The Sierra Foothill Range Field Station, where these trials took place, is a 5,700-acre ranch on the western slope of the Sierra Nevada overlooking the Yuba River and the historic gold fields of the Sacramento Valley near Sutter Buttes.

Foothill range management and fertilization improve beef cattle gains

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Seeding with annual legumes and fertilization of foothill ranges increased profits

Substantial profit resulted from fertilization in a three-year study on foothill range concluded in the early summer of 1985. The work was done at the University of California's Sierra Foothill Range Field Station east of Marysville near Browns Valley. An earlier report (*California Agriculture*, May-June 1984) gave details of the experiment and a first-year summary of results. Our final results showed that fertilization with moderate to high levels of phosphorus and sulfur or with combinations of nitrogen, phosphorus, and sulfur was profitable on this cleared and legume-reseeded grassland. Increases in stocking rates within the season and favorable weather may be needed to realize a profit.

Three-year study

Sixteen 33-acre fields were used to provide two replications of seven treatments. Nitrogen was applied at 40 and 80 pounds per acre; phosphorus and sulfur were applied together at 30 pounds phosphorus with 33 pounds sulfur and 60 pounds phosphorus with 66 pounds sulfur per acre; and the two nitrogen rates were each combined with the lower phosphorus-sulfur rate. For the seventh treatment, no fertilization as a control, we used the average of two fields for each replication.

Each year the grazing season began in late November or very early December, when each field was stocked with the same number of beef steers weighing approximately 475 pounds. The initial stocking rates varied between years but averaged about 4 acres per steer. The cattle were individually weighed initially and at either three-week or four-week intervals over a grazing season that averaged 190 days, ending in late May or very early June each year. Stocking rates were adjusted upward twice during the season to: (1) equalize forage allowance (unit weight of forage available per unit weight of animal) across treatments, and (2) maintain these forage allowance values at 10 pounds of forage per pound of animal or less.

Forage supply and animal gains

Table 1 gives information about selected grazing and forage availability levels as well as average daily gains of the animals. The three dates shown represent (1) the midwinter period of slow growth and low energy content of the forage; (2) the beginning of the rapid plant growth period characterized by longer days, better light, warmer soil, and a more noticeable growth of legumes; and (3) the rapid spring growth period characterized by plant maturation, soil drying, and a strong patchiness of grazing. At this time, average daily gains were near their seasonal maximum or just beginning to drop.

With similar forage availabilities, average daily gains on a given weigh date for animals grazing fertilized fields were similar to those for the control. As annual averages, average daily gains from fertilized fields were greater than in the control seven out of nine times. Averaging data for the full three years showed that average daily gain for the nitrogen-phosphorus-sulfur or phosphorus-sulfur treatments was significantly higher than control or nitrogen-only treatments, which were not statistically different.

Overall, animal performance showed a greater similarity across treatments than across the grazing season. More importantly, whenever a statistically significant increase in average daily gain for a fertilization treatment occurred, stocking rate and stocking weight values were either numerically similar to or higher than those for the control, and forage allowance values were similar to or lower than those for the control.

Nutritional quality

Evidence for the higher nutritional quality of fertilized forage was found in analyses of animal-selected samples. Esophageally fistulated steers were used to collect samples of forage over the grazing season.

Values for the average of all fertilizer treatments, which were not greatly different from each other, were always higher than for the control but the spread was greatest for the early part of the season (fig. 1 [first grazing season]). The narrowing of this difference during April and May probably reflects a seasonally determined increase in quality of all forage as well as an increasing proportion of legumes, especially subterranean clover. The overall downward trend reflects increasing plant maturity (note that nitrogen content began to decrease before forage digestibility did). Because the forage supply to grazing livestock is more restricted during the early part of the season, the quality improvement effect of fertilization during the winter is important.

Gains per acre

Ultimately, the economic profit or loss in grazing will depend on total gain per acre. Differences in liveweight gains between treatments were largest in year one (fig. 2), the grazing period immediately following fertilization, and one with ample rainfall and a long growing season. Gains were significantly higher than the control in all treatments. In year two, variation between replications within a treatment and a diminished response to fertilization following the first year's high rainfall resulted in fewer significant differences. In year three, the 40-pound nitrogen treatment yielded significantly less than the control, while the higher rate of phosphorus and sulfur yielded significantly more than any other treatment.

