NDSU

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COLLEGE OF AGRICULTURE

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March 25, 1997

Ms. Karlene Fine
Industrial Commission of North Dakota
600 E. Blvd., State Capitol
Bismarck, ND 58505

Dear Karlene:

Enclosed is a revised copy of project number LRC-XXVII-A "Reclaimed Grassland Management for Increased Plant Diversity." The only changes made are in the budget where the total amount requested decreased by $50 per year for a total request of $46,410. Annual requests for years 1 through 3 where revised to $15,970, $15,220 and $15,220, respectively.

Thank you for your efforts on our behalf. If you have further questions or suggestions, please call me.

Sincerely,

Don Kirby, Professor
Animal and Range Sciences
701-231-8386

03/25/97.kirby b.kfine.jrt

RECLAIMED GRASSLAND MANAGEMENT FOR INCREASED PLANT DIVERSITY

A Research Proposal Submitted
to the North Dakota Industrial Commission
by the Animal and Range Sciences Department
of the North Dakota Agricultural Experiment Station
and the Lignite Energy Council

Principal Investigators:

Donald R. Kirby, Ph.D.
and Mario E. Biondini, Ph.D.
Professors
Animal and Range Sciences Department
North Dakota State University

Date: February 1, 1997

Amount Requested: $46,410

Project Duration: 3 years

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ABSTRACT

The objective of this research is to evaluate and prescribe livestock grazing and haying strategies to improve plant species diversity and seasonal balance of reclaimed native grasslands.

NDAC 69-05.2-22-07(4)(a) states that success of revegetation of native grassland and tame pastureland will be determined based on productivity, ground cover, diversity, seasonality and permanence. Of these characteristics, re-establishment of diverse and seasonally balanced reclaimed grassland communities is the most difficult to achieve. Despite seed mixes heavily favoring warm-season grasses, obtaining a seasonal balance and diversity is difficult due to the competitiveness of the cool-season grasses in seed mixes and the abundant availability of spring moisture when cool-season grasses initiate growth.

Prior reports by reclamation specialists and researchers have noted the need for post-establishment management practices to maintain or improve the species diversity and seasonal balance of reclaimed grasslands. However, the effects of livestock grazing of reclaimed native grasslands has not been examined. The results of this study will provide the information needed to make recommendations concerning grazing management and haying strategies to improve diversity and seasonal balance and maintain productivity and ground cover of re-established native grasslands.

The project will commence May 1, 1997. Data will be collected over three field seasons with the short-term objectives completed and written in a final report due April 30, 2000. Although this proposal requests only three years of

funding, the long-term objectives of grazing and haying management strategies on previously untreated and newly re-established grasslands will require five to six years of evaluation. It is probable that a further proposal or extension will be requested at a later date. Major participants in this study will be range scientists and graduate and undergraduate students associated with the NDSU Animal and Range Sciences Department and member organizations of the Lignite Energy Council.

Project Summary

The objective of this research is to evaluate and prescribe livestock grazing and haying strategies on plant species diversity and seasonality of reclaimed grasslands.

NDAC 69-05.2-22-07(4)(a) states that success of revegetation of native grassland and tame pastureland will be determined based on productivity, ground cover, diversity, seasonality and permanence. Of the regulatory requirements for revegetation success, the re-establishment of plant diversity and seasonality is often the most difficult to satisfy (Hatton et al. 1986, Krabbenhoft et al. 1991).

Re-establishment of diverse and seasonally balanced grassland plant communities following surface coal mining in the Northern Great Plains is difficult to achieve due to the competitiveness of cool season grass species. Despite seed mixes using a warm to cool season grass ratio of 3:1 or greater, diverse and seasonally balanced grasslands are not easily established and maintained. Cool season grass species establish easier and have the advantage of making most of their growth in early spring when soil moisture is advantageous for plant growth. Warm season species grow most rapidly in summer when soil moisture is often deficient to sustain plant growth. The result is that reclaimed grasslands often become heavily dominated by cool season grass species especially during the first few growing seasons following their establishment (Williamson 1984, Nilson et al. 1985, Hirsch and Nilson 1990).

