A FIELD SURVEY OF RECLAMATION PRACTICES IN THE OVERTHRUST BELT[1]

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Abstract--Reclamation efforts were evaluated on numerous sites in the Overthrust Belt region. Water management was the most common problem observed. Slope steepness greatly affected erosion but reclamation on very steep slopes was possible, providing proper reclamation procedures were used. Natural recolonization was slow onto disturbed sites but could be enhanced by altering revegetation techniques. Mulching and topsoil salvage provided significant benefits to vegetation establishment and erosion control. Overgrazing and weeds were problems on many reclaimed sites.

INTRODUCTION

A field investigation was conducted at oil and gas disturbances located along the Bear River Divide and adjacent areas in the Overthrust Belt Region to determine the most common reclamation problems and to identify successful and unsuccessful reclamation practices. This information was used to develop guidelines for future reclamation efforts in the area. This study was part of the Cooperative Wildlife Program directed by the Overthrust Industrial Association and was funded by Chevron, USA.

METHODS

The study area encompassed disturbances located in Uinta and Lincoln Counties in Wyoming, Rich and Summit Counties in Utah and Bear Lake County in Idaho. The majority of sites were located in Wyoming since it had received the greatest development. Approximately 13 percent of the sites were located in Utah and 5 percent were located in Idaho. A total of 101 sites were sampled. Site selection was subjectively made to encompass a wide range of environmental conditions and reclamation practices. Types of disturbances included well sites, roads, and pipelines.

Descriptive information was collected at each site regarding location, elevation, types and extent of the disturbance, topography, land use ownership status, adjacent vegetation types and dominant species, and special concerns or problems. One to several subsites within a site were sampled that appeared to be characteristic of the environmental conditions and reclamation practices used at the site. A total of 176 subsites were sampled. The extent of erosion occurring on each subsite was determined through a modification of "Erosion Condition Classification" developed by the Bureau of Land Management (Clark 1980). Categories of litter, pedestalling, rills (<9" deep) and gullies (>9" deep) were assigned a numerical score ranging from 1 to 5 with 1 representing no visual effect and 5 representing extreme effects. The four categories were summed for each subsite to generate an erosion condition class for that subsite. Other physiographic factors influencing erosion were recorded including slope steepness, slope length and surface soil texture. Slope steepness was measured with a hand-held clinometer, slope length was estimated visually, and soil texture was classified into texture classes using field estimation procedures. Vegetation cover, cover of perennial species, and cover of litter, rock and bare ground were visually estimated. Aspect was measured with a compass and later converted to reflect solar radiation and effective moisture using a formula reported by Beers, Dress and Wensel (1966). Each site was thoroughly searched to identify species, both seeded and nonseeded that occurred on the site. Each species was rated for relative abundance using a modified Daubenmire classification (Daubenmire, 1954). Relative abundance is the percentage of the absolute cover that is contributed by the cover of the species of interest. The categories were: abundant (over 25%), common (5-25%), uncommon (1-5%) and rare (under 1%).

All data were transferred to magnetic disk storage for analysis by a Univac 1100 computer.

[1]Paper presented at the national meeting of the American Society for Surface Mining and Reclamation. [Denver, Colorado, October 8-10, 1985].

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Proceedings America Society of Mining and Reclamation, 1985 pp 190-195
DOI: 10.21000/JASMR85010190

https://doi.org/10.21000/JASMR85010190

Statistical summaries and analyses were analyzed using SPSS programs (Nie et al., 1978).

