8.45, or a net loss of 30 cents per acre, not counting application cost. The extra meat was produced at a fertilizer material cost of 20.7¢ per lb. Actually, the animals from this plot being fed a liberal supplement came off the fields in excellent condition and were sold for 21½¢ per lb. which would give a slight fertilizer profit over the cost of the material used.

The results of this test, while somewhat disappointing, would indicate that even in a very dry year fertilizer benefits may be appreciable. The field fertilized the previous year showed a fertilizer carryover gain of 18 lbs. of meat. In the areas where annual feed died out during the spring drought, there may well be a substantial carryover of residual nitrogen, with a resultant profit during the current grazing season.

J. W. SEVIER - GLENN COUNTY
December 21-May 31, 1955 - 161 days

Seasonal rainfall 15.76 inches

		A	B	C
I.	TREATMENTS			
	Nutrients/acre		1954 carryover	N_{60}
	Materials/acre			130 lbs.urea/ac.
	Field size/acres	365	133	200
II.	STOCKING AND GRAZING			
	Acres/animal/ Dec. 31-Feb. 10	8.7	4.4	3.3
	Acres/animal/ Feb. 10-Apr. 5	6.1	2.2	1.7
	Acres/animal/ Ap. 5-May 31	15.9	8.9	6.4
	Grazing days/acre	18.11	41.7	54.4
III.	WEIGHT GAINS			
	Average daily gain/animal	1.68 lbs.	1.53 lbs.	1.68 lbs.
	Total meat produced/acre	30,45	64.02	91.76
	Cost of supplement/acre	$ .39	$3.42	$4.50
	Meat @ 20¢ to pay for supplement	1.95 lbs.	17.10 lbs.	22.50
	Meat from pasture alone	28.50 lbs.	46.92 lbs.	69.26 lbs.
	Fertilizer gains		18.42 lbs.	40.76
IV.	EVALUATION			
	Grazing income/acre from pasture	$5.70	$9.38	$13.85
	Value of fertilizer gain/acre @ 20¢		$3.68	$ 8.15
	Cost of fertilizer material/acre			8.45 ($1.30 to apply)
	Gross profit/acre from fertilizer material		+$3.68*	-$ .30**
	Application cost/acre			$ 1.30
V.	FERTILIZER MATERIAL COST per lb. increased meat			20.7¢/lb.

* to be added to 1953-54 profit

** Animals from this plot were actually sold at 21½¢ per lb. Using this figure as the basis of calculation, the increase due to fertilizer was $9.07 /acre, or 67¢ over cost of fertilizer.

URRUTIA TEST - Madera County
by Walter Emrick, Farm Advisor

This test was located approximately five miles west of Friant Dam in brush-free open range on soil mapped as Vista fine sandy loam. Forage was largely native grasses and alfilaria with some clover in the swales. Previous fertilizer tests had shown the soil to be acutely deficient in sulfur but not responsive to added phosphorus.

A 40-acre field was fertilized on Dec. 15, 1954, with 380 lbs. of ammonium sulfate per acre, just as grass was starting to grow. An adjacent 30-acre field was fenced off as a control.

Growth on the fertilized field came rapidly and on Feb.1 both fields were stocked. The control field received ten head, or 3½ acres per yearling steer, as customary on this ranch. These remained in this field until June 8. The fertilized field was stocked with 30 head at an initial rate of 1 1/3 acres per animal. On March 17 it was necessary to add 15 steers to utilize the feed.

The animals on the control field gained 1.21 lbs. per day; those on the fertilized field the entire period gained 1.67 lbs. per day, while those added later gained 1.49 lbs. It is significant that both lots of animals on the fertilized field gained more per day than those on the control. It is also important that the animals on the fertilized field the entire period gained 60 lbs. more each than those on the control. This was 60 lbs. that would not have to be put on in the feedlot later.

The total meat produced per acre on the control was 44 lbs., while the fertilized field produced 207 lbs. in the same period - a fertilizer gain of 163 lbs. per acre.

If we evaluate the meat produced at 20¢ a lb., the total grazing income per acre of unfertilized land was $8.86 versus $41.46 on the fertilized field. Deducting the fertilizer cost of $10.71 and $1.00 for its application by Eezy-Flow ground rig, we have a net income from the fertilized field of $29.75, and a net profit of $20.89 was obtained as the result of fertilization.

The 163 lbs. per acre "Extra Meat" from the fertilized field was produced at a fertilizer cost of only 6.6¢ per lb.

Forage clippings were made from a fenced exclosure located where the regular nitrogen rate, a double rate (N_{160}), and an unfertilized strip had been crossed with applications of treble superphosphate and gypsum. Analysis of forage samples taken near maturity in mid-May showed only slightly higher crude protein with 80 nitrogen, but substantially greater with 160 lbs. of nitrogen. Phosphorus was quite high in all forage samples (over .250) and increased by added phosphorus only in the double nitrogen strip.