Figure 2 also puts animal yields per unit of land area in the context of successive yield levels. The experiment was conducted on lower-foothill land regarded as marginally productive. The gain level of 100 pounds per acre is typical for cleared and legume-reseeded land under good seasonal grazing management. The values for the control in all years and for some of the fertilizer treatments in years two and three cluster around this value. Low or nutritionally incomplete fertilizer applications may not change this response very much; if a response is obtained, it is likely to be short-lived. At the second level of 150 pounds per acre (exceeded by three of the treatments in year one and by the higher phosphorus-sulfur rate in year three), higher levels of fertilization, more favorable weather, better grazing management, or a pronounced increase in legume content of the forage may act singly or in combination. The "yield-doubling" level of 200 pounds per acre occurred only in the first year and for only two of the six fertilizer treatments. An excellent growing season, correction of all three major soil nutrient deficiencies, and higher stocking rates were all necessary to achieve this production level.

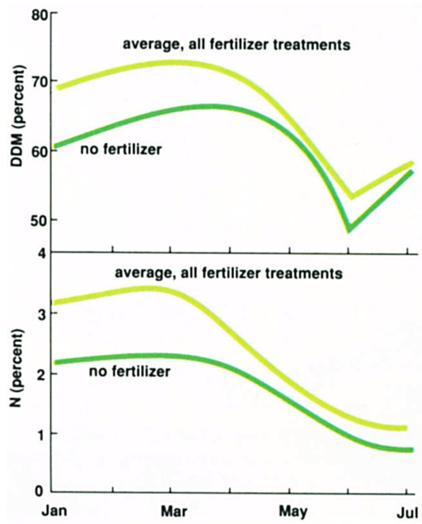

Fig. 1. Digestible dry matter (DDM) and nitrogen (N) in forage samples from esophageally fistulated steers in first season were always higher in fertilized treatments than in controls.

Differences in animal gains accumulated per unit area for the three years were highly significant (P<0.01, fig. 3). The treatments formed two groups, with the two nitrogen-phosphorus-sulfur treatments (which were virtually identical) and the higher phosphorus-sulfur treatment producing larger gains than the other treatments.

Within-year patterns

Averaging the values for average daily gain and forage level in all fertilizer treatments across each of the three years provides perspective for the other data (fig. 4).

Average daily gain showed a general rising trend from December to early May. Except for 1982-83, when late rainfall extended the growing season, average daily gain declined precipitously by the end of May or early June along with a rapid advance in plant maturity and peak values for forage accumulation.

TABLE 1. Stocking rate, stocking weight, and average daily gain for control (Contr.) and three treatment combinations for three representative weigh periods over three years

Weigh date	Stocking rate				Stocking weight				Forage allowance*				Average daily gain				
	Contr.	N	NPS	PS	Contr.	N	NPS	PS	Contr.	N	NPS	PS	Contr.	N	NPS	PS	LSD
	ac/animal				lb/ac				lb/lb				lb/steer/day				
1/7	3.3	2.8	2.0	3.1	160	190	260	170	9.4	10.1	11.6	9.9	0.64	1.14	0.90	0.95	
3/4	2.7	1.8	1.1	2.3	220	350	560	270	4.9	4.1	3.6	5.1	1.46	1.75	1.74	1.63	
5/6	2.8	1.8	1.2	2.3†	270	430	680	330†	7.9	4.7	3.3	10.2	2.16	2.31	2.18	2.38	0.33§
Avg.‡	3.4	2.8	2.3	2.9	220	310	430	340	6.7	5.3	4.9	7.4	1.45	1.64	1.68	1.74	0.18*
1983-84 (190 days)																	
12/20	4.1	4.1	4.1	4.1	120	120	120	120	3.9	4.2	5.1	4.4	1.01	0.90	0.95	1.05	
2/28	2.8	3.0	2.4	2.5	190	180	220	220	4.1	3.8	4.3	4.5	1.63	1.64	1.82	1.72	
5/8	2.1	2.2	1.7	1.7	330	330	450	430	6.1	5.8	5.2	5.9	2.45	1.98	2.31	2.51	0.40§
Avg.	3.3	3.4	3.0	3.1	200	200	250	240	4.5	4.3	4.5	4.7	1.51	1.62	1.70	1.60	0.11*
1984-85 (183 days)																	
12/20	4.1	4.1	4.1	4.1	130	120	130	120	6.2	6.2	6.4	5.7	0.82	0.74	0.93	0.86	
3/7	2.7	2.7	2.7	2.7	240	230	240	240	3.1	3.2	3.5	3.2	1.85	1.68	1.94	1.98	
5/9	1.3	1.5	1.1	1.2	540	470	650	600	2.8	3.1	2.5	8.0	2.01	1.83	1.98	2.22	0.37§
Avg.	2.7	2.8	2.6	2.7	300	270	340	320	4.1	4.1	4.2	4.7	1.44	1.36	1.61	1.62	0.11**
3-yr avg	3.2	3.0	2.7	2.9	240	260	340	300	5.1	4.6	4.5	5.6	1.47	1.54	1.66	1.65	0.11***

