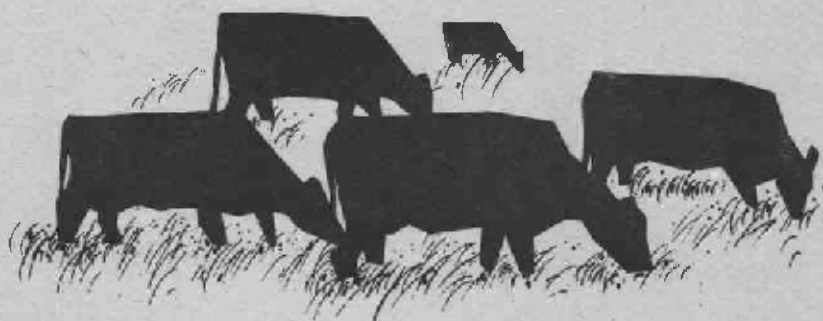
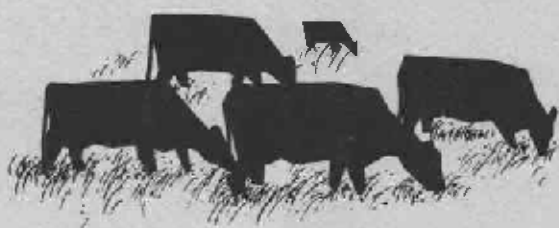


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Fertilizing Eastern Oregon Rangelands

Management Insights



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Fertilizing Eastern Oregon Rangelands

Management Insights

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Interest in range fertilization declined when fertilizer costs, particularly nitrogen, increased dramatically during the 1973-1975 period. Since that time, fertilizer prices have stabilized, even declined slightly in some cases; but more importantly, the value of yield responses from fertilization have increased. For example, in terms of some final products 300-500 pound feeder steers increased in value from about \$54 per cwt. in 1973 to about \$58 per cwt. in 1978, while good to choice feeder lambs increased in value from about \$30 per cwt. in 1973 to about \$60 per cwt. in 1978. As a result of changing economic conditions, eastern Oregon ranchers should evaluate the economics of rangeland fertilization as one option of obtaining needed feed at lower costs.

This pamphlet provides management insights which should be helpful to eastern Oregon ranchers considering range improvements through fertilization. Information on responses to fertilization, including interrelationships between fertilization and forage composition, forage utilization, shrub growth, and soil erosion are presented. Practical insights on rangeland management through fertilization are also offered. A simple worksheet as an aid to making fertilization decisions is presented, and instructions for its use are given.

Fertilization Response

Anticipated responses to fertilization of high desert range, foothill range, foothill meadows, and native flood meadows of eastern Oregon are briefly reviewed here. Responses are based on numerous fertilization trials which are appropriate to Oregon range conditions. Detailed results of these trials and an assessment of the economics of fertilizing established rangelands are presented in Oregon Agricultural Experiment Station Circular of Information 673 entitled, "Economics of Range Fertilization in Eastern Oregon." Copies of this circular can be obtained by writing to the Oregon Agricultural Experiment Station, Oregon State University, Corvallis, Oregon 97331.

The primary objective of fertilization is increased forage production at competitive costs. Other benefits, however, are often possible. Increased forage utilization might be achieved, and possibly an increase in plant vigor and a reduction in soil erosion can be accomplished. In some cases, fertilization increases total crude protein and digestible nutrients of the forage. An indirect benefit of fertilization often requiring additional management input is better animal distribution and, thus, increased overall forage utilization on previously under-utilized, non-fertilized range. This may also reduce grazing pressure on non-fertilized range areas.

A potentially negative effect of fertilization is an undesirable change in species composition. Large increases in forage production are frequently made up of less desirable forage species. For example, on sites containing cheatgrass, fertilization can promote cheatgrass development at the expense of perennial species. Several other factors that are not well identified are the possible shortening of the growing season due to earlier maturity of

fertilized grasses, the possibility of decreasing plant vigor through fertilization in below average rainfall years, and the possible increase in grazing pressure created by certain wildlife species on fertilized range areas.