Fertilizers Applied	Composition of Clipped Forage	
	Crude Protein	Total Phosphorus
Control	7.94%	.252%
P_{94} (200 Treble Superphosphate)	8.37	.253
N_{80} (380 Am. Sulfate)	9.37	.283
N_{80} P_{94}	9.50	.268
N_{160} (760 Am. Sulfate)	13.06	.288
$N_{160}P_{94}$	13.44	.379

URRUTIA TEST - MADERA COUNTY
Jan. 31-June 8, 1955 - 128 days

Seasonal rainfall 13.3 inches

		A	B
I.	TREATMENTS		
	Nutrients/acre	None	N_{80} S_{91}
	Materials/acre	--	380 lbs. Am. Sulfate
	Field size	35 ac.	40 ac.
II.	STOCKING AND GRAZING		
	Acres per animal		
	Jan. 31-Mar.17	3.5	1.33
	Mar. 17-June 8	3.5	.89
	Grazing days/acre	36.6	127.1
	Increase from fertilizer		90.5

III.	WEIGHT GAINS	10 animals Jan. 31-June 8	30 animals Jan. 31-June 8	plus 15 animals Mar. 17-June 8
	Average in-weight/animal	575 lbs.	551 lbs.	555 lbs.
	Average out-weight/animal	730 "	765 "	679 "
	Average gain/animal	155 "	214 "	124 "
	Average daily gain	1.21	1.67	1.49
			Average 1.63	
	Meat produced/acre	44.3	207.3	
	Fertilizer gains		163.0	

IV.	EVALUATION		
	Total grazing income/acre with meat @ 20¢	$8.86	$41.46
	Less fertilizer cost		
	Material	---	10.71
	Application	---	1.00
	Net income/acre	$8.86	$29.75
	Net profit/acre from fertilization		$20.89
V.	Fertilizer material cost/lb. extra meat		6.6¢ per lb.

LAWSON TEST - Marin County

Sheldon Jackson and W. L. Engvall, Farm Advisors

This test was put out on open rangeland in the rolling hills above Dillons Beach near the mouth of Tomales Bay. A field of ryegrass pasture was divided into three 10-acre fields; one for a control and two to be fertilized with ammonium phosphates. One received 400 lbs. of 16-5 to provide 64 lbs. of nitrogen and 20 available phosphorus while the second received 400 lbs. of 16-10 to give the same 64 lbs. of nitrogen but 40 lbs. phosphorus. The entire field had received some manure and superphosphate five years before. Materials were applied with a ground rig in Dec. 1, 1954.

Growth came rapidly on the fertilized fields and slowly on the control. On Feb. 3, all fields were stocked with ewes and lambs: The control at a rate of 1 1/3 pairs (ewe plus lamb) per acre, and the two fertilized fields with 2½ pairs per acre. On April 13 more animals were added to all fields, bringing the control up to two pairs per acre and the fertilized fields to 3.4 pairs per acre. The February and March drought prevented the fields from growing normally. April rains helped and the test was run until June 8.

Lambs and ewes were weighed initially, after 60 days, and at the conclusion. In the first period from Feb. 3 to April 13, lambs and ewes on both fertilized fields gained more per day although stocked at heavier rates than the control. During the second half of the grazing period the daily gains on the control were slightly greater than those on the fertilized fields which may have been slightly overstocked.

In evaluating this test, credit has been given for the lamb, mutton, and wool produced. The total grazing income per acre from each field has been calculated, using lamb weights at 17¢/lb., ewe gains 5¢/lb., and wool (pro-rated for the grazing period) at 60¢/lb. The two fertilized fields produced essentially the same meat and total income, indicating no advantage of higher phosphorus. After deducting the fertilizer cost and its application, the field fertilized with 64 nitrogen and 20 phosphorus showed a net profit of $3.63 per acre. The second fertilized field where more phosphorus had been used showed a lesser profit.

Strips with varying rates of nitrogen and phosphorus were set up in the control field. Treatments included those actually used in this grazing test, as well as higher rates of both phosphorus and nitrogen. Analytical results are listed in the table below. They show production very greatly increased by fertilization and suggest that higher rates of nitrogen would be desirable. The protein content of the forage was increased by the nitrogen applied and the phosphorus content, though adequate, was slightly increased. Further grazing tests at this location will include higher rates of nitrogen.

Effect of N & P Fertilizers on Yield and Composition of Forage

Treatment	Forage Yields lbs. dry wt/ac	Crude Protein	Total Phosphorus
Check	438	10.5%	.267%
N_{64}	1251	11.5	.315
$N_{64}P_{20}$	1592	14.2	.320
$N_{64}P_{40}$	1958	12.1	.324
$N_{64}P_{80}$	2230	13.4	.353
N_{128}	2200	13.6	.319
$N_{128}P_{20}$	2295	13.9	.339
$N_{128}P_{40}$	3285	14.5	.331
$N_{128}P_{80}$	3214	15.1	.311

