RECLAMATION RESEARCH IN NORTH DAKOTA

PART B

RESEARCH PUBLICATION BRIEFS

SOIL RESPREADING (SR)

Title: **USE OF SOIL MATERIALS ON SPOILS - EFFECTS OF THICKNESS AND QUALITY**

Authors: J.F. Power, R.E. Ries, and F.M. Sandoval

Organization: USDA-ARS, Northern Great Plains Research Center, Mandan, ND

Format: Paper

Reference: North Dakota Agricultural Experiment Station Farm Research 34(1):23-24, 1976

Key Index Words: Soil Requirements, Spoil Properties, Topsoil, Productivity

Brief Description

This paper summarizes the grass and wheat yields data from the wedge plot experiments at Glenharold for 1975 and 1976. The findings during this time frame were that yields did not increase when a soil thickness greater than 28 inches was respread. Also, yield did not vary much when the topsoil thickness was increased from 8 to 24 inches. It was emphasized that both thickness and quality of soil material spread on spoil will affect the crop yields. On sodic spoils, as little as two inches of soil material was found to be highly beneficial but it was found that at least 30 inches of soil material would be required for maximum production.

Analysis of Conclusions

The above findings were regarded by the authors as being tentative. Additional data would be required to draw proper conclusions.

Title: **SODIUM MIGRATION UPWARD ON RECLAIMED SODIC MINE SPOILS**

Authors: F.M. Sandoval, J.F. Power, and R.E. Ries

Organization: USDA-ARS, Northern Great Plains Research Center, Mandan, ND

Format: Paper

Reference: Western Society of Soil Science Meeting, 1978

Key Index Words: Soil Requirements, Spoil Properties, Sodium Migration, Topsoil, Fertilizer Use

Brief Description

Research was conducted in the Northern Great Plains to restore productivity of disturbed lands by returning topsoil to cover sodic spoils. Infiltration and water use efficiency were increased and productivity was found to be directly related to the thickness of good quality soil placed over the poor quality spoil. Grass establishment was difficult on silty clay loam sodic spoil (SAR or ESP greater than 25),and as little as 5 cm of respread topsoil considerably increased the productivity. High grass yields were obtained initially with 30 cm of topsoil plus NP fertilizer but the high productivity was not sustained. Productivity decline was partly attributed to upward sodium migration which deteriorated the respread topsoil.

Analysis of Conclusions

Further studies on the upward migration of sodium and other salts into the respread topsoil are necessary and should be continued.

Title: **EFFECTS OF TOPSOIL THICKNESS PLACED ON SPOILBANKS ON WHEAT AND CORN YIELDS IN NORTH DAKOTA**

Authors: M.W. Pole, A. Bauer, L. Zimmerman, and S.W. Melsted

Organization: North Dakota Agricultural Experimental Station (NDSU), Fargo, ND and Northern Great Plains Research Center, USDA-SEA, Mandan, ND

Format: Paper

Reference: Proceedings of 4th Annual Meeting of the Canadian Land Reclamation Association, Regina, Saskatchewan, 1979

Key Index Words: Soil Requirements, Spoil Properties, Topsoil, Productivity

Brief Description

This paper describes the results of field plot experiments conducted at Beulah where 2, 6, 12, and 24 inches of topsoil had been replaced over moderately saline and sodic spoil. Yields of spring wheat and corn were greatest with 24 inches of topsoil, with yield on 12 inches of topsoil often as good. Differences in yield due to greater topsoil thickness decreased with succeeding years; (the experiment was run for four years). No evidence of upward migration of sodium or other salts was observed.

Analysis of Conclusions

These yields were not compared to undisturbed soils and there is no indication that the plots with 24 inches of topsoil produced optimum yields.

Title: **TOPSOIL/SUBSOIL REQUIREMENTS TO RESTORE NORTH DAKOTA MINED LAND TO ORIGINAL PRODUCTIVITY**

Authors: J.F. Power, F.M. Sandoval, and R.E. Ries

Organization: USDA-ARS, Northern Great Plains Research Center, Mandan, ND

Format: Paper

Reference: Mining Engineering, pp. 1708-1712, December 1979

Key Index Words: Soil Requirements, Spoil Properties, Topsoil, Subsoil, Sodium Migration, Productivity

Brief Description

This paper summaries the various research projects conducted at the Northern Great Plains Research Center to determine the minimum thickness of topsoil and subsoil to achieve maximum production. The conclusions were that 1) at least 70 cm of soil material is needed to achieve maximum production, 2) topsoil must be segregated and spread separately from subsoil, 3) production depends on the quality of the soil materials returned, and 4) erosion and upward salt movement must be controlled for sustained production.

Analysis of Conclusions

Questions on the magnitude of sodium migration and adequate controls have not been answered.

Title: **ROOT ZONE MANAGEMENT IN NORTH DAKOTA COAL MINE RECLAMATION**

Authors: G.A. Halvorson, S.W. Melsted, S.A. Schroeder, M.W. Pole, C.M. Smith, and E. Deibert

Organization: Department of Soil Science, North Dakota State University, Fargo, ND

Format: Paper

Reference: North Dakota Agricultural Experiment Station Farm Research 37(6):9-12, 1980

Key Index Words: Soil Requirements, Topsoil, Subsoil, Compaction, Productivity

Brief Description

This paper describes the results of the first growing season following the establishment of the trench plots of Falkirk. Various soil thicknesses were placed over different textured nonsaline, nonsodic overburden. The preliminary results indicated that wheat yields improved with increasing thickness of topsoil from 9 to 18 inches; replacing topsoil and subsoil improved the yields over the gravelly sandy loam compared to the replacement of only topsoil. Compaction of overburden material placed in the trenches caused by scrapers resulted in lowering of wheat yields. Subsidence was almost equal on compacted and non-compacted trenches after one year.

Analysis of Conclusions

The results are based on one year yield data, and should therefore be considered preliminary.

Title: **CHANGES OF SODICITY AND SALINITY IN SOILS RECONSTRUCTED ON STRIP MINED LAND**

Authors: S.D. Merrill, E.J. Doering, and J.F. Power

Organization: USDA-SEA-AR, Northern Great Plains Research Center, Mandan, ND

Format: Paper

Reference: North Dakota Agricultural Experiment Station Farm Research 37(6):13-16, 1980

Key Index Words: Soil Requirements, Spoil Properties, Sodicity, Salinity

Brief Description

The upward migration of sodium and other salts into replaced soil materials at several reclamation research sites in western North Dakota is discussed. Evidence is presented in the paper that indicates chemical diffusion played an important role in this process. The potential for degrading the respread soil with upward migration of sodium is greatest when the underlying spoil consists of dispersed mine spoils with SAR of 20 or more, and where only 12 inches or less of high quality soil material is available for respreading.

