

**REGULATORY DIRECTIVES AND RECLAMATION
STRATEGIES IN THE DEVELOPMENT OF ECOLOGICALLY
DIVERSE POST-MINED LANDSCAPES**

by

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Abstract. The Surface Mining Control and Reclamation Act (SMCRA) requires that a reclamation plan provides for "a detailed description of how the proposed post-mining land use is to be achieved by the operator and the necessary support activities which may be needed to achieve the proposed land use" and that "the operation... restore the land affected to a condition capable of supporting the uses which it was capable of supporting prior to any mining, or higher or better uses...." The primary pre-mining land uses in the southeastern portion of Montana are wildlife habitat and domestic livestock grazing. These land uses encompass a wide range of land types (riparian zones, grassland, sagebrush steppe and pine forest) which are the focus in developing reclamation plans for lands disturbed by coal mining activities. In complying with the directives set forth in SMCRA, the State of Montana is working to develop reclamation strategies to create diverse, stable and ecologically sound post-mine landscapes that will support pre-mining land uses. Strategies discussed include: creation of topographically and ecologically diverse post-mined landscapes, riparian and wetland restoration and creation, and selective soil and spoil handling procedures for the establishment of discrete plant communities.

Additional Key Words: pre-mine topography, niche, restoration, rangeland

Introduction

Early surface coal mining operations focused solely on mineral extraction. Limited or no attention was given to the mitigation of environmental impacts during mining and the reclamation of disturbed sites following mining operations. Minimization of impacts to

environmental resources became mandatory following the enactment of federal legislation, such as the National Environmental Policy Act (NEPA) of 1969, the Environmental Quality Improvement Act of 1970, the Surface Mining Control and Reclamation Act (SMCRA) of 1977, and independent state legislation that equalled or in some cases exceeded the requirements of federal legislation (Bowling 1978). The State of Montana enacted legislation in 1973 governing coal mining [The Montana Strip and Underground Mine Reclamation Act (MSUMRA)] prior to the 1977 enactment of SMCRA. The principle intent of the Federal and State acts is to protect the environment while allowing mining to take place. This protection, with regard to coal mining, is facilitated by requiring post-mine restoration of a self-sustaining ecosystem comparable to

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that which was present in the pre-mine environment (Doll 1988).

Federal reclamation standards set forth by sections 508(a)(4) and 515(b)(2) of SMCRA require that the reclamation plan provides for "a detailed description of how the proposed postmining land use is to be achieved by the operator and the necessary support activities which may be needed to achieve the postmined land use" and that "the operation... restore the land affected to a condition capable of supporting the uses which it was capable of supporting prior to any mining, or higher or better uses...." [Federal Register 48(172):40140. September 2, 1983]. Montana reclamation standards in MSUMRA require that "As rapidly, completely, and effectively as the most modern technology and the most advanced state of the art will allow, each operator ... shall reclaim and revegetate the land affected by his operation ..." (82-4-231(1)), Montana Codes Annotated (MCA), in accordance with plans approved in the permit. In addition, "... the operator shall prepare the soil and ... establish on the [disturbed area] a diverse, effective, and permanent vegetative cover of the same seasonal variety native to the area of land to be affected ..." (82-4-233(1)), MCA. Moreover, "to the extent possible using the best technology currently available, [the operator must] minimize disturbance and adverse impacts on fish, wildlife, and related environmental values and achieve enhancement of such resources where practicable ..." (82-4-231(10)(j)), (MCA).

The majority of land permitted for surface coal mining activities in Montana is classified as semi-arid rangeland. The principle pre-mining land uses of rangeland in Montana are wildlife habitat and domestic livestock grazing. Habitat types which support these land uses include riparian zones, grassland, sagebrush steppe and pine forest. Traditional reclamation practices have generally fallen short of creating the biophysical diversity required to support such a wide range of habitat types in the post-mined landscape (Allaire 1979, Tyus and Lockhart 1979, Harju 1980, Karr 1980, Steele and Grant 1982). Therefore, the State of Montana is continually working to develop innovative reclamation

strategies which enhance post-mined biological diversity and restore the ecological character of the pre-mined landscape to comply with the full intent of SMCRA and MSUMRA.

The objectives of this paper are to discuss innovative reclamation practices based on fundamental ecological principles that are currently used or proposed in Montana. These practices include: creation of topographically diverse post-mined landscapes, riparian and wetland restoration and creation, and selective soil and spoil handling procedures for the establishment of discrete plant communities.