SUMMARY OF LAWSON SHEEP FERTILIZER GRAZING TEST

Tomales Bay, Marin Co., Feb. 3-June 8, 1955 - 125 days

Seasonal rainfall 26 inches

I.	TREATMENTS	A	B	C
	Nutrients/acre	None	$N_{64}P_{20}$	$N_{64}P_{40}$
	Materials/acre	--	400 lbs. 16-5	400 lbs. 16-10
	Field size	10 ac.	10 ac.	10 ac.
II.	STOCKING AND GRAZING			
	Pair/acre, Feb. 3-Apr. 13	1.34	2.50	2.50
	Apr. 13-June 8	1.96	3.43	3.43
	Pair grazing days/acre	203	362	362
III.	WEIGHT GAINS			
	Av. daily gain (lb./day)			
	Feb. 3-Apr. 13 Lambs	.44 lbs.	.60 lbs.	.50 lbs.
	60 days Ewes	.21	.30	.35
	Apr. 13-June 8 Lambs	.48	.44	.42
	56 days Ewes	.31	.28	.29
	Meat & Wool Wts./acre			
	Lamb	93.0 lbs.	170.4 lbs.	167.1 lbs.
	Mutton	53.8	106.4	110.5
	Wool clip.			
	Av. fleece weight	9.0	9.3	9.2
	Total wool/acre	18.0	28.0	27.5
	Pro-rate for grazing period	5.2	8.3	8.1
IV.	EVALUATION			
	Total grazing income			
	Lamb @ 17¢ per lb.	$15.81	$28.97	$28.40
	Mutton @ 5¢ per lb.	2.69	5.32	5.53
	Wool @ 60¢ per lb.	3.12	4.98	4.86
	Total	$21.62	$39.27	$38.79
	Less fertilizer cost	--	12.92	14.54
	Material application		1.00	1.00
	Net income/acre	$21.62	$25.35	$23.25
	Profit/acre from fertilization		$ 3.63	$ 1.63

WHEELWRIGHT TEST - Marin County

by Sheldon Jackson and W. L. Engvall, Farm Advisors

This test was laid out on a steep area of rangeland on the ocean coast near Muir Beach. Brush had been killed by spraying, and the entire area seeded to improved perennial species and legumes the previous season. Previous soil and field tests had shown this area to be deficient in phosphorus.

In December 1954, two 21-acre fields were fenced off; one was fertilized with 300 lbs. of ammonium phosphate sulfate (16-20) to give 48 lbs. of nitrogen and 60 lbs. of available phosphorus per acre. The second field received the same material plus 100 lbs. of urea, making a total treatment of 93 lbs. of nitrogen and 60 phosphorus. A 40-acre field served as control. Because of the rough terrain, fertilizers were, of necessity, applied by plane.

On March 9, all fields were stocked with yearling heifers at rates judged adequate for the existing feed. In mid-April it became necessary to add more animals to the fertilized fields. All animals were removed on June 14. Over the entire period the unfertilized field provided only 11 grazing days per acre, in contrast to 37 on the $N_{48}P_{60}$ field, and 62 days per acre with the $N_{93}P_{60}$ treatment.

Weights of the test animals reveal that the average daily gains were substantially greater in both the fertilized fields, and that meat production per acre was very greatly increased (almost eight times). The higher nitrogen ($N_{96}P_{60}$) rate produced nearly twice as much increase over the control as did the lower rate ($N_{48}P_{60}$).

The total grazing income per acre was calculated by multiplying the total meat yields by 20¢ a lb. Income on the control was only $3, as compared to over $23 on the high nitrogen field.

The value of the meat attributable to fertilization was about $20 an acre where 93 lbs. of nitrogen and 60 phosphorus had been applied. The value of the fertilizer gain was slightly greater than the cost of the fertilizer used but not enough to pay for the cost of application. 48 lbs. of nitrogen were clearly not enough for most effective result.

The extra meat produced by fertilization with $N_{93}P_{60}$ was made at a fertilizer cost of 18.6¢ per lb.

The results of this test are very encouraging since they demonstrate that land in a good climatic zone, but presently infertile and of low carrying capacity, can be greatly increased if proper materials are applied. More important perhaps is the fact that the improved seeded species and native grasses did not have a chance to make much growth after the brush was killed until some nutrients were applied to help them. It is hoped in areas such as this that the use of fertilizer may make it possible to more rapidly convert brush to productive rangeland. It is further felt that by increasing the carrying capacity of such land a more efficient ranch operation can be developed with fewer acres being required to sustain a herd of economic size.

WHEELWRIGHT TEST - STINSON BEACH - MARIN COUNTY
Mar. 9-June 14, 1955 - 100 days

Seasonal rainfall 24. inches

	A	B	C
I. TREATMENTS			
Nutrients/acre	--	$N_{48}P_{60}$	$N_{93}P_{60}$
Materials/acre	--	300 lbs. 16-20	300 lbs. 16-20 100 lbs. Urea 45
Field size	40 ac.	21 ac.	21 ac.
II. STOCKING AND GRAZING			
Acres per animal	9.3	2.7	1.6
Grazing days/acre	10.7	37.4	62.4
Increase from fertilizer		26.7	51.7
III. WEIGHT GAINS			
Average daily gains	1.43 lbs	1.87 lbs.	1.86 lbs.
Meat produced/acre	15.2	70.0	116.4
Gain from fertilizer		54.8	101.2
IV. EVALUATION			
Total grazing income/acre @ 20¢/lb.	$ 3.04	$14.00	$23.28
Value/acre fertilizer gain		10.96	20.24
Less fertilizer cost			
Materials	--	$12.35	$18.85
Application (plane)		3.00	4.00
Profit or loss per acre From fertilization			
Material only		- $ 1.39	+ $ 1.39
Material applied		- 4.39	- 2.61
V. FERTILIZER MATERIAL COST			
Per pound extra meat produced		22.5¢/lb.	18.6¢/lb.

