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# Fertilization of Wet Meadows

## ---A Progress Report

C. B. Rumburg

**Squaw Butte Experiment Station, Burns, Oregon**

Jointly operated and financed by the Agricultural Research Service, United States Department of Agriculture and the Agricultural Experiment Station, Oregon State University, Corvallis.

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## FOREWORD

Formal investigations into ways of improving the quantity and quality of hay produced on native meadows have been underway at the Squaw Butte Experiment Station since 1950. Fertilization studies have occupied a major portion of these investigations. Studies contained in this progress report are the results of several individuals who have been cited wherever possible. In particular, the author has drawn freely from earlier investigations conducted by C. S. Cooper, Agronomist (presently located at Bozeman, Montana).

Many individual experiments have been condensed to emphasize the more important concepts and considerations. Much of the detailed experimental data was lost in consolidation.

C. B. Rumburg, Agronomist

FERTILIZATION OF WET MEADOWS

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# I. DESCRIPTION OF THE AREA

## A. Location

The data reported in this paper were obtained from fertilization experiments conducted on native flood meadows in southeastern Oregon. Most of the experiments were located on the meadow unit of the Squaw Butte Experiment Station, 6 miles southeast of Burns, Oregon. These meadows (typical of many thousands of acres of native meadows in the western United States) are devoted almost exclusively to hay production which is used to provide roughage for wintering cattle.

## B. Native Vegetation and Soils

The soils are largely unclassified. They vary from clay loam to clay in texture, moderate to high in salinity, and moderate to high in alkalinity. The pH is usually 7.0-8.0. Organic matter in the surface 6 inches will average 5 percent.

The native vegetation that has developed under flood meadow conditions, i.e. annual fluctuations of excessive moisture and then drought, is dominated by rush (<u>Juncus</u> spp.) and sedge (<u>Carex</u> spp.). In areas not severely innundated there are water-tolerant grasses, clovers, and forbs in association with the rush and sedge.

## C. Climate and Flooding

All months have experienced temperatures below 32° F. The average frost-free period, based on 32° F. or below, is 72 days at Burns, but this period varies widely. Growing conditions in the spring are especially severe. Temperatures may reach a maximum in the high 60's or low 70's during the day and then drop below freezing during the night.

Flooding usually begins in early April and terminates in late June--a period of 8 to 12 weeks. The flooding period is determined by the amount of snow accumulated at higher elevations and the rate of spring run-off.

# II. HAY YIELD STUDIES WITH FERTILIZERS

## A. Response to Nitrogen

### 1. Procedure

The response of native meadows to nitrogen fertilizer has been studied over a period of 8 years at many different locations in southeastern Oregon. It is impossible to give a procedure applicable to all experiments; however, some methods were generally employed. The nitrogen was usually broadcast on the surface in the fall prior to the harvest year. Ammonium nitrate served as the source of nitrogen in all cases except where sources of nitrogen were being investigated. Nitrogen and phosphorus were generally applied alone and together to evaluate any possible interactions.

### 2. Results

Hay yields are quite variable from area to area, but in general 60 pounds of N per acre will increase hay yields by 3/4 ton per acre (Table 1). However, yields may continue to increase with increasing rates of application up to about 400 pounds of N per acre.

A study by Nelson and Castle (1958) indicated that the most economical rate was somewhere between 50 and 80 pounds of N per acre, depending on current prices. Within this range, yields of hay per pound of N vary from about 22 to 40, depending on the year.

Table 1. Hay yields in response to nitrogen at 21 locations[1/]

| Location | Pounds of N per acre: 0 | 60 | 120 |
|---|---|---|---|
| | T/A | T/A | T/A |
| 1 | 2.19 | 3.01 | 3.64 |
| 2 | 2.62 | 3.43 | 3.92 |
| 3 | 2.38 | 3.16 | 3.03 |
| 4 | 1.39 | 2.48 | 2.89 |
| 5 | 2.00 | 2.42 | 3.26 |
| 6 | 1.40 | 2.32 | 2.34 |
| 7 | 1.79 | 2.62 | 2.72 |
| 8 | .46 | 1.04 | 1.74 |
| 9 | 1.93 | 2.84 | 3.18 |
| 10 | 1.44 | 2.12 | 2.42 |
| 11 | 1.50 | 2.09 | 2.82 |
| 12 | 1.99 | 2.89 | 3.53 |
| 13 | .47 | .80 | .95 |
| 14 | .90 | 1.74 | 2.27 |
| 15 | 1.70 | 2.70 | 3.66 |
| 16 | 1.41 | 2.48 | 3.35 |
| 17 | 3.21 | 4.31 | 3.84 |
| 18 | 1.06 | 1.20 | 1.93 |
| 19 | .25 | .62 | .77 |
| 20 | 2.71 | 3.51 | 3.79 |
| 21 | 1.29 | 1.95 | 2.12 |
| Mean | 1.62 | 2.37 | 2.77 |

