HYDRIC SOILS AND THE RELATIONSHIP TO PLANT DIVERSITY WITHIN RECLAIMED STREAM CHANNELS IN SEMI-ARID ENVIRONMENTS

by

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Abstract. Wetlands are especially important in semi-arid environments, such as the Powder River Basin of northeastern Wyoming, where water is a limiting factor for living organisms (Orr, 1977). Within this coal mining region of northeastern Wyoming, "jurisdictional" wetlands are mapped according to the U.S. Army Corps of Engineers 1987 delineation procedure (Environmental Laboratory, 1987). Within the coal mining region of northeastern Wyoming, little or no full-scale mitigation or reconstruction attempts of jurisdictional wetland areas have been made until recently (Spackman, 1996).

Based on the importance of "wetlands" in a semi-arid environment and lack of information on existing or reconstructed areas, the specific objectives of the 1998 fieldwork were:

1) To define the pre-disturbance ecological state of hydric soils within jurisdictional sections of stream channels on two coal permit areas in northeastern Wyoming.

2) To determine the effect that hydric soil parameters have on plant community distribution and composition within the two coal permit areas.

Undisturbed sections of stream channels and disturbed sections of reconstructed or modified stream channels at the Rawhide Mine and Buckskin Mine, located north of Gillette, Wyoming, were selected for the study. Soils field and laboratory information and field vegetation cover were collected during 1998 within native stream channels and disturbed stream channels that had been reclaimed at each mine. Soils laboratory information is currently preliminary and included pH, electrical conductivity and sodium adsorption ratio. Results and statistical comparisons between soils and vegetation data will be presented.

Additional Key Words: stream reconstruction, plant community distribution

Introduction

Wetlands are an integral part of the natural environment, but are especially important in semi-arid environments, such as the Powder River Basin (PRB) of northeastern Wyoming, where water is a limiting factor for living organisms (Orr, 1977). Disturbance of these unique areas in the landscape may pose significant problems in mine permit areas where large sections of stream drainages and closed basins are drastically disturbed.

Many areas must be included in the evaluation and development of wetland mitigation designs (Halvorson,

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1991). Before the destruction of an existing wetland, data should be gathered such as vegetation composition, soil organic matter, and water quality. Once a new wetland is constructed, monitoring requirements for success should be implemented and standardized.

Monitoring of reconstructed wetlands within mining areas is generally limited in Wyoming. Some investigative work has been conducted within the bentonite mining areas of northeastern Wyoming where ponding in the narrow pits is commonly a result of mining (McKinstry, 1993). Within the coal mining region of northeastern Wyoming, little or no full-scale mitigation or reconstruction attempts have been made until recently (Spackman, 1996). No playa or closed basin reconstruction has been attempted on reclaimed areas, although many have been proposed; however, reconstruction of playas is not anticipated for the next five years (Spackman, 1996).

Objectives

The specific objectives of the overall project are:

1) To define the pre-disturbance ecological state of hydric soils within jurisdictional wetland areas on coal mining permit areas in northeastern Wyoming.

2) To define the seasonal fluctuations in soil physical and chemical characteristics, both between years and within a given year.

3) To determine the effect that hydric soils have on plant community distribution and composition.

4) To apply the knowledge obtained in #1 and compare to soil profiles within actual reconstructed and reclaimed stream channels.

Methodology

Field Sampling

Rawhide Mine Reclaimed. Sample sites were along the edge of an engineered and constructed wetland mitigation area. The area contained distinct vegetation zones which had been seeded or transplanted in 1991. Along the water's edge was a mosaic of hydrophytic plants such as *Eleocharis palustris* and *Scirpus acutus* referred to as the ELEPAL zone. The second distinct zone was designated as WET MEADOW and was dominated by *Phleum pratense* with some *Carex*, *Agropyron*, *Spartina pectinata* and *Hordeum jubatum*.

Two sites in each distinct vegetation zone were selected. A main transect tape was stretched from the water's edge to the end of the WET MEADOW on either side of the reconstructed water body. One random location on the main tape each in the ELEPAL zone and the WET MEADOW was selected, and another tape was stretched perpendicular in a random direction to the main transect for 20 meters. Three points along the perpendicular transect were randomly selected as sample locations. At each sample location percent cover by species was estimated in a ½ m^2 circular wire quadrat and a soil profile sample 8 centimeters wide and approximately 90 centimeters deep was extracted. Attributes such as color, texture, mottling, whether or not it was calcareous, and other special features were noted.

Rawhide Mine Native. Sample sites were selected on the deposition sides of meander bends in a native stream channel. Zones were similar to the reclaimed area and consisted of ELEPAL and WET MEADOW. Sampling methodology was also similar.

Buckskin Mine Reclaimed. The general sampling area is a constructed alluvial valley floor and stream channel seeded in 1990. Little or no water was flowing through the constructed relatively straight channel at the time of sampling. Terrace areas generally consisted of MIXED MEADOW characterized by a relatively large amount of *Bromus tectorum* and *Bromus japonicus* with numerous forbs, including *Ambrosia psilostachya*, as well as perennial grasses such as *Stipa viridula* and *Agropyron* spp. Along the MARGIN nearest the reconstructed stream, less annual grass was present while forbs and perennial grasses were more numerous. There were some large isolated patches of *Eleocharis palustris* which stretched across the channel in its entirety or halfway across. These patches were not continuous enough along the channel to be considered a zone. Zone distinction in the Buckskin sites was vague.