High Desert Range

Yield responses to the application of nitrogen on native, high desert range where annual precipitation rarely exceeds 11 inches have been highly variable. Effects on air dry yields of native range varied from a six-pound yield increase from 15 pounds of nitrogen per acre on a poor condition range site to a 77-pound yield increase at 30 pounds of nitrogen on good condition range. At these response levels, with urea costing \$202 per ton, and application costs of \$4.50 per acre, costs of obtaining forage from nitrogen fertilization exceeded the cost of obtaining forage by purchasing grass hay even at hay prices in excess of \$300 per ton. Native, high desert range was judged least likely of the range types evaluated to produce additional forage from fertilization at costs less than the purchase price of grass hay. Furthermore, on sites containing cheatgrass, fertilization led to an increase in this grass at the expense of native grasses.

Compared to native range, yield responses to nitrogen fertilization of seeded, high desert range were more substantial. Air dry yield increases ranging from 103 pounds per acre from an application of 10 pounds of nitrogen to 900 pounds from an application of 20 pounds of nitrogen were reported. Yield responses, however, varied among years, sites, and grass species and were interrelated with winter precipitation. During periods of below average precipitation, nitrogen stimulated only a small yield increase in the first production year after application, but significant yield increases from nitrogen carryover were evident the following year.

With respect to introduced grass species and their responses to fertilization, crested and streambank wheatgrasses generally responded better and more consistently to nitrogen than other species. Nitrogen fertilization also promoted improved ground cover of grasses, thus possibly reducing soil erosion. Furthermore, grasses seemed to grow faster and mature faster. At higher rates of fertilization, soil moisture was depleted more rapidly. Fertilization, however, increased the efficiency of soil moisture use by plants. The crude protein content of fertilized grasses was increased, but the difference in protein content between fertilized and unfertilized grasses diminished with forage maturity. Where cheatgrass was present, nitrogen fertilization promoted its development. It is generally believed that on seeded, high desert range the short run effect on the increase in the number of sagebrush plants from nitrogen fertilization is small.

Per unit costs of obtaining additional forage from the fertilization of seeded, high desert range were lowest with an application of 40 pounds of nitrogen per acre. At this application rate, urea costing \$202 per ton and application \$4.50 per acre, the cost of obtaining additional forage from fertilization equaled the cost of obtaining forage by purchasing grass hay priced at \$36 per ton. Lower costs per unit of production might be obtained with nitrogen application rates larger than 40 pounds per acre, but this could not be determined from the experimental data.

Foothill Range

Yield responses to fertilization of native, foothill range were highly variable. Much of this variability was due to site factors and precipitation levels. On sites receiving about 12 inches of precipitation, 60 pounds of

nitrogen increased air dry yield an average of 300 pounds of forage per acre; whereas, on sites receiving 16-22 inches of precipitation, yield increases ranged from 200 pounds of forage per acre with the application of 30 pounds of nitrogen to 990 pounds of forage with the application of 120 pounds of nitrogen. At these latter sites, phosphorus and sulfur in combination with nitrogen also increased yield, but usually the added yield response was small. Statistically significant yield increases from nitrogen carryover were also observed with applications of nitrogen of over 90 pounds per acre. On many of the drier sites, cheatgrass made the biggest yield increase to fertilization. Fertilization of steeper slopes also induced heavier grazing on these sites.

Per unit costs of obtaining additional forage from the fertilization of native foothill range were lowest with an application of 60 pounds of nitrogen. At this application rate, urea costing \$202 per ton, and application \$4.50 per acre, the cost of obtaining additional forage from fertilization equaled the cost of obtaining forage by purchasing grass hay priced at \$35 per ton. Lower costs per unit of production might be obtained with nitrogen application rates between 40 and 80 pounds, but this could not be determined from the experimental data.

