# SPOIL QUALITY AND HERBACEOUS YIELD RELATIONSHIPS ON SILTY RECLAIMED GRASSLANDS[1]

by

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**Abstract.** Soil removal and replacement is a major reclamation cost in surface coal mining operations. Currently, North Dakota Public Service Commission regulations require greater depths of suitable plant growth material (SPGM) to be respread, from 60 cm (24 in.) to 120 cm (48 in.), as spoil quality decreases. A study was conducted between 1988 and 1994 on the Glenharold Mine in western North Dakota to study the relationship between spoil quality and herbaceous yield on reclaimed grasslands. Nine transects, containing ten equidistant points, were established on two reclaimed grasslands of a silty soil type. Topsoil and SPGM depths, sodium adsorption ratio (SAR), and saturation percentage (SP) of the spoil and herbaceous yields were determined at each of the sampling points (n=90). Based on herbaceons yield, sample points were placed in successful or non-successful groups depending upon whether they passed or failed to meet herbaceous yield standards. Herbaceous yield was significantly different ($P<0.05$) for the two groups, yet average spoil quality was similar between the groups. Considering each spoil parameter (SAR and SP) regulating SPGM respread depths, no relationship was evident between these parameters and herbaceous yields on reclaimed, silty, mixed grasslands.

Additional Key Words: SAR, saturation percentage, North Dakota.

## Introduction

Cnrrent North Dakota grassland regulations for suitable plant growth material (SPGM) redistribntion thickness following surface coal mining operations vary depending npon the texture, sodium adsorption ratio (SAR), and saturation percentage (SP) of the underlying spoil (NDAC 1999). When the SAR is low (<12) and soil texture medium, 60 cm of SPGM is required. If SAR is moderate (12-20) and SP is low (<95) or high (>95), then 90 or 105 cm are required, respectively. If spoil quality is poor (SAR >20), SPGM redistribution thickness must equal or exceed 120 cm.

Kirby et al. (1993) reported on the relationship between soil depth and qnality, and grassland reclamation success. They concluded that soil depth regulations for reclaiming mined lands to permanent grasslands were excessive in North Dakota. In the study, SPGM and spoil quality were determined to a depth of 150 cm. This then led the mining industry to ask the question; "What is the relationship between spoil quality and success of grassland re-establishment?" Answering this question by examining herbaceous biomass is the objective of this paper.

## Study Area and Methods

The research was conducted on the Glenharold strip coal mine in west-central North Dakota. The mine is located within the Missonri Plateau Physiographic Region, which is on the western edge of an area where soils were formed from glacial deposits and residuum weathered from bedrock. The principal vegetative community on silty range sites of the study area is mixed grass prairie dominated by a variety of cool- and warm-season grasses (Barker and Whitman 1988). The climate is semi-arid and continental characterized by cold winters and hot summers. Average annual precipitation is 44 cm, of which 80% falls between April and September (Wilhelm 1978).

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The mined sites used in the study were reclaimed between 1979 and 1984. All sites were reclaimed by stockpiling and respreading top- and subsoil separately. Sites were drill seeded using a mixture of cool- (wheatgrasses, needlegrasses) and warm-season (bluestems, gramas, indiangrass, switchgrass) grasses.

The study began by permanently locating nine random transects on two silty reclaimed grasslands. Transects were located to produce maximum topographic variation among sampling points. Ten sampling points were located at 10 m intervals along each transect (n=90). Herbaceous biomass was estimated at each point at peak standing crop by clipping 0.25 $m^2$ quadrats. Soil cores were removed in 30 cm increments to 150 cm and tested for texture, SP and SAR.

Herbaceous yields were separated into successful and non-successful groups based on reclaimed sample points exceeding (success) or not exceeding (non-success) the mean annual native silty site herbaceous production. Spoil quality (SP, SAR) associated with these two groups were then tested for differences ($P<0.05$) with multi-response permutation procedures analysis (Biondini et al. 1988).

## Results and Discussion

Growing season precipitation (May through September) averaged 23.7 cm between 1988 and 1994. This is approximately 85% of the 20-year average of 28.0 cm.

Seventy percent of the 90 sites sampled were successful in achieving the herbaceous yield standard for reclamation (Table 1). Herbaceous yield was significantly higher ($P<0.05$) for the successful group of sample sites. However, average spoil SP and SAR did not differ between successful and non-successful groups. Topsoil and SPGM respread thickness averaged 3 and 4 cm greater, respectively, for the successful group compared to the non-successful group. Average spoil quality, SAR = 14.9 and SP = 89%, indicates a SPGM redistribution thickness of 90 cm, by current state regulations, would be required in reclaiming these sites. This required SPGM depth is significantly greater than the 47.3 cm average SPGM depth for the successfully reclaimed grassland sites.

