Profitable Use of Fertilizer on Native Meadows[1]

MICHAEL NELSON AND EMERY N. CASTLE

Department of Agricultural Economics, Oregon State College, Corvallis, Oregon

In an earlier article in this journal (8:20-22. 1955) C. S. Cooper and W. A. Sawyer of the Squaw Butte-Harney Range and Livestock Experiment Station, Burns, Oregon, presented results of experiments carried out in 1951 and 1952 on fertilization of mountain meadows in the Harney basin, Oregon. The subject of this paper is an economic interpretation of their most recent experiments with nitrogen, carried out in the same area in 1954 and 1955.

Three separate trials were conducted, all showing essentially the same degree of yield response to nitrogen. The pooled results of these trials are given in Table 1.

If the price of nitrogen is assumed to vary from 10 cents to 15 cents per pound, then the cost of additional hay in terms of the fertilizer requirement may be calculated from Table 1 (see Table 2).

Ranchers must figure that this additional hay is still in the field and to these figures one must add cost of harvesting and stacking. The additional hay has value, however, only if it can be used in the production of beef. The extent to which the hay can be utilized depends upon the amount of rangeland available and meadow acreage. The main purpose of the study is to investigate some aspects of the range-hay-livestock balance. The problem can be broken down into the following questions:

(1) What is the most profitable rate of fertilizer application as determined by its contribution in the production of beef?

(2) How is this rate affected by different ranch situations?

(3) How is the rate affected by changes in the price of beef and nitrogen fertilizer?

(4) What are the range policy implications of increased forage production from meadow land?

Study Procedure

Before it was possible to make an economic analysis of the experiments, it was necessary to consider the factors that influence a rancher's decision on whether or not to use fertilizer. This information was obtained from a survey of ranchers and from statements of federal and

Table 1. Pooled results of fertilizer-hay response data from three trials.

Rate of Nitrogen Application (pounds per acre)	Hay Yield per Acre		Pounds of Hay per Pound of N
	Pounds	Tons	
0	3664	1.83	—
50	5243	2.62	31.6
100	6102	3.05	24.4
150	6681	3.34	20.0
200	7316	3.66	18.3

[1] *Technical Paper No. 1045, Oregon Agricultural Experiment Station. This article is a portion of the senior author's Ph. D. thesis submitted to Oregon State College. W. G. Brown of that institution provided assistance in planning and carrying out the research.*

state agencies operating in the area. There are approximately 60 ranches in the Harney Basin, Silver Creek, and Diamond areas of Eastern Oregon. Because of the nature of the study it was decided that a selected sample of 20 ranchers would be sufficient to provide information on the various conditions and problems found in the area.

From the survey of ranchers the factors involved in a decision to use fertilizer were determined. These factors were as follows: The resource situation in terms of land, labor, and capital; the price of nitrogen and beef; the cost and requirements of stacked hay, bunched hay, and pasture.

The next step was the economic interpretation of the fertilizer experiments. To do this it was necessary to estimate hay yields for any given level of nitrogen (not just at the five levels of nitrogen used in the trials). This is obtained by formulating an estimating equation from the experimental data.

An exponential equation seemed to best fit actual yield conditions. The curves in Figure 1 were determined from this equation. The total product function is the total hay yield that can be expected with different applications of fertilizer. The average product curve represents the average yield per pound of nitrogen. The marginal product curve gives the additional hay yield associated with each additional or marginal pound of nitrogen.

Profitable Fertilizer Rate

Characteristics of ranching in the native meadow area make the determination of the most profitable rate of fertilizer application difficult. A ready market does not exist for wild hay. Therefore, it must be valued in terms of its use in producing beef. Some method was needed that would provide an analysis of the entire ranch business. There are a number of techniques available by which such an analysis could be made, notably budgeting, regression techniques, and linear programming.

Table 2. Cost of additional hay at various rates of nitrogen application.

