Revegetation of a High-Altitude, Barren Slope In Northern Idaho[1]

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A problem of erosion exists on high-altitude slopes near the Seven-Devils Mountains, about 17 miles west of Riggins, Idaho. The area, probably never suited to livestock grazing, had lost its vegetation cover, primarily as a result of grazing and early-spring trampling. In 1957 the Agricultural Research Service at Pullman, Washington, set up a study aimed at finding means to revegetate and stabilize these erosive slopes.

Description of Site

The problem area was approximately at the 7,000-foot elevation, with an east, southeast exposure, and a slope that varied from 10 to 65 percent. The medium-textured soil matrix was composed of decomposed granite material. Incorporated in the soil matrix and composing approximately 30 percent of the soil volume was a mixture of small granite pebbles. Even slight disturbance caused considerable soil movement down the steeper parts of the slope. The area was fenced and had been partially protected from grazing for more than 10 years. However, since the area was inaccessible to wheeled vehicles until approximately July 1 each year livestock generally reached the site in spring before the fence was repaired.

Chemical analysis of the soil indicated a pH of approximately 4.5 and a deficiency of calcium and potassium. The phosphorus content appeared to be satisfactory for grass growth. Soil organic matter exceeded 8 percent.

Vegetation on contiguous areas with similar soil and slope consisted primarily of needlegrass (*Stipa columbiana* Macoun.), spike trisetum (*Trisetum spicatum* (L.) Richt.), tufted hairgrass (*Deschampsia caespitosa* (L.) Beauv.), sedge (*Carex geyeri* Boott), lupine (*Lupinus* spp.), and wild buckwheat (*Eriogonum* sp.). This apparently stable vegetation complex formed an excellent cover and had stabilized the soil upon which it was growing.

Review of Literature

Only in recent years has there been any significant amount of research effort expended in attempting to find ways and means of revegetation and stabilizing high altitude, depleted sites. Hull, *et al.* (1962), reporting on studies underway since 1957 in six western states, found little reason to be optimistic about expected results. In general, mulches increased seedling establishment; fertilizers did not. A seedbed from which competing vegetation was eliminated was considered essential. Conclusions were that by following some general suggestions, "grass should be successfully established on most depleted sites except in seasons when precipitation is clearly below average."

Various combinations of wood chip mulches and fertilizers were used by Klomp (1960) in a study devised to revegetate scab ridges in eastern Oregon. He concluded

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that wood chip mulches were beneficial in promoting grass establishment, but that treatment differences decreased with increased age of the grass sand.

The use of various mulches for increasing plant emergence and establishment was reviewed by Bement, *et al.* (1961) in their paper dealing with the use of asphalt-emulsion mulches to hasten grass-seedling establishment. On the Central Plains Experimental Range, emergence and development of bluegrama plants were increased by asphalt-emulsion mulch. Bement, *et al.* further reported that soil moisture was maintained longer and soil temperatures were higher at the 1-inch depth under the asphalt-emulsion than in the check.

Field Studies, 1957-58

The study initiated in September 1957 consisted of five mulching treatments: one half inch of sawdust, one inch of sawdust, soil surface 100 percent covered by conifer boughs, soil surface 50 percent covered by conifer boughs, and none (check). The mulch treatments were crossed by five fertilizer treatments as follows: 40 pounds nitrogen per acre (N40), 40 pounds nitrogen plus 40 pounds phosphorus per acre (N40P40), 20 pounds nitrogen per acre (N20), 20 pounds nitrogen plus 20 pounds phosphorus per acre (N20P20), and none (check). Individual plots were 5 x 20 feet (and a mulch treatment across all fertilizer treatments 20 x 25 feet). Mulch treatments were applied up and down the slope and the fertilizers across the slope. The study, laid out as a split plot, was replicated four times. Replication one was on a 5-10 percent slope, two on a 10-15 percent slope, three on a 25-35 percent slope, and four on a 40-65 percent slope.

