CASPAR CREEK EROSION STUDY

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In the North Coast region of California, there are many streams which are used by anadromous fish for spawning grounds; therefore, siltation caused by logging activity and road construction near streams can affect stream ecology, water quality, and water quantity. Finding a method of protecting suitable gravel for spawning and minimizing erosion and resultant siltation due to logging is a problem facing every timber operator and timberland owner.

A study and demonstration of road spoil erosion control was initiated on Jackson State Forest in October 1964. The purpose of this study was to find an efficient and practical method of controlling erosion on road spoil and fills. The problem was to find a minimum cost approach that anyone engaged in timber harvesting can use with the equipment and manpower normally employed. Natural revegetation of fresh spoil with native forbs, grasses, and herbaceous plants, in the study area, requires a period of four to five years to become established. Since this is too long a duration to expose the site to all the erosion factors, protection should be provided to prevent excessive erosion.

The study area selected was in the Caspar Creek watershed which has a redwood (*Sequoia sempervirens*) and Douglas-fir (*Psuedotsuga menziesii*) association[2/] as vegetative cover. The study was divided into two phases: (1) a grass plot trial to determine which type of vegetation and fertilizer combination would be best for the area, and (2) an erosion study that would use the

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2/ Also found as minor conifers in the timber type are grand fir (*Abies grandis*), western hemlock (*Tsuga heterophylla*) and bishop pine (*Pinus muricata*).

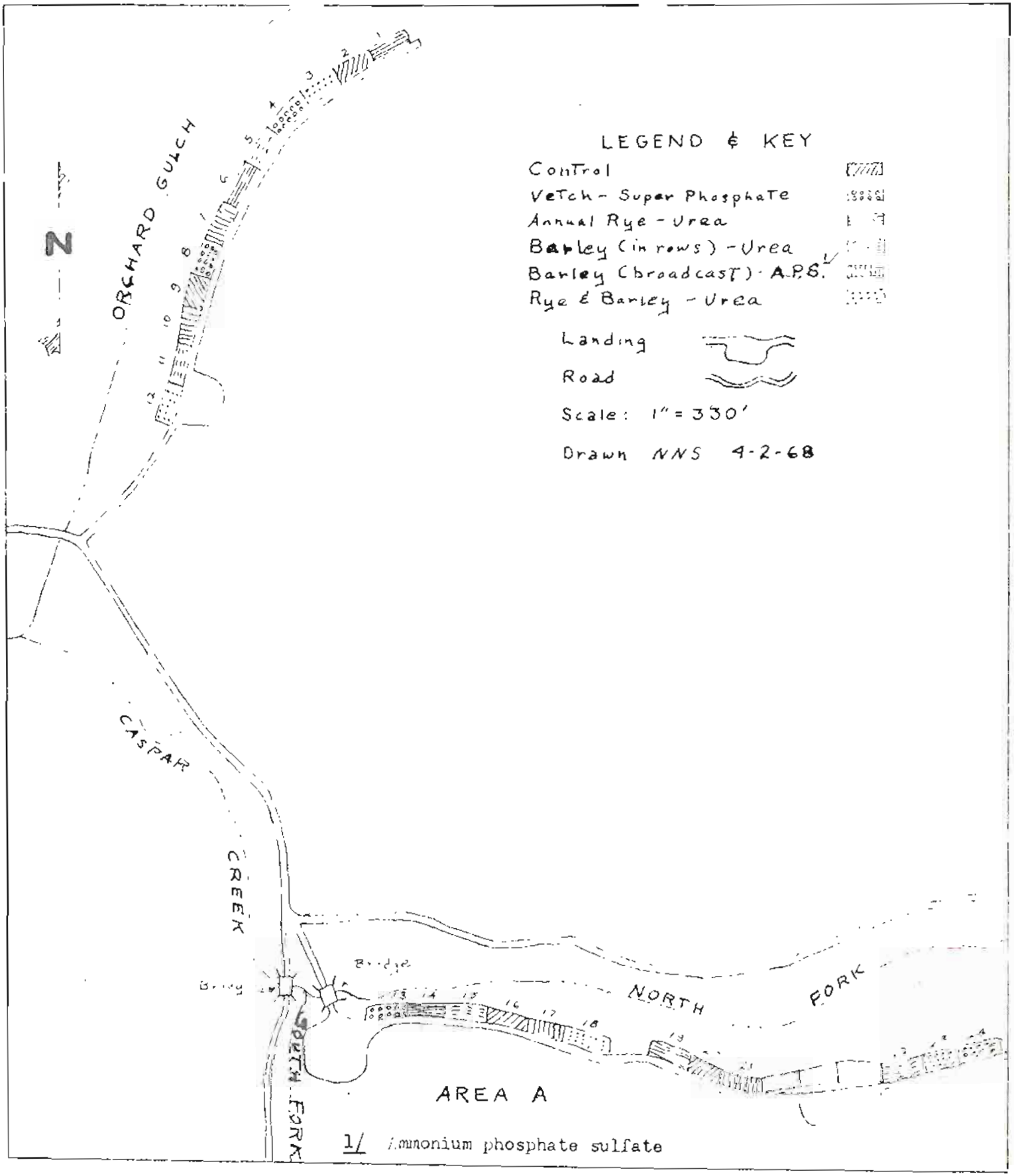

Fig. 1. Seed - fertilizer trial plot location in Caspar Creek erosion study.

Most successful grass-fertilizer combination to treat a large area of road spoil.