Rate of Nitrogen Application (pounds per acre)	Cost per Ton of Additional Hay	
	Price of N 10 cents/pound	Price of N 15 cents/pound
0	——	——
50	6.32	9.49
100	8.19	12.29
150	9.92	14.90
200	10.92	16.39

Linear programming is a mathematical procedure that allows a system of equations, subject to certain limiting factors, to be solved in such a way that returns to the limiting factors are maximized. Applying this technique to ranch management, the limiting factors become the land, labor, and capital that the rancher has available for production. The technique was used in this study because it permits the simultaneous selection of the level of beef production; areas of meadow to be fertilized for stacked hay, bunched hay and pasture; and the rate at which these should be fertilized in order to maximize profit. Such a simultaneous selection is not possible with budgeting, and experience has shown that regression analysis is often unsuitable for problems of this type.

The data used in the programming was obtained from the ranch survey, experiment station results, U. S. Department of Agriculture reports, and 1955 Ontario, Oregon, market reports.

In the use of programming it is necessary to establish a ranching situation. When this hypothetical ranch set-up has been established, it is possible to determine the economic use of fertilizer.

The first ranch organization studied was a two-man unit producing 167,900 pounds of beef and running 300 cows, with six limitational resources. The range permit was 3,025 A.U.M.'s, the base property was 750 acres of flood meadow, of which 260 acres (Meadow II) gave unsatisfactory response to fertilizer because of deep swales or excess alkalinity of the soil. This area gave a yield of one ton of wild hay per acre. For the purposes of the analysis this 260 acres is assumed to be unfertilized, with 66 percent cut for stacked hay and 34 percent for bunched hay, yielding one ton per acre. The remaining 490 acres (Meadow I) gave a yield of 1.2 tons of hay per acre without fertilizer. It was assumed that the meadow would only be fertilized to produce stacked hay,

Table 3. Fertilization rates, land use and beef production with limited and unlimited range

	Solution I*	Solution II**
Stacked hay	282 acres at 50 lbs. N.	313 acres at 100 lbs. N.
Bunched hay	118 acres at 40 lbs. N.	177 acres at 90 lbs. N.
Meadow pasture	90 acres at 50 lbs. N.	—
Increase in beef production due to fertilization	26%	66%
Increase in net return	$2058	(See 1 below)

* Range limited to 3025 A.U.M.'s.

** Range unlimited.

1 Although net income was determined for this situation, it is not presented since it has little economic meaning.

bunched hay and pasture. It was further assumed that all additional capital necessary for the operation of the ranch using nitrogen fertilizer and running additional cattle, would be available at 7 percent interest. As pointed out earlier, 1955 prices were used.

The solution shows that the optimum nitrogen application was 50 pounds per acre on 282 acres for stacked hay, 40 pounds on 118 acres for bunched hay and 50 pounds on 90 acres for pasture (Table 3). The 260 acres of meadow which do not respond to nitrogen were assumed to produce 170 tons of stacked hay and 90 tons of bunched. The level of beef production which this forage output would support is 212,000 pounds from a herd of 360 cows, selling yearlings. This operating system would involve pasturing 110 yearling steers on the meadow through the summer. The increase in beef production due to fertilization is 26 percent, and the additional operating expenses amount to $4900 with a net increase in return to fixed factors, land, labor, and management, of $2058.

A second ranch organization was set up to take account of any possible expansion in range grazing through development or purchase. In this case there were four limitational resources, Meadows I and II, stacked hay and bunched hay, and four levels of nitrogen on each of the two forage production methods. The results of this analysis showed that the optimum production level would be 280,000 pounds of beef given by an operation running 500 cows and selling yearlings. The range requirement for this system is 5053 A.U.M.'s, or 67 percent more than the requirement without fertilization of meadow. This points up the need for additional range production if additional hay production is to be utilized. The nitrogen application required to support this level of production would be 100 pounds on 313 acres for stacked hay and 90 pounds on 177 acres for bunched (Table 3). Production from Meadow II would be as it was in the first situation. If range rental is charged at current federal rates, the capital requirement of this system is $9900 more than an operation using no fertilizer.