* Calculated as (pounds forage per acre)/(pounds animal weight per acre) using the average of two successive weigh periods.
† Stocking rate and stocking weight were increased after May 6, 1983 to 1.1 acres per animal and over 700 pounds per acre, respectively.
‡ Annual means are for eight weigh dates.
§ LSD 0.05 values are for average daily gain, comparing fertilizer treatments in a weigh date row.
** LSD 0.05 values for annual mean differences for average daily gain in a weigh date row.
*** LSD 0.05 values for 3-year means for average daily gain in a weigh date row.

The rolling terrain of the Sierra foothills rangeland required that fertilizer be applied by helicopter.

Stocking rates during the trial were adjusted periodically to match forage biomass measured by an electronic capacitance forage meter (below) and a pressure plate sampling device (above).

TABLE 2. Economic comparisons of gross profit from various fertilizer treatments when stocking rates were seasonally increased vs. not increased after March 1

	Stocking rate				Gross profit above control‡		
Treatment	**1982-83**	**1983-84**	**1984-85**	**Practice cost†**	**1982-83**	**1982-84**	**1982-85**
	....	*ac/head*	....	*$/ac*	....	*$/ac*	....
Control, increased	2.7	2.2	1.4	0.00	—	—	—
Control, no inc.	3.3	2.7	2.7	0.00	—	—	—
Difference					—	—	—
40N, increased	2.0	1.9	1.6	16.80	5.00	7.80	1.20
40N, no inc.	3.0	3.0	2.7	16.80	− 5.10	− 3.60	− 5.20
Difference					10.10	11.40	6.40
80N, increased	1.6	2.5	1.4	29.00	11.20	10.00	2.70
80N, no inc.	2.7	3.3	2.7	29.00	− 9.00	− 9.90	−14.80
Difference					20.20	19.90	17.50
40N 30P 33S, increased	1.3	1.6	1.0	31.90	38.70	52.00	63.80
40N 30P 33S, no inc.	2.2	2.2	2.7	31.90	5.70	18.50	20.80
Difference					33.00	33.50	43.00
80N 30P 33S, increased	1.1	1.6	1.3	44.10	40.20	48.70	58.60
80N 30P 33S, no inc.	1.8	2.7	2.7	44.10	6.10	12.50	18.20
Difference					34.10	36.20	40.40
30P 33S, increased	2.7	1.9	1.6	15.00	− 3.70	− 0.80	− 5.10
30P 33S, no inc.	3.3	3.0	2.7	15.00	− 5.30	− 2.40	− 3.00
Difference					1.60	1.60	− 2.10
60P 66S, increased	2.0	1.5	1.0	25.45	8.10	17.70	40.10
60P 66S, no inc.	3.0	2.5	2.7	25.45	− 5.20	0.80	9.70
Difference					13.30	16.90	30.40

† Practice costs include costs of fertilizer materials, plus $4.25/acre application cost ($8.50 for NPS treatments), and interest charges at 12% for eight months.
‡ Gross profit = gross income − practice costs.

In contrast, forage levels were relatively stable from November to mid-March, and the period of rapid plant growth began rather consistently by late March or early April. Successively lower peak forage accumulation levels occurred over the three years, as adjustment of stocking rates to improve efficiency of plant to animal transfer improved (whole-season forage allowance values for the three years were 6.2, 4.5, and 4.3, respectively). Overall, average daily gain was not well correlated with forage level, an area that deserves more definitive research than we were able to accomplish in this study.

Stocking rates and profits

The addition of stockers in late February or early March is not a normal ranch practice, since most stocker cattle are purchased in the fall and early winter. Table 2 compares income with and without increasing the stocking rate after the first week of March. Average initial stocking rates (late November-early December) over the three years were between 5 and 4 acres per head. The three-year average maximum stocking rate with no upward adjustment after early March was 2.8 acres per head. The comparable value with seasonal upward adjustment was 1 acre per head, almost a three-fold difference.

With the cattle prices existing at the time of this study, most treatments were more profitable if cattle were added at the beginning of this rapid spring growth period. Although in the economic analysis these additional cattle were "purchased" at the prevailing higher prices and therefore had narrower profit margins, they did contribute to a higher income per acre.