Analysis of Conclusions

The magnitude of degradation of soil materials and consequent effect on vegetation production when greater thickness of topsoil and subsoil are replaced has not been quantified. Although on the basis of theoretical calculations it has been concluded that the zone of sodium accumulation will become greater as the thickness of the replaced soil is increased, the experimental verification of this assumption has not been made.

Title: **SALINITY AND SODICITY FACTORS AFFECTING SUITABILITY OF MATERIALS FOR MINED LAND RECLAMATION**

Authors: S.D. Merrill, F.M. Sandoval, J.F. Power, and E.J. Doering

Organization: USDA-SEA-AR, Northern Great Plains Research Center, Mandan, ND

Format: Paper

Reference: Adequate Reclamation of Mined Lands? A Symposium, pp. 3-1 to 3-25, Soil Conservation Society of America and WRCC-21 Committee, Billings, MT, March 1980

Key Index Words: Soil Requirements, Spoil Properties, Salinity, Sodicity

Brief Description

The upward migration of sodium into replaced soil materials of reclamation research sites in western North Dakota is discussed. The conditions for the greater migration of sodium are when the spoil has a high level of sodicity (SAR greater than 20), very low hydraulic conductivity, fine-texture, and montmorillonite clay fraction. If the hydraulic conductivity of the spoil is sufficient to allow some leaching of soluble salts, it is postulated that upward migration of sodium will not be a problem. Salinity and sodicity guidelines are included in the paper.

Analysis of Conclusions

This paper contains guidelines that are useful when dealing with only limited amounts of topsoil and subsoil and when the spoil is predominantly sodic clay material.

Title: **WATER USE EFFICIENCY AS INFLUENCED BY TOPSOIL THICKNESS AND FERTILITY ON RECLAIMED LAND**

Authors: S.A. Schroeder, M.W. Pole and A. Bauer

Organization: Department of Soil Science (NDSU) and Northern Great Plains Research Center (USDA-SEA-AR), Mandan, ND

Format: Paper

Reference: North Dakota Agricultural Experiment Station Farm Research 37(6):24-26, 1980

Key Index Words: Soil Requirements, Spoil Properties, Topsoil, Fertility, Water Use, Productivity

Brief Description

Water use efficiency (WUE) was determined on research plots at the Beulah and Glenharold mines. The plots had different treatments of topsoil (2, 6, 12, and 24 inches). The WUE of wheat and corn increased significantly in 2 and 3 years out of 5 years, respectively, as the thickness of respread topsoil was increased. Nitrogen fertilizer had minimal effects on WUE for wheat and some effect on corn silage.

Analysis of Conclusions

There was concern expressed in this paper about the variability in the experimental plots caused by the reclamation process that may have overshadowed some statistically significant differences. Also, differential damage by insects within plots had occurred during some years which may have further affected the data.

Title: **EFFECT OF SOIL THICKNESS UPON SOIL WATER AND NITROGEN USE BY CRESTED WHEATGRASS IN THE NORTHERN GREAT PLAINS**

Authors: S.D. Merrill, J.F. Power, and R.E. Ries

Organization: USDA-ARS, Northern Great Plains Center, Mandan, ND

Format: Paper

Reference: Agronomy Abstracts, p. 184, 1981

Key Index Words: Soil Requirements, Topsoil, Subsoil, Fertility, Water Use, Productivity

Brief Description

Soil water and nitrogen uses by crested wheatgrass over various thicknesses of topsoil and subsoil over sodic spoil are discussed. Nitrogen uptake was nearer to the surface with less thickness of soil. Water use above the 30 cm depth was greater with less thickness of soil. Conclusion was lower yields with less soil.

Analysis of Conclusions

This information is based on a published abstract and not a full length paper. For adequate analysis of the conclusions, additional data and details are needed.

Title: **EFFECTS OF TOPSOIL AND SUBSOIL THICKNESS ON SOIL WATER CONTENT AND CROP PRODUCTION ON A DISTURBED SOIL**

Authors: J.F. Power, F.M. Sandoval, R.E. Ries, and S.D. Merrill

Organization: USDA-SEA-AR, Northern Great Plains Research Center, Mandan, ND

Format: Paper

Reference: Soil Science Society of America Journal 45(1):124-129, 1981

Key Index Words: Soil Requirements, Spoil Properties, Topsoil, Subsoil, Sodicity, Water Use, Productivity

Brief Description

Crop production and water use data from the soil wedge plots of the Glenharold Mine is discussed. Yields of the crops grown on the plots increased as the total soil thickness increased to the 90-150 cm range. Yields with this amount of soil equaled or exceeded that expected on similar undisturbed soil types. Water was extracted from the upper 30 to 90 cm of spoils when the soil/spoil interface was within 90 cm of the soil surface. There was no evidence of any accumulation of soil water just above the soil/spoil interface.

Analysis of Conclusions

This is a very important study regarding optimization of topsoil and subsoil respreading depths. Monitoring should continue to detect any upward migration of sodium and consequent degradation of replaced soil and reduced productivity.

Title: **TOPSOIL MANAGEMENT ON MINED LANDS**

Authors: G.E. Schuman and J.F. Power

Organization: USDA-SEA-AR, High Plains Grasslands Research Station, Cheyenne, WY and University of Nebraska, Lincoln, NE

Format: Paper

Reference: Journal of Soil and Water Conservation 36(2): 77-78, March-April, 1981

Key Index Words: Soil Requirements, Spoil Properties, Topsoil, Sodicity

Brief Description

This paper summarizes various research projects that have been conducted in the Northern Great Plains on the amount and quality of topsoil and subsoil necessary for mined land reclamation. The paper contains several general recommendations for topsoil (and subsoil) management.

Analysis of Conclusions

The paper is of a rather general nature. For more specific details on the various aspects, see the materials that are referenced in this paper.

Title: **SOIL DEPTH REQUIREMENTS TO RECLAIM SURFACE MINED AREAS IN THE NORTHERN GREAT PLAINS**

Authors: R.C. Barth and B.K. Martin

Organization: Colorado School of Mines Research Institute, Golden, CO

Format: Report

Reference: Colorado School of Mines Research Institute Report for U.S. Bureau of Mines, Contract No. J0265025, 1982

Key Index Words: Spoil Properties, Soil Requirements, Topsoil, Subsoil, Productivity

Brief Description

Fourteen wedge plots were established at different mines in the Northern Great Plains. Soil was replaced over different types of spoil with soil thicknesses varying from 0 to 152 cm in each plot. Yield data was obtained to determine optimum soil depths for each type of spoil. Also, a microbiological study was conducted on four of the plots. Findings were that soil depth requirement for optimum productivity varied with the type of underlying spoil. The optimum amount of soil thickness over nonsaline, nonsodic spoil varied from 40 to 85 cm and 70 to 96 cm over sodic spoil.

