TOPSOIL VERSUS SPOIL AS A PLANT GROWTH MEDIUM

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Controversy generated by the actual depth of topsoil[(1)] required to adequately revegetate surface coal mined areas within the Northern Great Plains Coal Province (NGPCP) led the U.S. Bureau of Mines to fund the Colorado School of Mines Research Institute to research the problem. Results of the project should allow development of predictive models, useful within the NGPCP, for determining optimal topsoil depths for forage communities at minimal long-range costs.

EXPERIMENTAL METHODS AND RESULTS: Phase I of the study, initiated in 1976 consisted of canvassing the area's 17 existing mine sites for current reclamation practices. All of the mines apply topsoil, according to presiding state reclamation regulations, prior to seeding native and introduced plant species. Reclamation methods differ in the spoil treatments, depth of topsoil applied, time of year planted, species planted, use of cover crops, rate of seeding, use of fertilizers, use of mulch, and mowing or grazing of the revegetated areas(1).

Samples of regraded topsoil, and spoils, and undisturbed soil were collected from seven mine sites (2 in Wyoming, 1 in Montana, and 4 in North Dakota) and analyzed for a variety of physical and chemical characteristics (Table 1). Despite the varying climatic differences within the NGPCP and the geologic differences between the Powder River Basin and Williston Basin, all of the seven sites were generally similar to one another regarding existing plant growth media. Spoil salinity values were moderately high, and thus salinity is likely to inhibit salt intolerant plant species' growth. Soil and spoil pH for the Dave Johnston mine site was not included in the Table 1 averaged data because values were aberrantly acidic for the NGPCP. All values tend to fall within accepted state specifications. Because of known reclamation problem sites, the project sample number and design will be more inclusive in the future.

Phase II of the project consists of construction of 14 field wedge test plots (Figure 1) at existing surface coal mines in the NGPCP (Figure 2), and monitoring of plant growth on the plots. Plots were drill seeded at 30 seeds/0.1 m^2 during the spring of 1977 with a mixture of three of the following perennial grasses: Nordan crested wheatgrass (*Agropyron cristatum*), Luna pubescent wheatgrass (*A. trichophorum*), Critana thickspike wheatgrass (*A. dasystachyum*), Rosana western wheatgrass (*A. smithii*), and green needlegrass (*Stipa viridula*). Plant species were chosen for their ecological resilence and forage benefits. Fertilizer was applied at the rate of 30 ppm P as superphosphate and 50 ppm N as NH_4HO_3 over the entire plot.

(1) Topsoil is defined as the A (surface) horizon plus that portion of the underlying B and C horizons which is conducive to plant growth.

Vegetation characteristics measured after the first growing season were establishment and tillering of perennial grasses. These measurements do not necessitate plant harvesting, and the grasses were allowed to persevere. Volunteer species, primarily the annual Kochia, were harvested for above-ground biomass and for trace element accumulation. Percentage plant cover of both perennial grasses and annuals was estimated prior to plant harvest.

Perennial grass establishment on the wedge plots was 45.5% for topsoiled areas and 10.3% for spoils; differences were significant at the 1% level. Tillers, horizontal grass shoots, per plant average 2.8 for topsoil and 0.9 for spoils, significant at the 5% level. Above-ground biomass (Figure 3) of Kochia increased with increasing topsoil depth to approximately 35 cm, then leveled off. Although an empirical observation, the same trend occurred for percentage plant cover. Samples of annual plants are currently being analyzed for trace element accumulation; data will be correlated with substrate characteristics. Perennial grass samples will be assayed for trace element accumulation during the third, fourth, and fifth growing seasons, and uptake will be related to topsoil depth.

DISCUSSION: Although this study is in the preliminary stages, data indicate that topsoil allows for increased percentage plant cover and above-ground biomass, as well as increased plant establishment and tillering, over spoils treated in the same manner.

Future studies on this project will include increased soil/spoil sample design and number due to increased number of plots in various locations within the NGPCP. Soil/spoil studies will include percent organic matter, and seasonal changes in soil moisture and density. It is not intended that soil development will be detected within the longeveity of this project. However, significant differences between disturbed soil, which is essentially a secondary succession stage, and spoil, a primary succession stage, should be evident. Vegetative studies will include effective root depth correlated with suitable plant-growth medium depth, as well as physiological and morphological studies including plant susceptibility to drought, frost, and parasites.