SEED AND FERTILIZER TRIALS

The seed and fertilizer trial plots were established in two separate locations, Area A and Orchard Gulch. Each location had 12 plots one chain in length with the width being determined by the road fill width (fig. 1). The plots were selected randomly for four replications of six different treatments. The six treatments used were as follows:

1. Control - undisturbed road fill.
2. Lana Vetch (50 lbs/acre) and Super Phosphate (0-20-0) at 200 lbs/acre.
3. Annual Rye (100 lbs/acre) and Urea (45-0-0) at 100 lbs/acre.
4. Barley, in rows (150 lbs/acre) and Urea (45-0-0) at 100 lbs/acre.
5. Barley, broadcast, (150 lbs/acre) and Ammonium Phosphate Sulfate (16-20-0) at 100 lbs/acre.
6. Annual Rye (50 lbs/acre) and Barley (50 lbs/acre) and Urea (45-0-0) at 100 lbs/acre.

Treatments one, two, and three were applied to the plots October 27, 1964. Treatments four, five, and six were applied to the plots January 15, 1965. Observations were periodically taken during the first year after the plots were established. Table 1 is a record of the plot observations which were made of five individual plot conditions.

Several methods can be used in sowing seed and spreading fertilizer but the method used depends on the equipment that is readily available. In this study the hand operated "cyclone seeder" was used because it was thought to be the most practical on an area this size. The description of each treatment and a summarization of the observation results follows.

1. Control.

Four plots were randomly selected as control areas with no attempt made to change surface conditions of the plots after road construction (fig. 2). All the plots observed revealed that five percent or

Fig. 2. Plot 9, control established in Orchard Gulch showing an example of the road spoil.

less of the total area was covered by native vegetation, mostly red alder (Alnas rubra) seedlings, with silt and gully erosion quite pronounced. There was evidence in some areas that small slides and dropouts had occurred. Also it was indicated that a certain amount of silt had reached the live stream below the toe of the fill. The amount of silt reaching the stream appeared to be somewhat reduced on those areas where slash cover was directly below the side cast.

2. Lana Vetch - Super Phosphate.

The only variation found between plots was exposure and aspect.

Area A had a north aspect and Orchard Gulch had a westerly aspect. One problem became apparent during seeding and this was that since the vetch seed was large and round in shape, it had the tendency to roll off the fill slopes during the seed application. This treatment had good results on the two plots in Orchard Gulch but did not do well at all on the two similar plots in Area A. This may be attributed to the difference in aspects. The vetch on all plots had a high rate of germination within one week after seeding, but failed to put on satisfactory growth. Four months after seeding, the vetch averaged two inches in height, appeared very sparse in most areas, and had started to die out. From all evidence, deer cropping was responsible for the short vetch height. In area A the few remaining plants were green and flowering as late as August 18, but very sparse with 15 percent or less of the area covered. The trailing stems on individual plants measured 18 to 96 inches in length. Sheet erosion measured one to one and one-half inches with some rill or gullying evident up to four inches deep.
The two plots in the Orchard Gulch supported a fairly dense cover of vetch in a mature mat at the August 18 observational check (fig. 3), and the erosion did not appear as advanced on these plots as it did in Area A.

3. Annual Rye - Urea.

Two and a half months after seeding, the rye grass on the plots averaged six to eleven inches high and formed a dense ground cover. At maturity the annual rye measured 24 to 36 inches high and density was 85 to 95 percent of the plot areas (fig. 4). Sheet erosion to a depth of one half inch was found on the exposed surfaces that had

Fig. 3. Plot 8, Lana Vetch as it looked in Sept. 1965 in Orchard Gulch.

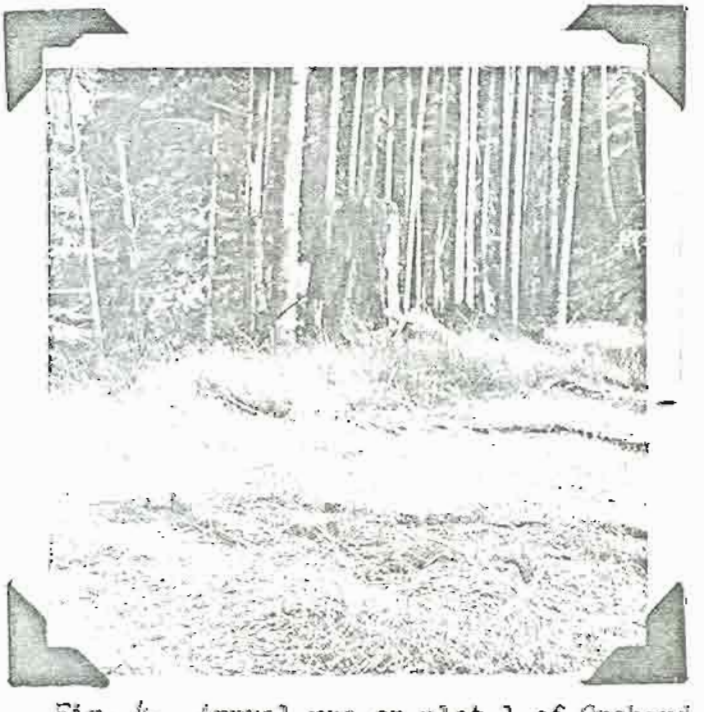

Fig. 4. Annual rye on plot 1 of Orchard Gulch showing the thatch-like mat that had developed by Sept. 1965.

a sparse grass cover; however, only slight rill erosion was evident. The annual rye grass on unfertilized areas outside the plots was only two inches high at two and a half months, very sparse, and formed no continuous ground cover. At maturity, the average height measured about six to eight inches, was still very sparse, and had some evidence of moderate erosion.

4. Barley (in rows) - Urea.

Germination and initial growth was very rapid and six weeks after planting, the barley was four to six inches high. The mature plants (fig. 5) measured 20 to 30 inches high and were very dense in the rows. Washing across the rows downslope was quite apparent on the steeper plots and there was also an indication of erosion between the rows.

Fig. 5. Barley, in rows, Sept. 1965. The soil between the rows had little protection.