[1/] Each value is the average for 0 and 80 pounds of $P_2O_5$ per acre.

On this basis the cost of additional production resulting from fertilizer varies from approximately $8.00 to $14.00 per ton (assuming nitrogen costs 16 cents per pound of N applied).

Not all meadow sites respond equally well to nitrogen fertilization. Areas that flood to a depth greater than 4 to 6 inches are almost pure rush, and respond much less to applications of N. The Nevada bluegrass and rush-sedge-grass types appear to have the greatest potential to respond to N.

In the majority of the experiments there was not a N times P interaction. The response to N has been about the same at all rates of P including the zero rate. This is true even though the soils generally test quite low in available P.

The crude-protein content of the hay produced will not be affected by applications of N fertilizers if the hay is cut during the normal haying period from late June to August. Sometimes applications of N fertilizer actually result in a decrease in the crude-protein content of the hay due to a decrease in the amount of clovers present.

3. Literature cited

COOPER, Clee S. 1955. More mountain meadow hay with fertilizers. Station Bulletin 550, Oregon State University.

COOPER, Clee S. and W. A. Sawyer. 1955. Fertilization on mountain meadows in eastern Oregon. Jour. of Range Management 8(1):20-22.

## B. Source and Time of Nitrogen Application

### 1. Procedure

The data presented under this section are the results of 4 separate experiments conducted on the station near Burns, Oregon. In 2 of these experiments ammonium sulfate was compared with calcium nitrate; in the other 2 urea was compared with ammonium nitrate.

Time of application was studied in combination with source of N in one experiment.

### 2. Results

No single source of nitrogen has been found to be consistently superior. There was some variation among years and locations that favored one source under a particular environmental condition, but the differences have been small. The source of nitrogen should be based on the cost per pound of N.

Fall and spring applications of N were equally effective in increasing yields of hay. The choice, therefore, as to time of application would seem to be a matter of convenience. However, there is always a chance of abnormally low water for irrigation, and if fertilization is delayed until spring it is usually possible to predict the amount of irrigation water available and adjust the fertility program accordingly. In excessively dry years it might be desirable to withhold fertilizer entirely.

## 3. Literature cited

COOPER, Clee S. 1956. The effect of source, rate, and time of nitrogen application upon the yields, vegetative composition, and crude protein content of native flood-meadow hay in eastern Oregon. Agron. Jour. 48:543-545.

## C. Effect of Phosphorus Fertilization on Hay Yields

### 1. Procedure

Phosphorus fertilization experiments were conducted on rush-sedge-grass type meadows, which were flooded from early April until late June or early July. The vegetation consisted principally of rush (*Juncus* spp.) and sedge (*Carex* spp.) with small amounts of grass and native clovers. The growing season of these species is concurrent with the flooding season.

Treatments were applied in all possible combinations in randomized blocks. Yield samples were obtained by harvesting a strip of forage 38-inches wide through the length of each plot. Subsamples from the yield samples were used in determining oven dry matter, protein, calcium, and phosphorus content of hay.

Seedling establishment was measured by the percentage stocked method. A 10- by 4-inch steel frame, subdivided into ten 2- by 2-inch units, was used in obtaining data. Ten frames at random were taken per plot for a total of one-hundred 2- by 2-inch units. A unit was considered stocked or occupied when one or more seedlings were present.

### 2. Results

Seeding white-tip clover (*Trifolium variegatum*) with an application of phosphorus substantially increased yields of hay and crude protein. Clover seed may be scarified to increase the germinable seed content and decrease the amount of seed necessary to obtain stands. Seeding rates affect stand density but have little effect upon first year performance of clover. One pound of germinable seed per acre will insure a good stand of clover if phosphorus requirements are met.

