THE CITY OF ANACONDA EROSION CONTROL AND STABILIZATION OF "C" HILL[1]

by

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Abstract. Prior to the late 1800's, the "C" hill was vegetated by a mosaic of Douglas-fir and aspen intermixed with grassland. The hill was excessively logged to supply fuel for the adjacent copper smelter. The deforestation, heavy metal and sulfide pollution from the smelter stack fallout as well as steep slopes, and a harsh climate inhibited plant growth and resulted in severe soil erosion. Sediments were deposited onto the streets and into storm drains.

Increased street maintenance costs in the city of Anaconda, as well as the concerns of noxious weed invasion and the aesthetics of the area, resulted in the development of The City of Anaconda Erosion Control and Stabilization of "C" Hill project in 1986.

Surface smoothness was manipulated with a Modified Hodder Gouger¯, which excavated minibasins to ameliorate acid soil surfaces and to trap water for plant establishment and growth. Lime was surface applied, following basin construction, according to soil test results. A native grass seed mixture and fertilizer were broadcast over the pits, and straw mulch was spread over part of the seeded area.

Shrubs and trees were planted to provide long-term stabilization to the hill. Tree and shrub seeds were collected from adjacent native species and grown under contract for planting on some of the disturbed sites following 2 years of weed control.

Good stands of grass, shrubs, and trees have been successfully established on "C" hill and have provided erosion control. The total cost of the project has been offset by decreased maintenance costs, restored productivity, and aesthetic benefits to the city of Anaconda.

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INTRODUCTION

Prior to the late 1800's, the foothills surrounding Anaconda, Montana--locally referred to as the "A" and "C" hills--were vegetated by a mosaic of Douglas-fir and aspen stands intermixed with grasslands. Copper refining began in the Anaconda area in the late 1800's and continued until 1980. Initially, the smelters were located north and across the valley from the project area. In the early 1900's, the smelter was moved adjacent to and east of the project area. The smelter site, tailing piles, and sediment ponds east and downslope from the study area have been declared an EPA Superfund cleanup site. In the late 1800's and early 1900's, the forested hills adjacent to the smelter were extensively logged. Immediately after the logging operations, much of the foothill area exhibited major soil erosion problems. Removal of the natural vegetative cover, combined with heavy metal and sulfide smelter pollution of the soil, as well as a harsh climate, has inhibited the reestablishment of plant cover (USDA--Soil Conservation Service, 1986).

Adams et al. (1986) reported only 20 percent of the project area vegetated prior to treatment. Plant cover and diversity increased with distance from the smelter. The most impacted areas are within a 5-mile radius of the smelter, inline with the prevailing wind. Studies show these sites have lost up to 16 inches (40.6 cm) of topsoil. Infertile, poorly structured subsoils--sometimes referred to as desert pavement--caused by past surface erosion comprise the upper part of the soil profile. Runoff from the project area has caused flood damage and sediment deposition in downtown Anaconda. Increased maintenance costs, concern for noxious weed invasion, and visual quality of the area resulted in the development of this cooperative erosion control project.

MATERIALS AND METHODS

The 664-acre (268-ha) project area is located in southwestern Montana near the city of Anaconda. The elevation ranges from 5,500 feet (1,676 m) near town to 7,193 feet (2,192 m) on the "C" hill south of town. The mean annual precipitation (MAP) is 14 inches (356 mm), with June being the wettest month. The growing season ranges from 100 to 117 days. The "C" hill has a predominantly northern exposure with an average 25 percent slope.

The project area was divided into three treatment units based on similar site characteristics. Only the work on a 51-acre (20.6-ha) area will be reported in this paper. This area was divided into two sites--a 12-acre (4.9-ha) east location, and a 39-acre (15.8-ha) west area. These sites were selected because they could be transversed with reclamation equipment. They were treated in 1987 and 1989, respectively. The areas contain a mixture of two main geologic types: quartzites and extrusive, fine-grained, volcanic rocks.