The erosion between the rows was greater than expected and it was

determined that barley planted in this manner has only a minimum degree of soil holding ability. Excessive time and labor was required for the seeding, since approximately one man day is required to row plant 200 feet of road spoil having an average width of 30 feet. In addition, the barley heads appeared to be browsed heavily by deer or harvested by rodents thereby making the chances of adequate reseeding very uncertain.

5. Barley (broadcast) - Ammonium Phosphate Sulfate.

Germination and initial growth was similar to the barley in rows, but had a sparse cover from the early growing stages to maturity. At maturity the barley was 18 to 24 inches high with 10 to 20 plants per square foot and provided a ground cover of 40 to 70 percent (fig. 6). Surface erosion was more noticeable under the barley

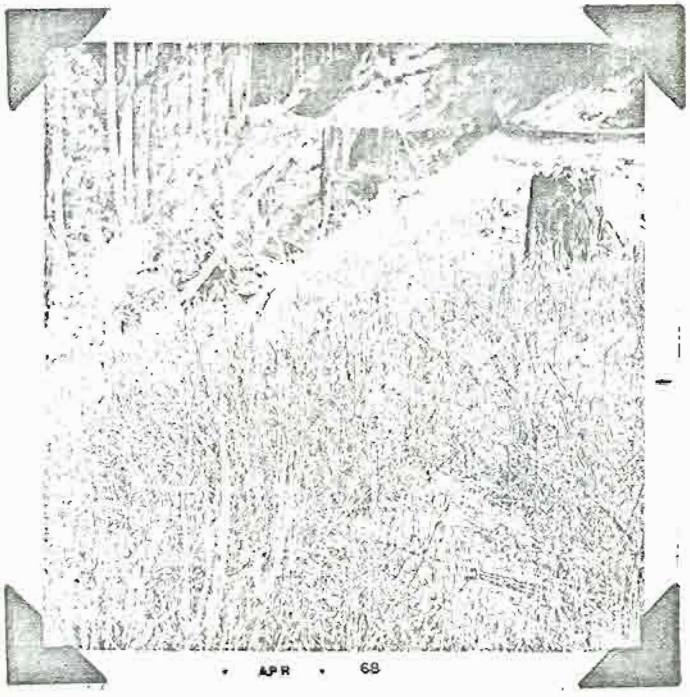

Fig. 6. Broadcast barley, on plot 10 in Orchard Gulch, with a dense grass stand of about 70 percent coverage.

than it was in the case of rye or the barley-rye combination. Because of weather conditions, it was not possible to compare

the early growth stages of this treatment with the broadcast rye treatment as the two applications were planted two and one-half months apart.

6. Annual Rye-Barley - Urea.

Six weeks after seeding, the barley was four to six inches high and was sparse in density. The rye grass grew quite dense at 50 lbs. per acre, but the initial growth was slower when compared to the barley seeded at the same rate at the same time. When maturity was reached, the cover appeared to be predominately annual rye grass (fig. 7) ranging from 24 to 36 inches high and covered the plot 70 to

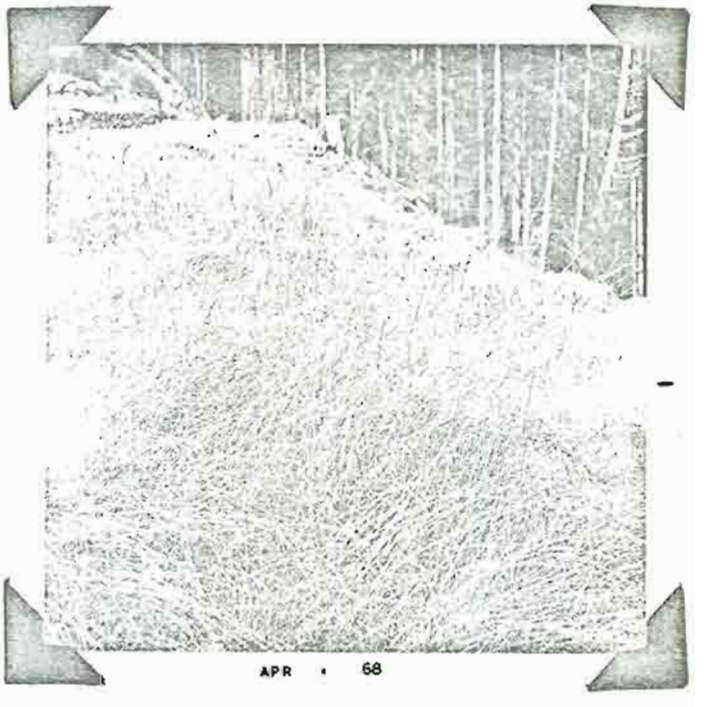

Fig. 7. Plot 12, annual rye and barley. Grass, Sept. 1965, showing mature dense mat with rye predominating.

90 percent. Erosion conditions on these plots appeared to be comparable to the plots seeded entirely with annual rye grass. In comparing the treatments it was felt that the density characteristics of the grass seeded at 100 lbs. per acre was not much different than the density at 50 lbs. per acre.

Seed which accidentally was spread beyond the unfertilized plot boundaries seemed to germinate well, but did not grow at all or had a slower rate of growth when compared to the seed which had been treated with fertilizer. From all observations it was found that fertilizer was needed for the growth desired. The plot data indicated that the best seeding approach was annual rye broadcast seeded and treated with Urea fertilizer (Treatment #3). Urea, with a higher nitrogen level than the other fertilizers used, appeared to be the best fertilizer to use in the study area. However in the second phase of this study provisions were made to compare it with another fertilizer not used in the plot study, the other fertilizer being di-ammonium phosphate (D. A. P. 21-23-0).

