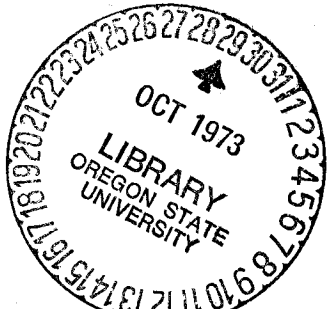
# Fertilizing Rangeland in Northeast Oregon

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# Fertilizing Rangeland in Northeast Oregon

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Livestock production is the primary agricultural enterprise in northeast Oregon. The livestock rancher's business is converting forage to meat. Management practices which increase forage production potentially increase livestock numbers and the quantity of meat produced.

The purpose of this report is to summarize results of experiments conducted over a ten-year period to determine the possibility of increasing summer forage available to livestock through the application of commercial fertilizers to rangeland in northeast Oregon. Nitrogen, phosphorus, and sulfur have increased yields and given economical returns when properly applied to cultivated grasses, grains, and legumes in northeast Oregon (Pumphrey, 1961, 1963, 1965). Nitrogen on grains, irrigated pastures, hay meadows, and grass seed crops has produced more response than any other element applied as a fertilizer. Occasionally combinations of phosphorus or sulfur with nitrogen or all three elements have been more productive than nitrogen alone. Legumes in many areas require additional phosphorus and sulfur for maximum yield. Soil tests have been valuable in estimating the need for fertilizing with phosphorus.

## Experimental Procedure

Fertilizer experiments were established on native rangeland growing mainly grasses and forbs, foothill meadows, and seeded rangeland. These locations received 15 or more inches average annual rainfall. Several experiments were established on crested wheatgrass and on native range growing mainly bluebunch wheatgrass, downy bromegrass, and sagebrush. These locations received less than 15 inches average annual rainfall. No location was sub-irrigated. Soils varied from moderately shallow to deep. Some native range locations contained sufficient rock on or near the surface to prevent tillage. No experiment was located on soil derived primarily from volcanic ash. Soil samples, taken prior to fertilizer application, were analyzed, and the results were interpreted.

Fertilizers were applied as a topdressing as spring growth was beginning. In a few experiments, fall fertilizer application was compared to spring fertilizer application. Plots were arranged in a randomized block design with three or more replications. Fertilizers used were ammonium nitrate (33.5 percent nitrogen), concentrated superphosphate (44 percent available $P_2O_5$), and gypsum (20 percent sulfur). Nitrogen, phosphorus, and sulfur fertilizers were applied singly or in various combinations. Green forage samples for yield determinations were taken at hay stage of growth. All forage yields were calculated on an oven-dry moisture basis.

If the difference in yield between treatments was as great or greater than the least significant difference (LSD) shown in the table for that experiment, it is assumed that the difference was because of fertilizer treatment. The LSD at the 5 percent level of significance was used. N. S. is used to denote that no significant difference at the 5 percent level existed among treatment yields. The CV value (coefficient of variation) is an indication of variation within the experiment.

The species of native plants varied from one location to another. Plants predominating on native grass and forbs range and on foothill meadows are listed in Table 1. Grassland type, estimated

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average annual precipitation, soil depth, and soil test data are reported in Table 2.

## Results

### Soil analyses

Soil test data show each soil was slightly acid, contained moderate to high amounts of available phosphorus and potassium, and was adequately supplied with calcium and magnesium (Table 2).

### Native range and foothill meadow fertilization

Forage yields from unfertilized native rangeland varied from 435 to 1,390 pounds per acre annually (Tables 3, 4, 5, and 6). This appears to be a normal range in production which can be expected among years and locations. An example of extreme variation in forage yield at one location between years is presented in Table 3. Yields in location 2 and 3 the year the fertilizers were applied were 1,160 or more pounds per acre. Yields the year following fertilization, a below-average rainfall year, averaged only about half those of the previous year.