THE ALEXANDER TEST - Napa County
by Irving Grover, Farm Advisor

This test is one of the most interesting of the entire group. It was laid out on carefully selected pastures in the rolling hills some six miles west of Napa. Soil tests showed the area to be quite low in phosphorus, so treatments were set up to compare varying nitrogen rates, each with a standard amount of phosphorus. Fertilizer materials were applied on Nov. 18 by plane, using combinations of urea (46% nitrogen) and 11-48 ammonium phosphate to provide the necessary nutrients with the least possible weight for plane application.

All fields were stocked with Hereford steers on December 8 as growth was starting. Stocking was heavy at about an animal per acre. The custom on this ranch has been to put animals on range having considerable dry feed and provide supplement as needed to maintain regular gains throughout the entire grazing period. Animals so handled on the control field gained 1.18 lbs. per day. In contrast, animals on fertilized pasture in the light nitrogen field ($N_{50}P_{60}$) gained 1.36 lbs. per day at the same stocking rate and came off the field 32 lbs. heavier at the conclusion.

The high nitrogen field ($N_{100}P_{60}$) produced so much forage that it was necessary to add more animals on March 10 and again on March 19. This brought the stocking rate up to double that of the control, or over two animals per acre for the last three months. The average daily gain of all animals on this field was 1.74 lbs. per day versus 1.18 on the control which were fed equal supplement daily.

The control field of unfertilized forage plus supplement produced 204 lbs. of meat per acre in contrast to 487 lbs. on the high nitrogen field. Deducting meat equal to the cost of the supplement, the production from pasture alone on the control was 67 lbs. per acre in contrast to 132 lbs. with phosphorus and light nitrogen, and 253 lbs. with phosphorus and high nitrogen.

Evaluation of this test presents some difficulties since there were both fertilizer and supplement effects to be measured. The total grazing income per acre has been calculated by multiplying the total meat production by 20¢ a lb. The total grazing income has also been calculated as income per animal day on each field. This shows 24¢ worth of meat was produced daily by each animal on the control, 27¢ with $N_{50}P_{60}$ and nearly 35¢ worth of meat on the $N_{100}P_{60}$ treatment. We may then deduct the cost of the actual supplement fed each day. This amounted to about 16¢ a day on both the control and the high nitrogen field. The difference we record as "grazing income per animal day from pasture alone." This grazing income was 8¢ a day on the control in contrast to 18¢ a day on the $N_{100}P_{60}$ field.

The net grazing income, after deducting the cost of fertilizers applied, shows the profit from fertilization. This amounted to $14 per acre on the high nitrogen field. The fertilizer cost of the extra meat produced in this field was only 10.8¢ per lb. Results on the light nitrogen field with $N_{50}P_{60}$ treatment were sufficient to pay for only the cost of fertilizer. Data from this test would certainly indicate that relatively high nitrogen rates would be justified at this location.

This test shows that with equal daily supplement many more animals may be carried on fertilized range, that they gain more daily, and that they come off in better condition.

ALEXANDER TEST - NAPA COUNTY
Dec. 8-June 9, 1955 - 183 days

Seasonal rainfall 17.5 inches

		A	B	C
I.	TREATMENTS			
	Nutrients/acre	Control	$N_{50}P_{60}$	$N_{100}P_{60}$
	Materials/acre	--	121 11-48 73 Urea 46	129 11-48 193 Urea 46
	Fertilizer cost/acre		$11.48	$ 19.99
	Field size	72 ac.	111 ac.	37 ac.
II.	GRAZING & STOCKING			
	Acres/animal Dec. 8-June 9	1.06	1.01	1.01 Dec. 8-Mar. 10 .64 Mar. 10-Mar. 19 .47 Mar. 19-June 9
	Ave. in-weight/animal	637 lbs.	654 lbs.	624 lbs.
	Grazing days/acre	172.5	167.3	280.0
III.	WEIGHT GAINS			
	Av. daily gain/animal	1.184 lbs.	1.358 lbs.	1.739 lbs.
	Total meat produced/acre	204.18	227.25	486.75
	Less meat @ 20¢/lb. to equal cost of supplement	137.05	94.90	234.20
	Meat from pasture alone	67.13	132.35	252.55
	Fertilizer gain		65.22	185.42
IV.	EVALUATION			
	Total grazing income/acre	$40.83	$45.45	$ 97.35
	Total grazing income/animal day	23.68¢	27.16¢	34.78¢
	Less supplement cost/animal day	15.89	11.34	16.73
	Grazing income/animal day from pasture alone	7.79	15.82	18.05
	Less fertilizer cost/animal day		6.86¢	7.14¢
	Net grazing income/animal day	7.79¢	8.96¢	10.91¢
	Net grazing income/acre	$13.44	$14.99	$30.99
	Gross profit/acre from fertilization		1.55	17.11
	Plane cost of application/acre		$ 1.65	$ 2.65
	Net fertilizer profit/acre		-.10	+$14.46
V.	Fertilizer (material) cost per lb. of extra meat		20.1¢/lb.	10.8¢/lb.

