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# TEST OF METHODS FOR AMENDING AND SEEDING SPOILS AT THE BLACKBIRD MINE

B. Z. Richardson  
and  
E. E. Farmer



USDA Forest Service Research Paper INT-265  
Intermountain Forest and Range Experiment Station  
U.S. Department of Agriculture, Forest Service

## THE AUTHORS

**BLAND Z. RICHARDSON**, research forester on the Mine Spoil and Reclamation Research Work Unit at Logan, Utah, joined the staff of Intermountain Forest and Range Experiment Station in 1962. His research activities have included studies to determine the effect of multiple logging roads on moisture regimen, the hydrologic and pedologic effect of grazing on rangelands, the infiltration and erosional behavior of contour trenches on high elevation watersheds, and the effect of voids on the accuracy of neutron moisture measurements. Since 1966 his research has been exclusively on surface mine rehabilitation. He is responsible for conducting research on surface mine problems, testing research results on demonstration areas, and applying these results in cooperation with other federal and state agencies as well as private industry.

**EUGENE E. FARMER**, forest hydrologist on the Mine Spoil and Reclamation Research Work Unit at Logan, Utah, joined the staff of the Intermountain Forest and Range Experiment Station in 1964. Since 1966 he has studied reclamation of lands mined for coal, copper, and phosphate. His primary investigations are in surface and subsurface hydrology, revegetation, and waste dump mass stability.

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**B. Z. Richardson  
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**INTERMOUNTAIN FOREST AND RANGE EXPERIMENT STATION  
U. S. Department of Agriculture  
Forest Service  
Ogden, Utah 84401**

## RESEARCH SUMMARY

Experimental vegetation plots on an acidic waste dump at the Blackbird copper/cobalt mine in Idaho were used to evaluate alfalfa (*Medicago* spp.) hay, as an organic spoil amendment. In addition, tests were made to determine the value for reclamation of three systems of seeding and 11 grass species. Plots on which alfalfa hay was an amendment produced the highest yields of grass the first year, but production was not significantly better after 6 years. Plots planted with a seeder-packer produced higher yields of grass from the beginning than those that were hydroseeded.

The use of a rotary tiller to incorporate organic amendments into rocky, mineral mine waste for reclamation purposes is not recommended.

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# INTRODUCTION

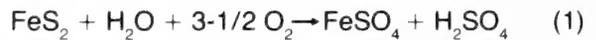
This paper describes and evaluates revegetation treatments of an acid mine spoils area on a surface mine in the western United States. Spoils on this area had not produced vegetation for 18 years. The value of lime as an amendment on acid spoils has long been recognized. Little has been done, however, in the West to show whether mixing organic mulch into acid spoils with a rotary tiller and seeding by various methods will enhance the establishment of vegetation on unfavorable sites.

## DESCRIPTION OF AREA

The Blackbird copper/cobalt mine is in the heart of the Salmon National Forest about 25 air miles (40 km) west and south of Salmon, Idaho. Its ownership has changed several times since it opened in 1893, and its operation was intermittent until 1967. Demands for cobalt in World Wars I and II stimulated its operation. Later, at the onset of the Korean War, ore production and milling operations expanded. Peak production was in 1958, and operation continued until 1960. After a temporary shutdown, it reopened in 1963 with both a surface pit and an underground operation. Production was not profitable, though, and it closed again in 1967.