Forage production was increased by fertilization, but the increase was not large at any location (Tables 3, 4, 5, and 6). The greatest increase in yield from fertilizing native range and foothill meadows occurred in the experiment reported in Table 5. Thirty pounds of nitrogen increased forage yield less than 600 pounds per acre. The second thirty pounds of nitrogen applied increased yields another 300 to 400 pounds per acre. Increasing the amount of nitrogen

**Table 1. Common and scientific names of plants predominating on fertilized native grass and forbs range and foothill meadow sites**

**Grasses**

Idaho fescue—*Festuca idahoensis*
Bluebunch wheatgrass—*Agropyron spicatum*
Kentucky bluegrass—*Poa pratensis*
Canada bluegrass—*Poa compressa*
Junegrass—*Koeleria cristata*
Timothy—*Phleum pratense*
Downy bromegrass (cheatgrass)—*Bromus tectorum*
Rattlesnake brome—*Bromus brizaeformis*

**Forbs**

Balsamroot—*Balsamorhiza sagittata*
Mules ear—*Wyethia amplexicaulis*
Eriogonum—*Eriogonum sp.*
Yarrow—*Achillea millefolium*
Clarkia—*Clarkia pulchella*
Geranium—*Geranium viscosissimum*
Lupine—*Lupine sp.*

**Table 2. Grassland type, estimated precipitation, soil depth, and soil test data for range fertilizer experiments**

| Locations | Grassland Type[1] | Estimated precipitation | Soil | Soil test data, 0-8″ depth[2] | | | |
|---|---|---|---|---|---|---|---|
| | | | | P | K | Ca | Mg |
| | | *inches, annually* | *depth* | *pH* | *ppm* | *me/ 100g* | *me/ 100g* | *me/ 100g* |
| 1 | Native foothill meadow | 22 | over 4′ | 6.6 | 15 | 0.71 | 6.5 | 2.3 |
| 2 | Native foothill meadow | 22 | over 4′ | 6.7 | 22 | 0.85 | 7.6 | 2.1 |
| 3 | Seeded foothill meadow | 22 | over 4′ | 6.6 | 26 | 0.56 | 12.0 | 4.9 |
| 4 | Native grass and forbs range | 15 | 1-3′ | 6.4 | 18 | 0.98 | 13.8 | 4.0 |
| 5 | Native grass and forbs range | 18 | 1-2′ | 6.4 | 17 | 1.29 | 15.2 | 4.5 |
| 6 | Native grass and forbs range | 18 | 2-3′ | 6.3 | 20 | 1.14 | 11.7 | 3.8 |
| 7 | Native foothill meadow | 24 | over 4′ | 5.9 | 16 | 0.80 | 15.0 | 4.0 |
| 8 | Mostly bluegrass | 16 | over 4′ | 6.1 | 23 | 1.16 | 16.3 | 4.1 |
| 9 | Seeded foothill meadow | 22 | over 4′ | 6.6 | 26 | 0.56 | 12.0 | 4.9 |
| 10 | Seeded range | 15 | 1-2′ | | | | | |

[1] No perennial shrubs as sagebrush grew on any of these sites.
[2] Soil test data from Soil Testing Laboratory, Oregon State University, Corvallis, Oregon.

applied above 60 pounds per acre increased forage yields very little. Phosphorus applied in combination with nitrogen or with nitrogen and sulfur had no effect on yield. Surfur applied alone did not increase forage production. A combination of nitrogen, phosphorus, and sulfur fertilization yielded slightly more than nitrogen alone at some locations.

One experiment (not harvested) was grazed by a few stray cattle prior to the hay stage of growth. Plots were identified easily by the grazing pattern. The cattle closely grazed plots fertilized with 90 or 120 pounds of nitrogen per acre. Plots receiving little or no nitrogen were practically ungrazed. In other experiments, there was more grazing by deer and elk in the spring on plots receiving the larger application of nitrogen.

**Table 3. Forage yields from fertilizing dry foothill meadows**

| Fertilizer, lbs/A $N$-$P_2O_5$-$K_2O$-$S$ | Native meadow 1 | Native meadow 2 | | Mixture seeded grasses 3 | |
|---|---|---|---|---|---|
| | | *Forage yield, lb/A* | | | |
| 0- 0-0-0 | 820 | 990[1] | 620[2] | 1,390[1] | 650[2] |
| 30- 0-0-0 | 1,500 | 1,030 | 590 | 2,120 | 800 |
| 60- 0-0-0 | 1,580 | 1,190 | 510 | 2,760 | 780 |
| 90- 0-0-0 | 1,420 | 1,070 | 470 | 2,580 | 940 |
| 180- 0-0-0 | 1,630 | 1,220 | 820 | 2,520 | 940 |
| 0-80-0-0 | 870 | 1,000 | 700 | 1,510 | 720 |
| 60-80-0-0 | 1,660 | 1,090 | 470 | 2,890 | 710 |
| 60-80-0-50 | 1,930 | 1,300 | 450 | 3,120 | 790 |
| 5% LSD | 403 | N.S. | N.S. | 530 | 228 |
| CV% | 19 | 24 | 29 | 15 | 19 |

[1] Forage yields the year the fertilizer was applied.
[2] Forage yields the year following the year the fertilizer was applied. Year was much drier than the previous year.