RESULTS AND DISCUSSION

Disturbances sampled occurred in seven different vegetation types. The sagebrush type was the most commonly disturbed vegetation type (53%), followed by pinyon-juniper (15%), grassland (11%), mixed-shrub (11%) conifer (5%), aspen (3%), and shadscale (1%). These percentages appear to reflect the overall distribution of oil and gas related disturbances along this portion of the overthrust belt. The most common woody species adjacent to disturbances included big sagebrush (*Artemisia tridentata*) on 76% of the sites, Douglas rabbitbrush (*Chrysothamnus viscidiflorus*) (75%), snowberry (*Symphoricarpos oreophilus*) (41%), serviceberry (*Amelanchier alnifolia*) (31%) and black sagebrush (*Artemisia nova*) (30%). Commonly occurring grasses on adjacent undisturbed areas were western wheatgrass (*Agropyron smithii*) (53%), bluebunch wheatgrass (*Agropyron spicatum*) (17%), bluegrass (*Poa* sp.) (34%), needlegrass (*Stipa columbiana*) (17%) and Indian ricegrass (*Oryzopsis hymenoides*) (16%). The most common forbs adjacent to disturbed areas included aster (*Aster* sp.) (44%), wild buckwheat (*Eriogonum* sp.) (42%), yarrow (*Achillea millefolium*) (41%), lupine (*Lupinus caudatus*) (19%), and arrowleaf balsamroot (*Balsamorhiza sagittata*) (16%).

Erosion Evaluation

The erosion condition classification was used as a dependent variable in a stepwise multiple regression analysis to determine the factors most influential in determining the erosion condition classification. Slope accounted for 48% of the variability in the erosion condition (fig. 1) and had a highly significant positive correlation ($r=.70$, $p< .01$). Other factors contributing significantly to the model ($p<.05$) included rock cover, vegetation cover and silts in the soil (all negatively correlated relationships). The amount of variability that was accounted for by all four factors increased to 57% ($r^2 = .57$).

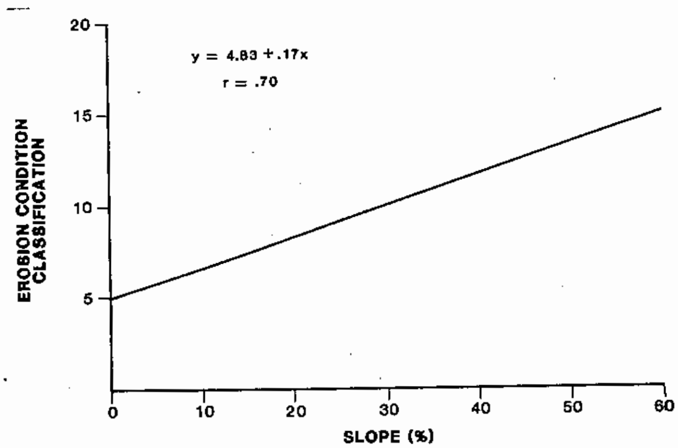

Figure 1.--A linear regression comparing the erosion condition class against slope

Slope obviously has a major impact on erosion, particularly if the soil is exposed with little vegetative or mulch cover. In order to break down the effect of slope on erosion, slope was divided into six categories: (1) 0-10%; (2) 11-20%; (3) 21-30%; (4) 31-40%; (5) 41-50%; and (6) >50%. The erosion condition classification values were lumped into five descriptive categories similar to that proposed by Clark (1980) and shown in table 1.

Table 1.--The number of subsites categorized by slope and erosion condition class.

Erosion Class[1]	Slope % 0-10	11-20	21-30	31-40	41-50	>50	Total
Stable	34	6	0	0	0	0	40
Slight	20	18	8	5	3	0	54
Moderate	5	8	10	6	1	1	31
Critical	0	3	9	6	3	4	25
Severe	0	0	0	1	0	2	3
Total	59	35	27	18	7	7	

[1]Erosion condition classification values. 0-4.0=stable, 4.1-8.0=slight, 8.1-12.0=moderate, 12.1-16.0=critical, 16.1-20.0=severe.

An analysis of variance indicated that there was a significant difference in the erosion classification value for the different levels of slope classification ($p< .01$). Average erosion on slopes ranging from 0-10% and 11-20% was rated as slight while steeper slopes were rated as moderate. Table 1 displays the number of occurrences of each erosion class for each slope class. Ninety percent of the slopes ranging from 0-10% had erosion rated as stable or slight while erosion on 68% of the slopes ranging from 11-20% was rated as stable or slight. Seventy percent of slopes ranging from 21-30% had erosion classified as moderate to critical while slopes ranging from 31-40% had 72% of their sites rated as moderate to severe. Slopes ranging from 41-50% had 43% of their sites classified as critical to severe. Slopes steeper than 40% comprised only 9% of the sites.