In summary, based on the data gathered, the best seed/fertilizer combination was annual rye and Urea each applied at 50 to 100 lbs. per acre. The optimum time to seed and fertilize appeared to be shortly after the first light rain. When seeding before any rain, "dry creep" on the steep fills tends to carry much of the seed to the toe of the fill. However if the seeding is delayed too long into the rainy season, the soil can become completely saturated and the fresh fills become impossible to work on because of mud flows that occur when they are disturbed. One of the most efficient and practical methods of sowing the grass seed and spreading the fertilizer is by using the hand operated cyclone seeder. The annual rye and Urea are particularly well adapted to this method because of the shape of the rye seed and the pellet form of the fertilizer. The ground coverage is good and the distance the seeder can cast the seed and fertilizer is adequate.

The results gained from the seed trial plots indicated the procedure to use in the second phase of the study, the procedure and results of which are given below.

DESCRIPTION OF EROSION STUDY

The second phase of the erosion study is located on five miles of access road built by logging contractors as part of a timber sale. Twenty plots, averaging 1.5 acres each, were established at 20 chain intervals along the road fill (fig. 8). The plots were seeded with annual rye grass at the rate of 50 pounds per acre and were selected randomly to determine which fertilizer would be used on each. The plot data are given in Table 2 and summarize the treatments applied. The two fertilizers were both applied at approximately 50 pounds per acre. The average slope of the plots was 59 percent with a range of 10 to 95 percent and had an average slope distance of 57 feet which ranged between 14 and 150 feet. All five miles of road were constructed in the Hugo soil series which is a moderately stable soil. Some clay deposits and rock outcroppings were found, but these were rare in relation to the total acreage involved. The entire road was well ditched, culverted and had water bars installed on the road surface to minimize runoff on the fill side.

Sixteen transects were set up in the first two study plots to measure the amount of erosion and were placed .5 to 1.5 chains apart along the road. Each transect had 10 points, five to eight feet apart, where an erosion pin was driven into the soil (fig. 9). The pin was constructed of number 9 iron wire, 18 inches long with an aluminum tag secured to the top. A notch was etched into the pin about six inches from the top and was placed in the soil until the notch was level with the fill surface (fig. 10) thereby allowing the recording of any change in surface level. The transects were established on a diagonal line to the slope direction and ran from the edge of the road to the bottom of the slope. A 2" x 2" redwood stake marked the beginning and end points of each transect. Four of these transects were placed on unseeded fill slopes to act as the control.

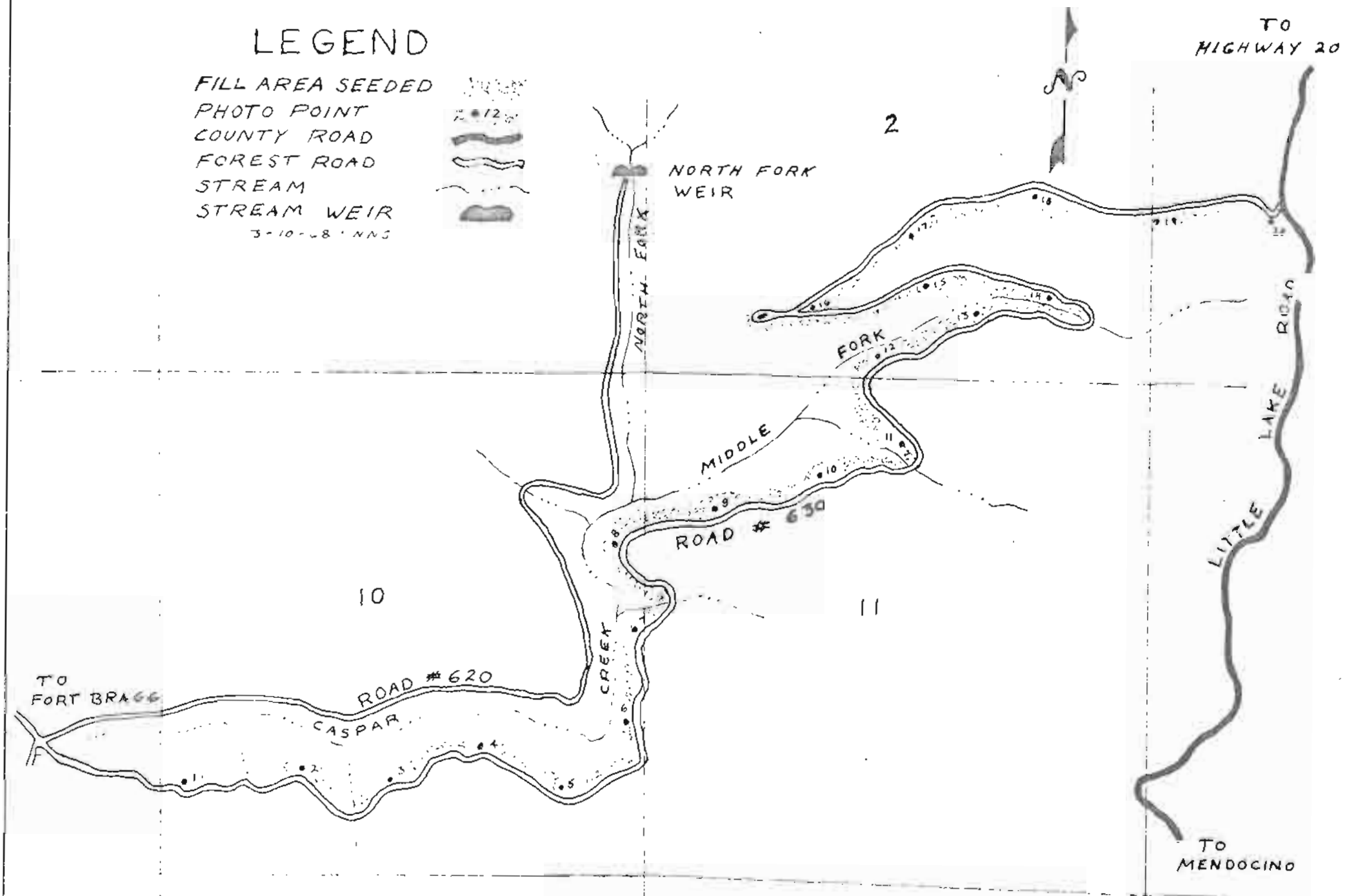

Fig. 8. Photo point and grass plot locations in the Caspar Creek Erosion Study.