THE VAN VLECK TEST - Sacramento County

J. T. Ellings, Farm Advisor

This test was laid out on open rangeland near Michigan Bar in eastern Sacramento County. A 160-acre field of Pentz loam, Peters adobe clay, and Redding gravelly loam was divided into four parts: 70 acres as control and three 30-acre fields to study the amounts of phosphorous necessary with nitrogen for efficient meat production.

Materials were applied by plane on November 1. The first field received 73 lbs of nitrogen from urea; the second, the same nitrogen plus treble superphosphate to provide 49 lbs of phosphorus per acre. Materials were mixed into the plane hopper and applied in one operation. The third field was to have had the same nitrogen but twice the phosphorus. Through an error in flying, material was applied to 7 acres of an outside field. Thus, the experimental field received only 59 lbs of nitrogen and 79 lbs of phosphorus.

Fall rains came early and the feed started rapidly in the two nitrogen-phosphorus treatments. On Dec. 16, all fields were stocked with yearling Hereford heifers. Six acres per animal were allowed on the control, as is customary on the ranch, 3 acres per animal on the straight nitrogen field and 2 acres for each animal on the two nitrogen-phosphorus fields. On Feb. 18, animals were added to all fields to utilize the increasing forage.

Carrying capacity for the season was increased threefold on the $N_{73}P_{49}$ field.

The rate of gain of test animals showed striking differences, particularly during the winter period. From Dec. 16 to Feb. 18, animals on the control and straight nitrogen fields with plenty of dry feed made no gains. In contrast, animals on the nitrogen-phosphorus fields gained about 2/3 of a lb per day.

In the second period, from Feb. 18 to March 25, gains on the nitrogen-phosphorus fields, although stocked heavier, were more than those on straight nitrogen, and far greater than gains on the control field.

In the final period, from March 25 to June 6, gains on the control were about the same as on two of the fertilized fields. The fourth field with the lighter nitrogen rate did not continue to produce, and animals were removed on May 18. Whether this was due to the lighter nitrogen rate or to some other factor is not known.

Meat production per acre was increased nearly fourfold by the best fertilizer treatment. The control field made only 57 lbs of meat, most of it in April and May. The straight nitrogen field (N_{73}) produced 135 pounds, principally in the spring after the weather had warmed up. The highest meat production of 221 pounds came from the combined treatment of 73 lbs of nitrogen and 60 phosphorus. The other NP field with less nitrogen and more phosphorus produced 152 lbs of meat per acre.

Evaluation of results has been made from the value of the meat produced. First, the total grazing income was calculated and then the fertilizer costs deducted to give the net income per acre for each field.

Profits from fertilization depend upon the price of meat used in the evaluation. Only the $N_{74}P_{49}$ field was really profitable. With meat at 20¢, it showed a net income of $27 per acre compared to $11 on the control, or a net profit of $16 per acre. Using the more conservative evaluation of $17\frac{1}{2}$¢/lb, the profit per acre was only about $12. Neither the straight nitrogen nor the low nitrogen high phosphorus treatments showed more than slight profits.

Fertilizer material cost of "Extra Meat" on the $N_{73}P_{49}$ was 9.0¢ per pound.

VAN VLECK TEST - Sacramento County
Dec. 14-June 6, 1955 - 173 days

Seasonal rainfall 20.3 inches

I. TREATMENTS	A	B	C	D
Nutrients/acre	None	N_{73}	$N_{73}P_{49}$	$N_{59}P_{79}$
Materials/acre (Nov. 2, 1954)		166 Urea 44	166 Urea 44 107 Treble Sup.	135 Urea 44 172 Treble Super.
Field size	70 ac.	30 ac.	30 ac.	30 ac.
II. GRAZING AND STOCKING				
Acres per animal:				
Dec. 16-Feb. 18	5.83	3.00	2.00	2.00
Feb. 18-June 6	3.68	1.67	1.20	1.20 (to May 18)
Av. in-weight/animal	444 lbs.	458 lbs.	417 lbs.	436 lbs.
Total grazing days/acre	40.5	88.1	122.5	106.5
III. WEIGHT GAINS				
Ave. daily gains/animal:				
Entire period	1.40 lbs.	1.53 lbs.	1.80 lbs.	1.43 lbs./day
(Dec. 14-Feb. 18)	- .02	.02	.72	.65
(Feb. 18-Mar. 25)	.84	1.26	1.68	1.48
(Mar. 25-June 6)	2.31	2.25	2.27	1.74 (to May 18)
Total meat produced/acre	56.9 lbs.	134.6 lbs.	221.0 lbs.	152.2 lbs.
Extra meat from fertilizer		77.7 "	164.1 "	95.3 "
IV. EVALUATION				
Grazing income/acre:				
with meat @ 20¢/lb.	$11.38	$26.92	$44.20	$30.42
with meat @ 17½¢/lb.	9.96	23.56	38.68	26.64
Less fertilizer cost:				
Material		$10.25	$14.74	$15.56
Application (plane)		1.50	2.14	2.18
Net income/acre				
with (@ 20¢/lb.	$11.38	$15.17	$27.32	$12.68
meat (@ 17½¢/lb.	9.96	11.81	21.80	8.90
Profit/acre				
with (@ 20¢ lb.		3.79	$15.94	$ 1.30
meat (@ 17½¢/lb.		1.85	11.84	- 1.06
V. FERTILIZER MATERIAL COST				
Per lb. of extra meat		13.2¢	9.0¢	16.3¢