Analysis of Conclusions

It would be desirable to monitor some of these sites to study if any changes have occurred in the respread soil due to an upward migration of sodium from the underlying spoil.

Title: **EFFECT OF SUBSOIL QUALITY AND THICKNESS UPON CROP GROWTH AND WATER USE ON MINE SOIL RECLAIMED BY TOPSOIL AND SUBSOIL RESPREADING**

Authors: S.D. Merrill, R.E. Ries, and J.F. Power

Organization: USDA-ARS, Northern Great Plains Center, Mandan, ND

Format: Paper

Reference: Agronomy Abstract, p. 253, 1982

Key Index Words: Soil Requirements, Spoil Properties, Productivity, Water Use, Subsoil

Brief Description

The differences in productivity and water use of two forage grass species and spring wheat due to the use of different types (texture and salinity) and thickness (0-110 cm) of subsoil, with a uniform layer (20 cm) of topsoil, respread on a sodic mine spoil are discussed. Maximum yields occurred with total soil thickness of 60 to 90 cm. Under favorable precipitation the yields and water use of wheat were greatest on saline soils, but grass yields were little affected by subsoil quality except at midslope positions where salinity had an adverse effect.

Analysis of Conclusions

The results demonstrate that a complex interaction exists among soil quality factors, crops and water availability. However, being an abstract rather than a full length paper it does not provide enough explanation as to the reasons for some of the variations in yield caused by subsoil quality.

Title: **QUALITY PARAMETERS OF SPRING WHEAT AND FORAGE CROPS RELATED TO TOPSOIL AND SUBSOIL THICKNESS**

Authors: J.F. Power, R.E. Ries, and F.M. Sandoval

Organization: USDA-ARS Northern Great Plains ResearchLaboratory, Mandan, ND

Format: Paper

Reference: Soil Science Society of America Journal 46: 381-386, 1982

Key Index Words: Plant Responses, Topsoil, Subsoil, Nitrogen, Nutrient Deficiencies

Brief Description

This experiment was conducted on wedge plots at two western North Dakota mines to determine the effects of different thicknesses of topsoil and subsoil over sodic spoil on N and P content of spring wheat, grasses, and alfafa, and on the milling and baking qualities of wheat. Crop growth and yield for all species increased with total soil depths to about 90 to 120 centimeters. Generally, the presence of topsoil enhanced crop quality by increasing nutrient uptake. Reduced water storage and availability caused by decreasing subsoil depth tended to accumulate higher N concentrations and increase associated quality parameters in grain and forage, but with a corresponding decrease in yield.

Analysis of Conclusions

This study highlights the importance of topsoil and subsoil thicknesses as they are related to crop quality and yield.

Title: **PLANNING THE POST-MINING LANDFORMS FOR OPTIMUM USE OF AVAILABLE SOIL MATERIALS**

Authors: N.C. Wollenhaupt and J.L. Richardson

Organization: North Dakota State University, Fargo, ND

Format: Paper

Reference: Can Mined Land be Made Better Than Before Mining?, Proceedings of a conference held at North Dakota, pp. 69-76, November 1982

Key Index Words: Soil Requirements, Prime Soils, Land Use

Brief Description

This paper advocates that the approach of exactly replacing the pre-mining soil is not valid. A land use oriented soil reclamation procedure has been given. Reclamation of "prime landscapes" rather than the philosophy of "preserving prime soils" has been stressed.

Analysis of Conclusions

Two approaches - "preservationist" and "constructionist"- in reclamation strategy have been discussed with the "constructionist" approach favored. In its emphasis on optimum use of soil materials, the paper provides interesting but familiar information, which is useful in planning reclamation procedure in a given situation.

Title: **WHEAT YIELDS ON PRIME AND NONPRIME SOILS AND SOIL MIXTURES IN A GREENHOUSE STUDY**

Authors: F.S. Carter and E.C. Doll

Organization: NDSU-Land Reclamation Research Center, Mandan, ND

Format: Report

Reference: Land Reclamation Research Center, NDSU-Agricultural Experiment Station Technical Report No. 3, 1983

Key Index Words: Soil Productivity, Prime Soils, Productivity

Brief Description

This report describes the results of two greenhouse experiments comparing the productivity of prime farmland topsoil, nonprime topsoil, and mixtures of prime and nonprime topsoils. Comparisons were made between Bowbells loam (prime) and Williams loam (nonprime) soils collected from the Coteau Mine. Also, the productivity of the A horizon soil material was compared to that of a mixture of the A and upper B horizon materials. No productivity differences were observed in the A horizon materials compared to a mixture of A and upper B horizon materials. In the first experiment, wheat yields were higher on prime soil and on mixtures containing 50% or more of prime soil. In the second experiment, where a second crop was grown in the same potted soils, no yield differences in the prime and nonprime soil were observed.

Analysis of Conclusions

Field experiments studying the productivity of prime and nonprime soils should be established. Such studies should include other soil types also.

Title: **SOIL CONSTRUCTION FOR RECLAMATION OF SALINITY AND SODICITY AFFECTED MINE SOILS**

Authors: S.D. Merrill and E.J. Doering

Organization: USDA-ARS, Northern Great Plains Research Center, Mandan, ND

Format: Paper

Reference: Symposium on Soil and Overburden in Arid/Semiarid Mined Land Reclamation, Casper, WY, January 1983

Key Index Words: Soil Requirements, Spoil Properties, Salinity, Sodicity, Productivity

Brief Description

This paper provides a summary of reclamation research that has been conducted by the USDA-Agricultural Research Service staff at Mandan, ND, on the dynamics of salinity and sodicity in the reconstructed mined lands and their effects on plant growth.

Analysis of Conclusions

The results of studies summarized in this presentation are very useful in understanding the relationships between the quality of spoil and soil materials and the respreading depths of topsoil and subsoil for achieving optimum growth and yield of plants.

Title: **SODIUM MOVEMENT IN SOIL-MINESPOIL PROFILES: DIFFUSION AND CONVECTION**

Authors: S.D. Merrill, E.J. Doering, J.F. Power, and F.M. Sandoval

Organization: USDA-ARS, Northern Great Plains Research Center, Mandan, ND

Format: Paper

Reference: Soil Science 136(5):308-316, 1983

Key Index Words: Sodicity, Topsoil, Spoil Properties

Brief Description

This paper discusses the results of model calculations and laboratory experiments conducted to study the upward movement of sodium and other ions from spoil into the respread topsoil. Upward migration of sodium was found to be considerably more due to diffusion than by convective flow generated by soil-water evaporation. More sodium movement occurred in columns without evaporation than in columns subject to evaporation; reduced water content reduced diffusion, and very low minespoil hydraulic conductivity severely restricted convective flow.