Although steep slopes should be avoided or minimized where possible, proper reclamation procedures can greatly decrease the amount of erosion that typically takes place (fig. 2). Slopes at two plant sites were good examples of proper erosion control when steep slopes are unavoidable. These slopes ranged from 31% to 70% and erosion was classified as stable to slight. These sites were topsoiled, seeded and mulched with steeper areas netted to keep the mulch in place. Water control methods were effectively used to divert water around or down the slopes. These sites had significantly lower erosion condition ratings and higher vegetative cover than other reclaimed slopes. Vegetation cover and litter cover also significantly affected erosion.

Problems with proper water control were the most common problems evidenced in the area. These included: (1) surface flow from the pad running over fill slopes; (2) improper water control

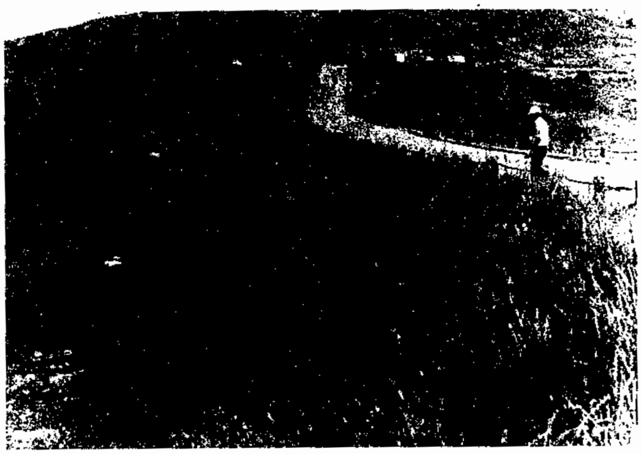

Figure 2.--Successful steep slope revegetation after two growing seasons using topsoil, mulch, netting, diversion dikes, and an adapted seed mix.

techniques, such as using terraces where contour furrows would have been sufficient; (3) improper construction of water bars or terraces, such as poor drainage, too shallow, draining too steeply, steep backslopes on terraces, not placed on contour, and not draining to stable ground; and (4) lack of interceptor ditches to divert runoff from slopes above the disturbance.

Water control problems, if not corrected, can result in severe erosion and can jeopardize the stability of a site. Proper erosion control during planning and construction can minimize expensive maintenance costs which may require remobilization of heavy equipment.

Recovery Rate

The rate of recovery (vegetative reestablishment) was dependent on a number of factors both natural, such as precipitation, and man induced, such as seeding, mulching, netting, etc. The most important variable in predicting perennial cover was age, as determined by stepwise multiple regression ($r=.55$, $p<.01$). Age was transformed by a log transformation which produced a better fit. The transformation makes intuitive sense because the amount of vegetation cover levels out as sites get older. The second variable that was identified in the regression analysis was silt content of the soil ($p< .01$). The higher the silt content, the higher the vegetation cover. The better soils aided vegetation establishment. The next variable was slope ($p<.01$) of the site with more gentle slopes having greater perennial cover. With these variables in the regression equation, 43% of the total variability was accounted for. The 57% of the variability unaccounted for was due to factors that were not included in the analyses such as mulching, site preparation, seed mix, precipitation in the year of seeding etc.

A simple regression between age and perennial cover is shown in figure 3. It shows that in three years the average cover of a site would be 19% and in ten years the cover would be 31%. This

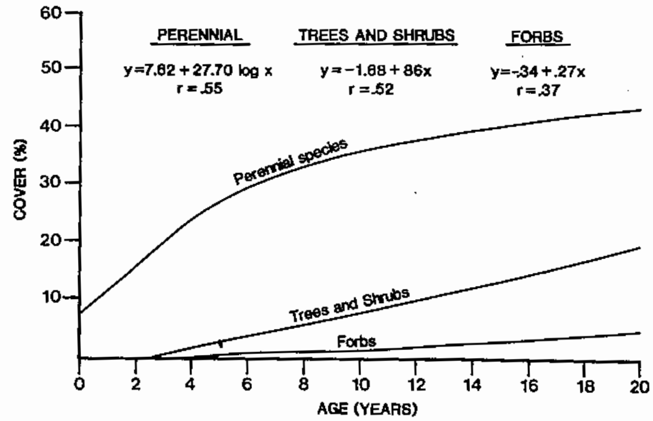

Figure 3.--Regression lines showing vegetation establishment for tree and shrub, forb and total perennial vegetation cover.

rate of recovery is fairly slow and less than what can be achieved using proper revegetation procedures under adequate precipitation levels (fig. 4). On several recently revegetated sites, cover has ranged from 35-70% after only two years.