Physiography of the general area is a succession of rugged high ridges with steep hillsides and deep, narrow draws, most of which are drained by perennial streams. Elevation of the general mine area ranges between 6,600 and 8,200 feet (2 012 and 2 500 meters). Annual precipitation averages 22 to 35 inches (56 to 89 cm). The dominant vegetation of the area is lodgepole pine (*Pinus contorta*) with some subalpine fir (*Abies lasiocarpa*). Spruce (*Picea* spp.), can be found on north- and east-facing slopes. The understory consists of huckleberry (*Vaccinium* spp.), Oregon grape (*Berberis repens*), spirea (*Spiraea* spp.), pinegrass (*Calamagrostis rubescens*), and some forbs. On disturbed sites, such as road cuts, the major vegetation is composed of bitterbrush (*Purshia tridentata*), alder (*Alnus* spp.), rose (*Rosa woodsii*), bluebunch wheatgrass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*), hairgrass (*Deschampsia caespitosa*), western yarrow (*Achillea millefolium*), and penstemon (*Penstemon fruticosus*). Rocks in the Blackbird district are mostly quartzites and metamorphosed Precambrian sediments. Occasional massive intrusions of chalcopyrite, cobaltite, pyrite, and pyrrhotite occur in mineralized lenses; the first two minerals are high grade ores, the other two are waste sulfide minerals.

Over the years, spoil material, which contained pyritic and sulfide minerals, was dumped in large piles on steep slopes in the draw at the head of Meadow Creek. This dump has a volume of more than one million cubic yards (765 000 m<sup>3</sup>). High winds, rain, and snowmelt constantly erode the surface of these waste piles and thereby expose fresh mineral elements to oxidation. When these sulfide minerals are exposed to oxygen, either in the air or when dissolved in water, oxidation produces acids (chiefly sulfuric) and other such substances as ferrous and ferric sulfates. The following equations express these basic chemical reactions (Sorensen and others 1980):



and



The sulfuric acid produced in these reactions acidifies the overburden materials and dissolves heavy metal compounds.

The products of sulfide mineral oxidation make it difficult, if not impossible, to establish vegetation without modifying the overburden. The leaching of acid and toxic metals described above, plus continuing erosion of the waste material in the mine dump during the past 20 or more years, has made the Blackbird mine a massive producer of sulfuric acid, as well as of copper and iron ions. Acid and heavy metals have eliminated all the fish, benthic organisms, and most of the streamside vegetation in Blackbird Creek and have eliminated the anadromous fishery in Panther Creek, downstream to the Salmon River.

As yet unanswered questions at the Blackbird Mine are:

- Can the production and drainage of acid and other pollutants be mitigated? If so, would the mitigation method be environmentally and esthetically acceptable?
- Would the cost of mitigation be reasonable? Will the mitigation system perpetuate itself, or will it require continuous management?

This problem is at least twofold. Part of it is the continuous production of acid and other toxic materials that result from constant exposure of the spoils area to erosion. The other part is the flow of water from underground mine tunnels.

Several years ago the Ohio State University Research Foundation (1971) pointed out three methods for abatement of acid production at its source: development of an oxygen barrier on the surface; development of chemical or biological control over the rate of pyrite oxidation; and prevention of the infiltration of water into disposal piles, inactive tailings ponds, and similar sources of production of acid.

An artificial covering, both waterproof and airproof, would stop the production of acid, but it would be difficult to install and maintain. Also, the cover probably would be feasible for temporary abatement only on comparatively small areas. A natural vegetative cover such as grass would be an alternative. A natural cover would be satisfactory both environmentally and esthetically, and presumably would be permanent and self-sustaining. Such a cover has been demonstrated to be a strong deterrent to overland flow and to soil surface erosion. It also functions as a oxygen barrier. Even if oxygen penetrated the root zone and the pyrites were eventually oxidized, no new pyrites would be exposed if the plant cover could be maintained.

The above suggest that the logical approach to the Blackbird Mine problem would be to establish a permanent vegetative cover over the waste piles. The Blackbird Mine, however, presents an especially difficult problem. Not only is the spoil material in the waste dump subject to severe acid problems, but the whole dump is located in steep, mountainous terrain that increases the difficulty of establishing a protective vegetative cover.