Analysis of Conclusions

Application of these model calculations and laboratory results to field observations of salt movement in topsoil-covered minespoil under semiarid, continental climatic conditions indicated that salt diffusion is a significant mechanism for sodium accumulation in soil, provided the spoil is highly dispersed and the necessary chemical gradient is present. These data also showed that significant quantities of sodium will diffuse only 10 to 15 cm upward in materials of this nature.

Title: **RECLAMATION OF SODIC MINESPOILS WITH TOPSOILING AND GYPSUM**

Authors: S.D. Merrill, E.J. Doering, and F.M. Sandoval

Organization: USDA-ARS, Northern Great Plains Research Center, Mandan, ND

Format: Paper

Reference: Paper No. 83-2141, Presented in ASAE 1983 Summer Meeting, Bozeman, MT, June 1983

Key Index Words: Revegetation, Spoil Properties, Topsoil, Amendments

Brief Description

The effects of topsoiling and gypsum applications on the growth of crested wheat grass was studied at four mined sites in western North Dakota. The test sites were located at Center, South Beulah, Glenharold, and Indian Head Mines. With only 30 cm of respread topsoil the forage yield increased by 8%, 25%, and 84%, respectively, on minespoils of non-sodic, moderate sodicity, and high sodicity character. Gypsum increased forage yield by 23% on non-topsoiled, moderately sodic spoils, and by 19% on topsoiled, highly sodic spoil. Although gypsum treatment produced yield increases, but it was not as effective as topsoiling. The chief limitation for gypsum amendment was the constraint on downward leaching.

Analysis of Conclusions

This research has proved that even relatively small thicknesses of topsoil are beneficial for increasing plant growth on mined lands. Also, the use of gypsum was not found to be greatly profitable. Research needs to be continued on the determination of optimum soil respreading requirements under various conditions of spoil and soil properties, topography, and land use.

Title: **PHYSICAL AND CHEMICAL REQUIREMENTS OF OVERBURDEN LOCATED WITHIN THE POTENTIAL ZONES OF PLANT ROOTS AS INFLUENCED BY FIRST AND SECOND LIFT MATERIALS**

Authors: NDSU-Land Reclamation Research Center Staff

Organization: NDSU-Land Reclamation Research Center, Mandan, ND

Format: Report

Reference: NDSU-LRRC Final Report, April 1983

Key Index Words: Soil Requirements, Spoil Properties, Productivity, Topsoil, Subsoil

Brief Description

Trench plot experiments were established at Falkirk to determine the amount of topsoil and/or subsoil needed to produce optimum yields over different textured, nonsaline, nonsodic overburden materials. Findings were that at least 18 inches of topsoil produced optimum yields over nonsaline, nonsodic spoil with an adequate water holding capacity. Additional topsoil or subsoil is needed when the spoil has a low water holding capacity, this amount is probably less than 60 inches total.

Analysis of Conclusions

The study did not determine the minimum soil thickness needed to produce optimum yields over nonsaline, nonsodic spoil with a low water holding capacity.

Title: **PRODUCTIVITY OF PRIME, NONPRIME AND RECLAIMED SOILS IN WESTERN NORTH DAKOTA**

Authors: S.A. Schroeder and E.C. Doll

Organization: NDSU-Land Reclamation Research Center, Mandan, ND

Format: Preliminary Report and Paper*

Reference: North Dakota Agricultural Experiment Station Farm Research, 41(5):3-6,31, 1984

Key Index Words: Prime Soils, Productivity

Brief Description

Field studies were conducted at the Beulah and Center Mines to identify factors related to productivity of undisturbed prime and nonprime soils and reclaimed areas using corn, wheat and barley as test crops. Yield differences between the prime and nonprime sites were noted. At Beulah the nonprime site yielded better than the prime site, at Center the opposite occurred. After the third year of the experiment, the reclaimed sites appeared to yield similar to the average yield of the undisturbed sites.

Analysis of Conclusions

Additional research should be conducted to determine the productivity of reclaimed lands as compared to undisturbed prime farmland and nonprime areas. In doing so, the differences or similarities in the physical and chemical characteristics of the prime and nonprime soils must be considered.

Title: **PLANNING AND EVALUATING CROPLAND RECLAMATION AFTER STRIPMINING IN NORTH DAKOTA**

Authors: E.C. Doll, N.C. Wollenhaupt, G.A. Halvorson, and S.A. Schroeder

Organization: NDSU - Land Reclamation Research Center, Mandan, ND

Format: Paper

Reference: Proceedings of the Third Biennial Symposium on Surface Coal Mine Reclamation on the Great Plains, pp. 88-101, Billings, MT, March 1984

Key Index Words: Topography, Prime Soils, Productivity

Brief Description

A high percentage of lands affected by stripmining in North Dakota are designated to cropland postmining use. The factors involved in returning reconstructed soils to a mature, steady state must be better understood in order to more effectively plan and evaluate cropland reclamation. In this paper emphasis is given to topographic design strategies, methods of overburden and soil characterizations, and to using soil parameters as they relate to productivity in assessing reclamation success. It discusses regulatory changes that may be necessary in order to develop more effective and cost efficient reclamation programs and better criteria to evaluate the success of reclamation.

Analysis of Conclusions

This is a useful step in a progessive system of research in the development and evaluation of reclamation in North Dakota. It combines past experience with present understanding and gives direction to future research in this area.

Title: **SOIL REPLACEMENT FOR RECLAMATION OF STRIPMINED LANDS IN NORTH DAKOTA**

Authors: E.C. Doll, S.D. Merrill, and G.A. Halvorson

Organization: NDSU-Land Reclamation Research Center and USDA-ARS Northern Great Plains Research Laboratory, Mandan, ND

Format: North Dakota State University, Agricultural Experiment Station Bulletin

Reference: North Dakota State University Agricultural Experiment Station Bulletin 514, 1984

Key Index Words: Soil Replacement, Spoil Properties

Brief Description

This bulletin summarizes the results of several field experiments which were conducted at various mine sites in North Dakota to study the response of some crops to different thicknesses of replaced suitable plant growth materials. The authors developed recommendations for topsoil and subsoil replacement thicknesses based on spoil properties such as sodium adsorption ratio and texture, assuming a rooting depth of four feet. A range of subsoil respread thicknesses has been proposed for various types of regraded spoil. The bulletin emphasizes the need for basing soil respread thicknesses on the properties of the underlying graded spoil rather than salving and respreading of all the available soil materials.

Analysis of Conclusions

This report provides an excellent summary of research data on soil replacement thicknesses and forms the basis for the rule changes made in 1986 regarding soil salvage and replacement.