Data collected over a five-year span should allow for development of predictive, perhaps site specific, models for determining optimum topsoil depth within the NGPCP at minimal reclamation costs.

REFERENCES:

(1) Barth, R. C., 1977, Reclamation practices in the Northern Great Plains Coal Province: Mining Congress Journal, May 1977, p. 60-64.

Site	Depth, cm From	Depth, cm To	pH in Water	pH in 0.01M $CaCl_2$	Soluble Salt Electrical Conductivity mmhos/cm	Sodium Water Soluble (milliequivalents/100 g)	Sodium NH_4 Acetate Soluble (milliequivalents/100 g)	Cation Exchange Capacity (milliequivalents/100 g)	Exchangeable Sodium Percentage	Ammonium ppm	Nitrate ppm	Phosphorus $NaHCO_3$ Extractable ppm
Reclaimed, Topsoil	0	19	8.0 (1)	7.5 (1)	5.6	0.31	0.50	24.7	0.8	8.5	35.2	15.6
Reclaimed, Spoils	19	50	7.7 (1)	7.4 (1)	10.1	0.87	1.23	23.7	1.5	8.9	29.1	12.1
Undisturbed	0	10	7.4	6.7	1.4	0.20	0.48	24.4	1.2	8.5	10.2	18.3
Undisturbed	10	50	7.9	7.2	4.9	1.30	1.91	24.9	2.4	7.9	5.0	10.5

Site	Depth, cm From	Depth, cm To	Potassium Available ppm	Water Soluble Sulfate ppm	Water Soluble Boron ppm	DTPA Extractable Copper ppm	DTPA Extractable Manganese ppm	DTPA Extractable Iron ppm	DTPA Extractable Zinc ppm	Molybdenum Anion Exchangeable ppm	Total Arsenic ppm	Total Cadmium ppm	Total Mercury ppm	NH_4 Acetate Extractable Nickel ppm	NH_4 Acetate Extractable Lead ppm
Reclaimed, Topsoil	0	19	294	422	1.45	1.8	24.5	90.3	1.0	0.3	1.9	<0.05	0.036	0.4	0.5
Reclaimed, Spoils	19	50	237	1375	1.26	4.9	29.1	156.0	1.4	0.4	1.7	<0.05	0.061	0.4	0.5
Undisturbed	0	10	413	74	1.16	1.9	28.0	73.7	1.9	0.2	1.7	<0.05	0.029	0.4	0.4
Undisturbed	10	50	294	495	1.21	2.6	34.4	81.9	1.0	0.2	1.7	<0.05	0.035	0.4	0.5

Site	Depth, cm From	Depth, cm To	Water-Holding Capacity, % (Dry Sample Wt. Basis) 1/3 Bar Suction	Water-Holding Capacity, % (Dry Sample Wt. Basis) 15 Bar Suction	Particle-Size Analysis, Wt. % Sand -2.0 +0.05 mm	Particle-Size Analysis, Wt. % Silt -0.05 +0.002 mm	Particle-Size Analysis, Wt. % Clay -0.002 mm	Textural Class
Reclaimed, Topsoil	0	19	17.3	9.0	58.3	23.8	18.0	Sandy loam
Reclaimed, Spoils	19	50	24.7	11.5	38.1	39.1	22.7	Loam
Undisturbed	0	10	22.4	11.7	47.6	36.6	15.8	Loam
Undisturbed	10	50	22.7	10.9	43.6	34.0	22.4	Loam

(1) Values from the Dave Johnston Mine site were not included.

TABLE I. AVERAGED SOIL TRAITS OF RECLAIMED AND UNDISTURBED SITES.

