REVEGETATION METHODS AND SUCCESSES AT THE BLACK THUNDER MINE, CAMPBELL COUNTY, WYOMING[1]

by

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Abstract. Modified Truax native seed drills are used to plant 19-21 species of grasses, forbs and shrubs at the Black Thunder Mine. With a goal of enhancing species diversity and shrub establishment on reclaimed lands, a series of changes in seed mixes and seeding methods have been made over the past 12 years based on evaluation of interim revegetation monitoring data. Alternatives to conventional mulching practices also have been successfully used. Companion crops of annual grain planted along with perennial revegetation species have enhanced the quality of vegetation establishment and proven to be very cost effective in Black Thunder's semiarid climate. Grazing demonstrations (utilizing yearling steers) in conjunction with ongoing wildlife monitoring have documented that Black Thunder's reclaimed lands can sustain grazing pressure 2.4 times that of premined lands, and support the same land uses that existed prior to mining.

Additional Key Words: Revegetation, Seed Drill, Species Diversity, Shrub Establishment, Semiarid Climate, Grazing

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Introduction

Fifteen years have passed since the enactment of the Surface Mining Control and Reclamation Act (SMCRA) and the subsequent passage of commensurate state laws regulating surface mining and reclamation. In Wyoming, many were skeptical as to whether surface-mined lands could be successfully revegetated in a semiarid climate, where frequent droughts have encouraged more than a few farmers and ranchers to seek another line of work.

The ongoing reclamation of Wyoming's coal mines has challenged the revegetation specialist to develop cost-effective methods of establishing stable self-perpetuating rangeland vegetation capable of supporting the same land uses (support of domestic livestock and wildlife) that existed prior to mining. Since 1977, great strides have been made in the development of cost-effective revegetation technology. Thousands of hectares (ha) have been successfully reclaimed at Wyoming's surface coal mines utilizing various revegetation methods.

It is the intent of this publication to help further the science of restoration ecology by presenting a summary of the revegetation methods and successes at the Black Thunder Mine, the largest surface coal mine in the western hemisphere.

Study Area Description

The Black Thunder Mine operated by Thunder Basin Coal Company, is located approximately 85 kilometers south of Gillette, Campbell County, Wyoming. Elevation of the mine ranges from 1408 to 1477 meters, and the climate is semiarid and continental. Annual precipitation averages 31 centimeters, most of which occurs as rain from April through July with May being the peak month for precipitation. Premining vegetation is characterized by a mosaic of native rangeland plant communities, containing elements of both shortgrass and northern mixed prairie plant associations (Fisser et al, 1975). Specific plant communities are variously co-dominated by cool-season perennial grasses [e.g. western wheatgrass, (Pascopyrum smithii) and needle-and-thread grass, (Stipa comata)], warm-season perennial grasses [e.g. blue grama, (Bouteloua gracilis)] and shrubs [e.g. Wyoming big sagebrush, (Artemisia tridentata ssp. wyomingensis)]. The primary pre-mining uses of area rangelands involve grazing by cattle and sheep, and support of wildlife (most conspicuously pronghorn antelope and mule deer).

Revegetation Methods

Tillage

The revegetation process is initiated once the reclaimed surface has been constructed and topsoil replaced to an average depth of 45-60 centimeters. Topsoil salvage and replacement is conducted using scrapers, dozers, loaders and trucks. Topsoil is directly hauled from salvage areas to reclaimed surface in lieu of stockpiling whenever possible. All reclaimed surface is ripped prior to topsoil replacement. The typical seeding seasons are from March 1 - June 1 and October 1 - December 1 of each year. In the initial step of the

revegetation process, topsoil is tilled to a depth of 30-45 centimeters with a drawn 7 meter John Deere 1610 flex-wing chisel plow. This primary tillage implement is very efficient at breaking up soil that has been compacted during replacement activities. In topsoil that is extremely dry and compacted, the wings can be folded to their transport positions on top of the center section, and just the center section (5 meters) used for tillage. The wings add extra weight to the center section allowing it to penetrate the compacted soil.