Nitrogen and nitrogen in combination with phosphorus significantly influenced yields of seeded, foothill range. No yield increases were noted with either phosphorus or sulfur. Air dry yield responses ranging from 250 pounds of forage per acre with the application of 30 pounds of nitrogen to 510 pounds of forage with the application of 120 pounds of nitrogen were reported on sites receiving an average of 12 inches of precipitation annually. These yield responses, however, were biased downward because of early season uses.

On sites receiving over 15 inches of precipitation annually, yield increases were noted even at an application rate of 140 pounds of nitrogen. Statistically significant yield increases from nitrogen carryover were evident with nitrogen applications of 40 pounds or more per acre. Nitrogen fertilization also produced about 70 percent more total protein and 30 percent more total digestible nutrients (TDN) per acre than unfertilized range. Phosphorus had only a slight effect on total protein and TDN production. Increased TDN production was a result of increased forage yield while protein production was a result of both increased yield and a higher crude protein content. Nitrogen alone and nitrogen in combination with phosphorus also promoted more uniform grazing, even several years after fertilization.

Based on yield responses affected by early harvest, the minimum cost of obtaining additional forage from nitrogen fertilization of seeded foothill range just equaled the cost of obtaining forage by purchasing grass hay when hay was priced at \$88 per ton. Some level of fertilization, however, is expected to result in the production of forage at lower costs, particularly if harvest is delayed until later in the growing season. With an application of 30 pounds of nitrogen costing \$0.22 per pound and application costs of \$4.50 per acre, a yield response of only about 560 pounds per acre is required to equate the cost of obtaining additional forage from fertilization to that of obtaining forage by purchasing grass hay valued at \$40 per ton. This or even a larger response could be obtained on many seeded, foothill range sites in eastern Oregon.

Foothill Meadows

Nitrogen alone and nitrogen in combination with phosphorus and sulfur significantly increased yields of native mountain meadows. Responses, however, varied by site location. With an application of 90 pounds of nitrogen, yield response of air dry forage was only 80 pounds per acre at one site and 600 pounds at another location. The average yield increase from 16 separate mountain meadow areas approached 770 pounds of air dry forage per acre with an application of 80 pounds of nitrogen.

Per unit costs of obtaining additional forage from the fertilization of native foothill meadows responsive to fertilizer were lowest with an application of 30 pounds of nitrogen per acre. At this application rate, with nitrogen at \$0.22 per pound and application costs of \$4.50 per acre, the cost of obtaining additional forage from fertilization equaled the cost of obtaining forage by purchasing grass hay priced at about \$32 per ton.

Only nitrogen significantly increased yield of seeded, mountain meadows. The greatest yield increase was 1,370 pounds of air dry forage per acre with an application of 60 pounds of nitrogen. Yield increases from nitrogen carry-over were evident with nitrogen application rates over 90 pounds per acre. Creeping meadow foxtail, intermediate wheatgrass, and intermediate wheatgrass-legume mixes exhibited the largest response to nitrogen. Pure grass stands, however, responded better to nitrogen than grass legume mixes. Total protein production showed a marked response to nitrogen in the year of fertilizer application but not in subsequent years.

Per unit costs of obtaining additional forage from the fertilization of seeded foothill meadows were lowest with an application of 60-80 pounds of

nitrogen per acre. At these application rates, with nitrogen at \$0.22 per pound and application costs of \$4.50 per acre, the cost of obtaining additional forage from fertilization equaled the cost of obtaining forage by purchasing grass hay priced at about \$35 per ton.