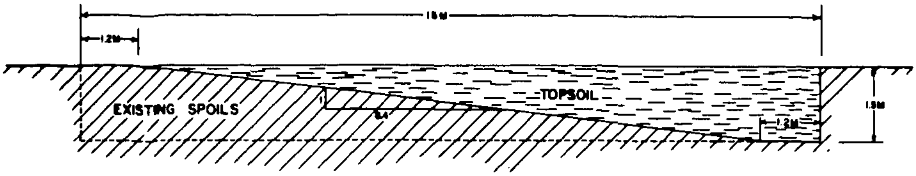

FIGURE 1. WEDGE TEST PLOT DESIGN.

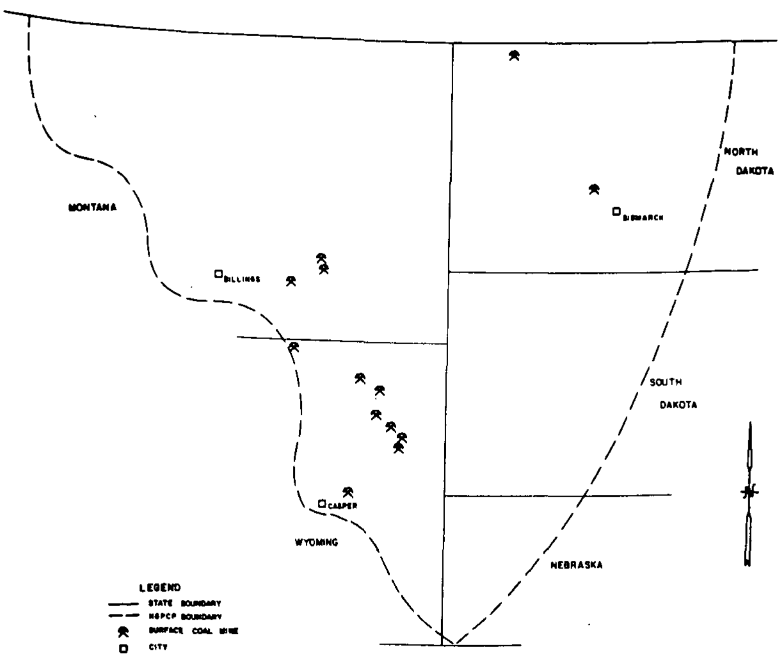

FIGURE 2. PHASE II WEDGE PLOT LOCATIONS.

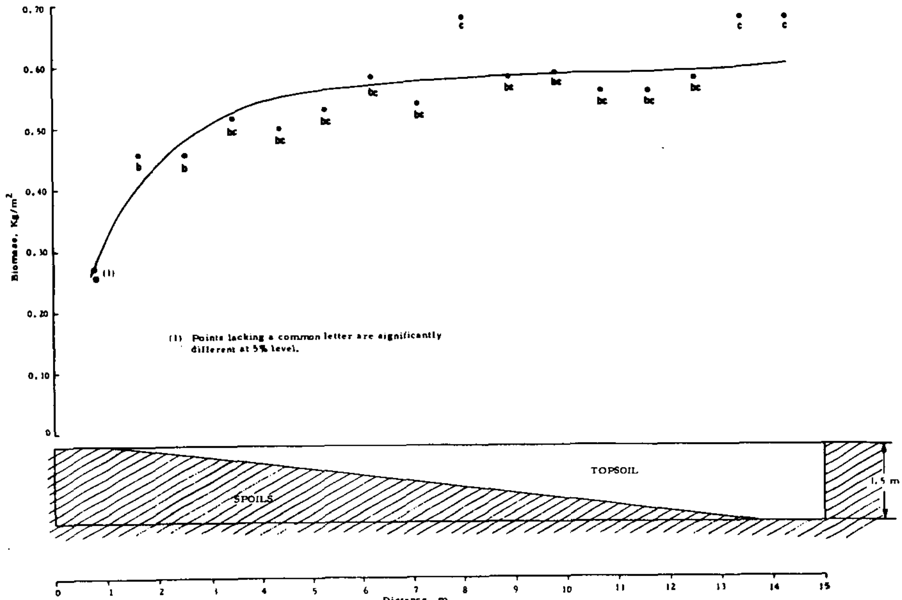

FIGURE 3. PHASE II ABOVE-GROUND BIOMASS AS A FUNCTION OF TOPSOIL DEPTH.