Phosphorus fertilization influenced seedling establishment and was a limiting factor in the growth of plants once established.

Nitrogen did not increase seedling stand densities, but did decrease the clover composition.

Delayed cutting to allow for seed dissemination in 2 years provided enough hard seed to insure good stands of clover in each of the 3 following years. Thus, it would seem possible to follow a regular phosphorus fertilization program on clover areas and maintain a seed source by delaying the harvest date about once every 3 years to provide for seed dissemination.

In some years clovers in native meadows are much more prevalent than in other years. From observations during this study it would appear that density of clover stands were largely dependent upon early spring temperatures and flood conditions. The mortality of seedlings is high whenever they become completely submerged. On meadows where flooding depth is more than 2 inches, seedlings seldom attain enough growth prior to flooding to keep from being submerged. These areas should not be considered for clover establishment.

3. Literature cited

COOPER, Clee S. 1957. A legume for native flood meadows: I. Establishment and maintenance of stands of white-tip clover (*T. variegatum*) in native flood meadows and its effect upon yields, vegetative and chemical composition of hay. Agron. Jour. 49:473-477.

## D. Phosphorus Requirements for Maintaining Stands of White-tip Clover (*Trifolium variegatum*)

### 1. Procedure

White-tip clover density in the experimental area was increased prior to the initiation of the experiment by phosphorus fertilization (40 pounds of $P_2O_5$ per acre) in conjunction with delayed harvest to allow for seed dissemination in each of 2 years. It was believed that ample hard seed was present in the soil to insure clover stands during the course of the experiment.

Levels of $P_2O_5$ application were 0, 40, 80, 120, 160, 200, and 240 pounds per acre in 1955; 0, 40, 80, and 120 pounds per acre in 1956; and 0, 40, and 80 pounds per acre in 1957. Phosphorus was applied as treble superphosphate in the fall preceding each year listed, but will be referred to in the text as applied during the year in which measurement data were taken. Fertilizer was surface applied with a belt-type tractor-mounted spreader.

### 2. Results

Annual applications of 40 pounds of $P_2O_5$ per acre resulted in nearly maximum yields of mixed clover-rush-sedge hay. Residual phosphorus was adequate for plant growth only when 120 pounds of $P_2O_5$ per acre or more had been applied in the previous year (Table 2).

Phosphorus content of hay increased in proportion to the amount of $P_2O_5$ applied. Nearly maximum yields were obtained when the phosphorus content of hay was between 0.20 and 0.23%.

Table 2. Yields of hay in 1957 as affected by fertilizer treatments in 1955, 1956, and 1957[1]

| Pounds of $P_2O_5$ and year of application | | | Yields of hay in 1957 |
|---|---|---|---|
| 1955 | 1956 | 1957 | T/A |
| 0 | 0 | 0 | 1.7 |
| 0 | 40 | 0 | 1.7 |
| 40 | 0 | 0 | 1.8 |
| 240 | 0 | 0 | 2.0 |
| 0 | 0 | 40 | 2.0 |
| 0 | 80 | 0 | 2.5 |
| 0 | 120 | 0 | 2.6 |
| 0 | 0 | 80 | 2.6 |
| 40 | 40 | 40 | 2.6 |

[1]Table condensed from the original article.

A phosphorus content of this magnitude is realized with annual applications of 40 pounds of $P_2O_5$ per acre.

Phosphorus fertilization increased crude protein indirectly as a result of an increased proportion of clover in the hay. Differences in the proportions of clover in the hay were marked among years and were related to early spring temperatures and flood conditions. When possible, the beginning date of flooding should be delayed to permit clover seedlings to become well established. Flooding may be controlled in some areas during the early season when the runoff is light.

3. Literature cited

COOPER, Clee S. 1959. A legume for native flood meadows: II. Phosphorus fertilizer requirements for maintaining stand of white-tip clover (Trifolium variegatum). Agron. Jour. 51:350-352.