Considering the four spoil quality categories, 64 to 76% of the silty reclaimed grassland sites met successful herbaceous yield standards (Table 2). Within each spoil quality category, herbaceous yield was greater for the successful sites compared to the non-successful sites. Spoil SP and SAR did not differ ($P>0.05$) between successful and non-successful sites for any spoil quality category with one exception. SAR was significantly lower ($P<0.05$) for non-successful sites when SAR exceeded 20 in the spoil, which would be opposite of the expected outcome. Spoil quality did not explain differences in herbaceous yield on successful and non-successful for sample points on silty reclaimed grasslands.

There was no relationship between SPGM depth of successfully reclaimed herbaceous yields and spoil quality standards for respread SPGM depths (Table 2). Successful herbaceous yields were achieved across spoil quality categories at SPGM depths ranging from 43.9 cm to 50.0 cm which is less than the 60 to 120 cm reqnired in the regulations. Also, SPGM depths associated with successful herbaceous yields did not increase as spoil quality decreased. For example, when spoil SAR was low (<12), 60 cm of SPGM is required, yet successful herbaceous yields were achieved with 48.8 cm SPGM. At the other extreme, when spoil quality was poor (SAR >20), 120 cm of SPGM is required by regulation, yet successful herbaceous yields were attained from SPGM redistribution thicknesses averaging only 43.9 cm.

There does, however, appear to be a trend of greater topsoil and/or SPGM depth with greater herbaceous yields (Table 2). Average topsoil depth was higher for successful sites in each spoil quality class. Average SPGM depth was higher for successful sites in three of four spoil quality classes. Where average SPGM respread thickness was less in the spoil SAR 12-20, SP<95 class, the topsoil thickness was 7 cm greater for the successful herbaceous yield sites.

## Conclusions

1. Spoil quality and herbaceous yield were not related on silty reclaimed grasslands.

2. Successful herbaceous yields were achieved at significantly less top- and subsoil redistribution depths when compared to required SPGM depths of the four North Dakota spoil quality classes.

3. There appears to be a positive trend between topsoil and SPGM depths and successful herbaceous yield on silty reclaimed grasslands. As topsoil and SPGM depths increased, herbaceous yields tended to increase.

Table 1. Average soil depths and spoil quality associated with successful and non-successful herbaceous yields from silty reclaimed grasslands.

| | Successful | Non-successful |
|---|---|---|
| Number of Sites | 63 | 27 |
| Topsoil Depth (cm) | 17.1 | 14.2 |
| SPGM[1] Depth (cm) | 47.3 | 43.3 |
| Spoil SP[2] | 89±3.2a[4] | 88±3.6a |
| Spoil SAR[3] | 14.0±1.0a[4] | 15.7±1.4a |
| Herbaceous Yield (kg/ha) | 1925a[4] | 1425b |

[1]Suitable Plant Growth Material.
[2]Saturation Percentage.
[3]Sodium Adsorption Ratio.
[4]Adjacent means followed by a different letter differ (P<0.05).

Table 2. Soil depths and spoil quality associated with successful and non-successful herbaceous yields for each spoil quality class on silty reclaimed grasslands.

| | Spoil Quality | | | |
|---|---|---|---|---|
| | SAR <12 | | SAR 12-20, SP <95 | |
| | Successful | Non-successful | Successful | Non-successful |
| Number of Sites | 29 | 9 | 11 | 6 |
| Topsoil Depth (cm) | 16.8 | 15.0 | 20.3 | 13.2 |
| SPGM[1] Depth (cm) | 48.8 | 46.0 | 45.7 | 48.5 |
| Spoil SP[2] | 72±2.7a[4] | 68±2.1a | 85±2.2a | 79±3.4a |
| Spoil SAR[3] | 6.9±0.4a[4] | 8.5±0.6a | 14.6±0.5a | 14.1±0.7a |
| Herbaceous Yield (kg/ha) | 1925a[4] | 1500b | 2030a | 1460b |

| | Spoil Quality | | | |
|---|---|---|---|---|
| | SAR 12-20, SP >95 | | SAR >20 | |
| | Successful | Non-successful | Successful | Non-successful |
| Number of Sites | 9 | 5 | 14 | 7 |
| Topsoil Depth (cm) | 18.5 | 14.2 | 14.2 | 14.0 |
| SPGM[1] Depth (cm) | 50.0 | 36.1 | 43.9 | 40.4 |
| Spoil SP[2] | 109±3.9a | 103±3.1a | 122±3.5a | 108±4.1b |
| Spoil SAR[3] | 17.1±0.7a | 17.1±1.1a | 26.4±1.0a | 25.4±1.7a |
| Herbaceous Yield (kg/ha) | 2000a | 1280b | 1820a | 1400b |

[1]Suitable Plant Growth Material.
[2]Saturation Percentage.
[3]Sodium Adsorption Ratio.
[4]Adjacent means followed by a different letter differ (P<0.05).

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