NORTH DAKOTA STATE UNIVERSITY

APPLICATION TRANSMITTAL

SPONSOR ORGANIZATION: ND Industrial Commission

Address

PROJECT TITLE: Comparative Evaluation of Productivity of Prime and Nonprime Soils

Principal Investigator/ Project Director: Gary Halvorson

Department: Land Reclamation Research Center

PROJECT BUDGET: $ 21,698

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COMPARATIVE EVALUATION OF PRODUCTIVITY OF PRIME AND NONPRIME SOILS

A PROPOSAL SUBMITTED TO THE
LIGNITE RESEARCH COUNCIL
OF THE
NORTH DAKOTA INDUSTRIAL COMMISSION

FOR YEAR THREE (3) FUNDING

PRINCIPAL INVESTIGATOR
GARY A. HALVORSON
INTERIM SUPERINTENDENT/SOIL SCIENTIST

INDUSTRIAL COMMISSION FUNDING REQUESTED
$21,698

LIGNITE ENERGY COUNCIL FUNDING
$21,699

LAND RECLAMATION RESEARCH CENTER
NORTH DAKOTA STATE UNIVERSITY
MANDAN, NORTH DAKOTA

August 30, 1993

LAND RECLAMATION RESEARCH CENTER

TITLE OF PROJECT

Comparative Evaluation of Productivity of Prime and Nonprime Soils

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FUNDING PROFILE

Program Year	Cost
FY'92	$108,241
FY'93	88,000
FY'94	88,000
TOTAL ESTIMATED PROJECT COST	$284,241

INDUSTRIAL COMMISSION FUNDING REQUESTED

$21,698

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TABLE OF CONTENTS

ABSTRACT

Prior to mining, coal companies in North Dakota are required to separate prime land topsoil from nonprime land topsoil. Following mining, the prime topsoil must be replaced in a prime location and the nonprime topsoil in a nonprime location. This separate handling of these materials is expensive and may be unnecessary. Many of the soils in the mining area of western North Dakota differ in depth of topsoil because of their position in the landscape. The parent material for such soils as Bowbells, Williams and Zahl is the same and the quality of the topsoil between them is very similar.

The objectives of this research is to (1) compare the productivity of prime and nonprime topsoil materials placed side by side in different topographic positions, (2) determine whether the separate handling of prime and nonprime topsoil is necessary.

It is anticipated that this research will show that there is no difference in productivity between the different topsoil materials. If this is true then separation of prime and nonprime topsoils should not be necessary. It is expected to take three growing seasons to determine if differences are occurring. This request is for the third year of funding of this project.

The total project cost over three years is $286,019. Funding from the Industrial Commission for the third year of this study is $21,698. This will be matched with $21,699 from the Lignite Energy Council and $44,603 from the Land Reclamation Research Center.

The participants in this study include the Coteau Properties Co., the Falkirk Mining Co. and the Land Reclamation Research Center of the North Dakota Agricultural Experiment Station.

PROJECT SUMMARY

Current surface coal mineland reclamation regulations require separate handling of prime and nonprime soils. The proportion of soils which qualify as prime due to their location in a landscape unit of west-central North Dakota is low, and hence the separate handling is costly. Previous research has not compared the topsoil material from prime and nonprime soils in the field. Past research has also suggested that a better measure of the productivity of a particular soil at a given topographic location is to measure soil properties which affect potential yield. The objective of this study is to systematically monitor both yield and the soil properties comparatively between prime and nonprime soils placed side by side in a given topographic position. This will be accomplished in three tasks. Task I will compile and analyze data from previous and ongoing prime/nonprime soil productivity research. Task II will establish experimental plots of prime and nonprime topsoil at a given topographic and different topsoil depths and monitor yield and soil and environmental factors that affect yield. Task III will summarize information from Task I and Task II and analyze the data to compare actual as well as potential yields between prime and nonprime soils. This research is expected to help answer the prime and nonprime productivity issues and generate a more objective tool to evaluate reclamation success.