Weather effects

Apart from the influences of soil nutrient availability and grazing management, plant productivity in any given year is strongly affected by the weather. The three factors of most importance are light, precipitation, and temperature; of these, the most critical is precipitation. Initiation of fall growth in this reseeding annual system and maintenance of sustained growth through plant maturity depend on both distribution of precipitation over the season and total seasonal amount. Moreover, the variability in successive annual precipitation cycles in much of California's annual rangeland frequently has a much greater effect on growth and quality of range forage than do either light or temperature.

Because it is not possible to predict the weather of one year, let alone several successive years, the outcome of a long-term experiment such as ours will be modified by chance alone. An initial objective of the experiment was to assess nitrogen carryover, as had been done in a number of short-term field trials in the 1950s and 1960s by Cooperative Extension Specialists W. E. Martin and L. J. Berry (*Effects of Nitrogenous Fertilizers on California Range as Measured by Weight Gains of Grazing Cattle*, Calif. Agric. Exp. Sta. Bull. 846, September 1970). They concluded that more than 30 inches of seasonal precipitation could eliminate nitrogen carryover.

The 1982-83 season had a total of 43.6 inches, nearly 50 percent more than Martin and Berry's cutoff value. That season was characterized by early germination, consistently adequate soil moisture, and abundant late spring (late April-early May) rainfall. This pattern also resulted in excellent legume growth, especially where adequate phosphorus and sulfur were provided.

In both of the following years, adequate rainfall for fall germination and sustained growth occurred early enough to ensure at least an average start of the growing season. Spring rainfall in both years, however, was only marginally adequate to sustain maximal rates of plant growth and terminated increasingly early in years two and three. Rainfall in 1984-85 was only 42 percent of that received in 1982-83, but its distribution was favorable.

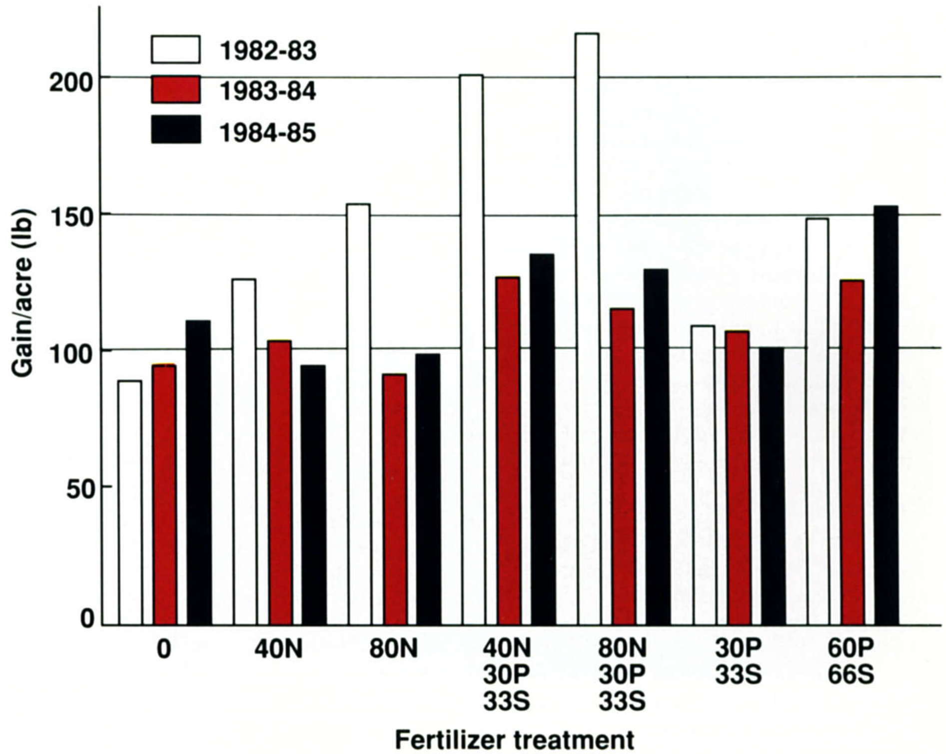

Fig. 2. Beef cattle gains were greatest in the year after fertilization, then dropped off. By the third year, higher phosphorus-sulfur fertilization yielded significantly more than other treatments.

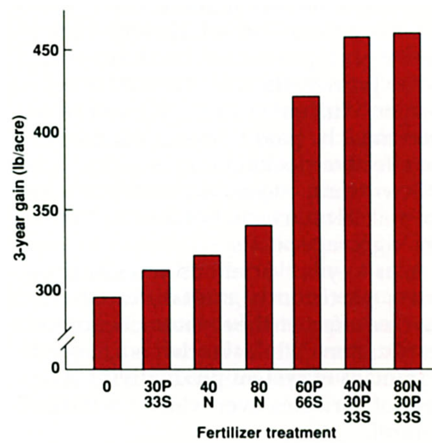

Fig. 3. Total three-year gains were substantially higher in the two nitrogen-phosphorus-sulfur and the higher phosphorus-sulfur treatments (three bars at right) than in the other treatments.