Title: **EFFECT OF SOIL THICKNESS ON NITROGEN DISTRIBUTION AND USE BY CRESTED WHEATGRASS**

Authors: J.F. Power, S.D. Merrill and S.J. Smith

Organization: USDA-ARS Lincoln, NE; USDA-ARS, Mandan, ND; and USDA-ARS Durant, OK

Format: Paper

Reference: Soil Science Society of America Journal 49:1461-1465, 1985

Key Index Words: Soil Replacement, Soil Productivity, Nitrogen

Brief Description

This study was conducted to evaluate the effects of soil thickness on the distribution and use of both available soil and fertilizer N. Microplots were established at four locations on reconstructed mine soils where total respread thicknesses were 0.25, 0.50, 0.75 and 1.00 m, over graded sodic (SAR 29.5) spoil. Enriched 15N fertilizer was applied to those microplots in either the spring or fall, forage was harvested, and the plots were excavated (in either the first or second year after application) to determine relationships between soil thicknesses and uptake of soil and fertilizer N.

Analysis of Conclusions

Increased soil thicknesses greatly increased forage and root growth, but much lesser effect on N concentration in plants. Uptake of labeled N was not greatly influenced by soil depth but uptake of soil N generally increased two to threefold as thicknesses of respread soil increased from 0.25 to 1.0 m. One of the most important conclusions to be drawn from this experiment is that increased plant N uptake resulting from increased soil thickness comes largely from better utilization of indigenous soil N. Further research is suggested to elucidate the role of microbial activity to the N transformations that occurred to account for better utilization of indigenous soil N in areas of increased soil respread thicknesses.

Title: **EFFECT OF DISTURBED SOIL THICKNESS ON SOIL WATER USE AND MOVEMENT UNDER PERENNIAL GRASS**

Authors: S.D. Merrill, S.J. Smith, and J.F. Power

Organizations: USDA-ARS, Northern Great Plains Research Laboratory, Mandan, ND

Format: Paper

Reference: Soil Science Society of America Journal 49: 196-202, 1985

Key Index Words: Water Use, Sodicity, Soil Replacement

Brief Description

Water use and movement and root growth were monitored in constructed soil profiles of 0.25, 0.50, 0.75, and 1.0 meter depth over sodic mine spoil. Forage yield was 2 to 3.5 times greater on 1.0 m profiles than on 0.25 m profiles. Water uptake from spoil was much lower than that from topsoil and subsoil. Low hydraulic conductivity was the dominant factor which limited water storage and use in spoil. Root growth and soil water potentials in spoil were not significantly different between spoil and subsoil. Reduced soil thickness resulted in reduced water use efficiency.

Analysis of Conclusions

This study describes the relationship between soil depth over sodic spoil and productivity. Because low hydraulic conductivity of sodic spoil inhibits soil water storage and release, soil depth becomes the limiting factor in water availability and, hence, productivity.

Title: **TOPSOIL AND SUBSOIL REPLACEMENT ON STRIPMINED LAND IN NORTH DAKOTA**

Authors: G.A. Halvorson and E.C. Doll

Organization: NDSU-Land Reclamation Research Center, Mandan, ND

Format: Paper

Reference: Second Annual Meeting American Society for Surface Mining and Reclamation Proceedings, pp. 232-241, Denver CO, October 8-10, 1985

Key Index Words: Spoil, Water Holding Capacity, Soil Replacement

Brief Description

This paper summarizes the results of several field trials conducted at various North Dakota mine sites to study the effects of different thicknesses of replaced suitable plant growth material on crop yields. The authors developed recommendations for topsoil and subsoil replacement thicknesses based on spoil properties. The importance of an adequate premine characterization of all soil and overburden materials was emphasized.

Analysis of Conclusions

This paper provides an excellent summary of research data on soil replacement thicknesses needed to achieve optimum yields. The authors felt additional research is needed to 1) study the use and amelioration of poor quality soil and overburden materials, 2) to adequately characterize the changes that occur in unweathered spoil materials placed within the root zone, and 3) to predict sodium movement in reclaimed soils over sodic spoils.

Title: **TOPSOIL AND SUBSOIL THICKNESS REQUIREMENTS FOR RECLAMATION OF NONSODIC MINED-LAND**

Authors: G.A. Halvorson, S.W. Melsted, S.A. Schroeder, C.M. Smith, and M.W. Pole

Organization: NDSU-Land Reclamation Research Center, Mandan, ND

Format: Paper

Reference: Soil Science Society of America Journal 50:419-422, 1986

Key Index Words: Soil Replacement, Soil Texture, Topsoil, Subsoil

Brief Description

Eight trenches were excavated to a depth of 4.6 m and filled with three different textures of spoil to evaluate topsoil and subsoil thickness requirements for crop production on nonsaline, nonsodic spoil material at the Falkirk Mine, near Underwood, ND. Wheat, barley and corn yields were compared on plots with 0.23, 0.46, or 0.69 m of topsoil replaced over loamy sand spoil with and without subsoil, over clay loam spoil, or over silty clay loam spoil. Some of the plots were also irrigated.

Analysis of Conclusions

Crop yields increased with increasing thickness of replaced topsoil, especially on trenches filled with loamy sand spoil. The study suggested that at least 0.7 m of topsoil and/or subsoil should be respread over coarse textured, nonsodic spoil for maximum yields. This is consistent with the current North Dakota regulations which require 36 inches of SPGM over coarse textured, nonsodic, nonsaline spoil.

Title: **CORN AND WHEAT RESPONSE TO TOPSOIL THICKNESS AND PHOSPHORUS ON RECLAIMED LAND**

Authors: G.A. Halvorson, A. Bauer, S.A. Schroeder, and S.W. Melsted

Organization: NDSU-Land Reclamation Research Center, Mandan, ND

Format: Paper

Reference: Journal of Environmental Quality 16(1):73-76, 1987

Key Index Words: Productivity, Soil Replacement, Sodicity, Plant Responses, Fertility, Water Use

Brief Description

This paper examines the effects of topsoil respread thickness and rates and placement of P on yield of wheat and corn on reclaimed land. Placement of 0.15 to 0.60 m of sandy loam topsoil over moderately sodic spoil increased corn and wheat yields compared to only 0.05 m. Yields consistently increased with topsoil thickness up to 0.30 m. However, results indicated that respreading of more than 0.30 m of coarse textured topsoil may actually reduce productivity because of poorer water holding capacity. Response to P broadcast at the topsoil-spoil interface or on the topsoil surface were small, and occurred at the low P rate. Wheat yields were not increased by drill applied P. Corn silage yields were improved by banded application at moderate rates in two out of of four years.