## E. Response of Wet Meadows to Major and Trace Elements

### 1. Procedure

The experimental design was a split-plot with main plots being a factorial placement of 0 and 120 lb. of $P_2O_5$/acre and 0 and 60 lb. of N/acre. Subplots were trace elements applied at the following rates: None, 50 lb. of copper sulfate, 100 lb. of mangenese sulfate, 100 lb. of zinc sulfate, and 50 lb. of borax per acre.

### 2. Results

Nitrogen and phosphorus significantly increased yields of hay. Sixty pounds of N increased yields by 0.80 ton and 120 pounds of $P_2O_5$ increased yields by 0.23 ton per acre.

Minor elements did not influence the yield of hay when applied alone or in combination with nitrogen and phosphorus.

# III. CHANGES IN BOTANICAL COMPOSITION THROUGH FERTILIZATION

## A. Effect of N, P, and Manure on Yield, Vegetative, and Chemical Composition of Native Meadow Hay

### 1. Procedure

A typical rush-sedge-grass meadow was selected in the fall of 1955. The treatments consisted of annual applications of 0, 200, 400, and 600 pounds of actual N per acre applied as ammonium nitrate; 0 and 240 pounds of $P_2O_5$ per acre as treble superphosphate; and 0 and 20 tons of manure per acre on a wet-weight basis. All treatments were surface applied to 6- by 20-foot plots.

Botanical composition was measured by harvesting a strip of forage 2 inches wide and 20 feet long from the edge of the mower swath in 2 replications. The samples were frozen and later separated by hand into individual species and species groups.

Nitrogen content of the hay was determined each year, and phosphorus content was determined in 2 years.

### 2. Results

Botanical composition--The fertilizer treatments affected both botanical composition and hay yields (Figure 1). The actual yields of grasses increased with increasing rates of N. At 400 and 600 pounds of N per acre hay yields were composed almost entirely of grasses. Meadow barley (*Hordeum brachyantherum* Nevski) and beardless wild-rye (*Elymus triticoides* Buckl.) made a greater response than other grasses investigated.