After the plots were staked but before application of mulch or fertilizer, each area was broadcast seeded to a grass mixture at the rate of approximately 25 pounds of seed per acre. The seed mixture consisted of equal portions of orchardgrass (*Dactylis glomerata* L.), Primar slender wheatgrass (*Agropyron trachycaulum* (Link) Malte), mountain brome (*Bromus marginatus* Nees), smooth brome (*Bromus inermis* Leyss), timothy (*Phleum pratense* L.), and Idaho fescue (*Festuca idahoensis* Elmer).

Fertilizers were applied broadcast following seeding. Mulch treatments were then applied over the seeding and fertilizer treatments.

On July 2, 1958, stand counts were made on all plots to determine seedling emergence. Counts were made by random placing of a 6 x 36 inch frame six times in each plot. Thus, 9 square feet composed the sample in each plot. Observation of all plots were continued during the summer and fall of 1958.

Seedling counts in July 1958 indicated significant variation in seedling establishment as a result of the various mulch treatments (Table 1). Average number of seedlings per square foot varied from a high of 34 for the 100 percent bough cover to a low of 12 for the check (Table 2). Average number of seedlings per square foot for the one half inch of sawdust, one inch of sawdust, and 50 percent bough cover were 19, 18, and 28 respectively (Table 2).

Initial seedling establishment was also influenced by fertilizer treatment (Table 1). The average number of grass seedlings per square foot varied from a low of 19 for the check to a high of 26 for the N20P20 (Table 2). Nitrogen alone had relatively little effect on initial establishment. Fertilizer treatments that included P resulted in consistently better stands than N alone.

These data indicate that the 100 percent bough mulch treatment coupled with fertilizer that contained both N and P resulted in excellent seedling establishment. Despite the significant differences for seedling establishment shown between treatments, differences appeared less distinct as the season advanced. Summer drought resulted in high seedling mortality. Final observations on the plots in October 1958 indicated no differences between treatments, and most seedlings were dead. Observations in July 1959 revealed only an occasional grass plant. Despite the excellent initial establishment, nearly all seedlings had succumbed to the rigorous environment.

Field Studies, 1959-60

By late summer of 1959 it was obvious that all treatments applied on the original field experiment were failures. Consequently on September 22 a study was started to determine the value of a native hay mulch containing viable native grass seed, for stabilizing the soil and establishing stands of grass.

In the summer of 1959 an excellent crop of native grass was

Table 1. Analysis of variance for grass seedling emergence based on seedlings per square foot July 1958.

Source of Variation	Degree of freedom	Mean squares
Total	99	3,373**
Treatment-mulch (tm)	4	1,978*
Replications (R)	3	459
R x tm (Error A)	12	482**
Treatment-fertilizer (tf)	4	11,311**
Tm x tf	16	79
Tm x tf x R (Error B)	60	

*Indicates significance at the 0.05 level.
**Indicates significance at the 0.01 level.

Table 2. Average number of grass seedlings emerged per square foot as a result of five mulch and five fertilizer treatments.[1]

Fertilizer treatment	½ inch sawdust mulch	1 inch sawdust mulch	100 percent bough cover	50 percent bough cover	No mulch (check)	Av.
None (check)	16	14	28	27	9	19
N40	17	11	41	17	10	19
N40P40	20	24	35	32	14	25
N20	16	24	30	29	12	22
N20P20	24	18	38	33	17	26
Average	19	18	34	28	12	22

[1]Average based on four replications.

produced on the area within the large enclosure surrounding the experimental plots. In late August this native grass containing mature seed was mowed, dried, and stored for use intact. Care was taken to retain as much of the seed as possible.

Since the amount of native grass hay mulch harvested was small, this part of the study was limited to only the area occupied by replication one of the original study. The remains of the bough mulches were removed from both the old 50-and 100-percent bough cover plots. Lime was broadcast over the entire study area at the rate of one ton per acre. The original fertilizer treatments as previously described were repeated. As an added precaution the area was also seeded to the same grass mixture as before. A hay mulch was then carefully spread over the plots which had originally been covered 100 percent with boughs and on those with one half inch of sawdust. By this time there was no visible trace of sawdust on the plot. The boughs were then replaced over the hay mulch on the bough plot to prevent the hay mulch from blowing and to provide additional cover. Chicken wire was then stretched over the remaining hay mulch plot and staked down to stabilize the mulch.