The next step is final seedbed preparation. This is accomplished with a drawn 6.4 meter Farmhand flex-wing Ultra Mulcher 43 (roller harrow), with 48 centimeter heavy duty rollers and front and rear looped C-Tines. This secondary tillage implement breaks up the clods left from primary tillage operations and firms up the final seedbed.

Seeding

A model 12 Truax Native Seed Drill is used to seed 19-21 species of cool and warm season grasses, forbs and shrubs (Table 1). The seed drill has been modified to optimize the seeding of various seed types at appropriate seeding depths. The seed drill modifications along with adjustments to seeding rates have been made in a series of changes over several years, based on periodic evaluation of interim vegetation monitoring data with the goal of enhancing species diversity and shrub establishment.

Seed drill modifications include pulling the tubes from the small seed box out of the drill opener assemblies to allow broadcasting of small seed types; replacing the accordion tubes used to transmit fluffy seed types to the drill opener assemblies with long, straight tubes which broadcast the seed above the ground between the openers (to distribute the seed more evenly); attaching a 1.2 meter by 2.5 meter removable drag built from an English tine harrow to the back of the drill to cover broadcast seed; and removing the press wheels on the drill opener assemblies to allow the drag to move the seed around and diminish some of the "row" effect from the seed drill. These modifications result in essentially all species, except for the four different wheatgrasses, green needlegrass (Stipa viridula) and sainfoin (Onobrychis viciaefolia) (Table 1), being broadcast seeded by the drill and being covered by the drag. Fine shrub seed, such as big sagebrush and rubber rabbitbrush (Chrysothamnus nauseosus) are broadcast seeded from the drill on a second pass with the drag removed.

Mulching/Companion Crops

The standard practice for many years was to blow mulch on top of the seeded area at approximately 2,300 kg/ha and then crimp the straw into the soil to secure it. The main purpose of this practice was to control erosion prior to plant establishment and to help retain soil moisture. To avoid contamination from weed seeds contained in the mulch, grass straw was originally used from certified fields previously inspected by the County Weed and Pest for designated weeds, noxious species and pests. A primary concern became the durability, availability and cost of grass straw. A switch was then made to using barley or winter wheat straw from

TABLE 1

Permanent Upland Seed Mixture

Scientific Name	Season of Growth	Common Name		Kilograms Pure Live Seed Per Hectare
*Pascopyrum smithii (Rosana)	C	Western wheatgrass		1.7
*Elymus lanceolatus (Critana)	C	Thickspike wheatgrass		1.7
*Elymus lanceolatus (Sodar)	C	Thickspike wheatgrass		1.7
*Elymus trachycaulus (Pryor)	C	Slender wheatgrass		1.1
*Stipa viridula (Lodorm)	C	Green needlegrass		3.4
Oryzopsis hymenoides (Nezpar)	C	Indian ricegrass		3.9
Calamovilfa longifolia (Goshen)	W	Prairie sandreed		4.5
Bouteloua gracilis	W	Blue grama		2.2
Sporobolus cryptandrus	W	Sand dropseed		2.2
Sporobolus airoides	W	Alkali sacaton		2.2
Bouteloua curtipendula (Pierre)	W	Sideoats grama		3.9
Schizachyrium scoparium (Camper)	W	Little bluestem		2.2
Medicago sativa (Ladak)	C,W	Alfalfa		.8
Onobrychis viciaefolia (Eski)	C	Common Sainfoin		2.2
Astragalus cicer (Monarch)	W	Cicer milkvetch		1.1
Ratibida columnaris	W	Upright prairie coneflower		.8
Artemisia tridentata (Wyomingensis)	C	Big sagebrush	(5.6)	-
Chrysothamnus nauseosus	C	Rubber rabbitbrush	(5.6)	-
Atriplex canescens	W	Fourwing saltbush	(1.1)	.6
Atriplex gardneri	W	Gardner saltbush	(1.1)	.6
Ceratoides lanata	C	Common Winterfat	(1.1)	.6
			(50.1)	37.4

Cool-season species:warm-season species ratio 10:10

* Comprises the base mix used for all permanent and semipermanent seed mixes. 9-11 kg/ha of annual grain is added as a companion crop.