In the case of the AVF there were no definite meanders and the sites were established on the side with the most available access. Relative zones were defined between the channel and the terrace on the constructed floodplain. A main transect tape was stretched from the waters edge to the end of the mixed meadow near the upland edge of the constructed terrace. Because of the minimal zone distinction, the margin zone was considered to be 1 meter from the edge of the stream

channel. One location each in the margin zone and the wet/mixed meadow was randomly selected and another tape was stretched perpendicular to the main transect in a fashion similar to the Rawhide sample areas.

Buckskin Mine Native. Sample sites were along a relatively straight channel section on the floodplain adjacent to a short terrace. On the opposite side of the creek was a much narrower floodplain adjacent to a steep hill similar to the set-up on the reclaimed AVF sites. Comparable native sites were limited. The MIXED MEADOW was characterized by *Carex geyeri*, *Spartina pectinata*, and *Hordeum jubatum*, with numerous small forbs including *Aster falcatus* adults and seedlings. MARGIN areas were characterized by *Spartina pectinata* and *Eleocharis palustris* with some *Scirpus americanus*, *Scirpus acutus*, *Carex*, forbs and grasses.

Two sites in each vegetation zone were selected in a straight channel section of the creek, on a relatively large floodplain. Where zone distinction was less apparent, the MARGIN area constituted the area within 1 m from the waters edge. Sample locations were selected similar to Rawhide mine locations.

Statistical Analysis

Analysis of data was limited to correlation by mine, native vs. reclaimed within a given mine, and vegetation type within a given mine and native or reclaimed. Correlation analysis was conducted on the following soil and vegetation parameters: pH, electrical couductivity or EC, dry colors according to Munsell, wet colors according to Munsell, soil texture, percent clay, sodium adsorption ratio or SAR, perennial grass (PG) cover percent, grass-like (GL) cover percent, annual grass (AG) cover percent, perennial forb (PF) cover percent, annual forb (AF) cover percent, and shrub (S) cover percent. Correlation results were initially obtained from Microsoft EXCEL and verified with SAS on the University of Wyoming mainframe computer.

Results

Rawhide Mine

Reclaimed. In the reclaimed WET MEADOW, total vegetation cover estimates were 55-85%, while in the ELEPAL zone, total vegetation was between 35 and 75 %. Water was encountered in soil sample holes at 15-30 inches in the ELEPAL zone and 45-90 inches in the WET MEADOW.

Significant ($p \leq 0.05$) correlations within the combined Rawhide reclaimed and native area streams were EC and SAR at 0.8865 and PG and GL at -0.7879. Significant correlations within the Rawhide reclaimed sampling locations were EC and SAR at 0.9201. Results for the Rawhide reclaimed WET MEADOW zone were: EC and SAR at 0.9265; and PG and GL at -0.7340. Results for the Rawhide reclaimed ELEPAL zone are shown in Table 1.

Table 1. Significant correlation analysis for the Rawhide Reclaimed ELEPAL zone ($p \leq 0.05$).

		R value
pH	EC	-0.5342
pH	SAR	-0.5285
pH	PG	-0.6911
pH	GL	-0.6548
EC	SAR	0.9782
Clay	PG	-0.6392
Clay	PF	0.5110
PG	PF	-0.5818

Note: pH = soil pH; EC = electrical conductivity (mmhos/cm or dS/m); Clay = percent clay; SAR = sodium adsorption ratio; PG = percent perennial grass cover; GL = percent grass-like cover; PF = percent perennial forb cover.

Native. In the native WET MEADOW, total vegetation cover estimates were 30-50%, while in the ELEPAL zone, total vegetation was between 30 and 70 %. Water was encountered in soil sample holes at 6-18 inches in the ELEPAL zone and 15-24 inches in the WET MEADOW.

Significant ($p \leq 0.05$) correlations within the combined Rawhide reclaimed and native area streams were EC and SAR at 0.8865 and PG and GL at -0.7879. Significant correlations within the Rawhide native sampling locations were: EC and SAR at 0.8289; and PG and GL at -0.6081. Results for the Rawhide native ELEPAL zone were: pH and clay at 0.6253; and EC and SAR at 0.9439. Results for the Rawhide native WET MEADOW zone are shown in Table 2.

Table 2. Significant correlation analysis for the Rawhide Native WET MEADOW zone ($p \leq 0.05$).

		R value
pH	EC	-0.6071
EC	SAR	0.6653
SAR	PG	-0.6250
SAR	GL	0.6017
SAR	PF	0.6426
GL	PF	0.7121

Buckskin Mine

Reclaimed. In the reclaimed MIXED MEADOW, total vegetation cover estimates were 55-75%, while in the MARGIN zone, total vegetation was between 25 and 55 %. Saturated soil was encountered in soil sample holes at 18-32 inches in the MARGIN zone and were nonexistent in the MIXED MEADOW.