Seedling counts in the spring of 1960 indicated that the native hay mulch held in place by chicken wire resulted in good seedling establishment as compared with native hay mulch plus boughs and no-mulch. Average number of seedlings per square foot were 25, 10, and two native hay plus boughs and check respectively. Seedling counts respectively. Seedling counts repeated in September 1960 indicated that there had been a high seedling mortality under all treatments. Number of seedlings per square foot for native hay plus chicken wire, native hay plus boughs, and check had been reduced to three, two and one respectively.

A close inspection of the seedlings on the plots indicated they were primarily native grasses, presumable from seed in the native hay mulch. These plants appeared to be well established and thriving. Only an occasional seedling of the introduced orchardgrass and timothy were found. In addition, plants indigenous to surrounding areas were becoming established on the mulched plots. These plots included sedge, lupine, and buckwheat. Observations continued in the summer of 1961 indicate that grasses were becoming stabilized in both of the native hay-mulched plots.

Additional plots were established contiguous to the hay mulch plots in July 1960 to test the effects of an asphalt-emulsion mulch placed over seeded rows of various grasses. Four 25-foot rows, each of timothy, orchardgrass, mountain brome, and pubescent wheatgrass (*Agropyron trichophorum* (Link) Richt.) were seeded with a one-row hand seeder. Two of the four rows of each species were covered by a band approximately eight inches wide of asphalt-water emulsion. The emulsion was applied using a back-pack Indian pump. In September, counts were made by randomly selecting six feet of each row to determine the value of the mulch in seedling establishment.

Seedling counts in September 1960 indicated that asphalt-emulsion mulch was much superior to no mulch for grass seedling establishment. The asphalt-emulsion mulch resulted in better seedling survival of all species during the summer, but in July 1961 although the asphalt was still visible and appeared to be giving some soil stability, all seedlings were dead. The asphalt-emulsion used by itself did not appear to be a satisfactory mulch for getting seedlings established on the sites under study.

These data indicate that steep, erosive sites like those described in this paper can be stabilized by proper use of mulches. They also seem to indicate the superiority of the indigenous grass for becoming established on the sites. When protected from excessive grazing, the native species appear to be much better adapted to the environmental extremes of the site and become established where exotic species fail.

Table 3. Average numbers of plants from 50 seeds of five grass species in the greenhouse on soil from the Seven-Devils experimental area.[1]

Soil treatment	Mountain brome	Slender wheatgrass	Timothy	Smooth brome	Orchard grass	Av.
Screened	12	41	24	37	42	31
Unscreened	12	38	22	38	44	31
Average	12	40	23	38	43	31

[1]Average based on four replications of 50 seeds each.

There appears to be a real need to select native species adapted to extreme environmental sites and developing and increasing seed stocks. The increased pressure now being put on some of the high-altitude lands for recreation and other activities would permit expenditure in excess of that which could be justified for forage alone.

Table 4. Average[1] number of plants and grams of forage produced[2] from 50 planted seeds of five grasses seeded in the greenhouse in soil from the Seven-Devils experimental area, limed and fertilized.

Fertilizer treatment	Lime (1 ton/A)		No lime	
	Number	Grams	Number	Grams
N50	31	1.0	22	0.4
N50P50	20	0.8	20	0.7
N50P50K50	23	0.7	20	0.7
Check	37	0.7	37	0.4
Average	28	0.8	25	0.6

[1]Average based on four replications of 50 seeds each for five grasses.
[2]Plants clipped at ground level six weeks after seeding.

1958-59 Greenhouse Studies

In the fall of 1958, enough soil was collected from the experimental area to be used for greenhouse studies during the forthcoming winter. Greenhouse studies were then begun to determine whether the soil was a limiting factor in establishing grass.