Discussion

Post-mined Topography

Complex topography is common in the pre-mine landscape of Montana's rangeland. The natural variability of pre-mine topography provides a variety of habitats which support a wide array of flora and fauna. Current reclamation practices often permanently reduce or eliminate pre-mine topographic diversity (Steele and Grant 1982). In an attempt to restore complex pre-mine topographic, vegetative and wildlife diversity to the post-mine landscape, the Montana Department of State Lands (MDSL) is allowing for or proposing a variety of innovative reclamation strategies and techniques.

Bluff Extensions/Creation. These features are portions of final pit highwalls designed to blend with and expand desirable undisturbed topographic features. They are intended to preserve natural bluffs at the final highwall or replace those eliminated by mining, thus, creating an environment which closely represents pre-mining conditions in areas where feasible. Bluff extensions/creation substantially reduce the need for disturbance of native plant communities and related habitats by precluding highwall reduction.

The legal authority providing for bluff extensions/creation as an alternative to complete highwall elimination in Montana emanates from section 82-4-232(7) of MSUMRA. This section states, in part: "An operator may propose alternative plans other

than backfilling, grading, highwall reduction, topsoiling.... if the restoration will be consistent with the purpose of [MSUMRA]...." The MDSL rules which have been adopted pursuant to this provision of the law state that alternatives to highwall reduction may be allowed where the MDSL determines that: "(a) [the alternatives] are compatible with the proposed postmining land use; (b) they are stable, achieving a minimum static safety factor of 1.3; and (c) they are in compliance with the applicable portions of [other rules including protecting public health and safety and the environment, monitoring as necessary, and certain administrative review procedures]" [Administrative Rules of Montana (ARM) 26.4.515(2)].

The major benefits of bluff extensions/creation include 1) enhanced topographic diversity, 2) creation of diverse habitat for select plant and animal species both on the face and at the base of the bluff, 3) provision of nesting sites for wildlife and 4) thermal variability and cover for wildlife and livestock. In some cases creation of bluffs provides post-mine islands of natural landscape that are surrounded by more artificial (low in structural diversity) reclaimed areas. These islands contribute to an aesthetically pleasing post-mine landscape which supports native plant and animal communities and may act as a source of propagules for dispersal to adjacent reclaimed lands.

Native tree and shrub communities are required by wildlife and livestock for forage and cover. However, tree and shrub community types have been difficult to establish and maintain in Montana using accepted reclamation strategies (slopes < 5:1, use of homogeneous soils, and limited hydrologic variability). Successful shrub establishment on reclaimed areas is often limited by unpredictable and unreliable reproduction response (Redente and Deput 1988). Pulses of favorable environmental conditions and seeds with inherently variable difficult-to-meet germination requirements further confound the reproduction process (Romney et al. 1989, Young et al. 1983).

Exacting establishment requirements exhibited by select tree and shrub species may be exacerbated by a lack of

natural complex topographic and edaphic diversity in the reclaimed landscape. Factors further limiting establishment include: adverse environmental conditions; damage from herbivory by livestock, wildlife and insects; animal trampling; and frost heaving; and damage from various disease organisms (Medin and Ferguson 1972).

The use of bluff extensions/creation has provided a variety of planting environments which more closely resemble the pre-mine tree and shrub topographic and edaphic environment. These features may potentially increase the probability of establishment, survival and regeneration of plant species with exacting environmental and habitat requirements.

Bluff extensions/creation have also allowed for the economic recovery of coal resources underlying thick overburden. Bluff extensions/creation have successfully been incorporated into the reclamation plans at the Peabody Coal Company (PCC) Big Sky Mine and Western Energy Company (WECO) Rosebud Mine in Montana.

Hill, Ridge and Breaks Reclamation. Many important pre-mine plant communities and animal habitats occur on areas with pronounced topographic relief (slopes $\geq 1.5:1$). The environmental characteristics of natural hill, ridge and breaks habitat in Montana include largely undeveloped soils, drastic topographic relief and variable vegetation community types. These types generally consist of sites with little vegetative cover and high floral and faunal diversity.

Increases in the survival of native seeded plant species and enhancement of faunal composition have occurred in areas of unreclaimed spoils in comparison to reclaimed sites (Kimmel and Samuel 1980, and Steele and Grant 1982). Increases in woody plant survival have been attributed to diversity in unreclaimed post-mined topography, steep slopes, variability of soil quality, changes in hydrology, and encouraged colonization by native and seeded plant species (Allaire 1979, and Harju 1980, Lang 1985, Thompson et al. 1986). Similar field observations have been made by MDSL on pre-law Northern Pacific spoils at WECO's Rosebud Mine at Colstrip and other unreclaimed spoil sites in Montana.