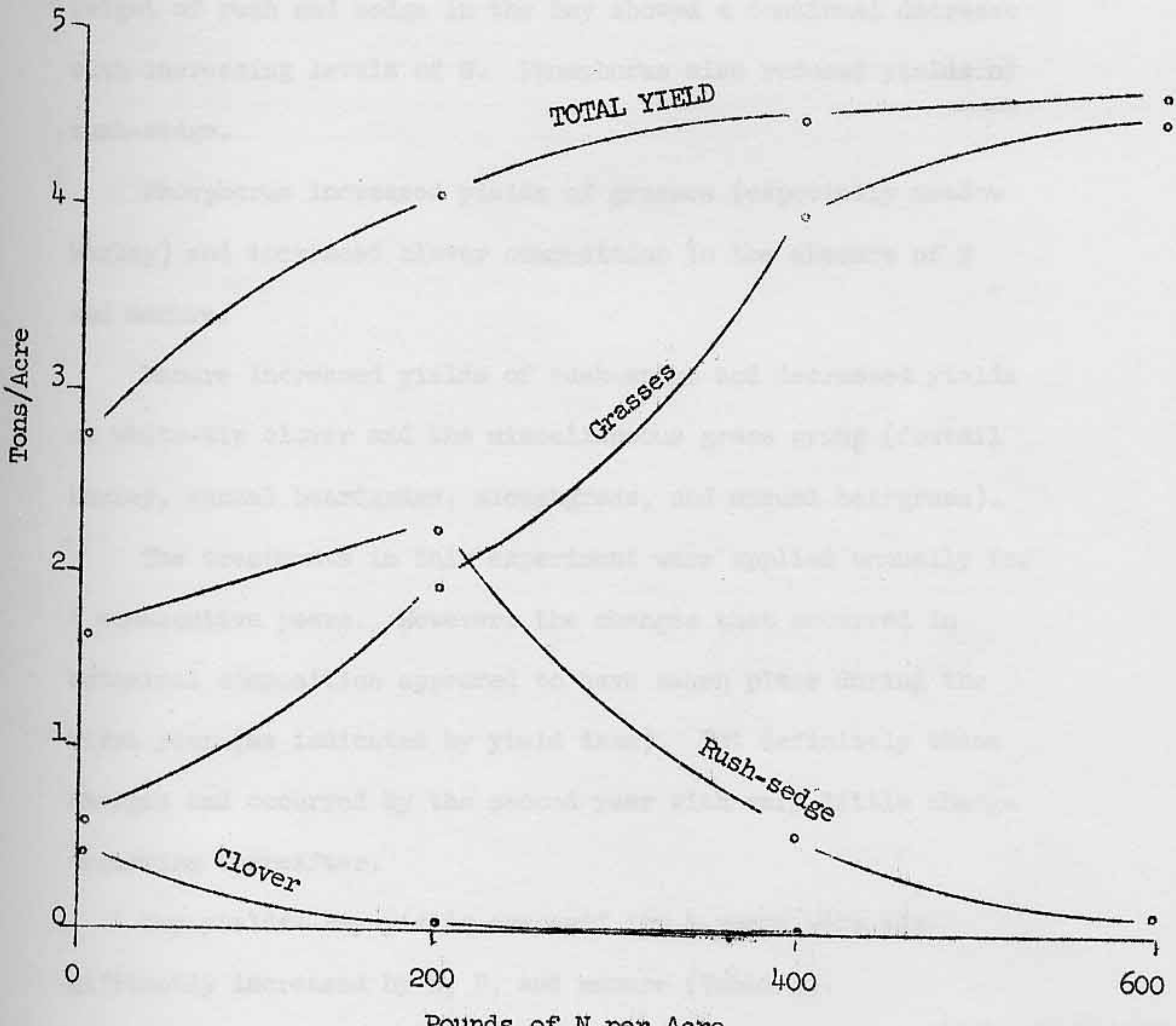


Figure 1. Yields of hay and its species composition in response to nitrogen averaged for phosphorus, manure, and years.

Nitrogen at 200 pounds per acre resulted in an increase in yields of rush and sedge, but at 400 and 600 pounds per acre greatly depressed them (Figure 1). The percent composition by weight of rush and sedge in the hay showed a continual decrease with increasing levels of N. Phosphorus also reduced yields of rush-sedge.

Phosphorus increased yields of grasses (especially meadow barley) and increased clover composition in the absence of N and manure.

Manure increased yields of rush-sedge and decreased yields of white-tip clover and the miscellaneous grass group (foxtail barley, annual beardgrass, sloughgrass, and annual hairgrass).

The treatments in this experiment were applied annually for 4 consecutive years. However, the changes that occurred in botanical composition appeared to have taken place during the first year (as indicated by yield data). But definitely these changes had occurred by the second year with very little change occurring thereafter.

Hay yields--Hay yields averaged for 4 years were significantly increased by N, P, and manure (Table 3).

Hay quality--Increasing levels of N did not result in an increase in crude protein. However, increasing rates of N decreased the phosphorus content of the forage. The P content was 0.31, 0.18, 0.17, and 0.16 at N levels of 0, 200, 400, and 600 pounds per acre, respectively. The P content of the forage was maintained with applications of either P or M.

Table 3. Effect of nitrogen, phosphorus, and manure on yields of meadow hay averaged for 4 years

| Manure and phosphorus treatments[1] | Pounds of N per acre | | | | |
|---|---|---|---|---|---|
| | 0 | 200 | 400 | 600 | Mean |
| | T/A | T/A | T/A | T/A | T/A |
| No manure: | | | | | |
| No $P_2O_5$ | 2.42 | 3.82 | 4.08 | 4.40 | 3.68 |
| 240 lb. $P_2O_5$/acre | 3.21 | 4.31 | 4.45 | 4.93 | 4.22 |
| 20 tons manure/acre: | | | | | |
| No $P_2O_5$ | 2.81 | 4.34 | 5.08 | 4.95 | 4.30 |
| 240 lb. $P_2O_5$ | 2.82 | 4.62 | 4.79 | 4.53 | 4.19 |
| Mean | 2.82 | 4.27 | 4.60 | 4.70 | |

[1] Main effects of manure and phosphorus significant at .01 level.

LSD for comparing nitrogen means (P.05) = 0.22
(P.01) = 0.29

These data show that the botanical composition and yields of native rush-sedge-grass meadows can be radically changed with high levels of fertilization. These changes probably take place during the first growing season after application of the fertilizer.