Native Flood Meadow

Native flood meadows were found to be responsive to fertilizer, although not all meadows responded equally well. Nevada bluegrass and rush-sedge-grass meadows showed the greatest response to nitrogen. Mixed clover-rush-sedge meadows showed the greatest response to phosphorus. At 21 different sites, mean yield responses to the applications of 60 and 120 pounds of nitrogen were 0.75 and 1.15 air dry tons per acre, respectively. At still other locations, yield responses approached 2.0 air dry tons per acre with the application of 200 pounds or more of nitrogen. Yields were not statistically different with nitrogen applications above 240 pounds and yield increases from nitrogen carry-over were not statistically significant. Applications of 18 pounds of phosphorus produced maximum yield responses of from 0.3 to 0.4 tons of air dry forage per acre. Phosphorus also increased crude protein content of forage. Fertilization changed the botanical composition of meadows. Nitrogen stimulated rush-sedge components, while phosphorus stimulated the annual white-tip clover component. But nitrogen had no effect on yield until late May; thereafter, yields increased until about mid-July. No single source of nitrogen was superior for fertilizing flood meadows. Fall and spring applications were equally effective, but spring application must be completed prior to June to attain maximum yield response. Minor elements did not influence yields when applied alone or in combination with nitrogen or phosphorus. Neither nitrogen nor phosphorus stimulated regrowth

after harvest; however, nitrogen with supplemental irrigation stimulated re-growth.

Per unit costs of obtaining additional forage from the fertilization of native flood meadows were lowest with an application of about 200 pounds of nitrogen per acre. At this application rate, with nitrogen at \$0.22 per pound and application costs of \$4.50 per acre, the cost of obtaining additional forage from fertilization equaled the cost of obtaining forage by purchasing grass hay priced at \$27 per ton. This comparison does not account for the added cost of harvesting the forage production attributed to fertilization. Since many native flood meadows are hayed, additional harvest costs can be expected and will increase the cost of obtaining additional forage from fertilization. Lower costs per unit of production might be obtained with nitrogen applications exceeding 200 pounds, but this could not be determined from the experimental data. Of the range types evaluated, native flood meadows were most responsive to nitrogen fertilizer and judged most likely to produce additional forage from fertilization at costs less than the purchase price of grass hay.

Management Insights

In order to realize the maximum benefit from rangeland fertilization, the following management insights are offered:

- 1) Yield responses to fertilization are greatest on sites where soil moisture is least limiting, fertility is low, and deeper soils of medium texture and good structure exist. Sites with these characteristics should be considered as having fertilization potential.
- 2) Attempting to increase forage production of native grasses by fertilization is not recommended for range sites receiving less than 10-12 inches of precipitation annually.
- 3) Nitrogen is the fertilizer element having the greatest effect on forage production on eastern Oregon rangelands. It, therefore, should be the primary component of a range fertilization program.

- 4) No single source of nitrogen is superior for rangeland fertilization; hence, nitrogen source should be based on the cost per pound of actual nitrogen.
- 5) Introduced forage species are more yield responsive to fertilizer than native grasses. Responsiveness, however, varies among all grass species and is interrelated with precipitation. On high desert sites receiving about 11 inches of precipitation annually, crested wheatgrass responds better and more consistently to nitrogen than other species or species mixtures. Creeping meadow foxtail, intermediate wheatgrass, and intermediate wheatgrass-legume mixtures show the largest response to nitrogen on sites in northeastern Oregon receiving 16-22 inches of precipitation annually.
- 6) Spring application of fertilizer is recommended because soil moisture availability can be predicted better, and a fertilization program can be adjusted accordingly.
- 7) Nitrogen fertilization hastens spring "range readiness." If this early range is utilized, it is important to occasionally defer spring grazing on the site or cease grazing early enough to allow desirable grasses to reach maturity before utilization commences again; otherwise, the stand will die out prematurely.
- 8) Fertilization can be used as a tool to improve livestock distribution. Nitrogen fertilization can significantly increase utilization of forage on previously lightly grazed areas. The areas fertilized, however, must be coordinated with herding, salting, and water development. Care also must be taken not to fertilize areas where animals normally congregate and to make the fertilized area sufficiently large so that excessive use is not experienced.
- 9) Attempting to increase forage production on cheatgrass problem sites by fertilization is not recommended because it will encourage even more cheatgrass growth. Flash (intensive but short duration) grazing in early spring is the best management practice for these sites as this method of grazing tends to reduce competition from this grass and improve the yield response of more desirable grass species.