Table 2. Grass and fertilizer used on erosion plots.

Plot No.	Date Seeded	Plot Acres	Pounds Per Acre Seed	Pounds Per Acre Fertilizer	Fertilizer Used
1	Sept. 29, 1965	1.54	51.9	91.0	D. A. P. a/
2	Sept. 29, 1965	1.56	51.3	54.5	D. A. P.
3	Sept. 29, 1965	1.88	57.5	53.3	Urea b/
4	Sept. 29, 1965	1.09	54.8	77.9	D. A. P.
5	Sept. 29, 1965	1.99	50.3	50.3	Urea
6	Sept. 29, 1965	1.96	51.0	51.1	Urea
7	Sept. 29, 1965	1.34	52.3	64.2	D. A. P.
8	Sept. 28, 1965	2.21	56.7	51.6	D. A. P.
9	Sept. 28, 1965	1.70	53.0	50.0	Urea
10	Sept. 28, 1965	1.71	49.7	49.7	D. A. P.
11	Sept. 28, 1965	1.92	52.0	43.7	D. A. P.
12	Oct. 5, 1965	1.95	51.3	51.4	Urea
13	Oct. 5, 1965	1.46	51.4	68.5	D. A. P.
14	Oct. 5, 1965	2.10	52.5	66.7	D. A. P.
15	Nov. 2, 1965	1.57	44.5	54.1	D. A. P.
16	Nov. 2, 1965	0.60	50.0	83.3	D. A. P.
17	Nov. 2, 1965	1.19	31.6	58.8	D. A. P.
18	Nov. 2, 1965	1.60	43.6	53.1	D. A. P.
19	Nov. 2, 1965	1.05	52.4	66.7	D. A. P.
20	Nov. 2, 1965	0.78	51.4	89.8	D. A. P.
	Totals	31.20	1,009.2	1,229.7	

a/ D. A. P. (21-23-0)
b/ Urea (45-0-0)

$\frac{31.20 \text{ acres}}{5 \text{ mile}} = 6.24 \text{ acres/mile}$

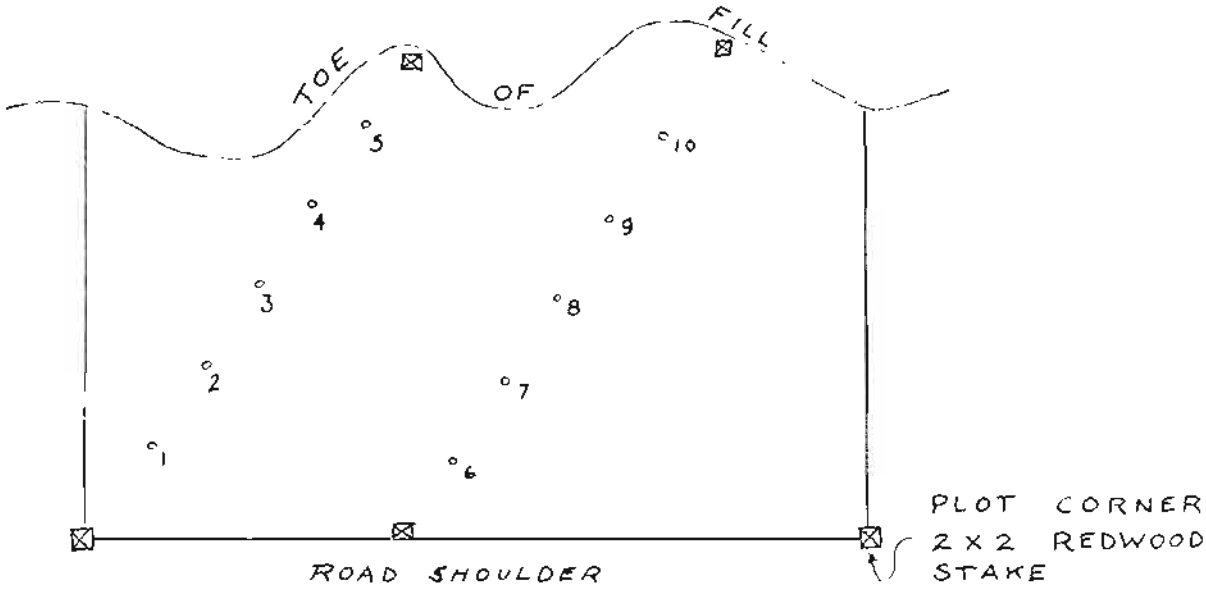

Fig. 9. Layout of erosion pin transects on road fill.