3. Literature cited

RUMBURG, C. B. and C. S. Cooper. 1961. Fertilizer-induced changes in botanical composition, yield, and quality of native meadow hay. Agron. Jour. 53:255-258.

# IV. PRODUCTION OF FORAGE AFTER HAYING

## A. Production of Fall Forage with Fertilizer and Supplemental Irrigation

### 1. Procedure

Native meadows do not usually produce any forage after haying. In many cases this is due to the lack of late season water, but regrowth is light even when water is available. The native species recover very slowly after being clipped and often go completely dormant.

Five experiments were conducted during the summers of 1959 and 1960 to study the effect of fertilizers and water on regrowth yields of native meadows. Water was applied to all experiments at a near-optimum rate (when 50% of the available moisture was removed) with sprinkler irrigation. The effects of combinations of N and P and dates of hay removal on regrowth yields were measured by harvesting the regrowth forage in September.

### 2. Results

Regrowth yields were increased with applications of N but not with P (Table 4). Similar experiments in 1960 yielded almost identical results. Efficiency values were 10.4, 8.8, 8.9, and 8.3 pounds of dry matter per pound of N applied at rates of application of 60, 120, 180, and 240 pounds per acre, respectively. Nine inches of water were applied during the growing season.

Table 4. Effect of fertilizers and supplemental irrigation on the regrowth yields of native flood meadow vegetation, 1960.

| Pounds of $P_2O_5$ per acre | Pounds of N per acre | | | | | |
|---|---|---|---|---|---|---|
| | 0 | 60 | 120 | 180 | 240 | Mean |
| 0 | 600 | 1420 | 1630 | 2120 | 2640 | 1680 |
| 60 | 630 | 1060 | 1700 | 2300 | 2510 | 1640 |
| Mean | 615 | 1240 | 1665 | 2210 | 2575 | |

LSD for nitrogen mean (P.05 ) = 280

Yields of regrowth were increased by early hay harvest (Table 5) without sacrificing yields of hay. Delaying the hay harvest from June 22 to July 12 did not result in any increase in hay yields, but decreased regrowth yields by 200 pounds per acre.

Fall applications of N to increase hay yields did not significantly increase regrowth yields after haying.

These experiments show that forage can be produced on native meadows after haying through the use of fertilizer and supplemental irrigation. However, it is doubtful if this practice, by itself, is economically sound. Using the highest efficiency values obtained, one could not expect to produce more than 10 pounds of forage per pound of N. Sixty pounds of N per acre would produce approximately 1,200 pounds of forage and cost $9.60 per acre (at 16 cents per pound of N). This forage would have to be valued at $16.00 per ton to pay for the nitrogen. Assuming a cost of $2.00 per acre inch of water, an additional expense of $18.00 per acre is encountered. To cover expenses for the 60 pounds of N per acre plus the 9 inches of water the forage would have to be valued at $46.00 per ton. However, it is possible that N applied in the summer to produce regrowth may increase hay yields the following summer. If this proves to be true, it may be economical to fertilize and irrigate native meadows after haying.

Table 5. Effect of nitrogen and date of hay harvest on regrowth yields of native meadows, 1960

| Date of hay harvest | Pounds of N per acre | | | | Mean |
|---|---|---|---|---|---|
| | 0 | 40 | 80 | 120 | |
| June 22 | 568 | 884 | 1430 | 1550 | 1108 |
| June 28 | 430 | 911 | 1480 | 1430 | 1063 |
| July 5 | 396 | 842 | 980 | 1260 | 870 |
| July 12 | 413 | 791 | 1030 | 1360 | 898 |
| Mean | 452 | 857 | 1230 | 1400 | |

# V. EFFECT OF FERTILIZERS ON QUALITY OF NATIVE MEADOW HAY

## A. Response of Beef Cattle to P Fertilized Hay

### 1. Procedure

The hays used in the study were grown on a typical rush-sedge-grass meadow.

The fertilized hay received a surface application of 40 pounds of $P_2O_5$ per acre during the fall of 1955 and 1956. The increase in crude protein and some mineral elements (Table 6) as a result of fertilization was due to an increased content of annual white-tip clover (*Trifolium variegatum* Nutt.).