## RESEARCH

Research designed to devise an effective technique for vegetating the mineral waste piles at Blackbird started in 1972 (Farmer and others 1976) and has continued until the present. Nielson and Peterson (1972) demonstrated that liming was necessary for initial establishment of vegetation on acid spoils, and Farmer, Richardson, and Brown (1976) showed that mulching and fertilizing aided in establishing grass cover. It remained to be shown, however, how soil organic amendment mixed into the spoils and varied seeding methods could enhance establishment of vegetation on this unfavorable site. This paper reports results of a study using alfalfa (*Medicago* spp.) hay as a soil organic amendment and of three systems of seeding the spoils area. The study began in the fall of 1973 and will continue until 1982.

## Study Site

Experimental treatments reported here were applied to a slightly sloping area 132 by 198 ft (40.23 by 60.35 m) of

east-facing aspect on the waste dump at the head of Meadow Creek. This experimental block contains 24 test plots, each of which has an area of 1/40 acre (0.01 ha); the total test area occupies approximately 3/5 acre (1/4 ha).

## TREATMENTS

The study area was limed with a lime spreader at the rate of 900 lb/acre (1 009 kg/ha), the requirement as calculated by a university laboratory using a modified SMP buffer method (Shoemaker and others 1961). The lime was then harrowed into the ground by a Triple-K<sup>1</sup> harrow to a depth of about 8 inches (20.3 cm).

On 12 of the 24 test plots, hay was used as soil organic amendment by being worked into the surface 10 inches by a Howard rotovator at the rate of 70 lb (31.75 kg) per plot, 2,800 lb per acre (3 136 kg/ha).

## Seeding Methods

The three seeding methods used were:

1. Seeding by a Brillion seeder-packer followed by hydromulching and fertilizing.
2. Hydraulic seeding (Bowie hydromulcher) with simultaneous mulching and fertilizing (one-step method).
3. Hydraulic seeding followed by mulching and fertilizing (two-step method).

Each method was tested on both amended and non-amended plots, giving a total of six combinations of treatments randomly located (fig. 1).

On all plots, the seed mixture (table 1) was applied at the rate of 2-1/2 lb (1.13 kg) per plot, or 100 lb (45.36 kg) per acre (112 kg/ha). Plots planted by the seeder-packer were later fertilized and mulched by the hydromulcher. The fertilizer (NPK ratio: 10-34-0) was in a slurry mixed with wood-fiber mulch and a binding agent. Uniform application rates were:

	Lb/acre	Kg/ha
Seed	100	112
Fertilizer	907	1 016
Mulch	2,000	2 240
Binding agent	40	44.8

<sup>1</sup>The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others which may be suitable.