The soils are eroded and heavily polluted with copper, iron, lead, zinc, cadmium, and arsenic in the surface 2 to 3 inches (5.1 to 7.6 cm) of soil. The heavy metals have become phytotoxic due to the acidifying effects of the sulfide stack emission fallout. The erosion rates are 24 tons-per-acre (53.8 t ha^{-1}) per year. The allowable soil loss for these soils is 3 tons-per-acre (6.7 t ha^{-1}) per year (USDA--Soil Conservation Service, 1978). (Erosion greater than the allowable tolerance means that the soil is eroding faster than it is being formed.)

The area has 15 to 35 percent slopes, very gravelly loam surface textures, and a very gravelly clay loam subsoil derived from volcanic and quartzite rock. The surface 2 to 3 inches (5.1 to 7.6 cm) varies from

4.2 to 5.3 pH. The pH range improves to 6.2 and 7.7 at the 2- to 10-inch (5- to 25.4-cm) depth (Long, 1986). The area consists of a mixture of rock fragments, erosion pavement, bare soil, patches of grass, clumps of quaking aspen *Populus tremuloides* Michx., and an occasional Rocky Mountain juniper *Juniperus scopulorum* Sarg.

The reclamation strategy was to scrape away patches of the acid soil surface 2 to 3 inches (5.2 to 6.7 cm), and plant suitable indigenous species into the basic pH subsoil (Adams et al., 1986, and Schafer, 1988). Minibasins were constructed with a Modified Hodder Gouger˜[1/] (USDA--Forest Service, 1977) on the east and west sites during April 1987 and April 1989, respectively. The excavated basins were approximately 3 feet long by 1 foot wide (.91 x .3 m), and 4 inches (.1 m) deep, with alternating centers at 1 foot (.3 m) in between basin rows. The basins were orientated lengthwise downslope. The final surface modification resulted in approximately 7,260 basins per acre (17,932 per ha).

Fertilizer and ground lime were broadcast over the basins following the seeding. Lime was applied with an all-terrain spreader at a rate of 2.2 tons-per-acre (4,931.7 kg ha^{-1}) (Western Fertilizer Handbook, 1985). This consisted of an agricultural grade lime passing through an 80-mesh screen and testing 85 percent $CaCO_3$ equivalent. Two hundred pounds-per-acre (224.2 kg ha^{-1}) of 16-20-0 NPK was applied with the Modified Hodder Gouger˜ during broadcast seeding.

Adams et al. (1986) collected soils from the "C" hill at various depths and conducted bioassay studies at Montana State University using six plant cultivars. The following species' recommendations were ascertained from their study.

A native species cultivar mixture containing, by weight, 50 percent 'Magnar' basin wildrye *Leymus cinereus* (Scribner & Merrill) A. Love, 40 percent 'Critana' thickspike wheatgrass *Elymus lanceolatus* (Scribner & J. G. Smith) Gould, and 10 percent yellow blossom sweetclover *Melilotus officinalis* (L.) Lam. was prescribed for the west site. Approximately 23 pounds-per-acre (25.8 kg ha^{-1}) pure live seed were broadcast with the Modified Hodder Gouger˜ into the minibasins in April 1987. On the east site, native species cultivar mixture, by weight, was 40 percent 'Magnar' basin wildrye, 30 percent 'Critana' thickspike wheatgrass, and 30 percent 'Sodar' streambank wheatgrass *Elymus lanceolatus* (Scribner & J. G. Smith) Gould. Approximately 24 pounds-per-acre (26.9 kg ha^{-1}) pure live seed were broadcast with the Modified Hodder Gouger˜ into the minibasins in April 1989. One-half of the west side planting was mulched with 3,000 pounds-per-acre (3,362.5 kg ha^{-1}) of barley straw.

The cost of establishing grass was $873 per acre. (See Table 1 for an itemization of expenses.) This amount does not include the $65 per acre that was spent on a one-time, weed control application.

Table 1.

Per Acre Cost of Grass Seeding

Grass	$203
Pitting and Seeding	55
Fertilizer	32
Lime	286
Lime Application	55
Straw Mulch	242
Total Cost Per Acre	$873

[1/] Trade names used solely to provide specific information. Mention of a trade name does not constitute a guarantee or endorsement by the U.S. Department of Agriculture, Soil Conservation Service.

