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 FOUR (4) FUNDING

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INDUSTRIAL COMMISSION FUNDING REQUESTED = $21,116
LIGNITE ENERGY COUNCIL FUNDING = $21,216

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LAND RECLAMATION RESEARCH CENTER

TITLE OF PROJECT

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FUNDING PROFILE

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TOTAL FUNDING

$42,332

TABLE OF CONTENTS

ABSTRACT

Before mining, coal companies in North Dakota are required to separate primeland topsoil from non-primeland 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 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 are to (1) compare the productivity of prime and nonprime topsoil materials placed side by side in different topographic positions, and (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. Wheat has been harvested for three years and the data for the first two years has been analyzed. Data from the first year was not reliable because of the extremely late planting date. This request is for a fourth year of funding for this project.

The total project cost over four years is $326,573. Funding from the Industrial Commission for the fourth year of this study is $21,116. This will be matched with $21,216 from the Lignite Energy Council.

The participants in this study include the Coteau Properties Company, the Falkirk Mining Company, Knife River Coal Mining Company, BNI Coal 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 locations in a landscape unit of west-central North Dakota is low, and therefore 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 data from the first three years of this experiment and will continue the analyses of soil samples for chemical and physical parameters. Task II will continue the field experiment for a fourth year. Wheat will be grown and harvested on the field plots. Task III will be to collect all of the data from the four years of this study along with the data from associated studies into a comprehensive final report. Recommendations will be made regarding the mixing of prime and nonprime topsoil. These data will be submitted for publication in a peer review journal and in popular, nontechnical publications. This research is expected to help answer the prime and nonprime productivity issues and generate a more objective tool to evaluate reclamation success.

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 runoff 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 macroclimate 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 primeland 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. The large amount of data gathered in the last three years will be compiled and analyzed in a complete picture of the factors involved in the study of prime and nonprime topsoil. These factors include yield and soil moisture data. Data from soil physical and chemical parameters will also be compiled. These data include soil pH, electrical conductivity (EC), sodium adsorption ratio (SAR), texture, bulk density and hydraulic conductivity. Soil samples taken from the sites in 1994 will continue to be analyzed and the data will all be analyzed in 1995.

Task II. Plots have been established at the Falkirk and Coteau mines. Wheat will be planted on these sites for a fourth year. The plots will be sampled for fertility needs including nitrogen and phosphorus. Each plot will be fertilized individually to bring all plots up to equal fertility level. Soil moisture content will be monitored at the plot sites during the growing season. Precipitation will also be monitored at these sites. Additional soil samples for chemical and physical parameters may be taken as climatic and plant growth factors warrant.

Task III. All of the data that has been compiled in Task I will be put together into a comprehensive report on the productivity of prime and nonprime soils. In addition to the data gathered in this field study, information obtained from our other studies on prime and nonprime land will be included. From this comprehensive report, recommendations will be made regarding the mixing of prime and nonprime topsoils. These recommendations will be presented to the Public Service Commission. Information gathered in this study will be submitted

for publication in a scientific peer review journal and in a popular nontechnical publication.

D. Review of Data from the First Two Years

In the first year of the study dry matter yields and grain yields were lower on Zahl than on Bowbells or Williams topsoils. These differences could be accounted for by differences in initial soil moisture levels. Grain yields were significantly related to initial soil moisture.

In 1993 rainfall was abundant and temperatures were mild. The grain yield data at the Coteau site ranged from 34 - 59 bu/ac. The average yields at this site were 48 bu/ac. There were significant differences in grain yield between land types (crop and rangeland sites). The mean grain yield under cropland condition was 52 bu/ac and under rangeland condition was 43 bu/ac. The lower mean grain yield at rangeland condition could be due to the shallower topsoil depth (avg. 20 cm) compared to cropland conditions (avg. 43 cm). The deeper topsoil depth at the cropland would have better physical and chemical conditions for root and plant growth, which will result in improved yields. The grain yields were not significantly different between topographical position (prime and nonprime sites) or between soil series. The year 1993 was a wet year and the crop had significant available moisture in the profile throughout the season in the top 0 - 60 cm depth. There were no significant grain yield differences between prime (Bowbells, 49 bu/ac) and nonprime soils (Williams and Zahl, 47 and 49 bu/ac). Since moisture was not a limiting factor this year there were no significant grain yield differences observed between the topographic position in the landscape (mean yields of prime and nonprime sites were 48 bu/ac).

The grain yields at the Falkirk site ranged from 30 bu/ac - 54 bu/ac. The average yield at this site was 45 bu/ac. There were significant yield differences between the topographic positions (prime and nonprime locations) in the landscape. Considering the location in the landscape it would be expected that the prime location would yield higher than the nonprime location. However the situation was reversed at this site (mean grain yield at prime site was 40 bu/ac and nonprime site was 50 bu/ac). From visual observation it was noted that there was more lodging and disease infestation at the prime site when compared to the nonprime site and this possibly could have resulted in lower yields at the prime site.

At the Falkirk location there were no significant differences between prime (Bowbells, 43 bu/ac) and nonprime soil series (Williams, 43 bu/ac; Zahl, 48 bu/ac). The straw yields followed a pattern similar to the grain yield response.

E. Anticipated Results

The differences that occurred in 1992 were due to differences in initial moisture content of the topsoil. Data from 1993 showed that there were no differences between the yields of prime and nonprime topsoils. This trend is expected to continue through the last two years of this study. Assuming this trend continues we will be able to recommend mixing of prime and nonprime topsoils. This will result in substantial savings to the cost of coal production.

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 are 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. Total savings to the industry will be $100,000 to $200,000 per year. 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 there is any difference in productivity between prime and nonprime topsoil. This will allow us to proceed in seeking changes in the regulations.

BACKGROUND

Research was done 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 showed that the physical structure of the soils was appreciably better than when the first crop was planted. These results show that yields on reclaimed prime soils may initially be higher than yields on reclaimed nonprime soils. However, after soil structure has 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 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. Although these plots were designed for statistical comparison, 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 was 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 showed 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 three scientists and two support staff and has laboratory facilities 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 15 years of experience in the reclamation of land in North Dakota following mining. Research projects he has been involved with include the depth of topsoil replacement on cropland and rangeland, a study of how topography affects crop yields, the fertility requirement 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**
Compilation of previous data	*	*	*									
Planting					*							
Maintenance of plots				*	*	*	*					
Harvest								*				
Weather data				*	*	*	*	*	*			
Soil samples (as needed)								*	*			
Laboratory analysis	*	*	*	*								
Evaluation of data	*	*	*	*						*	*	*
Reports					*			*		*	*	*

BUDGET - YEAR 4

	Industrial Commission	Lignite Energy Council
SALARIES		
Scientists	$ 9,000	$ 9,000
Support	3,000	3,379
Fringes (.27)	3,240	3,342
TOTAL SALARY	$15,240	$15,721
OPERATING		
Supplies	$ 750	$ 750
Travel	750	750
Publication Costs	400	
TOTAL OPERATING	$ 1,900	$ 1,500
TOTAL DIRECT COSTS	$17,140	$17,221
Indirect Costs (.232)	$ 3,976	$ 3,995
TOTAL	$21,116	$21,216

TAX LIABILITY

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

Appendix A.

LITERATURE REFERENCES

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