Seeded species represented nine of the top ten most common perennial species occurring on the disturbed sites. The most common species was crested wheatgrass which occurred on 63% of the sites. Wheatgrasses comprised 4 of the top 5 species and 6 of the 10 most common species. There was one shrub, big sagebrush, represented in the 10 most common species. This species occurred on 43% of the sites. Likewise there was only one forb, alfalfa, among the 10 most common species which occurred on 24% of the sites. Smooth brome and foxtail barley were the only two non-wheatgrass grasses that were in the top 10. Numerous other species were included in seed mixes but they were present on only a very few sites.

The major species that were not seeded but have colonized naturally were: big sagebrush, occurring on 43% of the subsites; Douglas rabbitbrush and yarrow (Achillea millefolium), both 17%; rubber rabbitbrush (Chrysothamnus nauseosus), 12%; aster

Figure 4.--Vegetation reestablishment on a 20-year-old site. Limited success was attributed to lack of topsoil.

(Aster sp.) and snowberry (Symphoricarpos oreophilus), both 11%; locoweed (Astragalus spp.) and bluebunch wheatgrass (Agropyron spicatum), both 7%; and penstemon (Penstemon spp.), 6%. Many more occurred on less than 10 of the 176 total sites.

Natural recolonization appeared to be a slow process but did occur on many of the older sites. Sites with minimal topsoil disturbance had greater invasion of nonplanted species. Areas along pipelines that were only bladed and were not extensively disturbed had much greater invasion especaially from rhizomatous and sprouting plant parts. Portions of drill sites that were only scraped also had rapid reinvasion.

An interesting technique that increased shrub recolonization evolved from the use of water bars. The water bars were often not seeded, particularly if the site was drill seeded, as generally the drill would be pulled more or less on contour which was also parallel to the water bars. The water bar would be skipped because of the uneveness in the terrain leaving a strip several feet wide that was not seeded to the conventional grass dominated mixture. In other cases, water bars would be cut into already established vegetation. Shrub invasion was accelerated along waterbars, mainly because of the decreased competition from the grasses (fig. 5). The approach of leaving unseeded strips was purposefully implemented at one site. Perennial vegetation cover on a 4-year-old site was lower on the nonseeded strips (5-12%) than on the seeded strips (25-27%) but forb and shrub cover were greater on nonseeded strips (4-10%) than on seeded strips (< 0.3%). Species richness was also greater on nonseeded areas (9.5 species) than on seeded areas (5.5 species). Although these strips do encourage invasion, they should be kept narrow because of the lower amount of cover and consequently, greater potential for erosion.

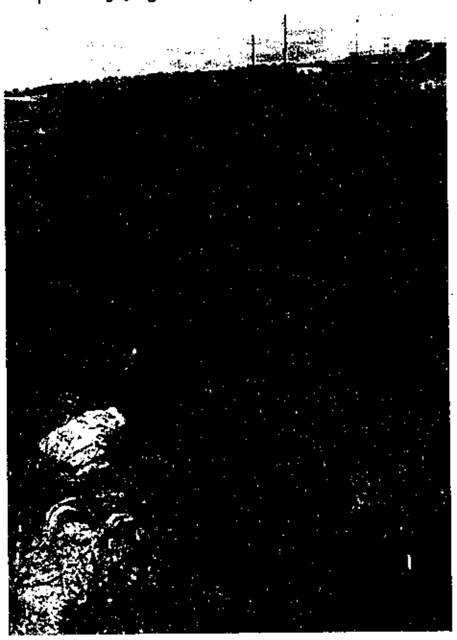

Figure 5.--Recolonization of woody species into strips were not seeded.