Shrub and tree seeds were collected from native stands adjacent to the reclamation site during 1986 and 1987. Species collected were Rocky Mountain maple *Acer spicatum* Lam., serviceberry *Amelanchier alnifolia* Nutt., rose *Rosa woodsii* Lindl., buffaloberry *Shepherdia argentea* Nutt., dogwood *Cornus stolonifera* Michx., aspen *Populus tremuloides* Michx., and oregongrape *Berberis repens* Lindl. Seedlings were propagated by the Montana Department of State Lands, Division of Forestry; State Forest Tree Nursery; and Bitterroot Growers (a private nursery). From 1989 through 1992--following grass establishment and weed control--21,800, 1-year-old, 20-cubic-inch (327.7-cm^3) "cone-tainer" nursery stock seedlings were transplanted into the grass seedings by city of Anaconda personnel. One, .35-oz (10-gm), Agriform 20-10-5 fertilizer tablet was planted with each seedling to provide a 2-year nutrient source.

In 1989, seedlings were planted in the upper 10 acres (4 ha) of the west area. There were 360 seedlings per acre (865 plants per ha) planted at a spacing of 11 by 11 feet (3 x 3 m). In April 1990, the remaining 25 acres (10 ha) were planted with the same seedling species and numbers per acre. The east area treatment site was planted in April 1991 with the same seedling species, but at a rate of 680 plants per acre (1,630 plants per ha) on an 8- by 8-foot spacing (2.44 x 2.44 m). The cost of planting shrubs was $1,006 per acre (Table 2).

Table 2.
Per Acre Cost of Shrub Planting

Plants (\$.70 per plant x 680 plants)	$ 476
Planting Plant (\$.70 per plant)	476
Fertilizer (\$.08 per plant)	<u>54</u>
Total Cost Per Acre	$1,006

Percent ground cover was estimated in 20 constructed minibasins, using the line-intercept transect method. Data was collected during September 1988 for initial cover within the 1987 planting, and in September 1992 for established cover. Cover was estimated during September 1992 within the 1989 planting. Also during September 1992, three, random, 9.6-square-foot (.89-m^2) plots on the west site and five on the east site were harvested for total herbage yield. The percent cover and herbage yield from the treatment areas were compared to bare ground prior to reclamation. Tree and shrub survival was monitored by the city of Anaconda for each planting year. MAP recorded for the city of Anaconda was used as an estimate for the reclamation sites.

RESULTS AND DISCUSSION

Grass Seeding Evaluations

<u>West Area Planted 1987</u>

The initial percent ground cover transect was estimated in November 1987, after the first growing season. Percent cover (includes standing live and dead plant material and surface residue) in the basins ranged from 1 percent up to 30 percent (Figure 1). Plant vigor was generally low, with plants in only a few basins showing good vigor. This site was heavily infested with Canada thistle *Cirsium arvense* L., which affected the grass seedling vigor and stand establishment.

Thickspike wheatgrass was the dominant species in 65 percent of the basins; with basin wildrye present in 95 percent, but dominant in only 15 percent. The yellow sweetclover was present in only 25 percent and showed low vigor and growth.

Plant establishment in interspaces in-between the basins was observed in 65 percent of the transect plots.

The 1992 data collected in the 20 original basins along the permanent transect showed dramatic improvement in percent cover and plant vigor (Figure 1). A large part of the improvement was due to chemical control of the Canada thistle on the site. Percent ground cover ranged from a low of 40 percent (which occurred in the single basin with a low of 1 percent in 1987) up to 100 percent in one-half of the basins.

Basin wildrye became the dominant species in 50 percent of the pits. The yellow sweetclover is no longer present in any of the basins along the transect. One native grass species that is becoming more dominant in plant composition is redtop *Agrostis alba* L. This plant is the dominate species occurring in the undisturbed areas between the basins.

The straw mulch was blown off the windward portion of the treatment area and heaped onto the downwind sites. This excessive mulch cover was detrimental to seedling establishment.

Vegetative clippings for grass production were taken in October 1992. No previous data for comparison is available. Three plots were clipped, using a 9.60-square-foot (.89-m) frame, and produced an average air-dry herbage yield of 563 pounds-per-acre (631 kg ha^{-1}) within and in-between the basins (Figure 2).