Table 4 shows the manner in which the optimum rate of fertilization is related to changes in the price of beef and nitrogen. This table was developed by using the hay-nitrogen relationship shown in Figure 1, and is based on the assumption that the value of stacked hay is directly related to the price of beef. This may not be a realistic assumption for heavy rates of nitrogen, say above 50 pounds. It would be realistic for lower rates of application. It is doubtful, however, if an operator should put on less than 30 pounds of N since too little is known about hay response for small application.

From Table 3 it can be seen that under the currently feasible

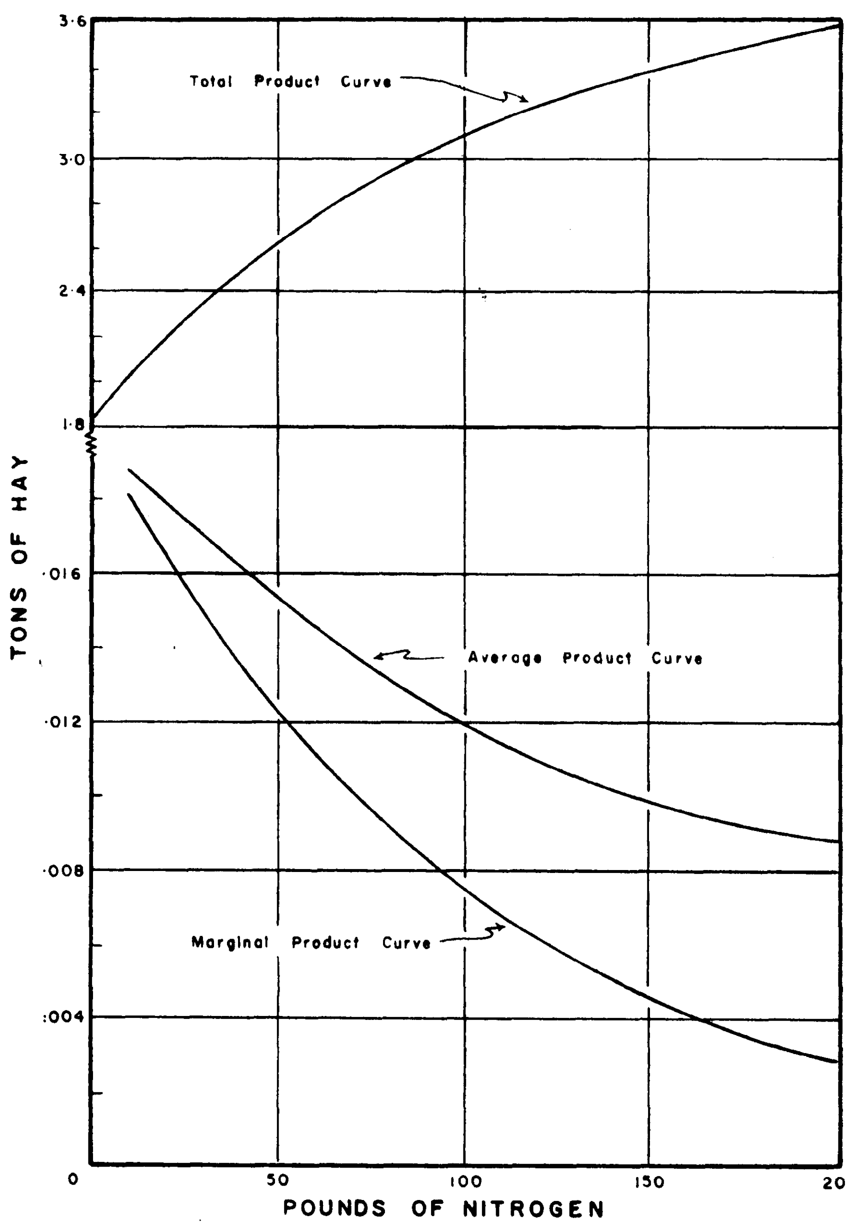

FIGURE 1. Total, average, and marginal hay yield response to nitrogen calculated from the results of experimental trials on mountain meadows in eastern Oregon.