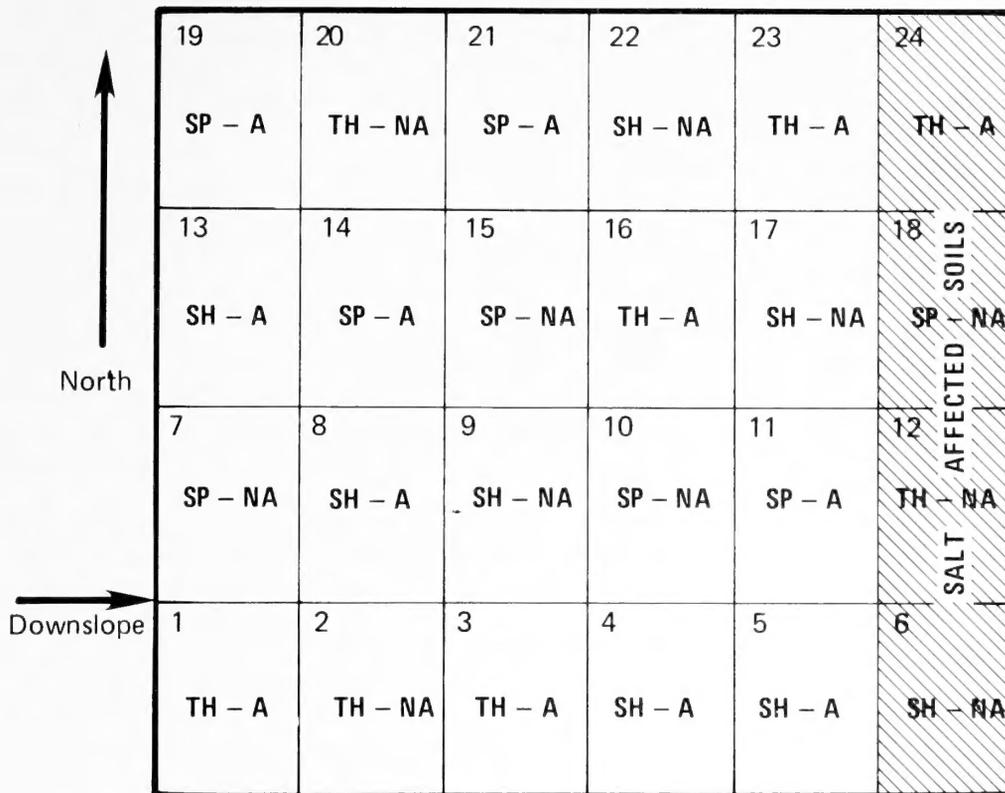


Figure 1.—Layout of experimental plots at Blackbird mine by numbers and treatments: SP, seeded by seeder-packer, followed by application of mulch and fertilizer; SH, hydroseeded, followed by hydromulching and fertilizing; TH, seed, mulch and fertilizer all applied by hydromulcher in one operation; A, amendment by addition of hay; and NA, no amendment.

Table 1.—Mixture of grasses seeded at Blackbird Mine, October 1973

Species	Mixture		Composition
	Weight		
	Pounds	Kg	Percent
Smooth brome ( <i>Bromus inermis</i> )	15	6.804	25
Timothy ( <i>Phleum pratense</i> )	8	3.628	13
Alta fescue ( <i>Festuca arundinacea</i> )	7	3.175	12
Orchardgrass ( <i>Dactylis glomeratus</i> )	7	3.175	12
Intermediate wheatgrass ( <i>Agropyron intermedium</i> ) Tegmar	6	2.721	10
Great Basin wildrye ( <i>Elymus cinereus</i> )	5	2.268	8
Meadow foxtail ( <i>Alopecurus pratensis</i> )	4	1.814	7
Slender wheatgrass ( <i>Agropyron trachycaulum</i> )	3.8	1.723	6
Mountain brome ( <i>Bromus carinatus</i> )	3	1.360	5
Intermediate wheatgrass ( <i>Agropyron intermedium</i> ) Grenar	1	0.453	2
Bottlebrush squirreltail ( <i>Sitanion hystrix</i> )	0.2	0.090	0.3
Total for 0.6 acre	60.0	27.21	

Hydroseeded plots (methods 2 and 3) were planted by the Bowie hydromulcher. In method 2, seed, fertilizer, mulch, and binding agent were mixed together in the hydromulcher and applied as a slurry in a single operation (one-step method). The plots seeded by the two-step method (method 3) first received seed and water applied by the hydromulcher, then a slurry of fertilizer, mulch, and binder was sprayed over the seed at the standard rates of application.

Two years after seeding, the area began to reacidify and Richardson recognized that the present method of lime determination was not satisfactory. After incubating a sample of the spoils, it was determined that at least 4 more tons of calcium carbonate ( $\text{CaCO}_3$ ) per acre (8 960 kg/ha) should be added to the test plots. The entire surface area was relimed at this rate. Later, a more accurate method of determining lime requirements for these spoils was developed (Sorensen and others 1980).

## DATA COLLECTION

Data on grass production were collected in the summers of 1974 and 1979 by a double sampling technique utilizing a Neal capacitance meter (Neal and Neal 1973). Additionally, in 1979, we collected data on individual grass species.

## RESULTS AND DISCUSSION

### Production

Total production of grass, by plots and treatments, is summarized in table 2 and figure 2. The decreased production in 1979 was due partly to unfavorable weather (precipitation was 22 percent less than the 4-year average) and to the reduction in plant nutrients. Other factors, such as reacidification, probably contributed.