Mulches And Netting

One of the reasons for the large variability in perennial cover among the sites was due to the different reclamation techniques utilized. This was particularly true with the various mulches and netting that were applied on the steeper slopes. Evidence of the use of mulch and netting has been fairly limited in the Overthrust Belt area until recently, despite the fact that many sites have very steep slopes. Results of reseeding success on areas where mulch or netting were applied were varied. Where properly installed on steep slopes, netting resulted in good vegetation establishment and erosion condition classes that were excellent while on comparable slopes with no netting, serious erosion had occurred. On nearly flat surfaces, mulch appeared to be of little added benefit except on sites with poor or limited topsoil. Examples of the use of jute, burlap, nylon mesh, plastic mesh, excelsior, straw, hydromulch and annual cover crops were evident. Burlap was relatively ineffective because its tight weave limited vegetation growth.. Jute netting that was properly installed was effective in controlling erosion after 3-4 years. Plastic netting (e.g., Conwed) has begun deteriorating after one year and was fairly indistinguishable 3 years following installation. This netting was the least durable. Hydromulch when used alone, appeared less effective than straw, if the straw was anchored in place. This is probably due to the short fiber length in the hydromulch. In either case, straw or hydromulch lasted approximately one year. Several sites had used an annual cover crop for a mulch. It was fairly ineffective where a good stand of annual cover had not been achieved, possibly from the lack of precipitation while the seed was germinating. An annual stubble mulch does have potential on gentler slopes but requires monitoring and an alternative method if the cover crop fails.

The use of mulch and netting does not preclude the use of proper water control devices such as water bars and berms, but must be used in conjunction with them to be effective. In some cases, mulch or netting was placed over previously eroded areas to prevent further erosion without eliminating the source of erosion, water running from a pad over a fill slope. This was not effective and should be avoided.

Test plots at one production facility were installed in 1983 to assess the importance of various techniques including mulching. Results showed that on steep southwest-facing, non-topsoiled slopes, mulch with tack was quite effective at increasing cover and density and decreasing erosion (table 2). Mulch that was blown onto the slope without tack was not as effective since most of the mulch was blown off from the strong winds that are characteristic of the area, but was still significantly better than no mulch at all. Total cover increased over 300% on the mulched and tacked treatments compared to the no mulch treatment and over 160% compared to the mulch with no tack. Differences in plant density were not as large with the mulch and tack treatments increasing

Table 2.--Density, vegetation cover and erosion on test plots two growing seasons following seeding. Means followed by a common letter are not significantly different for a particular slope (<.05).

West Facing Slope

Treatment	Plants/ m^2	Cover (%)	Erosion (mm)
No mulch	28.9^a	7.5^a	8.0^a
Mulch, no tack	33.8^b	16.3^b	4.2^{ab}
Mulch, tack	51.8^c	16.7^c	1.9^b

North Facing Slope

Treatment	Plants/ m^2	Cover (%)	Erosion (mm)
No mulch	44.2^a	44.5^a	4.8^a
Mulch, no tack	50.4^a	40.3^a	2.3^a
Mulch, tack	41.0^a	40.0^a	0.9^a

density 180% and 150% above the no mulch and mulch with no tack, respectively.

Soil loss was significantly reduced by the application of mulch and tack. Soil loss was measured by erosion pins as described by Toy (1983). This technique involved placing a metal rod into the soil and marking the soil line on the rod. After a given period of time, a measurement is taken from the original mark to the soil surface with the difference representing the amount of soil lost. The no mulch treatment had an average erosion value over 4 times greater than that of the mulch and tack treatment and two times that of the mulch without tack treatment.

On an adjacent gentler (15%) north-facing, topsoiled slope, mulch had no significant effect on vegetation cover or density. It did, however, appear to have an effect on soil erosion. The mulched and tacked sites tended to have less erosion, although the difference was not statistically significant due to large variability of the data (table 2). The soil was protected by mulch during the period prior to vegetation establishment.