Analysis of Conclusions

This study confirms that topsoil replacement increases crop yield on reclaimed lands. It also indicates that the texture of soil and underlying spoil have an effect on the ability to continuously supply water to the growing crop, and should therefore be considered in determining soil respread thicknesses. Current North Dakota soil test recommendations for P were found to be accurate for reclaimed soils.

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Title: **EFFECT OF LANDSCAPE POSITION ON SPRING WHEAT YIELDS AND WATER** USE

Authors: G.A. Halvorson

Organization: NDSU-Land Reclamation Research Center, Mandan, ND

Format: Paper

Reference: Planning, Rehabilitation and Treatment of Disturbed Lands, Billings Symposium, 1990

Key Index Words: Topography, Soil Water, Soil Moisture, Runoff

Brief Description

A 4-year study of wheat yields and water use from different soil series in Underwood and Beulah, ND, areas is reported. The soil series included Zahl, Williams, Bowbells, and Tonka , which are located on hilltops, sideslopes, foot- and toeslopes, and depression areas, respectively. At each site topo factor was calculated by measuring the slope in 4, right-angle apart, directions, and adding them up. The downward slopes were considered positive (i.e., the site would receive water due to run-on) and the upward slope negative (i.e., the site would lose water due to runoff). The topo factor was calculated from 3, 6, 15, and 30 m from each site. Wheat yields on different soils were related to water use and occurred in the order Tonka, Bowbells, Williams, Zahl. Inclusion of topo factor in the regression between wheat yield and water use increased coefficient of determination in all cases. Topo factor measured at 15 m distance from the sampling site gave the best result.

Analysis of Conclusions

The results presented in this paper underscore the importance of topographic location and wheat yield, and relate it to the distribution The relationship of landform to water distribution has been quantified by using an easily derivable topo factor, which can be plugged into a regression model to predict wheat yields. This concept is quite useful for predicting wheat yields on undisturbed as well as reclaimed lands.

Title: **RELATION OF SATURATION PERCENTAGE TO SODIUM ADSORPTION RATIO IN NORTH DAKOTA SPOIL**

Author: E.C. Doll and F.S. Carter

Organization: NDSU-Land Reclamation Research Center, Mandan, ND

Format: Report

Reference: NDSU-Land Reclamation Research Center Technical Report No. 8, 1991

Key Index Words: Saturation Percentage, Sodium Adsorption Ratio, Spoils

Brief Description

This report recommends that the spoil saturation percentage (SP) parameter, required by ND reclamation rules to be used in conjunction with SAR to determine the soil replacement thickness, should be eliminated. It further recommends that the total depth of soil replacement over all spoils with SAR between 12 and 20 should be 36 inches. These recommendations are based on the authors' evaluation of a large number of spoil samples from the Falkirk, Beulah, Indian Head and Glenharold mines, with respect to the distribution and relationship of their SP and SAR values. The authors claim that in North Dakota soils and spoils SP is primarily dependent on the level of SAR rather than on the kind oramount of clay present in them. Basing their arguement on the effective rooting depth of most crops in North Dakota as being 4 feet, the authors claim that by replacing 36 rather than 42 inches of soil over the regraded spoils having SAR between 12 and 20 and SP greater than 95%, only a 3% loss in soil productivity is likely to occur.

Analysis of Conclusions

The data and discussion presented in this report are important in determining whether the SP parameter should be dropped from the existing rule regarding soil replacement depths.

Title: **TOPOGRAPHIC POSITION EFFECTS ON SOIL WATER AND WHEAT YIELDS ON RECLAIMED**

Author: S.A. Schroeder

Organization: NDSU-Land Reclamation Research Center, Mandan, ND

Format: Report

Reference: North Dakota Farm Research 48(5):3-5, 1991

Key Index Words: Topography, Soil Water, Productivity

Brief Description

This field investigation was conducted at the Center and Falkirk mines to study the effect of landscape position on water distribution and wheat yield. The topographic effects on available soil water at planting and wheat yield were significant. Available soil water and wheat yields were generally higher on the downslope compared to upslope landscape positions. However, year to year variations were also noted.

Analysis of Conclusions

The results presented in this paper, and several other papers of similar theme, suggest that higher crop yields on the prime farmland soils in North Dakota are due to their favorable topographic position rather than due to any intrinsic differences in the quality of their soils. This line of research is useful as it will help determine if segregation of prime and non-prime topsoil is necessary.

Title: **TILLAGE EFFECTS ON WATER USE AND YIELDS OF WHEAT FROM RECLAIMED SOILS**

Authors: K.C. Vining and S.A. Schroeder

Organization: NDSU-Land Reclamation Research Center, Mandan, ND

Format: Paper

Reference: ND Farm Research 49(4):8-11, 1992

Key Index Words: Tillage, Soil Water, Subsoil

Brief Description

Field experiments were conducted over a period of three years at the Glenharold and Beulah Mines to study the effects of conventional chisel and subsoil tillage treatments on compaction, root growth, soil water status, and crop yield. This paper focuses on soil water usage and spring wheat yields only. Chiseling was done to a depth of 6 inches with 12-inch shank spacing, and subsoiling was done to a depth of 24 inches with 42-inch shank spacing. The tillage treatments had an inconsistent effect on wheat yield as well as the usage of soil water. Also, responses varied with the location.

Analysis of Conclusions

The inconsistent results do not allow any valid conclusions. Deep tilling of the subsoil did not seem to improve soil water storage or use.

Title: **SOIL DEPTH AND QUALITY REQUIREMENTS FOR RECLAMATION OF RANGELANDS**

Authors: G.A. Halvorson, and D.R. Kirby

Organization: NDSU-Land Reclamation Research Center, Mandan, ND

Format: Report

Reference: Report to the North Dakota Legislative Council, Pursuant to Section 5 of H.B.1005 of the fifty-second Legislative Assembly, June 30, 1993

Key Index Words: Soil Replacement, Topoedaphic Unit, Alpha Diversity, Productivity, Cover

Brief Description

This report consists of a large number of data tables with one and a half page of text, summing up the results of an investigation conducted at the Center, Indian Head, and Glenharold Mines on the relationship of rangeland vegetation yield, cover and diversity to replaced soil depths. Topoedaphic land units were identified, using stepwise multivariate analysis on soil physical, chemical and topographic information, and proposed as a classification system for reclaimed lands. A major conclusion of the study was that replaced soil thicknesses lesser than those required by the North Dakota rules may be needed for adequate revegetation of post-mine rangelands.

Analysis of Conclusions

The assumption made in this report that meeting 90 percent of the standard (as required by the federal rules) would be considered as successful revegetation in North Dakota is not correct. Otherwise, the study is quite important and significant for the lignite industry and the regulatory agency to determine if any changes in the SPGM replacement requirements are needed.