Task I is continuing. Other studies have been looking at prime and nonprime soils and the effect their topographic location has on yields. In Task II the plots are essentially established and we have begun collecting soil and yield data. Task III has just begun during the second year of the study, and we need to collect the third year of data to come out with some definite conclusions.

PROJECT DESCRIPTION

A. Introduction

Current federal and state regulations require separate handling of prime and nonprime topsoils. According to the present interpretation of prime farmland criteria, soils designated prime in the ustic moisture zone of North Dakota qualify because of landscape position. Most of these soils occur on nearly level or concave portions of the landscape and receive run off from adjacent soils in a higher position which do not meet prime farmland criteria. Prime soils are therefore, the product of microclimate and local surface and root zone hydrology rather than macro-climate or parent material.

In western North Dakota, availability of water is the most dominant factor controlling crop yields. Under conditions of limited rainfall, which is the general rule, the yield potential of prime land may not be significantly different from the yield potential of nonprime land. If the differences in the productive capabilities of prime and nonprime soils are the result of moisture differences due to topographic location rather than to differences in the properties of soil materials, then the currently required separate removal and placement of topsoil materials is unwarranted. In addition, higher overall productivity of reclaimed land may be attained by replacing available soil materials uniformly on an area reshaped to the most effective topographic configuration.

B. Objectives

1. Compare the productivity of prime and nonprime topsoil materials in different topographic positions.

2. Determine whether the separate handling of prime or nonprime topsoil is necessary.

C. Methodology

The objectives of this research will be accomplished using three separate tasks:

Task I. Sites on reclaimed land have been established and monitored for yield for the past five years. Yields from these sites will be measured again in the coming years to evaluate effect of topographic positions in a reclaimed landscape. These sites include three soils on a topographic sequence at the BNI mine at Center, North Dakota and a site at the Falkirk mine near Underwood, North Dakota. In addition, an undisturbed micro-catchment at the Falkirk mine is also being monitored for wheat yields. Information from this undisturbed site should provide data that can be used to compare with reclaimed sites.

Task II. Plots will be established at two different locations on reclaimed land. Topsoil material from prime and nonprime soils will be transplanted to the site and respread on separate plots in the different topographic positions. Wheat will be grown on these test plots and yield measurements will be taken. In addition, the soils will be monitored for SAR, EC, saturation percentage, soil moisture throughout the growing season, texture, bulk density, hydraulic conductivity and water holding capacity. Precipitation will be

monitored at the sites. Plant parameters which will be monitored include rooting depth, grain yield, degree of weed and insect infestations, and plant disease problems.

Task III. The data obtained from Tasks I and II will be compiled to determine if prime and nonprime topsoils need to be handled separately.

D. Report of Prior Year's Findings

This study was established in 1992. At Coteau site, the plots were constructed on June 10, 1992 and wheat was planted on June 23, 1992. Due to the busy schedule of Falkirk mine reclamation personnel we were able to construct the plots at this site only by October 14, 1992. Thus there was no crop grown at this site in 1992. The findings from 1992 growing season at Coteau mine site are summarized below:

(1) Soil types did have differences in initial soil moisture levels. Zahl had the lowest soil moisture (13.9%) when compared to Bowbells (15.1% wt. basis) and Williams (14.9% wt. basis).

(2) Dry matter yields were lower on Zahl (1068 kg ha^{-1}) than Bowbells and Williams (1350, 1275 kg ha^{-1}, respectively). Significant interactions in dry matter yields were observed between soil and land types (crop and range) and between soil type and sites (prime and nonprime).

(3) Grain yields were lower on Zahl (5.8 bu/ac) than Bowbells and Williams (9.9 and 9.4 bu/ac, respectively).

(4) The soil chemical analysis revealed that none of the topsoils used at this site had saline or alkaline problems. The Zahl had loamy texture whereas Williams and Bowbells had silty loam texture.

(5) The penetrometer data did not show any differences between soil types and topsoil depths in both crop and rangeland sites.