SKYWAY TEST - San Mateo County

by Bryan Sandlin and Robert Ward, Farm Advisors

This test was located between Half Moon Bay and Redwood City on the ridge just west of the City of San Francisco reservoir. A 29-acre field was divided into four equal parts. Native vegetation here was largely rye grass, alfilaria, bur clover, and foxtail. Urea and treble superphosphate were applied early in November 1954. Treatments were made to determine the effects of varying amounts of nitrogen and phosphorus. One field received 144 lbs. of actual nitrogen and no phosphorus; the second field, the same 144 lbs. of nitrogen plus 64 lbs. of phosphorus, and the third received the same 64 lbs. of phosphorus but only 74 lbs. of nitrogen.

Fertilizers were applied just after the first effective rains in November but growth came rather slowly because of the cold weather here. The fields receiving both nitrogen and phosphorus produced grass very much earlier than did the control or the straight nitrogen field.

On February 2 all pastures were stocked with Holstein heifers at rates estimated as proper for the existing feed. As the weather warmed up and feed increased animals were added as needed to fully utilize the feed. The animals used in this test were thin when placed in the fields and all gained weight rapidly. On May 12, the original animals were sold and the pasture restocked immediately with another group of the same kind of heifers. The average stocking rate on the control was about three acres per animal - two acres per animal with straight nitrogen, and one to 1½ acres per animal on the nitrogen-phosphorus fields.

The meat production in this test was phenomenal on the fields treated with both nitrogen and phosphorus. Nitrogen alone did not stimulate much extra growth because of the acute phosphorus deficiency of the soil. The control field produced nearly 130 lbs. of meat per acre, while the high nitrogen-phosphorus treatment produced nearly 400 lbs. Gains of meat due to fertilization on the nitrogen-phosphorus fields were well in excess of 200 lbs. per acre.

The results of this test are difficult to evaluate. Gains were probably greater than normal because both batches of animals were quite thin when placed in the fields. The weight which they gained put them into good condition and greatly increased their value. At that period, meat of dairy cows had a market value of about 15¢ a lb. This figure is used in evaluating results.

The net grazing income per acre in this test was $19 on the control and $37 on the $N_{74}P_{64}$ field after deducting fertilizer costs, or a net profit of $18 an acre. The $N_{144}P_{64}$ field showed a net profit of $11 an acre.

Fertilizer Cost of Extra Meat was low where proper materials were used. The $N_{144}P_{64}$ treatment, which cost $27.06 an acre for materials, produced meat for 10.8¢ a lb. The $N_{72}P_{64}$ treatment, costing $16.32 per acre, made meat for only 7.6¢ per lb.

SKYWAY RANCH - SAN MATEO COUNTY
February 7-June 29, 1955 - 148 days

Seasonal rainfall 25.2 inches

	A	B	C	D
I. TREATMENTS				
Nutrients/acre		N_{144}	$N_{144}P_{64}$	$N_{72}P_{64}$
Materials/acre		320 urea	320 urea 139 treble-super	160 urea 139 treblesuper.
Field size/acres	7¼	7¼	7¼	7¼
II. STOCKING AND GRAZING				
Acres/animal	3.12	2.00	1.07	1.26
Animal days/acre	47.4	74.5	138.2	117.1
Increase		27.1	90.8	69.7
III. WEIGHT GAINS				
Average in-weight	617.8	553.3	512.2	542.5
Average out-weight	801.8	717.0	686.7	718.2
Average increase	184.0	158.7	174.5	175.7
Average daily gain	2.69	2.35	2.88	3.17
Total meat produced/acre	126.9	175.7	395.5	368.9
Gain due to fertilization		48.8	268.6	242.0
IV. EVALUATION				
Total grazing income/acre				
Meat @ 20¢	$25.38	$35.06	$79.10	$73.78
Meat @ 15¢	19.03	26.36	59.33	55.34
Less fertilizer cost/acre				
Materials	--	$21.44	$27.06	$16.32
Application	--	1.00	2.00	2.00
Net income/acre				
Meat @ 15¢/lb.	$19.03	$ 3.92	$30.27	$37.02
Profit from fertilization		-15.11	11.24	17.99
V. Fertilizer material cost /lb. extra meat		$ 4.60	10.8¢	7.6¢

NETTLES TEST - Santa Clara County
by M. S. Beckley, Farm Advisor

The test was located east of San Martin on the terrace at the east edge of the Santa Clara Valley. Soil was mapped as Pinole loam. Previous fertilizer tests had shown it to be deficient in nitrogen, sulfur, and to a lesser extent phosphorus. Soil tests showed it deficient in phosphorus, as measured by water extraction, but nearly adequate by the bicarbonate method.