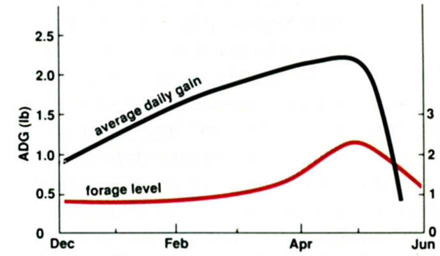

Fig. 4. Over the three years, average daily gain rose from December to early May, then rapidly dropped off. Forage levels, stable from November to mid-March, rose to seasonal highs by late April and then declined.

Plant species responses

We compared botanical composition of seeded legumes and resident grasses and forbs for the three-year period immediately before the fertilization experiment and the three years of the experiment. In only one case was there a significant difference: an increase in legumes under the phosphorus-sulfur treatment in the first year. Under proper grazing management and with low to moderate applications of nitrogen (usually together with phosphorus and sulfur), early-season increases in both forage yield and quality are potentially possible without detrimental effects on the population of seeded legumes.

Conclusions

For the geographic area and soil and vegetation types represented in our study, plant and animal productivity may be enhanced by either of two fertilization strategies. The first, and probably preferable, is to introduce annual legumes, especially sub and rose clovers, and apply phosphorus and sulfur at levels sufficient to stimulate legume production and symbiotic nitrogen fixation. The second strategy is to apply moderate levels of nitrogen together with adequate levels of phosphorus and sulfur, which will both increase plant production and have a somewhat greater effect during the fall and winter. With either strategy, careful attention must be paid to management, since an effective stocking rate is critical to an efficient forage-to-animal conversion and to maintenance of botanical stability among forage plants.

Year-to-year variations in weather patterns, particularly rainfall, can have a marked effect on the economic outcome of fertilization. While weather is a major determinant of system productivity, it consists of variables over which we have no control.

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Systemics prove impractical for control of eucalyptus borer

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The larva of the eucalyptus longhorn borer (right) creates extensive galleries in the cambium layer of a tree and can ultimately cause its death. The inch-long adult beetle, though observed feeding on the flowers of eucalyptus trees, apparently causes little direct damage to the trees.

Low response rate and high application costs make systemic insecticides a poor defense against longhorn borer

The eucalyptus longhorn borer was first discovered in California in October 1984 (*California Agriculture*, July-August 1986), and since then has spread to an area of about 9,600 square miles in six southern California counties: San Diego, Riverside, San Bernardino, Orange, Los Angeles, and Ventura. Because of its recent introduction and lack of natural enemies in California, there are few means available to contain the borer, *Phoracantha semipunctata* (Fab.). We investigated the effectiveness and economics of using systemic insecticides in a control strategy.

Two-phase experiment

The studies took place during the summer and fall of 1986 (phase I) and winter and spring of 1987 (phase II) in a heavily infested grove in Irvine, California. In each phase, two eucalyptus settings were selected: a woodlot and a windbreak. The woodlot species was river red gum, *Eucalyptus camaldulensis* Dehnhardt, and the windbreak species was blue gum, *E. globulus* Labill.

The experiment included five treatments: Acecap (97% technical Orthene [acephate]), Furadan 10G (carbofuran), DiSyston 8E (disulfoton), MetaSystox-R 2E (oxydemeton-methyl), and an untreated check. The experimental design was a randomized complete block with four replications in the woodlot and five in the windbreak during phase I, and four replications in both settings in phase II. The five treatments were assigned randomly to plots within each replication. Individual plots receiving a treatment contained four trees each. Average tree diameters (breast height) in inches were: phase I, woodlot, 9; windbreak, 19; and phase II, woodlot, 11; windbreak, 18.

Acecap capsules were inserted singly in holes made in the trunk 1 inch deep, spirally spaced 6 inches apart, beginning 12 inches above the ground. Furadan was applied in an 8-inch-deep trench circling the tree about 6 feet from the trunk; the application rate was 0.5 ounce per inch of trunk circumference (breast height). DiSyston and MetaSystox-R were injected into the soil 6 inches deep along the tree's drip line; application rates were 1 and 0.4 fluid ounces, respectively, per inch of trunk diameter (breast height) mixed with equal amounts of water.