**Table 4. Forage yields from fertilizing native grass and forbs rangeland**

| Fertilizer, lbs/A $N$-$P_2O_5$-$K_2O$-$S$ | Location 4 | 5 | | 6 | |
|---|---|---|---|---|---|
| | | *Forage yield, lb/A* | | | |
| 0- 0-0-0 | 1,030 | 1,370[1] | 1,150[2] | 1,250[1] | 1,050[2] |
| 30- 0-0-0 | 1,080 | 1,970 | 1,250 | 1,450 | 1,070 |
| 60- 0-0-0 | 1,170 | 2,230 | 1,630 | 1,950 | 1,170 |
| 90- 0-0-0 | 1,460 | 2,080 | 1,740 | 2,060 | 1,480 |
| 120- 0-0-0 | 1,260 | 2,120 | 1,670 | 2,240 | 1,700 |
| 0- 0-0-20 | 1,070 | 1,340 | 1,220 | 1,290 | 1,070 |
| 60- 0-0-20 | 1,370 | 2,240 | 1,190 | 2,170 | 1,360 |
| 60-80-0-20 | 1,390 | 2,390 | 1,280 | 2,010 | 1,250 |
| 5% LSD | N.S. | 520 | 290 | 600 | 305 |
| CV% | 15 | 15 | 12 | 19 | 14 |

[1] Forage yields the year the fertilizer was applied.
[2] Forage yields the year following the year the fertilizer was applied.

**Table 5. Forage yields from fertilizing dry foothill meadow**

| Fertilizer, lbs/A | Location 7 |
|---|---|
| $N$-$P_2O_5$-$K_2O$-S | *Forage Yield, lbs/A* |
| 0- 0-0-0 | 790 |
| 30- 0-0-40 | 1,400 |
| 60- 0-0-40 | 1,700 |
| 90- 0-0-40 | 1,870 |
| 120- 0-0-40 | 1,930 |
| 0-80-0-40 | 740 |
| 30-80-0-40 | 1,240 |
| 60-80-0-40 | 1,640 |
| 90-80-0-40 | 1,900 |
| 60-80-0-0 | 1,600 |
| 5% LSD | 418 |
| CV% | 17 |

**Table 6. Range fertilization—mostly bluegrass**

| Fertilizer, lbs/A | Location 8 |
|---|---|
| $N$-$P_2O_5$ | *Forage yield, lbs/A* |
| 0-0 | 435 |
| 30-0 | 810 |
| 30-40 | 850 |
| 0-40 | 460 |
| 5% LSD | 270 |
| CV% | 27 |

## Fertilizing seeded rangeland

Fertilizing with nitrogen increased forage yields of introduced grasses seeded on rangeland (tall oatgrass, timothy, intermediate wheatgrass mixture in location 3, Table 3; intermediate wheatgrass in locations 9 and 10, Table 7). Applying nitrogen at rates of 30 and 60 pounds per acre was more effective per pound of nitrogen applied in increasing yield than higher rates of application. Applying more nitrogen than 60 pounds per acre did not produce additional forage. Yields were slightly higher where sulfur fertilizer was applied alone or in combination with nitrogen fertilizer, but yield increases were not sufficiently large to suggest fertilizing with sulfur. Slight yield increases were measured where phosphorus fertilizer had been applied; these increases were not significant.

Yield increases varied considerably from one location to another and from year to year. Much of the variation in forage production and in response to fertilization from year to year can be accounted for in variations in annual rainfall and effectiveness of the rainfall in producing plant growth. The larger increases in forage production from fertilizing were obtained during years when rainfall was above normal.