Based on literature, MDSL observations and current regulation requirements, WECO has proposed an initial demonstration project. The project if implemented would consist of retaining a portion of two cast, physically and chemically suitable spoil ridges with slopes up to 1.5:1. The demonstration site would be seeded and planted with native tree and shrub species. This reclamation type is intended to replace disturbed pre-mine hill, ridge and breaks habitat. Currently other coal mines in Montana are in pursuit of similar reclamation projects.

The legal basis for allowing hill, ridge and breaks reclamation strategies is derived from the same section which allows for bluff extensions/creation, section 82-4-232(7) of MSUMRA. However, the Office of Surface Mining Reclamation and Enforcement (OSM) has indicated that federal law (SMCRA) does not allow for ungraded spoils as a reclaimed feature except under the provision for experimental practices. Therefore, the future of hill, ridge, and breaks reclamation types and related variants thereof (involving minimal grading) is currently uncertain.

Additional concerns regarding hill, ridge and breaks reclamation include the stability of steep-sloped ungraded spoils and potential high rates of erosion. Preliminary results of a geotechnical study of the ungraded slope stability conducted on the WECO demonstration area indicate that these spoils meet the minimum static safety factor level of 1.3 (relating to mass stability) required by the Administrative Rules of Montana (ARM 26.4.501A). The Montana Strip and Underground Mine Reclamation Act only requires that WECO's demonstration exhibit erosion rates no greater than the pre-mining habitat counterpart.

Benefits of hill, ridge and breaks reclamation are similar to advantages of bluff extensions/creation. These features can provide topographic and edaphic diversity, variation in moisture regimes and development of independent microsites more representative of the pre-mine environment.

Wildlife density, diversity and presence on mine spoils is related to

the structural diversity and heterogeneity of the vegetative composition (Elliott 1989, Parmenter et. al. 1985). Deciduous and coniferous tree and shrub species provide important hiding and thermal cover for a variety of wildlife which depend on well developed habitat (structurally diverse) for reproduction and foraging (Frischnecht 1978). Wildlife sightings of species not typically associated with reclamation have been reported in the demonstration area at WECO's Rosebud Mine. Species reported include the Wyoming pocket mouse (Perognathus fasciatus), red fox (Vulpes fulva) and lark sparrow (Chondestes grammacus) (nesting documented).

Riparian and Wetland Restoration and Creation

Sub-section 26.4.751(2)(g) of the Administrative Rules of Montana requires the operator to "restore ... or avoid disturbance to natural riparian vegetation on the banks of streams, lakes, ponds, and other wetland areas...." Sediment ponds, final pit impoundments, spring developments and well/stock tank overflow areas are all means by which mine operators can restore or create water features and associated vegetation. A complex of wetland features ranging from shallow temporary pools to deeper permanent water ponds greatly add diversity to the available habitat and subsequently increase the diversity of wildlife species (Bultsma, 1991). Most surface mine impoundments in the northern Great Plains contain water suitable for use as drinking water for wildlife and livestock (Rumble 1989).

Compliance with existing regulations has resulted in several innovative practices to restore riparian/wetland sites on surface coal mines in Montana. Western Energy Company has enhanced two temporary (potentially permanent) sediment ponds as aquatic habitat and, in response to an MDSL requirement, has submitted a plan for retention of a 9-acre final pit impoundment blended with the surrounding landscape on the Rosebud Mine. Aquatic and semi-aquatic plant species have been planted around the perimeter of the sediment ponds to enhance their utility for waterfowl. Species reported using these ponds include: mallard (Anas platyrhynchos), blue-winged teal (Anas discors),

American coot (Fulica americana), great blue heron (Ardea herodias), pintail (Anas acuta), gadwall (Anas strepera), northern shovelers (Anas clypeata), canada geese (Branta canadensis moffitti), osprey (Pandion haliaetus), white pelican (Pelecanus erythr-orhynchos), peregrine falcon (Falco peregrinus), and a snow goose (Chen caerulescens) (Western Energy Co. 1980-1990). It is anticipated that the proposed final pit impoundment will provide similar habitat enhancement.