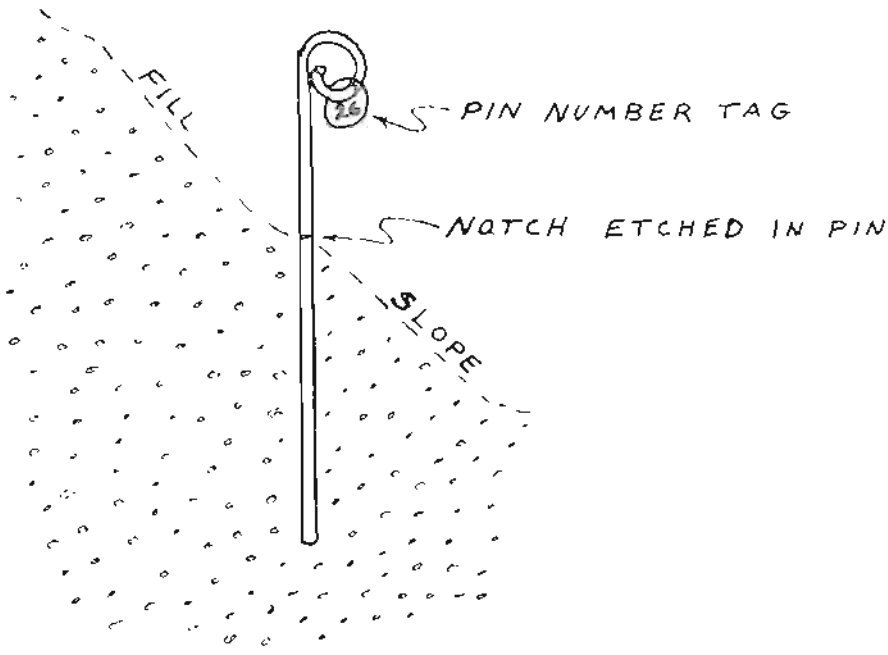

Fig. 10. Erosion pin description showing how it was established on road fill.

The erosion pins within these transects failed to give the desired information on how much erosion occurred. The reasons that they did not function properly were due to the following: (1) the whole fill area was loose when the pins were established and with the normal settling and compaction of the fill, this in itself would give an erroneous reading on the pin; (2) when sheet erosion occurred, the top layer of soil became saturated and moved en masse down the slope. This dislodged several pins and bent others so that if a measurement were taken it was worthless.

The transect portion of the project has been abandoned with only visual observations being recorded. Photographs were taken of each plot over a two-year period from permanent photo points. These photographs have recorded valuable observations on types of erosion and soil movement and also show how effective the grass cover was in relation to the erosive factors affecting each plot.

STUDY PLOT OBSERVATIONS

Plots Before Germination

Dry creep was a problem on the plots that had a slope of 60 percent or more. On these steep slopes the soil was very loose and a man walking across the fill when seeding or fertilizing would usually start small landslides. The best procedure when working on slopes this steep was to wait until the slides had subsided and then reseed or refertilize the exposed soil. In many cases the angle of repose was so steep that the addition of seed or fertilizer would generate soil movement in rills which would carry the seed and fertilizer to the toe of the slope. Also when these same areas became saturated during an intensive storm, the consistency of the top inch or two of soil became plastic in form and flowed down the slope taking the grass seed with it. This problem

might be corrected by mulching or terracing, but the costs involved should be investigated.

Plots During Germination

The grass seed germinated in six to nine days after the first fall rains. Grass became established under all plot conditions (fig. 11), including clay deposits and rocky areas, when enough soil was present to support root development.

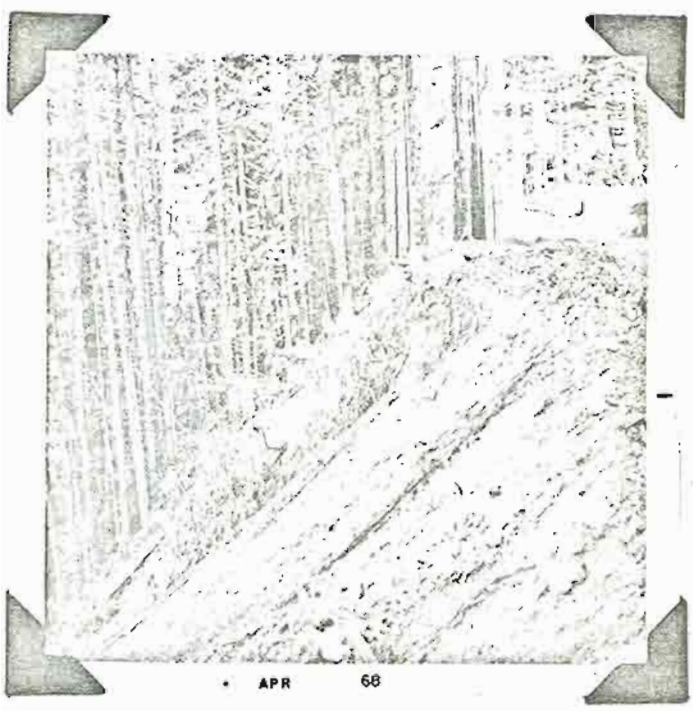

Fig. 11. Station 9, Oct. 1965, showing grass germinating on steep fill.

On the moist north-facing slopes, grass germinated sooner than on plots more exposed to sun. However shortly after germination, growth stagnated until more rains came. The stagnation of growth on these plots allowed the other plots to overtake them, but by the end of the growing season all the plots had about equal grass height and density.

Plots After Germination

The intensity and duration of the first few rain storms determined how much damage the grass plots could sustain and still remain a check on erosion. Rainfall duration and the measured amounts occurring during the germination and initial growth period are shown in Table 3 for the two growing seasons. In many cases the top few inches of soil would become saturated and sluffed off the slope in sections. The slip would occur even when a root mat had developed and the grass would be two or three inches high. If the root mat was well developed and extended deeper than the saturation level, the grass would prevent the slope from sluffing (fig. 12). The ideal situation is to have moderate rainfall,

Fig. 12. March 1966 grass at Station 9 in intermediate growth stage. Note absence of large slash, appearing in first picture (fig. 11), which apparently moved to the toe of the fill. The berm has also slipped.

enough to support plant growth, but not enough to cause the described slippage. Gully erosion was found in several places in the study area, but in most cases the grass did not have a chance to become established before this occurred.