- 10) Fertilization will not reverse decreasing yield trends associated with aging crested wheatgrass stands, although fertilized stands will maintain a higher yield level than non-fertilized stands.
- 11) Total dry matter response to fertilization is greatest when grasses are harvested near maturity; however, crude protein and TDN levels have diminished from earlier levels. Ranchers interested only in quantity of production should delay harvest until grasses near a mature stage, while quality of production can be achieved with earlier harvest.
- 12) Fertilization at time of seeding is not recommended on high desert range; it will not improve stand establishment.
- 13) Before an extensive fertilization program is undertaken, a pilot project might be considered to obtain estimates of yield responses to various sites, species, fertilizers, and their application rates. This additional effort will generate more insights on rangeland fertilization and make possible more informed and superior fertilization decisions.

Budgeting: An Aid to Decision Making

Because responses to fertilization of rangelands are so highly variable from site to site, year to year and even among grass species, it is imperative that the economics of each fertilization decision be evaluated before the actual commitment of any capital or physical resources. One method of evaluating these decisions is through the use of a fertilization worksheet which is illustrated in Exhibit I. This worksheet is a simple budgeting framework that can be used to determine if the estimated cost of obtaining forage from rangeland fertilization is more or less than that of obtaining forage by another option (i.e., purchasing hay, lease grazing, buy additional rangeland, spray sagebrush, etc.). The worksheet should be viewed as a general guide in the evaluation process rather than a rigidly followed form to be completed. Specifically, it is used to estimate costs and forage responses associated with a rangeland fertilization decision for the period of time from the application of fertilizer through the first production year following fertilization. It is this period of time when costs and responses most seriously affect the fertilization decision. Use of this worksheet can be both a time and money saver as it directs the decision maker away from unprofitable decisions.

Exhibit I
Fertilization Worksheet

I. Forage Response

A. Additional production from fertilized area:

(AUM's, pounds,
or tons forage)

B. Additional production, if any, from non-fertilized range:

(AUM's, pounds,
or tons forage)

C. Total additional production available to the ranch operation for utilization due to fertilization:

(A + B)

II. Fertilization Costs

D. Fertilizer costs: $\frac{\text{(application rate per acre)}}{\text{(application rate per acre)}} \times \frac{\text{(materials cost per unit)}}{\text{(materials cost per unit)}} \times \frac{\text{(acreage to be fertilized)}}{\text{(acreage to be fertilized)}} = \$ \underline{\hspace{2cm}}$

E. Equipment costs: depreciation
interest on ave. investment
other costs = \$

F. Labor costs: $\frac{\text{(labor hrs)}}{\text{(labor hrs)}} \times \frac{\text{(wage rate)}}{\text{(wage rate)}} = \$ \underline{\hspace{2cm}}$

G. Custom charges: $\frac{\text{(rate per acre)}}{\text{(rate per acre)}} \times \frac{\text{(acreage)}}{\text{(acreage)}} = \$ \underline{\hspace{2cm}}$

H. Other costs: depreciation
interest on ave. investment
other costs = \$

I. Opportunity costs: $\frac{\text{(D+E+F+G+H)}}{\text{(D+E+F+G+H)}} \times \frac{\text{(interest rate)}}{\text{(interest rate)}} \times \frac{\text{(fraction of year between fertilization \& utilization)}}{\text{(fraction of year between fertilization \& utilization)}} = \$ \underline{\hspace{2cm}}$

J. Total fertilization costs:

(D+E+F+G+H+I)

III. Unit Costs of Production from Fertilization

K. Unit costs: $\frac{\text{(J)}}{\text{(C)}} = \$ \underline{\hspace{2cm}}$
(per AUM, pound or ton forage)

IV. Unit Cost Comparisons

Unit costs from fertilization \$ (K) vs. unit costs from purchasing hay = \$
unit costs from leased grazing = \$
unit costs from spraying brush = \$
unit costs from = \$
unit costs from = \$

Instructions

The worksheet is divided into four sections: I) forage response, II) fertilization costs, III) unit cost of production, and IV) cost comparisons.