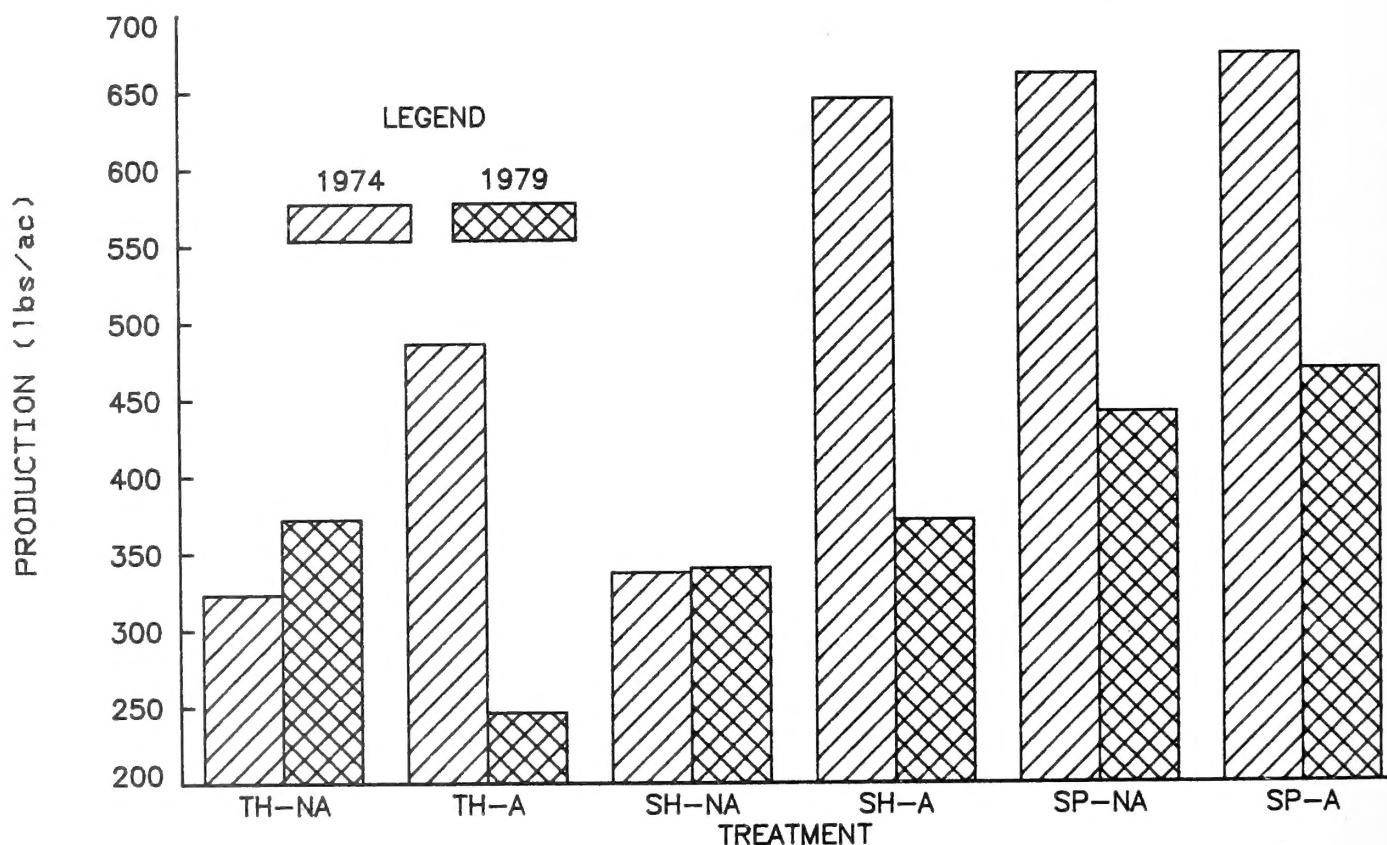


Figure 2.—Average grass production by treatment at Blackbird Mine, 1974 and 1979: SP, seeded by seeder-packer, followed by application of mulch and treatments; SH, hydroseeded, followed by hydromulching and fertilizing; TH, seed, mulch, and fertilizer all applied by hydromulcher in one operation; A, amendment by addition of hay; and NA, no amendment.