<u>East Area Planted 1989</u>

Two transects were set up on this area for determining percent ground cover. No previous data was collected from this area for comparison, but a comparison can be made with the area of gravel pavement and no vegetative cover before the reclamation treatment. A total of 20 basins along each transect were evaluated.

Cover ranged from no cover in one basin to 100 percent in four basins (Figure 1). Overall, plant vigor was very high in all the basins. Chemical control of spotted knapweed *Centaurea maculosa* Lam. and Canada thistle resulted in the very high plant vigor of the seeded species.

Streambank wheatgrass was the dominant grass species in 82 percent of the basins evaluated, with basin wildrye being the dominant species in only 15 percent. Thickspike wheatgrass was never a dominant component and was absent in 32 percent of the basins. Average air-dry herbage yield was 340 pounds-per-acre (381-kg ha^{-1}) during 1992 (Figure 2).

Interbasin plants, comprised primarily of streambank wheatgrass, occurred in-between 70 percent of the pits. Unlike the west area treatment, very little redtop was present in this area.

Tree and Shrub Plantings

The objective of the tree and shrub planting was to have a minimum of 100 plants per acre established within 10 years after planting. They could provide a minimum of 25 percent cover, which would reduce the current erosion by 50 percent. Survival rate of the seedlings ranges from 70 to 95 percent.

CONCLUSION

It remains to be seen how effective the treatment measures will be in achieving the long-term goals of the project; however, there have been some very immediate and observable benefits resulting from the treatment measures. The grass cover catches and holds more of the winter snow, and the basins allow more of the rainfall and snowmelt to infiltrate the soil profile, rather than becoming runoff. This allows favorable moisture regimes for maintaining established vegetation, and encourages vegetation to spread and establish between the basins.

Noxious weeds are still a problem and will have to be treated annually to maintain the health of the grass stands and insure high tree and shrub seedling survival.

The area is stable and aesthetically pleasing with the grass cover, and will improve as the trees and shrubs mature. Community pride in the project has increased as seen in less litter and vehicle damage to the area. Less runoff is occurring from the slopes, which means less sediment coming onto the city streets and into the storm drains, reducing city maintenance costs.

Figure 1. Total percent ground cover.

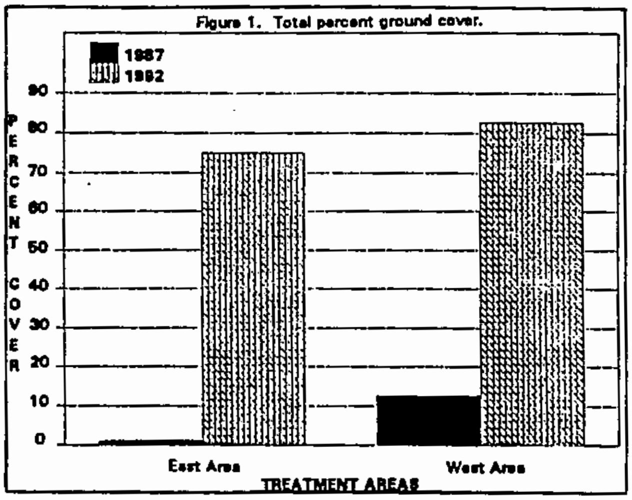
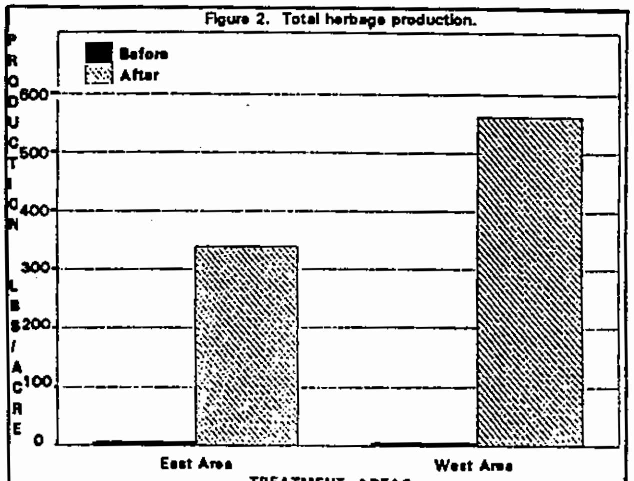


Figure 2. Total herbage production.



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