Forage responses for the first production year following application of fertilizer are identified in Section I. Only those responses occurring in this production period are estimated as they most significantly affect the fertilization decision.

Estimated additional production from your specific range site to be fertilized is entered on line A. This estimate includes any yield response available for utilization that is directly attributed to fertilization and, when appropriate, increased production due to increased overall forage utilization on the site. Research has shown that on under-utilized sites, increases in forage utilization ranging up to 23 percent with the application of 20-30 pounds of nitrogen per acre are possible. No increase in forage utilization can be anticipated, however, on sites where prior forage utilization has been heavy.

When appropriate, additional production from non-fertilized range is specified on line B. Increased production might be the added growth on non-fertilized range where grazing can be deferred longer than usual because fertilized range will support a longer grazing period, or it might be increased production due to increased overall forage utilization on the rancher's range because of improved livestock distribution attributed to fertilization. This additional production may vary from a few pounds to several hundredweight per acre depending on range conditions and management practices.

The forage response section is completed by summing the individual response items (A and B) on line C. This sum represents the total additional forage production available to the ranch operation for utilization due to fertilization.

Fertilization costs are estimated in Section II. Total fertilizer costs (the application rate per acre, times the materials cost per unit, times the acreage to be fertilized) are specified on line D.

Equipment costs, line E, include fuel, oil, and repairs associated with all equipment used in the process of fertilization. If equipment is specifically purchased primarily for rangeland fertilization uses, ownership costs (annual depreciation, interest on average investment, taxes, and insurance) should also be included in the equipment cost estimate. If more than one site is fertilized during the year in question, ownership costs should be prorated on a total acres fertilized basis.

Line F, labor cost, is calculated by multiplying estimated labor hours required by the hourly wage rate paid labor or what labor is worth in its next best productive use, whichever is higher.

Total custom charges, when used as an alternative application method, are identified on line G. These charges often include all costs: materials, equipment, and labor costs.

Other charges which might not be directly related to fertilizer application but which are related to the realization of increased production should be entered on line H. These charges might include the increased cost of herding livestock onto fertilized areas, or the cost of hauling water, etc. If capital investments are made, annual ownership costs of these investments should also be included on line H.

Opportunity costs are estimated on line I. It is important to consider the cost of having money invested in range fertilization because the opportunity of investing it productively elsewhere is foregone. Opportunity costs are estimated by multiplying the sum of lines D through H (to avoid double accounting, subtract depreciation and interest on average investment of capital items

included on lines E and H before these lines are summed) by the annual interest rate paid on borrowed capital or the rate of return on the next best use of capital, whichever is higher. The resulting product is then multiplied by the fraction of a year, based on months, that elapses between fertilizer application and forage response utilization. This fraction represents the period of time that money is actually invested in range fertilization and it adjusts the opportunity charge to correspond to this period of time. The fraction is easily calculated. For example, if a range is to be fertilized in April and the forage response grazed in August about four months later, the fraction of the year that money will be invested in fertilization is $4/12$ or $1/3$ of a year.

The cost section is completed by summing the individual cost items (D through I) on line J. This sum represents the estimated cost to fertilize a range site and then utilize the forage response attributed either directly or indirectly to fertilization.

The unit cost of producing forage from rangeland fertilization is calculated in Section III. This unit cost is determined in line K by dividing forage responses (line C) into total fertilization costs (line J).

Unit costs of producing forage by fertilization are compared to the unit cost of obtaining forage by another option or options in Section IV. For some alternative options like spraying sagebrush to release a forage response, unit costs of producing forage will have to be determined by using a worksheet similar to the fertilization worksheet in Exhibit I. For other options like purchasing hay or leased grazing, unit costs are more easily determined. This cost comparison quickly permits the rancher to evaluate rangeland fertilization as one option of obtaining forage at lower costs.