Retention of final pit impoundments has also occurred at PCC's Big Sky Mine and Knife River Coal Company's Savage Mine middle impoundment. Neither area has been planted with aquatic or semi-aquatic plant species. However, over time the banks of both impoundments have become partially vegetated with aquatic and semi-aquatic plant species and serve as valuable wildlife habitat. Impoundment water quality at PCC's Big Sky Mine has been documented as being sufficient for wildlife and livestock use and is considered to be superior to adjacent groundwater (Goering and Dollhopf 1982).

Enhancement of sediment ponds and development of natural springs are practices currently proposed at the PCC's Big Sky Mine. Peabody Coal Company is also proposing to replace wells removed by mining with new wells and associated overflow areas developed (planted and fenced to exclude livestock) for wildlife enhancement.

Selective Soils and Spoils Handling

The MDSL has promoted the use of selectively handled soils and regraded spoils which may enhance infiltration and permeability, and assist establishment, regeneration and long-term maintenance of tree and shrub stands on reclaimed sites in Montana. Sandy and skeletal soils are being selectively handled for use as tree and shrub planting media on upland sites. Regraded spoil with a high sand and/or rock fragment content is also considered suitable material for direct planting of certain tree and shrub species.

Spring Creek Coal Company, at the request of MDSL, has initiated special handling of alluvial and colluvial soil materials for use in a major drainage channel reconstruction. Selective

salvage and distribution of alluvial and colluvial soils may aid in the re-establishment of riparian vegetation.

In the semi-arid environment of southeastern Montana, water is the primary limiting factor to establishment of vegetation on reclaimed lands (Verma and Thames 1978). Infiltration and percolation rates are generally enhanced in sandy and rocky soil and spoil material (Munn et al. 1987). Increased infiltration results in decreased evaporation potentials in the upper portion of soil or spoil and enhanced water availability deeper in the reconstructed plant root profile (Sabey et al. 1987). Deeper penetration of water into the soil profile may favor woody plants with deeper rooting habits. Decreased moisture content in the surface of the reconstructed soil profile may reduce competition from volunteer (annual and perennial) herbaceous plants for limited moisture and nutrient reserves. Placement of sandy and/or rocky soils on steeper reclaimed slopes planted to trees and shrubs also reduces erosion because of increased infiltration and decreased surface runoff (USDA 1977, McCormack et al. 1984).

Selective Soil Handling. The results of a soil/vegetation correlation study conducted by WECO at the Rosebud Mine indicated that ponderosa pine (Pinus ponderosa Laws.), skunkbush sumac (Rhus trilobata Nutt.), and hill, ridge and break shrub communities are associated with sandy soils containing a high percentage of coarse fragments (Lang 1985). Based on this information and baseline soil survey data for the Rosebud Mine, the MDSL required WECO to selectively handle tree and shrub soils (Table I). These soils are neutral to alkaline in reaction, low in soluble salts, high in sand and/or coarse fragment content, and had high infiltration and percolation rates (Table I). Western Energy Company is salvaging a single 60-cm lift of the "tree soils" and re-spreading these materials to a 60-cm thickness on areas designated for ponderosa pine and skunkbush sumac planting.

Selective soil handling at the Absaloka Mine operated by Westmoreland Resources, Inc. (WRI) consists of salvaging clinker⁷-derived soil

Table I. Physical properties of ponderosa pine and skunkbush sumac soils of the Rosebud Mine, Colstrip, Montana.

Soils	Horizon	Sand(%)		Clay(%)		Coarse Fragments(%)	
		Mean	Standard Deviation	Mean	Standard Deviation	Mean	Range
Armells	A	59.7	17.9	11.9	9.1	30	0
	C	59.1	14.2	9.3	6.4	55	30 - 75
Birney	A	50.1	8.3	12.5	3.9	26	20 - 35
	B	47.5	16.1	14.9	5.4	42	35 - 60
	C	51.7	9.5	10.1	5.0	49	20 - 80
Busby	A	73.7	7.6	8.9	3.1	*	*
	B	70.8	8.8	9.2	2.9	*	*
	C	71.4	7.5	10.2	2.9	*	*
Cabbart	A	37.3	13.6	22.9	10.6	5	0 - 10
	C	30.6	16.9	24.6	10.0	17	10 - 40
Kirby	A	51.0	8.2	9.9	5.1	40	25 - 80
	C	54.1	13.3	9.4	4.7	64	35 - 85

Data provided by Western Energy Company, Colstrip, Montana.