## Residual value of the applied fertilizer

All experiments were observed the second year following fertilizer application for visible differences in forage growth from the fertilizer applied. In most experiments, little if any difference in growth was observed between the unfertilized areas and areas fertilized the previous year. Yields were measured in four locations where visible differences occurred. Yields were several hundred pounds per acre higher where rates of nitrogen from 60 to 120 pounds per acre had been applied the previous year (Tables 3 and 4). Total increase in forage yield for two years from one application of nitrogen did not exceed 1,650

**Table 7. Forage yields from fertilizing intermediate wheatgrass**

| Fertilizer, lbs/A | Location 9 | Location 10[1] |
|---|---|---|
| $N$-$P_2O_5$-$K_2O$-S | *Forage yield, lbs/A* | |
| 0-0-0-0 | 1,090 | 720 |
| 30-0-0-0 | 1,690 | 970 |
| 60-0-0-0 | 2,350 | 1,050 |
| 90-0-0-0 | 2,180 | 1,120 |
| 120-0-0-0 | 2,270 | 1,230 |
| 0-0-0-20 | 1,250 | 800 |
| 60-0-0-20 | 2,340 | 1,080 |
| 90-0-0-20 | 2,350 | ..... |
| 60-80-0-20 | ..... | 1,060 |
| 5% LSD | 380 | 180 |
| CV% | 13 | 10 |

[1] Pastured nearly a month in early spring before cattle were removed.

Table 8. Fall versus spring fertilization effect on forage yield

| Fertilizer, lbs/A $N$-$P_2O_5$-$K_2O$-$S$ | Dry foothill meadow | | Mixture seeded grasses | | Intermediate wheatgrass | |
|---|---|---|---|---|---|---|
| | *Fall* | *Spring* | *Fall* | *Spring* | *Fall* | *Spring* |
| | *Forage yield, lbs/A* | | | | | |
| 30- 0-0-0 | 1,050 | 1,500 | 1,810 | 2,120 | ..... | ..... |
| 30-80-0-0 | 1,120 | 1,400 | 1,920 | 2,320 | ..... | ..... |
| 60- 0-0-0 | 1,240 | 1,580 | 2,000 | 2,760 | ..... | ..... |
| 60-80-0-0 | 1,615 | 1,660 | 2,690 | 2,890 | ..... | ..... |
| 90- 0-0-0 | 1,760 | 1,420 | 2,290 | 2,580 | ..... | ..... |
| 90-80-0-0 | 1,800 | 2,090 | 2,630 | 3,390 | ..... | ..... |
| 0-80-0-0 | 810 | 870 | 1,340 | 1,510 | ..... | ..... |
| 30- 0-0-10 | ..... | ..... | ..... | ..... | 1,400 | 1,520 |
| 60- 0-0-10 | ..... | ..... | ..... | ..... | 1,810 | 2,100 |
| 90- 0-0-10 | ..... | ..... | ..... | ..... | 2,160 | 2,270 |
| mean | 1,340 | 1,500 | 2,100 | 2,510 | 1,790 | 1,960 |

pounds per acre in any experiment. Phosphorus and sulfur fertilizers did not increase yields during the residual year.

### Fall versus spring fertilization

Fertilizing in the spring when plant growth was starting resulted in more forage production than fall fertilization. Yields averaged 270 pounds per acre higher where the fertilizer was spring applied than where the fertilizer was fall applied (Table 8). Yield differences in favor of the spring applied fertilization were affected very little by the fertilizer applied or the rate of nitrogen applied.

### Drier locations

Early growth where nitrogen fertilizer was applied was observed to be darker green, slightly earlier, and grazed more by deer than non-fertilized forage. Small increases in the growth of crested wheatgrass and native grasses were observed where nitrogen had been applied. Downy bromegrass growth was increased as much or more than the growth of native or introduced grasses. Fertilizing with nitrogen, phosphorus, and sulfur did not produce more growth than where only nitrogen was applied. No difference in growth could be seen between plots fertilized with phosphorus or sulfur (alone or together) and plots not receiving any fertilizer.

These observations from fertilizing the drier native and seeded rangeland in northeast Oregon are consistent with results reported by scientists at the Squaw Butte Experiment Station (Sneva, et al, 1958; Sneva, 1963; Sneva and Hyder, 1965).