Another production facility provided a qualitative comparison of the effects of different types of netting. Three different netting materials were used on steep east-facing slopes. These included jute, excelsior, and hay plus Conwed netting. The different netting all performed equally well on erosion condition classifications showing no visual signs of erosion. The excelsior appeared to favor vegetation establishment with a slightly higher perennial vegetation cover of 40% compared to 30% for jute and 25% for hay and Conwed. Samples were not replicated so no statistical comparison could be made between treatments. These cover values are exceptionally good considering that the slopes are steep (45%) and the vegetation has had only two growing seasons prior to sampling.

Topsoil

Another important factor in enhancing vegetation reestablishment was the use of topsoil. This is often required by current regulations. Reclamation of older sites, however, may have a limited quantity of topsoil available for reclamation. Only a limited analysis of the effectiveness of topsoil was possible from this sampling since there were only four sites that had comparative areas that were clearly topsoiled and not topsoiled. In every case the topsoiled area had higher perennial cover, total cover, number of species present and a better erosion condition classification. Paired-t analysis showed that only total cover was statistically different at the 95% probability level but definite trends exist for the other factors as well. The other factors, perennial cover, number of species and erosion classification, were significant between the 90 and 95% level. The importance of topsoil cannot be overemphasized. The presence of silt and rock in many of the multiple regressions indicated that good topsoil heavily influences vegetation cover, including shrub establishment.

Weeds

Weeds presented localized problems on reclaimed sites. Ten major weeds were identified on the sites sampled. The dominant weed species included Canadian thistle (Cirsium arvense), elk thistle (Cirsium foliosum), musk thistle (Carduus nutans), knotweed (Polygonum sp.), Russian thistle (Salsola kali), pigweed (Amaranthus sp.), cheatgrass (Bromus tectorum), pennycress (Thalaspi arvense), henbane (Hyoscyamus niger), and halogeton (Halogeton glomeratus). Prompt revegetation efforts helped reduce weed infestation problems. Weed cover from annual species generally declined after perennial vegetation was established. Several of the weeds are classified as "noxious" by the states involved. Musk thistle and henbane are noxious weeds that have spread extensively throughout the Overthrust Belt area in the past few years. Thus, it is important to deal with weed problems quickly before the seed is spread to nearby disturbed sites. Mowing of annual weeds or proper herbicide control are recommended in problem areas.

Grazing

Only one site provided a good control/treatment type of analysis on the effects of grazing. Two subsites, one with steep slopes (45%) and one with almost no slope (1%) were inside the fence and two were outside, one with 34% slopes and one with 1% slopes. These had been seeded in 1983. The ungrazed steep subsite averaged 35% cover with an erosion condition value of 5.0 (slight), while the grazed site averaged 10% cover with an erosion condition value of 9.0 (moderate). The ungrazed flat subsite averaged 65% cover while the grazed subsite averaged 20% cover. Both sites had erosion conditon values of 4.0 (stable). In both cases the nongrazed subsites had over 3 times the cover of the grazed plots. This cover was important in reducing erosion on steeper slopes. Continued overgrazing can be expected to further reduce vegetation cover. Grazing management such as fencing, controlled season of use and salt placement should be utilized to properly control grazing on revegetated areas.

SUMMARY

Water management and erosion control were the most serious problems observed on past reclamation sites. Erosion control became increasingly important as slope increased. For the revegetation of steep slopes to be successful effective water control was necessary. Slopes with appropriate water control and mulching techniques were significantly better in erosion control than other slopes. Appropriate reclamation techniques such as topsoiling, mulching and netting also significantly enhanced vegetative establishment.

Vegetation reestablishment was fairly slow except where aided by proper revegetation methods, particularly with the use of topsoil. Limiting the soil disturbance to scraping where possible, greatly enhanced recolonization of areas by native species. Narrow unseeded strips greatly augmented shrub recolonization, particularly if topsoil was present. Topsoil enhanced diversity, shrub establishment and overall vegetation establishment.

Mulching reduced erosion on most areas and aided in vegetative establishment on drier, steeper sites. Netting effectively reduced erosion on steep slopes when used in conjunction with proper water control features.

Overgrazing of newly reseeded areas was a common problem reducing a vegetation cover and accelerating erosion. Weeds were localized problems, particularly musk thistle, canadian thistle, and henbane. Other weed problems generally decreased after the first couple of years after perennial species became better established unless site disturbance continued.

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