Fertilized hay harvested in 1957 was fed for the first 94 days of the study and hay harvested in 1956 was fed for the last 38 days. All animals received 2 pounds of barley per day.

Forty Hereford weaner steer calves were used to study the influence of phosphorus fertilization on the nutritive value of flood meadow hays when fed as the main source of nutrients in the wintering ration of beef calves with and without cottonseed meal supplementation. Four lots of 10 steers each were fed for a 132-day period extending from December 6, 1957 to April 18, 1958. Rations were as follows:

Lot 1 - Unfertilized flood meadow hay *ad libitum*.

Lot 2 - Unfertilized hay plus one pound of cottonseed meal.

Lot 3 - Phosphorus fertilized flood meadow hay *ad libitum*.

Lot 4 - Phosphorus fertilized hay plus one pound of cottonseed meal.

Table 6. Summary of crude protein, calcium, and phosphorus content of feeds

| Feed | Crude protein | Calcium | Phosphorus |
|---|---|---|---|
| | % | % | % |
| 1957 Unfertilized hay | 7.61 | 0.40 | 0.11 |
| 1957 P fertilized hay | 9.34 | 0.63 | 0.20 |
| 1956 P fertilized hay | 8.54 | 0.57 | 0.17 |
| 1957 Barley | 12.45 | 0.07 | 0.39 |
| 1957 Cottonseed meal | 40.42 | 0.10 | 1.34 |

## 2. Results

Both phosphorus fertilized hay and cottonseed meal supplementation resulted in significant increases in average daily gain. An increase in average daily gain of approximately 0.25 pound resulted from both treatments (Table 7). There was no interaction between the fertilization and supplementation treatments.

The amount of hay consumed did not differ due to any of the experimental treatments (Table 7). It required 11.6 pounds of total feed for 1 pound of body weight gain in the case of the fertilized hay as compared to 15.4 pounds for the unfertilized hay.

## 3. Literature cited

HUBBERT, Farris, Jr., R. R. Wheeler, C. S. Cooper, and W. A. Sawyer. 1958. The response of beef cattle to phosphorus fertilized and unfertilized flood meadow hay with *in vitro* observations on factors influencing rumen microorganism activity. Western Section Proceedings Amer. Soc. of Animal Prod.

Table 7. Summary of body weights, average daily gains, feed intakes, and feed cost data for the 132-day feeding period

| | Treatment | | | |
|---|---|---|---|---|
| | Unfertilized hay | | Phosphorus fertilized hay | |
| | No Cottonseed meal | Cottonseed meal | No Cottonseed meal | Cottonseed meal |
| Lot number | 1 | 2 | 3 | 4 |
| No. steers | 10 | 10 | 10 | 9[1] |
| Initial weight (lb.) | 409 | 403 | 399 | 404 |
| Final weight (lb.) | 520 | 551 | 543 | 595 |
| Avg. daily gain (lb.) | 0.84 | 1.12 | 1.09 | 1.45 |
| Avg. daily hay consumed (lb.) | 10.9 | 10.7 | 10.6 | 10.7 |
| Avg. daily barley consumed (lb.) | 2.0 | 2.0 | 2.0 | 2.0 |
| Avg. daily cottonseed meal (lb.) | --- | 1.0 | --- | 1.0 |
| Avg. daily bonemeal (lb.) | 0.021 | 0.012 | 0.012 | 0.010 |
| Avg. total feed consumed (lb.) | 12.9 | 13.7 | 12.6 | 13.7 |
| Feed per lb. gain (lb.) | 15.4 | 12.2 | 11.6 | 9.4 |
| Feed cost per lb. gain[2] | $ .202 | $ .180 | $ .152 | $ .139 |

1/ One calf was removed in early December because of pneumonia.

2/ Unfertilized and fertilized hays valued at $20 per ton.
Barley " " $60 per ton.
Cottonseed " " $70 per ton.

## B. Fertilization of Meadows for Use as Summer Pasture

### 1. Procedure

A native meadow area was fenced into 4 pastures of 1 acre each, and 4 pastures of 2 acres each. The 1-acre pastures were fertilized with 80 pounds of N per acre while the 2-acre pastures were not fertilized.

Fertilized pastures were stocked at the rate of 2 yearling steers per acre and unfertilized pastures at the rate of 1 yearling steer per acre.