Table 4. Relationship between price changes in beef and nitrogen and the optimum rate of fertilization.

Price of Beef	Price of Nitrogen—Cents per Pound										
	13.5	14	14.5	15	15.5	16	16.5	17	17.5	18	18.5
$ per cwt.	Pounds of Nitrogen Applied per Acre										
$10	30	30	30	20	20	20	10	10	10	10	0
11	40	40	40	30	30	30	20	20	20	20	10
12	50	50	50	40	40	40	30	30	30	20	20
13	60	60	50	50	50	40	40	40	30	30	30
14	70	60	60	60	50	50	50	50	40	40	40
15	80	70	70	60	60	60	50	50	50	50	40
16	80	80	70	70	70	60	60	60	60	50	50
17	90	80	80	80	70	70	70	60	60	60	60
18	90	90	90	80	80	80	70	70	70	60	60
19	100	100	90	90	90	80	80	80	70	70	70
20	100	100	100	90	90	90	80	80	80	80	70
30	150	140	140	130	130	130	120	120	120	120	110

price range for beef, up to $20 per 100 pounds, the highest optimum rate of fertilization is 100 pounds per acre at the lowest nitrogen price. At the nitrogen prices above 16 cents per pound, beef must be worth $9 or more per 100 pounds before any fertilization is profitable.

Conclusions

It is apparent from this study that any likely increase in range capacity can readily and profitably be matched by meadow output under a system of fertilization. However, Solution I indicates that without some development of range, the expansion through fertilization of meadow alone is limited to around 25 percent.

The prices of beef and nitrogen also affect the profitable limit of expansion with fertilizer. For instance, if the price of beef increases, relative to other prices paid by ranchers, then expansion of 30-35 percent may be profitable, using heavier applications of nitrogen (see Table 4).

The policy implications of meadow improvement are only indirectly related to fertilizer, but are nevertheless of importance. Fertilizer provides a relatively flexible method of increasing hay production and reserves. In this way it acts as a form of insurance and reduces the uncertainty in the operation. Where this is true the rancher can increase production, but summer range is still the most limiting factor. The administrators of public lands are therefore faced with the problem of obtaining the best utilization of range, and at the same time allowing the best use to be made of the meadows. There are two courses of action available to them. One is to develop rangeland, either themselves, or by financial assistance to ranchers; the second is to change the management of rangeland in light of meadow potential. In some cases it is impossible for the rancher to hold cattle on meadows in April and May due to pasture damage or because the meadows are covered by water. However, he may well be able to pasture them from July onwards or to bring them in from rangeland earlier in the fall. Other ranchers may be able to hold some cattle on pasture throughout the spring and summer. It is not the purpose of this article to go into range administration. The important point is that there exists a relationship between meadow improvement and range management.

Acknowledgement

The authors wish to acknowledge the assistance given by the staff of the Squaw Butte-Harney Experiment Station, particularly by Mr. C. S. Cooper and Mr. W. A. Sawyer whose field experiments formed the basis of this study.

Special recognition is also due to all ranchers, visited in the survey, for their splendid cooperation.

CALL FOR PAPERS FOR THE 1959 ANNUAL MEETING

Members who wish to present papers at the next annual meeting of the Society, to be held in Tulsa, Oklahoma, in January 1959, are requested to sumbit titles and short abstracts to the Program Committee. Final date for titles to reach the Committee is July 15, 1958.—E. H. McIlvain, Chairman Program Committee, U. S. Southern Great Plains Field Station, Woodward, Oklahoma.