Table 3. Rainfall during germination and initial growing stages of grass.[a]

1965		1966	
Date	Amount of Precipitation	Date	Amount of Precipitation
Sept. 25	0.04	Sept. 13	0.02
Oct. 5	0.32	Oct. 1-31	0.0
Oct. 14	0.15	Nov. 7	0.83
Oct. 20	0.10	Nov. 14	3.20
Nov. 4	0.50	Nov. 15	0.23
Nov. 8	1.60	Nov. 16	0.89
Nov. 12	1.32	Nov. 20	1.07
Nov. 15	2.30	Nov. 21	1.05
Nov. 18	1.30	Nov. 22	0.64
Nov. 19	0.20	Nov. 23	0.02
Nov. 23	0.05	Nov. 28	0.28
Nov. 24	1.20	Nov. 29	0.54
Nov. 27	1.42		
Total	10.50	Total	8.77

a/ Rainfall data was taken from standard rain gage located at Jackson State Forest Headquarters, Fort Bragg, California.

During observations of what was occurring on the plots, one other factor became evident. In many places along the toe of the fill when slash was found, it prevented erosion from reaching the stream. The only exception noted was some gully erosion that penetrated this slash, but even then, it was greatly reduced when compared to the locations that had little or no slash below the road fill.

Plots With a Mature Grass Stand

Two conditions promoted stability in the mature grass stand. The first condition was soil erodibility. By the time a mature grass stand had developed, most of the fill shrinkage had taken place and the loose fine material had either compacted or washed down slope during the first rains (figs. 13 and 14) leaving a soil pavement which tended to reduce any further erosion. Second,

Fig. 13. Showing road and berm at Station 5 during germination and before first heavy rains. Photo taken Oct. 1965.

the grass developed a turf which shed water and helped reduce erosion (fig. 15). On areas where grass was sparse it was noted that partial protection was gained

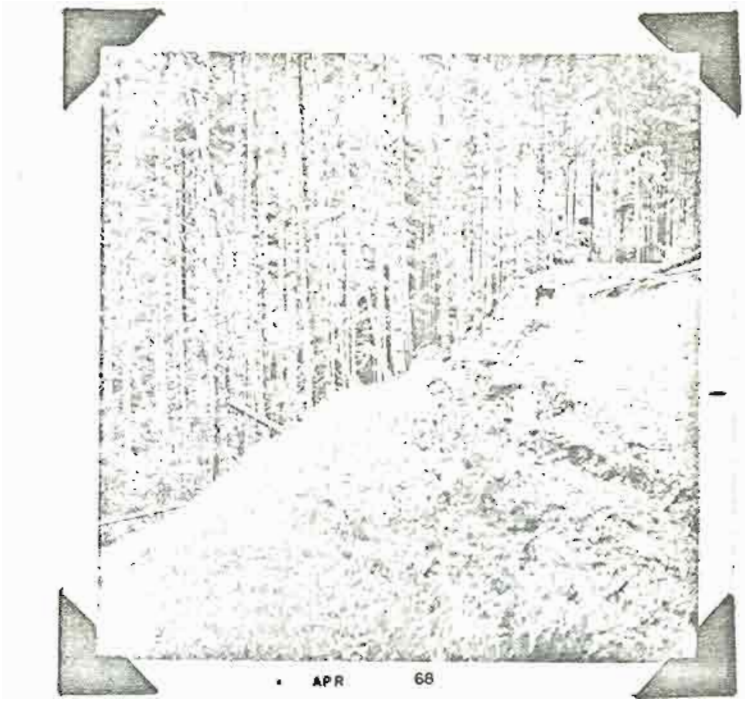

Fig. 14. Note how berm has slipped and the amount of fill shrinkage that was evident in March 1966. Six months later.

from the adjacent grass which bent over to form a thatch-like roof. In many instances this thatch-like roof was observed to give as much protection to the spoil as a full cover of grass.

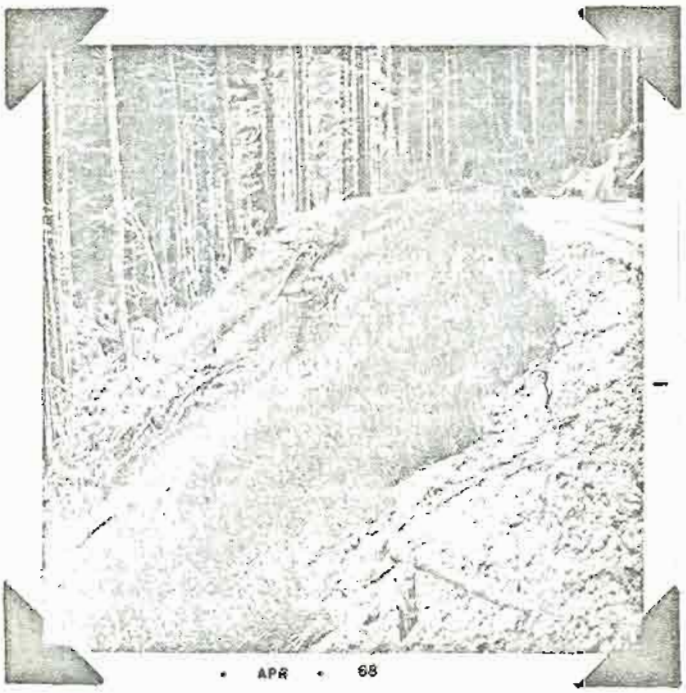

Fig. 15. Mature grass as it appeared at Station 9 in June 1966.

Plots During Second Growing Season

The plots usually became stabilized during the first year and the areas which had slipped were naturally reseeded from the surrounding parent stock the second year. The residual grass formed a mat of dead grass which provided a thatch-like turf that served the same function as mature live grass (fig. 16).