The grazing season began on May 7 when adequate forage became available. Except for one replication of the fertilized pasture, steers grazed the flood meadow pastures until July 19, at which time the remaining forage was mowed and rake-bunched. With the exception of the last week of this period, the meadows were continuously flooded. Steers on replication B of the fertilized pasture had to be removed from this pasture on June 27 due to a scarcity of forage. They were put back into the pasture on July 11 where they grazed until July 17. There was no mowable forage remaining on the fertilized pastures by July 17 and grazing was terminated. Steers on unfertilized pastures grazed bunched hay until September 17, at which time most of the bunched hay was consumed.

### 2. Results

Average daily gains for the 73-day grazing period, May 7 to July 19, were 1.80 and 1.94 lb. for steers on fertilized and unfertilized pastures, respectively. These values were not significantly different. Steers grazing unfertilized pastures had an average daily gain of 1.63 lb. from July 19 to September 17, and 1.80 lb. for the period May 4 to September 17.

Total gains per acre for the fertilized and unfertilized pastures were 250 and 239 lb., respectively, for the grazing period for each pasture group. It should be emphasized, however, that the grazing period for steers on fertilized pastures was 73 days from May 7 to July 19, and for steers on unfertilized pastures the grazing period was 115 days from May 7 to September 17.

Average crude protein content of fertilized pasture herbage was 3.68 percent greater on May 4 and 1.1 percent greater in June than unfertilized pasture herbage. The crude protein content of herbage may serve to explain the rather poor results of nitrogen on a pasture basis as compared to those obtained with hay yields. On the basis of previous fertilizer work, 80 lb. of N per acre could be expected to double the yield of herbage. The higher crude protein value of fertilized herbage indicates that much of the nitrogen was taken up early by the plants and utilized by the grazing animals rather than by the plant. Therefore, it was not available to the plant for growth to the same degree that occurs with nitrogen fertilization for hay production. The increased protein content of fertilized herbage, however, was not reflected in increased gains of the grazing animals.

## C. Effect of Nitrogen Fertilizer and Date of Cutting on Crude-Protein Content and In Vitro Cellulose Digestion of Native Meadow Forage

### 1. Procedure

Rates of nitrogen of 0, 80, 160, 240, 320, and 400 pounds of N per acre were applied to strips 3 feet wide and 80 feet long in the early spring. Sub-plots were harvested in strips across fertility rates at approximately 2-week intervals beginning on May 4 and ending July 13.

All samples (up to 320 lb. N/acre) were analyzed for cellulose. *In vitro* cellulose digestion was determined over a 48-hour digestion period (Hubbert, 1958).

### 2. Results

Nitrogen fertilization increased the crude-protein content in the forage early in the season, but had no effect on the crude-protein content with advanced maturity. The uptake of N ceased about June 6, but dry matter continued to increase until about July 13. The increase in dry matter was roughly proportional to the amount of nitrogen fertilizer applied. The cessation of N uptake with continued dry matter production resulted, by June 15, in a forage of approximately the same crude-protein content among all rates of nitrogen fertilization.

In vitro cellulose digestion in native meadow hay increased when the date of harvest was delayed from May 4 until May 18, and then declined with each later date of harvest.

Cellulose digestion was lower in forage produced with 240 and 320 pounds of N per acre than in forage produced with 0, 80, and 160 lb. of N per acre. The decline in cellulose digestion with advanced maturity of the forage was probably associated with increased lignification, but the reasons for the decline in cellulose digestion at 240 and 320 lb. of N per acre are not clear.

The cellulose content of native meadow hay increased and crude protein decreased with increasing dates of harvest.

3. Literature cited

HUBBERT, Farris, Jr., R. R. Wheeler, C. S. Cooper, and W. A. Sawyer. 1958. The response of beef cattle to phosphorus fertilized and unfertilized flood meadow hay with in vitro observations on factors influencing rumen micro-organism activity. Proc. West. Sec. Amer. Soc. Anim. Prod.

WALLACE, Joe D., C. B. Rumburg, and R. J. Raleigh. 1961. Evaluation of range and meadow forages at various stages of maturity and levels of nitrogen fertilization. Proc. West. Sec. Amer. Soc. Anim. Prod.