* Data not available.

material (Wibaux channery loam > 35% coarse fragments) or sandy subsoil material (Nelson and Alice fine sandy loams) to provide desirable tree and shrub planting media. Wibaux soil is salvaged to a 46-cm depth and re-spread as first lift material to a 30 cm thickness over 30 cm of sandy subsoil. A total of 60 cm of sandy B horizon material (> 60% sand) from the Nelson and Alice soil mapping units are salvaged and re-spread to a 60 cm thickness. These soils are generally re-spread on north and south-facing re-contoured slopes for planned ponderosa pine and skunkbush sumac plantings.

The Spring Creek Coal Mine of Spring Creek Coal Company is separately salvaging alluvial and colluvial soils in association with a large ephemeral drainage. These soils will be used to reconstruct the ephemeral drainage following mining. Alluvial and colluvial soils from drainage and terrace sites sampled at 71 locations on 30 m centers yielded mean saturation percentage and particle size distribution values (Table II). These soils and subsoils are neutral to slightly alkaline in reaction, low in soluble salts, loamy in texture, have a relatively high sand content and are expected to have high infiltration and percolation rates. These soil properties may potentially enhance the establishment of tree and mixed shrub species associated with riparian

habitat. In addition, selectively handled alluvial and colluvial soils may retain native plant propagules in the upper portions of the topsoil stockpile (Johnson and West 1989, Iverson and Wali 1982). The extent of propagule survival will be dependent on soil stockpile shape, size, duration of soil storage and type of propagules present.

These soils will continue to be salvaged in separate lifts (as are most soils) which consist of 15 cm of topsoil (A and sometimes B or C horizon material) and variable subsoil thickness (1.2 - 1.5 m) depending on location. The soils are stockpiled separately by lift and will be redistributed to a 1.2 m thickness (15 cm topsoil and 1.1 m subsoil) within the regraded drainage channel.

The Use of Suitable Regraded Spoil.

In 1990, the MDSL approved a soil substitution plan for WRI's Absaloka Mine. This plan consists of direct planting of ponderosa pine, Rocky Mountain juniper (*Juniperus scopulorum* Sarg.), and skunkbush sumac seedlings directly into 3.6 ha of regraded spoil. Spoil material was sampled to a 1.2 m depth to determine the chemical and physical suitability of the material. The spoils were chemically suitable (electrical conductivity <8 mmhos/cm and sodium adsorption ratio <20), coarse in texture, and contained a high percentage of rock fragments. A major portion of the spoil material was derived from clinker overburden and large rocks were brought to the

⁷Clinker is a general term applied to rock that has been thermally altered by the burning of coal seams (Woessner et al. 1978)

Table II. Physical soil characteristics of alluvial and colluvial soils at the Spring Creek Mine.

Horizon	Saturation (%)		Sand (%)		Silt (%)		Clay (%)	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Topsoil	46.6	6.4	36.6	12.4	42.7	9.3	20.7	6.2
Subsoil	41.5	5.0	44.2	9.7	35.7	6.8	20.0	3.8

Derived by MDSL from data provided by Spring Creek Coal Company Decker, Montana.

regraded surface during spoils grading.

Results of spoil sampling and field analysis by MDSL indicated that the regraded spoil material would have high infiltration and percolation rates and serve as a suitable planting medium for establishment of ponderosa pine and Rocky Mountain juniper and related plant communities.

Conclusion

Research efforts have defined a wide range of important ecological relationships that are critical to the restoration of a functional and stable ecosystem in the post-mine landscape. Recognition and application of fundamental ecological principles and planned interactions between topography, soils, vegetation, wildlife and livestock will be required to develop reclamation plans that will achieve the ecological balance in the post-mined landscape of Montana as required by SMCRA and MSUMRA. Bluff extensions/creation, hill, ridge and break reclamation, water source enhancement, selective soils and spoils handling procedures and discrete and opportunistic vegetation plantings are necessary to support a biophysically diverse post-mine environment capable of supporting the pre-mine land uses in Montana.

State and federal regulatory authorities and the coal industry should strive for permitting and implementation of innovative reclamation strategies that promote a post-mined environment which preserves and/or enhances pre-mine environmental function and stability. In order to foster future advancement in restoration technology, a closer evaluation of SMCRA and MSUMRA based on fundamental ecological principles will be required. The legal environment in Montana provides some flexibility in interpretation, such that

implementation of creative approaches to establishing a diverse and productive post-mine environment is possible. These approaches 1) will better ensure compliance with SMCRA and MSUMRA, 2) will enhance the utility of the post-mined landscape and 3) may generate a wider acceptance of the results of surface and underground coal mine reclamation efforts by the public and private environmental organizations.

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