Title: **RELATION OF COMPACTION AND SOIL PHYSICAL PARAMETERS TO PRODUCTIVITY OF RECLAIMED SOIULS**

Authors: S.A. Schroeder and K. Vining

Organization: NDSU-Land Reclamation Research Center, Mandan, ND

Format: Report

Reference: Report to the North Dakota Legislative Council, Pursuant to Section 5 of H.B.1005 of the fifty-second Legislative Assembly, June 30, 1993

Key Index Words: Compaction,Tillage, Bulk Density, Soil Strength, Soil Water

Brief Description

The report contains the results of field experiments initiated in 1987 at the Center and Freedom Mines to investigate 1) the initial and long term effects of various tillage treatments on compaction of respread soils and on crop yield, 2) quantify the effects of plant species, root growth, and climate on compaction, and 3) the effects of precropping with forage species on spring wheat yield. The tillage treatments included chiselling, grader ripping and deep ripping. The results indicated that subsoil tillage teatments applied prior to topsoil respreading did not alleviate compaction because the subsoil was recompacted in the topsoiling process. Bulk density and soil strength increased with time due to reconsolidation. Tillage treatments did not affect crop yield or root growth either. Wheat yields were unaffected by precropping with forages. Weather alone played a dominant role in affecting forage and wheat yields.

Analysis of Conclusions

The study clearly indicates that other approaches to solving the compaction problem in respread soils needs to be explored and developed.

Title: **RESEARCH ON THE RECLAMATION OF PRIME FARMLAND IN NORTH DAKOTA**

Authors: G.A. Halvorson and M.V. Nathan

Organization: NDSU-Land Reclamation Research Center, Mandan, ND

Format: Report

Reference: Report to the North Dakota Legislative Council, Pursuant to Section 5 of H.B.1005 of the fifty-second Legislative Assembly, 58p, June 30, 1993

Key Index Words: Prime Farmland, Prime Soils, Topsoil, Subsoil, Topography

Brief Description

This report reviews the findings of past and recent research on the reclamation of prime agricultural soils in North Dakota. Most of the experimental data examined showed that topography plays an important role in determining the productivity of a given area. The studies reviewed include field plot experiments (initiated at the Glenharold Mine in 1974, Indian Head in 1975, Falkirk in 1978, Beulah and Center Mines in 1980, Freedom and Falkirk in 1992); greenhouse studies conducted in 1983, and other topography related research conducted at several reclaimed as well as undisturbed sites.

Analysis of Conclusions

Much of the scientific evidence collected indicated that productivity differences between prime and nonprime soils are not as much due to any inherent differences in the quality of the soil materials *per se* , but are due to their topographic location and, thus, related to the availability of moisture for plant growth. If this conclusion is correct, then the regulations addressing prime soil removal/respreading would have to be amended, which would lower reclamation cost without sacrificing other standards.

Title: **PREDICTING REGRADE SPOIL QUALITY FOLLOWING RECLAMATION AT A SURFACE COAL MINE**

Author: J.D. Friedlander

Organization: The Coteau Properties Company, Freedom Mine, Beulah, ND.

Format: Paper

Reference: Proceedings of 10th National ASSMR Meeting, pp. 796-814, Spokane, WA, 1993

Key Index Words: Soil Replacement, Soil Thickness, Spoil Properties

Brief Description

This paper analyzes the state regulatory policy (formula) for determining the amount of suitable plant growth material that must be salvaged to meet the respread depth requirement, which is tied to the properties of the regraded spoil It involved an in-depth review of field data regarding the predicted and the actual thicknesses of soil respread on a large acreage of graded spoil. The paper also discusses the research that led to the current soil replacement rule. The analysis showed that the actual replacement depths were about 10% less than predicted by the

Analysis of Conclusions

The author suggests that the assumptions used to determine the quantity of soil required for replacement should be reevaluated, as it may be possible to reduce this requirement by as much as 10%, thereby saving some cost in soil salvage. How widely would this conclusion be applicable to other mines remains to be tested.

Title: **EFFECTS OF SOIL DEPTH AND DROUGHT ON RECLAIMED WOODLANDS IN WEST CENTRAL NORTH**

Authors: D. Nilson, D. Kirby, and K. Krabbenhoft

Organization: Basin Cooperative Services, Glenharold Mine, Stanton, and NDSU- Animal and Range Science Department, Fargo, ND

Format: Paper

Reference: Decades Later: A Time for Reassessment, Proceedings of 12th National ASSMR Meeting, pp. 141-150, Laramie, WY, 1995

Key Index Words: Soil Replacement, Drought, Woodlands, Diversity, Plant Species

Brief Description

Survival, stem densities, and diversity of deciduous woodlands reestablished on reclaimed land a the Glenharold mine were studied over a period of 1983 to 1994. Stem densities declined following drought in 1988, but increased with the onset of cool, wet weather in 1992. However, the recovery in stem density was nil on sites respread with 25 -50 cm of soil, but significantly higher on sites respread with 100-150 cm of soil. Species diversity was not significantly affected by drought. Diversity value (H')t increased from 1.207 to 1.462. over the study period and was similar to the premining woodland communities.

Analysis of Conclusions

This study emphasizes the importance of soil replacement depths and root zone characteristics for reestablishing woodlands on reclaimed land. The effects of drought on tree survival and its interaction with soil thickness (or moisture holding properties of root zone) are also underscored.

Title: **COMPARATIVE EVALUATION OF PRODUCTIVITY OF PRIME AND NONPRIME LAND**

Author: G.A. Halvorson

Organization: NDSU-Land Reclamation Research Center, Mandan, ND

Format: Report

Reference: Report on Contract No. LRC-XVIII-58 - Submitted to the Industrial Commission of North Dakota, 11p. March 20,.1996

Key Index Words: Prime Farmland, Prime Soils, Topography

Brief Description

The 1995 results of field plot experiments conducted at the Freedom and Falkirk Mines since 1992 are discussed. At each of these mines, plots had been constructed out of Bowbells, Williams and Zahl soils placed at topgraphically prime (runon) and nonprime (Runoff) locations. Each soil type was respread to two different soil depths. In 1995, wheat yield was unaffected by soil depth at both sites and affected by topographic position at the Freedom Mine only. Bowbells and Williams soils gave similar yields, but Zahl responded inconsistently.

Analysis of Conclusions

The author recommends that topsoil from Zahl locations can be mixed with Bowbells and Williams because its productivity potential is very close to the other two soils, and that the proportion of soil mass contributed by Zahl in a prime location would be quite low. The report purports that all soils may not need to be separately salvaged in prime farmland situations.