The soil was divided into two separates. One separate was passed through one half inch mesh screen to remove the larger rocks. The screened and unscreened separates were then each divided and placed in four greenhouse flats. Each flat was considered a replication.

Two ten-inch rows of 25 seeds each of slender wheatgrass, smooth bromegrass, mountain bromegrass, timothy, and orchardgrass were randomly seeded in each flat. Seedlings were counted of all grasses as they emerged and again six weeks after planting.

All grasses were harvested six weeks after seeding by clipping at the soil level. Material from the two rows of each species in each replication was placed in a separate bag, oven-dried, and weighed.

Plant responses to lime and fertilizer were also studied. Ground limestone at the rate of one ton per acre was added to the soil in four flats; four had no limestone. In addition, one flat each of the limed and unlimed soil received the following treatments: nitrogen fertilizer at the rate of 50 pounds of nitrogen per acre (N50); 50 pounds of nitrogen plus 50 pounds of available P_2O_5 plus 50 pounds water soluble potassium per acre (N50-P50K50) and no fertilizer. Grasses were seeded in these flats as previously described. Seedling counts following emergence and production six weeks following seeding were also determined as previously described.

The average number of plants of all species, established from 50 seeds, was the same for both screened and unscreened soil. However, there was a wide variation among species (Table 3). Average numbers of plants per 50 seeds were 12, 23, 38, 40, and 43 for mountain brome, timothy, smooth brome, slender wheatgrass, and orchardgrass, respectively. Average forage production per 50 seeds planted followed similar trends as number of plants. Six weeks after seeding, average oven-dry forage production per 50 planted seeds varied from a high of 2.22 grams for orchardgrass to a low of 0.35 gram for mountain brome.

These data show that despite rockiness and relatively low pH, these soils will support stands of forage grasses in the greenhouse.

Little difference was apparent in the average number of seedlings established from 50 seeds in soils in the limed and unlimed flats (Table 4). Insofar as average number of plants per 50 planted seed was concerned, no benefit was derived from any fertilizer treatment. However, there was some increase in the amount of herbage produced as a result of both liming and fertilizer treatments (Table 4). Fertilizer treatments N50, N50P50, N50P50K50, and check produced 1.0, 0.8, 0.7, and 0.7 grams of herbage respectively in limed flats. In unlimed flats, yields were 0.4, 0.7, 0.7, and 0.4 grams for N50, N50P50, N50P50K50, and and check respectively. These data indicate that, while neither fertilizers nor lime increased the number of seedlings, average herbage production was increased as a result of their application.

Summary and Conclusions

The effects of several mulch and fertilizer treatments on emergence and establishment of grasses on high-altitude, harsh-environment sites were studied in northern Idaho. Mulch treatment included two rates of sawdust, two rates of evergreen boughs, native hay, and asphalt emulsion. Fertilizer treatments included lime and various rates of nitrogen, phosphorus, and potassium. Several grasses not indigenous to the area were seeded with the various mulch and fertilizer treatments.

Except for native hay, all mulch treatments were considered failures. Native hay mulch held in place by chicken wire and boughs resulted in good grass establishment. Field application of fertilizer did little to increase grass emergence and had no effect on seedling survival. Fertilizer studies in the greenhouse with soil from the experimental area indicated no increase in number of seedlings as a result of fertilizer or lime. Fertilizer and lime both increased the amount of herbage produced.

The following conclusions were drawn from these studies:

1. Mulch treatments do increase seedling emergence of seeded grasses.

2. Owing to extremely harsh environment, seedling mortality is high.

3. Non-indigenous grasses do not appear to be adapted to the experimental sites.

4. Indigenous grasses established as a result of native hay mulch appear to be adapted to the sites.

5. Grass breeding and selection of native grasses for extreme environments is definitely needed.

6. Stabilization and revegetation on sites included in this study will be costly and of long duration.

7. Owing to the critical nature of the sites, high costs of revegetation, in excess of that which could be justified for herbage alone, can be justified.

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