( ) Rates for permanent upland shrubland/grass sites.

C Cool-Season Species

W Warm-Season Species

certified fields. This source of mulch was substantially less expensive and proved to be more durable than the grass straw.

But there were still major concerns associated with the practice of mulching such as finding application times when wind conditions were appropriate, the cost of mulch and mulch application, and the difficulty of achieving a uniform application. There had to be a better mousetrap!

Attention then focused on revegetated topsoil stockpiles (semipermanent reclamation). The practice for several years had been to mulch only the areas susceptible to rill and gully erosion (slopes), and not mulch the top portions of the stockpiles. The 5.5 kg/ha of annual grain included in the seed mix had worked well in stabilizing the top portions of stockpiles until the perennial grasses were established.

The decision was then made to increase the seeding rate of the annual grain used as a companion crop from 5.5 to 11 kg/ha in the permanent seed mix. Areas susceptible to rill and gully erosion would be mulched at 2300 kg/ha. The companion crops would be mowed prior to maturity in early July to prevent reseeding and subsequent competition. The mowed material would provide a thin layer of mulch on top of the perennial seedlings for protection and also help retain soil moisture.

The use of companion crops of annual grain in lieu of mulching on permanent reclamation was initiated in 1988 and to date has yielded very positive results. Utilization of companion crops has resulted in the establishment of successful vegetation with a cost savings of 53% (Black Thunder Mine 1992 Annual Report). Observations from 1988-1992 indicate that companion crops are more successful when planted in the spring. Fall plantings are susceptible to wind erosion when dry soil conditions limit freezing of surface soils.

No Fertilization or Irrigation

Results from studies conducted at Black Thunder's sister mine (Coal Creek), 40 kilometers to the north, indicated that fertilization and irrigation are not necessary for revegetation success (Stoecker-Keammerer and Assoc., 1986). In fact, observations indicated fertilizers were more beneficial to annual forbs during the first growing season. A more successful approach was to allow these seeded species to establish under natural conditions over time.

Monitoring

Vegetation

Interim vegetation monitoring data have been collected periodically over the last 10 years. The purpose of the monitoring was to evaluate the results of various revegetation methods and to document vegetation trends. The vegetation data collection program consists of obtaining information about productivity, species composition, shrub density and vegetation canopy cover.

Table 2 compares vegetation data from reclaimed lands to vegetation data collected from native lands immediately adjacent to Black Thunder. This table

TABLE 2

1991 Vegetation Monitoring Data Comparing
Reclaimed Areas Seeded in 1988, 1989 and 1990
to Undisturbed Native Vegetation Types

	Mean Total Vegetation Cover (Percent)	Mean Production (kg/ha)	Mean Species Density Value (# Species/m^2)	Mean Shrub Density (# Shrubs/m^2)
Reclaimed Areas				
PR-S88-1 (grassland)	34.0	1832	6.4	.2
PR-F88-1 (grassland)	18.0	998	10.9	.3
PR-S89-3 (shrubland)	38.5	2813	6.7	2.9
PR-F89-1 (shrubland)	21.8	1124	15.6	6.1
PR-S90-1 (shrubland)	26.5	2257	13.4	12.8
Native Vegetation Types				
Mixed Grass Prairie	28.0	984	11.2	.5
Big Sagebrush Shrubland	31.4	559	13.6	2.1
Playa Grassland	23.2	1106	5.1	.02
Streamside Meadow	48.7	2324	8.4	.03

includes vegetation data collected on areas seeded in 1988, 1989 and 1990 and baseline vegetation data collected the same year on the adjacent West Black Thunder Coal Lease Tract (Stoecker-Keammerer and Assoc., 1991). It is interesting to note that reclaimed areas PR-S88-1 and PR-F88-1 were seeded in 1988, during one of the worst droughts in the last 10 years.