Significant ($p \leq 0.05$) correlations within the combined Buckskin reclaimed and native area streams were: pH and Clay at 0.5106; EC and SAR at 0.9082; Clay and GL at 0.5478; SAR and AG at -0.6211; PG and PF at 0.8012; and GL and AG at -0.5067. Significant correlations within the Buckskin reclaimed sampling locations were EC and SAR at 0.9201. Results for the Buckskin reclaimed MIXED MEADOW zone were: EC and SAR at 0.5374; PG and AG at -0.6797; and AG and PF at -0.7029. Results for the Rawhide reclaimed MARGIN zone are shown in Table 3.

Table 3. Significant correlation analysis for the Buckskin Reclaimed MARGIN zone ($p \leq 0.05$).

		R value
pH	EC	-0.7757
pH	SAR	-0.6460
EC	SAR	0.7527
PG	AF	-0.6211
GL	AG	-0.5731

Native. In the native MIXED MEADOW, total vegetation cover estimates were 60-98%, while in the MARGIN zone, total vegetation was variable between 10 and 70%. Moist or saturated soils were encountered throughout soil sample holes in the MARGIN zone and moist in the lower portions of the profiles in the MIXED MEADOW.

Significant ($p \leq 0.05$) correlations within the combined Buckskin reclaimed and native area streams were: pH and Clay at 0.5106; EC and SAR at 0.9082; Clay and GL at 0.5478; SAR and AG at -0.6211; PG and PF at 0.8012; and GL and AG at -0.5067. Results for the Buckskin native are shown in Table 4. Results for the Buckskin native MARGIN zone were: pH and PG at -0.5561; and PG and GL at -0.7119. Results for the Buckskin native MIXED MEADOW zone are shown in Table 5.

Table 4. Significant correlation analysis for the Buckskin Native ($p \leq 0.05$).

		R value
pH	PF	0.5966
EC	SAR	0.9050
EC	PG	0.6240
EC	PF	0.6476
Clay	AG	-0.5376
Clay	PF	-0.5087
SAR	PG	0.5942
SAR	PF	0.6655
PG	GL	-0.8129
PG	AG	0.5183
PG	PF	0.9115
GL	PF	-0.6467
AG	PF	0.5629

Table 5 Significant correlation analysis for the Buckskin Native MIXED MEADOW ($p \leq 0.05$).

		R value
pH	EC	-0.5658
EC	SAR	0.7950
Clay	AG	-0.5242
PG	GL	-0.8967
PG	PF	0.8293
GL	PF	-0.6537

Discussion

Results of the various reclaimed and native areas reflected unique differences at each mine site. Correlation was not combined over the two mine sites because of this difference. In general, EC is almost always correlated with SAR, regardless of mine or vegetation type, i.e., native or reclaimed area. Also, there is generally a negative correlation between PG and GL where conditions suitable for the growth of each lifeform varies and results in zonation.

Zonation at the Rawhide reclaimed area is more distinct than at Buckskin reclaimed and is primarily a result of an increased amount of water being discharged into the system from upstream sources. pH and clay were significant parameters at the Rawhide reclaimed ELEPAL zone while SAR was the most significant parameter at the Rawhide native WET MEADOW.

pH was a significant parameter on the Buckskin reclaimed MARGIN community. Reclaimed areas at both mines had more than five significant correlations when combined over vegetation types.

The most significant correlations were found in the Buckskin native areas when combined over vegetation types. Only two significant correlations were found in combined native areas at Rawhide. The native MIXED MEADOW at Buckskin had more significant correlations than the MARGIN zone which only had two.

The consistent presence of water within an arid area is the overriding factor for the establishment of wetland vegetation types or zones within or adjacent to reconstructed stream channels. However, it also appears that soil factors such as pH, EC, SAR, and possibly clay, play significant roles especially where ephemeral discharges in stream channels are present.

These soil factors should be considered upon eventual reestablishment of diverse zones. The pre-hydration chemical and physical condition of the material used adjacent to reclaimed stream channels should be considered prior to reconstruction in order to promote diversity.

Literature Cited

Environmental Laboratory, Department of the Army. January, 1987. Corps of Engineers Wetlands Delineation Manual, Technical Report Y-87-1.

Halvorson, B. 1991. Progress in Wetlands. Restoration & Management Notes 9 (2):87-89.

McKinstry, M.C. 1993. Evaluation of Wetlands Created or Reclaimed as a Result of Miuing in Northeast Wyoming. M.S. Thesis, University of Wyoming, Laramie, Wyoming.

Orr, H.K. 1977. Reestablishment of Wooded Waterways and Associated Upland Shrub Communities in Surface Coal Mining Areas of the Northwestern Great Plains. In Fifth Symp. Surf. Min. and Reclam., NCA/BCR Coal Conf. and Expo IV [Oct. 18-20, 1977, Louisville, KY.]

Spackman, L. 1996. Personal Communication, WDEQ.