(6) The estimated available soil moisture for the surface 30 cm depth decreased from about 30 mm to 0 mm by one month after planting in all plots. The below average precipitation received at this site was probably insufficient to cause moisture redistribution in the profile, thus resulting in no differences between prime and nonprime sites.

(7) There was a significant linear relationship between the initial soil moisture at the 0-30 cm depth and grain yield. This suggests the yield differences what we observed between Zahl, Williams and Bowbells were probably due to the initial soil moisture status of these topsoils.

It is to early to draw conclusions from the 1992 data at this time for the following reasons: 1) Wheat crop was planted quite late in the season, 2) There has been not enough time for moisture redistribution in the landscape yet. Based on the previous work done in the field and greenhouse, it is anticipated that the nonprime topsoil (Williams, Zahl) and prime topsoil (Bowbells) will have equal productivity, 3) A good set of data should be obtained in 1993, but more than one years' data is necessary for conclusions to be drawn.

E. Anticipated Results

The year 1993 received much higher precipitation than the average and both sites were planted in early May. The harvest will be done by the first week of September. Since moisture should not be a limiting factor this year, we expect that the nonprime topsoil material from the Zahl and Williams soil will have productivity equal to that of the Bowbells soil. The year 1993 is the first year in which we will have a complete crop and soil data from this study and another year of complete data is essential before we could come to definite conclusions of this research study. If the data do show no differences between topsoils, recommendations will be made to eliminate the separate handling of prime and nonprime soil.

F. Facilities, Resources and Techniques to be Used

Plots have been established on reclaimed land at the Coteau Properties Company Freedom Mine and at the Falkirk Mine. Personnel and equipment from these mines were used in the establishment of these plots.

The plots will be maintained by personnel from the LRRC. Equipment sufficient to do this job is owned by the LRRC. The LRRC is located on the grounds of the Northern Great Plains Research Laboratory, just south of Mandan, North Dakota. Laboratories at this location are sufficient to handle analyses of the physical and chemical characteristics of the soil and spoil in this study.

G. Environmental and Economic Impacts

This project is occurring in conjunction with the ongoing reclamation program of the Coteau Properties Company and the Falkirk Mining Company. During the course of the project

therefore, the environmental impacts should not be very different from the normal mining and reclamation process.

Economically, the two companies involved do incur some costs related to the cost of the project. These costs are mainly equipment time for the construction of the plots. Compared to the overall cost of the mining operation, these costs were rather minor. In the long term, the economic benefit to the coal companies could be substantial. If the requirement to separate prime and nonprime topsoil can be eliminated the coal companies should see a substantial savings in soil handling costs. It is also our belief that a better job of reclamation can be done if the depth of topsoil is uniform throughout the landscape rather than deeper in the prime positions and shallower in the nonprime positions.

Need for the Project

This project is needed because the present regulations requiring separate handling of prime and nonprime topsoils may not be necessary. This project is designed to determine whether separate handling is necessary. If it can be shown that separate handling of prime and nonprime topsoils is not necessary substantial savings to the coal companies in reclamation costs should occur. In addition, a better job of reclamation would occur if the topsoil depth was uniform across a landscape.

STANDARDS FOR SUCCESS

The project will be considered successful if the data from the field experiment shows clearly whether or not there is any difference in productivity between prime or nonprime topsoil. This will allow us to proceed in seeking changes in the regulations.

BACKGROUND

Research was performed in a controlled greenhouse experiment comparing wheat yields from prime (Bowbells) and nonprime (Williams) soils from the same soil association (Carter and Doll, 1983). Two successive crops were grown under optimum conditions using the same soil materials. In the first crop, yields from the prime soil were significantly higher than from the nonprime soil. The higher organic matter content of the prime soil may have resulted in better aeration for crop growth. The structure of the soil samples was severely disrupted during the process of drying and screening. However, in the second crop, yield differences between the prime and nonprime soil were not apparent. Visual observations of the soil materials during reporting for the second crop indicated that the physical structure of the soils was appreciably better than when the first crop was planted. These results indicate that yields on reclaimed prime soils may initially be higher than yields on reclaimed nonprime soils. However, after soil structures have been reestablished, yields between the soils would not be expected to differ. Carter and Doll (1983) recommended the use of field experiments to adequately evaluate productivity differences among both disturbed and undisturbed prime and nonprime soils.