Title: **THE SUCCESS OF CURRENT SOIL DEPTH REQUIREMENTS ON MINELAND IN NORTH DAKOTA: AN ASSESSMENT**

Author: G.A. Halvorson

Organization: NDSU-Land Reclamation Research Center, Mandan, ND

Format: Report

Reference: Final Report on Contract No. ILRC-XV-50 - Submitted to the Industrial Commission of North Dakota, 13p. April 15,.1996

Key Index Words: Soil Replacement, Productivity

Brief Description

This report summarizes the results of a large number of investigations conducted to assess the relationship between the depth of soil replacement and crop yield. Wheat yields were measured from reclaimed and undisturbed lands and regressed with soil thickness in an attempt to determine whether the current soil replacement rules (based on spoil quality) are adequate to achieve or exceed the premining levels of productivity. The study was conducted in 1994 and 1995, and involved extensive sampling for yield assessment at the Center, Glenharold, Beulah, Freedom, and Falkirk Mines. The sampling sites selected included those that were reclaimed under the early as well as the current soil replacement rules. Data showed that in 1994 undisturbed lands yielded more than the reclaimed lands, which was ascribed to poorer management received by the latter. No difference was noted in average yields obtained under the two current alternative soil respreading options. No consistent relationship was found between the soil respread depth and yield, especially under the 'up to 60 inch soil salvage/respread' requirement.

Analysis of Conclusions

Evidence has been presented that yields from land reclaimed under soil respeading option No. 2 are similar to those produced under option No. 1. Based on the results, the author recommends that soil respreading option No. 2 could be made permanent. The enormous variability in the yield data is, however, a matter of concern to this reviewer.

Title: **PRODUCTIVITY OF PRIME AND NONPRIME TOPSOIL RECLAIMED IN EQUIVALENT TOPOGRAPHIC POSITIONS**

Author: G.A. Halvorson and M.V. Nathan

Organization: NDSU-Land Reclamation Research Center, Mandan, ND

Format: Paper

Reference: Successes and Failures: Applying Research Results to Insure Reclamation Success; Proceedings of 13th Annual Meeting of the American Society for Surface Mining and Reclamation, pp. 402-406, Knoxville, Tennessee, May 1996

Key Index Words: Soil Replacement, Productivity

Brief Description

Field experiments were conducted at the Freedom and Falkirk mines in North Dakota to compare the productivity of prime and nonprime topsoil materials placed side by side in different topographic locations. The ultimate purpose was to determine if separate handling of prime and nonprime topsoils, as required by rules, is really necessary. At each mine, Plots were located at 'prime' and 'nonprime' topographic locations. At the Freedom Mine, two topsoil respread thicknesses were employed. Topsoils used were from Bowbells series (prime) and from Williams and Zahl series (nonprime). Grain yield on Zahl was lower in the first year compared to the other soils, and this was attributed to lower initial moisture content in Zahl. In the years with good moisture, yields on the three soils were not significantly different, nor seemed to be affected by the thickness of the topsoil layer or the topographic position. But in drier years topographic position had a significant effect At the Freedom Mine, Zahl's productivity seemed to be consistently lower than the prime soils.

Analysis of Conclusions

The results of this study seem to point out that prime and nonprime soils have very little intrinsic difference with respect to their productivity potential. But their differences are either masked or accentuated by the sufficient or insufficient availability of soil water. The data presented in this paper has been the subject of many other reports and papers summarized in this volume.

Title: **COMPACTION EFFECTS ON MINELAND SOIL QUALITY**

Author: P.P. Sharma and F.S. Carter

Organization: NDSU-Land Reclamation Research Center, Mandan, ND

Format: Paper

Reference: Successes and Failures: Applying Research Results to Insure Reclamation Success; Proceedings of 13th Annual Meeting of the American Society for Surface Mining and Reclamation, pp. 430-441, Knoxville, Tennessee, May 1996

Key Index Words: Compaction, Soil Water

Brief Description

The authors emphasize that quantification of soil pore characteristics will allow evaluation of soil quality for reclamation success. Field saturated hydraulic conductivity and post infiltration redistribution of water was measured on 26 premine and postmine profiles at the Indian Head and Velva mines. The undisturbed soils had high effective porosities and associated hydraulic conductivities. The abandoned mineland locations had the widest range of variability in their pore structure attributes, depending on the presence/location of sodic spoil in the profile. The post-SMCRA reclaimed profiles with replaced subsoil and topsoil had improved pore structure but similar to that found in compacted soils.

Analysis of Conclusions

Under the North Dakota soil and climatic conditions regeneration of soil structure by natural processes is extremely slow to non existent. The current reclamation technology allows improvement in pore structure to a depth of about 0.3 m. At deeper depths, replaced subsoils lack pore space and pore continuity. This restriction in root zone limits productivity in reclaimed minelands. The authors' recommend that soil respreading techniques, post-reclamation land management, and the guidelines for evaluation of reclamation success must be focused on reclaiming the effective porosity of the entire root zone.

Title: **SUBSOIL CHARACTERISTICS AND LANDSCAPE POSITION AFFECT PRODUCTIVITY OF RECONSTRUCTED MINE SOILS**

Author: S.D. Merrill, R.E. Ries, and J.F. Power

Organization: USDA-ARS, Northern Great Plains Research Laboratory, Mandan, ND

Format: Paper (submitted for publication)

Reference: Unpublished draft

Key Index Words: Revegetation, Soil Water, Topography

Brief Description

Responses of spring wheat, crested wheatgrass, and Russian wildrye, grown on a reconstructed minesoil wedge-plot having different subsoil materials, were studied at the Indian Head Mine. The subsoil was of varying clay content (50%, 29%, and 13%), 1.2 m thick at its maximum, and covered by a 0.2 m thick layer of topsoil. Wheat grain yields were higher on plots with higher clay content. However, both crested wheatgrass and wildrye produced greater biomas on plots with least amount of clay in the subsoil. Greater water holding capacity of high-clay subsoil was cited as a reason for better wheat response. Wheat yields were also higher on the south sideslopes of two higher clay subsoils, reaching maximum at 1.0 m total soil depth. Forages yields were higher on the north sideslopes of the sandy loam subsoil plots.

Analysis of Conclusions

This study is important in that it shows how different species can meet their water requirement for best performance. In case of wheat the demand for water being highest in late vegetative and early reproductive stages, the presence of clayey subsoil with high water holding capacity in the soil profile fulfills that demand. On the contrary, forage grasses have a greater demand for water during their earlier stages of growth. In sand loam subsoils over impervious spoil, the easier interflow of water from higher to lower slope positions made water available to the forage species The results of this study further demonstrate that relatively lesser thicknesses of soil are required at the side slopes and lower landscape positions compared to the upper and summit positions of a reclaimed site.

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