## Discussion

Vigorous, adapted introduced grasses such as intermediate wheatgrass, tall oatgrass, and timothy yielded more forage per acre than native grasses and range plants. Also, the introduced grasses were more responsive to fertilization. Nitrogen was the only element which produced significant increases in forage yields. No response was measured when phosphorus or sulfur was applied alone or together. Combinations of phosphorus and sulfur with nitrogen occasionally increased yield more than when only nitrogen was applied. A response to phosphorus fertilizer application would not be expected with the amount of available phosphorus found in these soils (Table 2).

Greater efficiency of nitrogen was obtained from the lower rates of application, 30 and 60 pounds of nitrogen per acre, than from the higher rates. At best, less than 30 pounds of dry forage at hay stage of growth was obtained per pound of nitrogen applied. Using these figures,

estimated costs for fertilizer and fertilizer application would be near five dollars per animal unit month (AUM) of feed. The average cost of the AUM for all experiments harvested would be approximately ten dollars for the 30- or 60-pound rates of nitrogen application. Grazing prior to peak production would reduce the amount of additional growth which could be expected from fertilization (Hyder and Sneva, 1961; Hedrick, et al, 1965).

Forage yields were higher when fertilizer was applied in early spring than when the fertilizer was applied in the fall. From a practical standpoint, there are some advantages of fall fertilization which might outweigh the small yield advantage for spring fertilization. Much rangeland in the higher precipitation areas in northeast Oregon is too wet in the early spring to accommodate ground machinery used to apply fertilizers. By the time the ground has dried enough, spring growth has long since begun and the ideal time to fertilize has passed. In early spring, the rancher usually has several pressing demands for his labor. In the fall, more time may be available for fertilizing.

These results from fertilizing rangeland grasses and forbs growing on soils not derived from volcanic ash are in contrast to results published by Geist, 1971, and Pumphrey, 1971, on fertilizing soils derived from ash in northeast Oregon.

## Summary and Recommendations

Consistent increases in forage yields were not obtained from fertilizing native grass and forbs rangeland, dry foothill meadows, and seeded rangeland having soils not derived from volcanic ash. Residual value of the fertilizer applied was low. Fertilization with 30 to 60 pounds of nitrogen per acre is most apt to be profitable when used on high-yielding introduced grasses and during years of above-normal rainfall. Early spring applications will produce slightly larger yield increases of forage than fall applications.

## Literature Cited


Geist, Jon M. 1971. Orchardgrass response to fertilization of seven surface soils from the central Blue Mountains of Oregon. USDA Forest Serv. Res. Paper PNW-122, 12p. Pac. Northwest Forest & Range Exp. Sta., Portland, Oregon.

Hedrich, D. W., J. A. B. McArthur, J. E. Oldfield, and J. A. Young. 1965. Seasonal yield and chemical content of forage mixtures on a pine woodland meadow site in northeastern Oregon. Oregon State Univ. Agr. Exp. Sta. Tech. Bul. 84, 42p.

Hyder, D. N., and F. A. Sneva. 1961. Fertilization on sagebrush-bunchgrass range —A progress report. Oregon Agric. Exp. Sta. Misc. Paper 115. 6p.

Pumphrey, F. V. 1961. Winter wheat fertilization in northeast Oregon. Oregon State Univ. Agr. Exp. Sta. Circ. Inform. 610. 8p.

Pumphrey, F. V. 1963. Sulfur and phosphorus fertilization of alfalfa and clover in northeast Oregon. Oregon State Univ. Agr. Exp. Sta. Circ. Inform. 619. 10p.

Pumphrey, F. V. 1965. Fertilizing Kentucky bluegrass and fine fescue for seed production in northeast Oregon. Oregon State Univ. Agr. Exp. Sta. Bul. 601. 15p.

Pumphrey, F. V. 1971. Grass species growth on a volcanic ash-derived soil cleared of forest. J. Range Manage. 24:200-203.

Sneva, Forrest A., D. N. Hyder, and C. S. Cooper. 1958. The influence of ammonium nitrate in the growth and yield of crested wheatgrass on the Oregon high desert. Agron. Jour., 50:40-44.

Sneva, Forrest A. 1963. A summary of range fertilization studies 1953-1963. Oregon Agric. Exp. Sta. Special Report 155, 6p.

Sneva, Forrest A., and D. N. Hyder. 1965. Yield, yield-trend, and response to nitrogen of introduced grasses on the Oregon high desert. Oregon Agric. Exp. Sta. Special Report 195, p18.