From the results of a three-year experiment comparing crop yields from reclaimed and undisturbed prime and nonprime soils located at two different mines, Schroeder and Doll (1984) concluded that, due to rainfall differences and insect and small animal damage on sites isolated from other cropped areas, precise evaluation of soil factors contributing to yield differences was not possible. Even though these plots were designed for statistical comparisons, and statistically significant differences were obtained, no consistent trends were obtained. Over the three-year period, the relation of yields on reclaimed soils to those on undisturbed soils were inconsistent;

in some cases they were significantly higher, in others significantly lower, and sometimes not different.

The capacity of a soil to produce a potential yield depends on soil parameters which can be measured quantitatively. Research at the Land Reclamation Research Center has shed new light on the measurement and importance of using soil parameters for the determination of reclamation success. Carter, et al. (1987) reported that "*in situ*" soil properties such as bulk density, macropore space, and hydraulic conductivity are the soil parameters most severely disrupted during mining and reclamation. In continued studies, Carter (1991) found that average values of soil chemical properties, texture, and calculated percents of pore sizes were not significantly different between prime and nonprime soils located in a 10 ha site. Bulk densities at all measured depths were generally higher (not significant) from the prime soils during all four years of the study. Surface infiltration rates, measured in 1990, were significantly higher from the nonprime soil which indicated the existence of greater or larger continuous macropores than in the prime soil. These results indicated the need for more investigation into the properties of reclaimed and undisturbed prime and nonprime soils and the effects of these properties on soil productivity.

QUALIFICATIONS

The Land Reclamation Research Center (LRRC) is a branch station of the NDSU Agricultural Experiment Station and has been conducting research exclusively on reclamation for more than a decade. The staff consists of six scientists and six support staff and has laboratory facilities located at the Northern Great Plains Research Laboratory. Research in the past has dealt with all aspects of returning soil to productivity following mining.

Gary Halvorson has a Ph.D in soil chemistry and fertility and has 14 years of experience in the reclamation of land in North Dakota following mining. Research projects he has been involved with include depth of topsoil replacement on cropland as well as rangeland, a study of how topography affects crop yields, the fertility requirements of reclaimed land and the productivity of reclaimed prime and nonprime land.

VALUE TO NORTH DAKOTA

If it can be shown that prime and nonprime topsoils do not need to be separated, substantial savings to the coal companies in soil handling and planning should occur. In addition, a better job of reclamation will occur. This will benefit the ultimate landowner in terms of the productivity of the land. Because of the lower costs for lignite production and the higher productivity of the land, the whole state of North Dakota will benefit.

MANAGEMENT

The project will be managed by the LRRC on land reclaimed by the Falkirk Mining Company and the Coteau Properties company. The plot sites will be seeded, fertilized, and harvested using good management techniques for agriculture. Soil physical and chemical parameters will be measured using techniques commonly used at the LRRC and recognized as standard procedures in *Agronomy Monograph #9*.

Timetable												
Task	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Planting					*							
Maintenance of plots				*	*	*	*					
Harvest								*				
Weather Data				*	*	*	*	*	*			
Soil Samples								*	*			
Laboratory Analysis										*	*	*
Evaluation of Data	*	*	*	*						*	*	*
Reports					*			*				*

BUDGET			
YEAR 3			
	Industrial Commission	**Lignite Energy Council**	**LRRC**
Salaries			
Scientists	10,586	13,278	10,000
Technicians	2,691	0	14,952
Fringe Benefits (.27)	3,585	3,585	6,737
Operating			
Supplies	250	750	3,000
Travel	500	0	1,871
Total Direct Costs	17,612	17,613	36,560
Indirect Costs (22%)	4,086	4,086	8,043
TOTAL	$21,698	21,699	$44,603

TAX LIABILITY

The LRRC as an institution of the State of North Dakota does not pay taxes.

Appendix A.

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