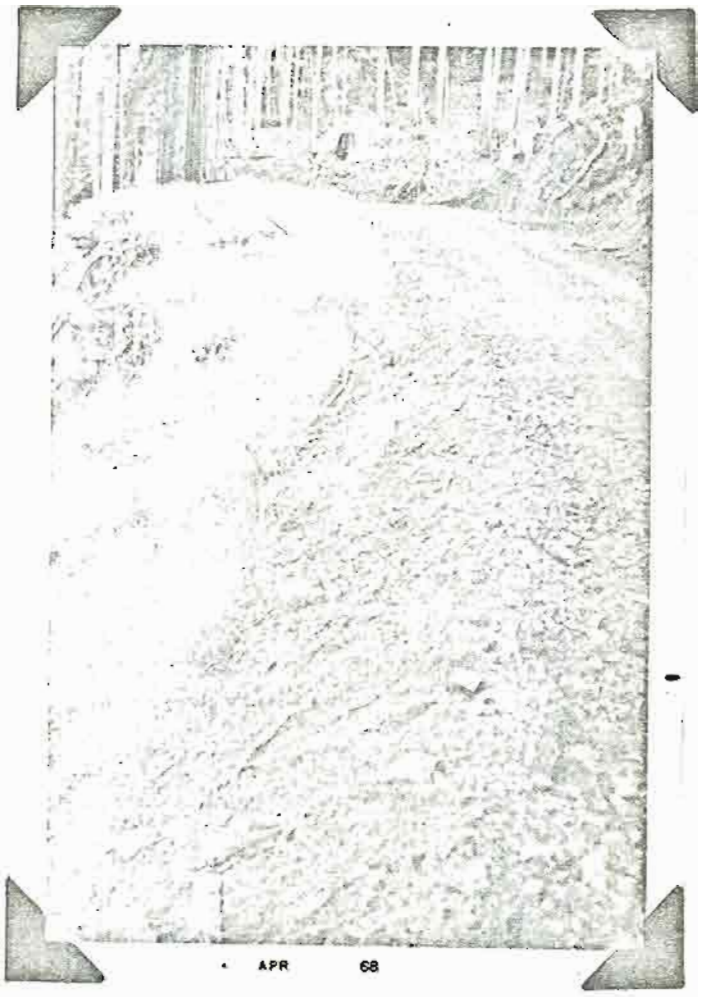

Fig. 16. Mat of first year's growth and second year's growth during initial growth period.

With the erosion pavement which had formed and the increase in total grass cover, the erosion observed the second winter was minimal.

GRASS COVER DENSITY

In the areas where the grass cover was firmly established it had excellent

ground coverage with the density about 85 percent the first year and almost 100 percent the second year. Including the areas that had damaging erosion, the grass cover the first year was observed to be about 70 percent. During the second year, the density increased to about 80 percent overall. Even with the problems of maintaining the initial grass cover, the density percentage achieved accomplished the objective of protecting the road spoil.

COMPARISON OF FERTILIZER TREATMENTS

The plots were randomly picked for the two fertilizer treatments. The Urea treatment had five replications and the D. A. P. treatment had 15 replications. Both the Urea and the D. A. P. were applied at approximately 50 pounds per acre. The D. A. P., because it is in powder form, had to be spread by hand. This caused it to be spread more unevenly and was somewhat slower in application than Urea. The Urea was in pellet form and could be spread rapidly and uniformly with the cyclone seeder.

The first measurement was taken during the first week in December 1965 and resulted in finding that the plots which had been treated with Urea had an average growth of 4 inches more than the plots treated with D. A. P. The second measurement was taken in June 1966 near the end of the growing season and it was found that the Urea plots had a growth average of 9 inches more than the D. A. P. plots. There was no noticeable difference in the germination or percentage of area covered with grass between the two treatments.

SUMMARY

It was found that a grass cover is effective in controlling erosion on fresh spoil areas, but there are many variables which affect both grass establishment and how effective it is after establishment.

The intensity of the precipitation, its duration, and when it occurs during the development of the grass stand are the most critical factors in this study. If the first few rains were intensive and came before an adequate root mat had developed, the plot suffered severe damage. The steep slopes (50%+) had more erosion of all types than the more moderate slopes and grass establishment was more difficult because of this accelerated erosion.

Where the fill slopes had slash deposits between the toe of the slope and the stream, very little, if any, soil movement reached the stream. From the observations made in this study, the slash could be spread below areas which have potential erosion problems and would give interim protection while the grass mat was developing.

The plots treated with Urea (45-0-0) had more growth than the plots treated with D. A. P. (21-23-0). Apparently this was due to Urea's having more than double the nitrogen when compared to D. A. P. The phosphate in the D. A. P. did not compensate for its lower nitrogen level. The two fertilization treatments indicated that nitrogen is more critical than phosphate for growth under the conditions of this study.

COST DATA

A. Grass

Annual rye	$190.00 per ton
Application rate	50 lbs. per acre
Application time	One man can seed one acre per hour

B. Fertilizer

1. Urea (45-0-0)	$108.00 per ton
2. D. A. P. (21-23-0)	$309.00 per ton
Application rate	50 lbs. per acre
Application time	One man can fertilize one and a third acres per hour

C. Cyclone seeder

Purchase cost	$6.00 approximately

D. Cost per acre

1. Seed	@ 9.5¢/lb.	@ 50 lbs.	=	$ 4.75
2. Man	@ $4.00/hr.		=	4.00
3. Fertilizer (UREA)	@ 5.4¢/lb.	@ 50 lbs.	=	2.70
4. Man	@ $4.00/hr.	3/4 hrs.	=	3.00
5. Seeder	@ $6.00	50¢	=	.50 — wrong .00
Cost per acre				$14.95

COST PER MILE OF ROAD SPOIL TREATED

$14.95/acre x 6.24 acres/mile = $93.29/mile