Treatments were made to provide equal nitrogen in three test fields but to vary the amount of phosphorus. Three 10-acre fields were fertilized with 400 lbs. of 16-5, 16-10, and 16-20 ammonium phosphate sulphates to give 64 lbs. of nitrogen to all fields, and phosphorus at rates of 20, 40, and 80 lbs. per acre. A nearby 50-acre field was used as control.

Fall rains came early and growth on the fertilized fields started well. On January 19 all fields were stocked with yearling Angus heifers. The three fertilized fields at .9 acres per animal and the control, which had little or no green feed, stocked at a rate of 5 acres per animal. Extreme drought prevailed during most of the grazing season. No rain fell from January 28 to April 17. In the first part of this period fertilized fields grew well, but little feed was produced on the control. It was necessary to feed some hay on this field. None was fed on the fertilized fields but by March 23 feed was so short that it was necessary to reduce the stocking rate by 50%. The control field provided 18 grazing days per acre in contrast to 69 days where fertilized.

Weight gains in this test under drought conditions are of particular interest. The control animals, given some hay supplement, gained slightly less than 1 lb. per day. On the best fertilizer treatment at nearly 4 times the stocking rate and no supplement, animals gained 1.4 lbs. per day. The control produced only 17 lbs. of meat per acre, while the fertilized fields produced 80 to 98 lbs.

The results of this test have been evaluated, using a figure of 20¢ per lb. for meat produced during the grazing period. The control produced only $3.48 worth of meat while the $N_{64}P_{20}$ treatment produced meat worth $19.50.

The net income per acre from pasture has been calculated by deducting the cost of the fertilizing material and the cost of the hay fed to animals on the control field. This shows a net income on the control of $3.14 per acre in contrast to a net income of $6.58 from the field which received 64 nitrogen and 20 phosphorus. The fields receiving higher amounts of phosphorus did not produce enough additional meat to pay for extra phosphorus.

In this test, even under severe drought conditions, fertilization with nitrogen and a low rate of phosphorus paid for the fertilizer applied, doubled the net income per acre, and showed a net profit of $2.44 per acre, including application. These results show clearly that even in a bad year fertilization may be profitable, provided only the materials needed are applied and costs kept down by this means.

Chemical analysis was made of clipped forage samples taken on March 8 from fertilized and adjacent control areas. Fertilizer treatments greatly increased crude protein content of forage. Phosphorus content of untreated forage was believed adequate for animal needs, but was increased greatly and to the same extent by all phosphorus treatments.

NETTLES - SANTA CLARA COUNTY
January 19-April 19, 1955 - 91 days

Seasonal rainfall 16.7 inches

		A	B	C	D
I.	TREATMENTS				
	Nutrients/acre	Control	$N_{64}P_{20}$	$N_{64}P_{40}$	$N_{64}P_{80}$
	Materials/acre	-	400 16-5	400-16-10	400-16-20
	Field size/acres	50	10	10	10
II.	STOCKING AND GRAZING				
	Number of animals	10	11	11	11
	Average initial weight	778	718	792	798
	Acres/animal:				
	January 19-March 23 (63)	5.0	.9	.9	.9
	March 23-April 19 (28)	5.0	1.8	1.8	1.8
	Grazing days/acre	18.2	69.3	69.3	69.3
III.	WEIGHT GAINS				
	Average daily gain/animal	.96	1.41	1.15	1.38
	Meat produced/acre	17.4	97.5	79.5	95.5
	Increase over control		80.1	62.1	78.1
IV.	EVALUATION				
	Gross income per acre from meat produced @ 20¢/lb.	$3.48	$19.50	$15.90	$19.10
	Less cost of fertilizer material	-	12.92	14.54	16.47
	Less application cost	-	1.00	1.00	1.00
	Less cost/acre of supplement fed*	.34	-	-	-
	Net income/acre from pasture	$3.14	$5.58	$ .46	$1.63
	Net profit/acre from fertilization	-	2.44	(-2.68)	(-1.51)
	Composition of forage (Mar. 8)				
	Percent crude protein	10.8%	17.5%	15.6%	17.5%
	Percent total phosphorus	.21	.38	.32	.35

*1700 lbs. hay at $20.00/ton fed to animals on 50-acre control field.

JOHN LAWLER TEST - Solano County

by Arthur K. Swenerton, Farm Advisor

This test was a follow-up on one carried out on the same fields the previous season. The lands were about three miles east of Fairfield on flat terrain made up principally of soils of the Antioch series having a thick claypan layer beginning at 18" and causing a waterlogged condition in wet seasons. The same control field was used as the previous year. A 66-acre field which had then received 42 nitrogen and 29 phosphorus was left unfertilized to measure carryover effects.