Wildlife

Wyoming is noted for its wildlife populations. Consequently, wildlife use is one of the designated postmining land uses. Wildlife studies have been conducted at the Black Thunder Mine since operations were initiated. Over the years, a wildlife monitoring program was developed that includes annual surveys for big game animals, raptors, waterfowl, sage grouse and migratory birds of high federal interest. Passerine surveys and small mammal trapping were added in recent years.

Wildlife monitoring conducted from 1983-1992 has documented use of Black Thunder's reclaimed lands by raptors, waterfowl, passerines, small mammals and big game (Postovit and Postovit, 1992).

Livestock Performance

One of the standards of reclamation success is demonstrating the ability of the reclaimed community to sustain grazing pressure at least equal to premining grazing pressure. In 1988, a two pasture rotational grazing demonstration was initiated (Moore, Keammerer and DePuit, 1989). Two fenced pastures, one 40 hectares in size and the other 34 hectares, were constructed on the oldest reclaimed areas at the Black Thunder Mine. The fenced pastures included areas that were reclaimed in 1981, 1982 and 1983. The site was drill seeded with a mixture of native and introduced cool and warm-season perennial grasses, forbs and shrubs. By 1988, the site had become dominated (approximately 71% composition) by the seeded cool-season native grasses, thickspike (Elymus lanceolatus), western and slender (E. trachycaulus) wheatgrasses. Crested wheatgrass (Agropyron cristatum), the only introduced grass species, was a co-dominant species at approximately 23% composition. The study design called for livestock (yearling steers) to be placed in one of the pastures the first part of May continuing until around July 15th or until a level of approximately 50% utilization of the forage had occurred. If 50% utilization had not been attained by July 15th, the cattle would still be moved to the other pasture, where they would remain until approximately October 1st. After the first of October, the cattle would be removed from the second pasture and sold. The sequence of early and late season use would be alternated between the two pastures among successive years of grazing. No dietary supplements other than salt blocks would be provided.

To date, the pastures have been grazed for five consecutive years (1988-1992) utilizing the previously described study design with 25-30 yearling steers. Forage utilization ranged from 50% to 85% in the pastures. This wide range of utilization is due to unpredictable droughts encountered during the 1988 and 1992 grazing seasons. The average stocking rate for the reclaimed pastures during the past five years was .9 ha/animal unit month (AUM). When compared to the average stocking rate of 2.2 ha/AUM on native rangelands adjacent to Black Thunder, the reclaimed pastures sustained grazing pressure 2.4 times that of adjacent native rangeland. Weight gain responses were excellent with the steers averaging .86

kilograms/animal/day during the five-year period. A summary of livestock weight responses from 1988-1992 is presented in Table 3.

Summary and Conclusions

The revegetation methods developed over the last 12 years at the Black Thunder Mine have demonstrated proven success. Seeding utilizing modified Truax Native Seed Drills have established vegetation on reclaimed lands capable of supporting the same land uses that existed prior to mining. Companion crops of annual grain have been successfully used as an alternative to mulching. Continuing wildlife studies have documented extensive use of reclaimed lands by raptors, passerines, waterfowl, small mammals and big game. Results over 5 years of livestock grazing have shown that reclaimed lands can sustain grazing pressure 2.4 times that of premined lands while supporting excellent livestock weight gains averaging .86 kg/animal/day.

TABLE 3

Comparison of 1988, 1989, 1990, 1991 and 1992 Livestock Weight Responses

Grazing Period	Year	Duration (Days)	Beginning Average Weight	Ending Average Weight	Total Gain/ Animal	Average/Gain/ Animal/Day
			kg			
May 17 - September 26	1988	131	231	340	109	.83
May 22 - September 27	1989	127	231	356	125	.98
May 2 - October 14	1990	165	301	433	132	.81
April 28 - October 2	1991	157	271	399	128	.82
May 6 - September 16	1992	133	243	356	114	.86

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