**Table 2.—Average production of grass in experimental plots, by treatment, at Blackbird mine, 1974 and 1979**

Treatment <sup>1</sup>	Plots treated	Production			
		1974		1979	
		Lb/acre	Kg/ha	Lb/acre	Kg/ha
TH-NA	1, 2, <sup>2</sup> 12, 20	323	362	372	417
TH-A	3, 16, 23, <sup>2</sup> 24	486	544	246	276
SH-NA	<sup>2</sup> 6, 9, 17, 22	337	377	340	381
SH-A	4, 5, 8, 13	645	722	371	416
SP-NA	7, 10, 15, <sup>2</sup> 18	661	740	441	494
SP-A	11, 14, 19, 21	674	755	469	525

<sup>1</sup>Treatment code:

SP, seeded by seeder-packer, followed by application of mulch and treatments;

SH, hydroseeded, followed by hydromulching and fertilizing;

TH, seed, mulch, and fertilizer all applied by hydromulcher in one operation;

A, amendment by addition of hay;

NA, no amendment.

<sup>2</sup>Study site extended into a salt-affected area which influenced results. Those plots were not included in calculations.

## Species

Just as total production was less in 1979 than in 1974, so was the number of grass species in the stands. In 1979, the dominant species were timothy, orchardgrass, and smooth brome—all introduced species. Other grasses that survived the 6-year period were the intermediate wheatgrasses and Great Basin wildrye, a native. In 1979, we found that hairgrass (*Deschampsia caespitosa*) had invaded the study site, especially in areas where some of the planted grasses had declined because of reacidification.

The data on both grass production and persistence of species lead to the following conclusions:

- Seeding by the seeder-packer gave higher grass yields, both first year and long term, than either method of hydroseeding.
- On areas too steep for the seeder-packer, the two-step hydroseeding and mulching system gave higher grass yield results than the standard one-step hydroseeding technique.

- Although plots planted by the standard one-step system produced less, stands generally are acceptable in terms of ground cover protection and, at the same time, encourage natural succession.
- Use of alfalfa hay as a soil amendment produced higher yields of grass in 1974 at the 95 percent statistical level, but this benefit was not so evident after 6 years.
- The rotary tiller is not a satisfactory implement for mixing organic mulch into the rocky mine spoils found on this mine because:

1. The rotary tiller crushes rocks and increases the reactive fraction of the spoil. The tiller can overpulverize the spoils, destroying texture and decreasing infiltration.

2. The rotary tiller uses more energy per cubic foot of soil moved than any other tillage instrument and more than three times that used by the moldboard plow (Buckingham 1976). Rocks dull the blades, and hay that is not cut by the dull blades is ineffective. The machine is soon destroyed.

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1980. Test of methods for amending and seeding spoils at the Blackbird Mine. USDA For. Serv. Res. Pap. INT-265, 6 p. Intermt. For. and Range Exp. Stn., Ogden, Utah 84401.

Describes the acid waste drainage problem at the Blackbird copper/cobalt mine in Idaho and explains the rationale for attempting to establish vegetative cover over the mineral waste dump. Lists equipment and materials used in six experimental treatments. Evaluates performance of hay as a spoil amendment, of 11 grass species tested, and of three methods of seeding.

**KEYWORDS:** acid mine drainage, hydromulching, hydroseeding, liming, mine spoils, mulching, pyrites, spoil amendment, sulphide (sulfide) minerals, surface mining, vegetative cover.

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