Fields used to compare calcium nitrate and ammonium sulfate the previous year were reversed and the same two materials applied at rates to give 100 lbs. of nitrogen per acre. Split applications - 50 lbs. on October 1, and 50 lbs. on the first of March - were made by plane, as a matter of convenience, to ensure quick, uniform treatments on the indicated dates.

Growth was rapid on the two nitrogen-fertilized fields, with little difference noted in the first growth. Following the March application, growth was somewhat faster from calcium nitrate than from ammonium sulfate. Rainfall was below normal during the late winter and spring months, and there was too little moisture after the second fertilizer application to fully utilize the nutrients applied. The first application received 13 inches of rain; the second, only three inches.

Fields were stocked at "half capacity" on January 11 with yearling heifers and steers. Additional animals were put in all fields on February 18, giving a stocking rate of one acre per animal on the two nitrogen-fertilized fields, and 1.4 acres per animal on the control and carryover fields.

Meat production was good in all fields. Meat yields were increased about 45% by nitrogen applications, with no difference between the two nitrogen sources. The carryover field showed no residual effect of fertilizers applied, and produced a little less meat than the control. Heel flies "ran" the cattle more in the carryover and fertilized fields than in the control, since the latter had two small ponds for the animals to stand in.

The standard figure of 20¢ per lb. of animal gain during the grazing period has been used for the evaluation. On this basis, the gains on the ammonium sulphate field were almost exactly equal to the cost of the fertilizer. The gains from the calcium nitrate were almost the same as from ammonium sulfate, but substantially less than the cost of this fertilizer.

It is uncertain whether failure to show a profit at this location should be attributed to the cold winter and relatively dry spring, which prevented full utilization of the fertilizer, or to the fact that more fertilizer was applied than could economically be used. The same two fields will be studied this year to measure possible carryover effects.

Forage samples were taken in mid-March from exclosures in the ammonium sulfate and calcium nitrate fields. These showed a higher crude protein content in the fertilized areas. The phosphorus level was high in all samples, although no phosphorus had been applied. Soil samples indicated the soil to be deficient in phosphorus according to the water extraction method, but adequate according to the newer bicarbonate method.

JOHN LAWLER - SOLANO COUNTY

January 11-May 9, 1955 - 127 days; Seasonal Rainfall 16.18 inches

I. TREATMENTS	A	B	C	D
Nutrients/acre	Control	N_{100}	N_{100}	None
Materials/acre	-	480 Am. Sulphate	646 Cal. Nitrate	1954 carry-over
Field size/acres	92	60	65	66
II. STOCKING AND GRAZING				
Ac./animal: Jan. 11-Feb. 18	2.96	2.00	2.20	3.10
Feb. 18-May 19	1.46	1.03	1.00	1.43
Grazing days/acre	74	107	108	74
III. WEIGHT GAINS				
Average in-weight	390 lbs	388 lbs	379 lbs	376 lbs
Average daily gain	1.99	2.03	1.97	1.81
Total meat produced/acre	148	216	213	134
Increase due to fertilizer	-	68	65	-14
IV. EVALUATION				
Total grazing income/acre meat @ 20¢/lb	$29.60	$43.20	$42.60	$26.80
Value of fertilizer increases	-	13.60	13.00	-2.80
Cost of fertilizer material/acre	-	13.56	18.00	-
Gross profit/acre	-	.04	-5.00	-
Cost of Application	-	3.30	4.00	-
Net profit/acre from fertilization	-	-$3.26	-$9.00	--

Analysis of Forage and Soil Samples Taken March 16, 1955

Areas Sampled		Forage Composition		Soil Analysis Data	
		% Crude Protein	% Phosphorous	Phosphate Soluble in: Water	Bicarb.
Am. Sulfate Field	Untreated	17.1	.344	.28 p.p.m.	42 lbs.
	480 Am. Sulf.	23.0	.325	.19	39
Calcium Nitr. Field	Untreated	12.9	.285	.18	31
	646 $Ca(NO_3)_2$	22.7	.299	.21	32

RANGE FERTILIZATION CAN PAY DIVIDENDS

THIS REPORT HAS SHOWN THAT FERTILIZATION CAN HELP THRU:

Increased Carrying Capacity	Control	Fertilized
Grazing Days per Acre	58	126 days per acre
Better Animal Gains		
Average daily gains per animal	1.49	1.77 lbs. per day
More Meat per Acre		
Pounds of Meat Produced	.72	197 lbs. per acre
Greater Income per Acre		
Gross Grazing Income	$ 13.01	$35.92 per acre
But it Cost		
for Fertilizer		$13.52 per acre
to apply it		$ 2.01
Leaving a Net Income of	$ 13.01	$20.39
for a Net Profit of		$ 7.38 per acre
"Extra Meat" from Fertilization	was	125 lbs. per acre
"Fertilizer Material" Cost of this "Extra Meat" was		12.4¢ per lb.

The figures above are average values for the ten tests in the report.

1/56---2000

Co-operative Extension work in Agriculture and Home Economics, College of Agriculture, University of California, and United States Department of Agriculture co-operating.
Distributed in furtherance of the Acts of Congress of May 8, and June 30, 1914.
J. Earl Coke, Director, California Agricultural Extension Service.