Post-establishment techniques on recently seeded (2-4 yr) as well as established grasslands (5-10 yr) in order to maintain and enhance diversity and

seasonality of plant species need further study. The proposed research will evaluate livestock grazing and time-specific haying effects on plant species diversity and seasonality of recently seeded and established reclaimed grasslands in western North Dakota.

Project Description

The hypothesis of this research is that time-specific livestock grazing or haying can maintain or improve plant species diversity and seasonality of re-established grasslands. Techniques that influence initial stand diversity and seasonal balance are well understood and universally practiced by reclamation specialists in North Dakota (Williamson 1984, Krabbenhoft et al. 1993). However, little is known concerning maintaining initial stand diversity or secondary succession of re-established grassland stands using various cultural practices such as grazing or haying effects secondary succession and success of these stands (Nilson et al. 1985, Krabbenhoft et al. 1993).

Experience has shown that re-establishing grasslands with the characteristics of diversity and seasonal variety native to the area is dependent on a number of variables. Variables addressed by the reclamation plan that are considered controllable include: (1) topography, (2) soil removal and respread, (3) seedbed preparation, (4) seed quality and mix plans, (5) seeding and mulching techniques, and (6) management during and following establishment. Other uncontrollable variables include: (1) weather, (2) soil quantity and/or quality, and (3) invasion by introduced plants such as smooth bromegrass (Bromus inermis), quackgrass (Agropyron repens), Kentucky bluegrass (Poa pratensis) and others

(Nilson et al. 1985, Krabbenhoft et al. 1993). Due to these variables, post-establishment management of re-established grasslands will generally be required to maintain or modify the diversity and seasonal balance during the reclamation liability period. Failure to manage reclaimed grasslands may result in additional costs in materials, labor , lease costs and bonding if performance standards are not met at the end of the liability period. Considering these added costs, it is important to recognize deficiencies in diversity and seasonal balance of developing re-established grasslands early considering the ten-year liability period.

Choosing a management practice(s) requires justification that it will produce the desired results required to meet reclamation success standards, have universal applicability to the industry, and be cost-effective. Employing livestock grazing and/or haying to re-established grasslands would meet the applicability and cost-effectiveness requirements. Using these practices to produce beneficial change in diversity or seasonality characteristics of reclaimed grasslands is presently an unknown.

On native grasslands, it is well known that livestock influence plant community diversity through differential utilization or trampling of plants (Grime 1973, Collins and Barber 1985, Archer and Smeins 1991, Belsky 1992, West 1993). This phenomena is also prevalent in reports for the mixed grass prairie of the northern United States (Collins and Barker 1985, Cid et al. 1991, Frank et al. 1995, Hartnett et al. 1995). Moderate intensities and planned periodicities of grazing usually increase diversity of mixed grass prairie. This is accomplished by decreasing the ability of dominant plants, such as cool season grasses, to

competitively exclude other species and by creating space and freeing resources such as light, moisture and nutrients for associated plant species maintenance and growth. Re-established grasslands, seeded to a similar mixture of cool and warm season grasses, should behave in a similar fashion to prescribed time-specific livestock grazing and/or haying.

Two post-establishment grassland management strategies will be evaluated, prescribed livestock grazing and time-specific haying. Livestock grazing of re-established native grasslands has already been conducted and monitored on section 18 of the Coteau Mine (1994-1996) and on section 2 of the Indianhead Mine (1989-1996). If additional grazed re-established sites are available they will be added to this analysis. Annual exclosures along with random or systematic transects are used to collect production and utilization (0.25 m^2 quadrats), and cover and diversity (10-point frame) data for evaluation purposes. Evaluation of plant composition changes will be made by comparison to similar data annually collected from exclosures and permanent reference areas of similar range sites. These data and analyses will compose the short-term objectives of this study.

The longer-term portion of this research proposal will involve both livestock grazing and haying treatments on re-established grasslands. Coteau, Indianhead, Falkirk and Glenharold Mines and maybe others have recently or will implement livestock grazing on newly re-established native grasslands. In order to manage cool season grass dominance, early grazing will need to be initiated in early to mid May and terminated prior to the reproduction growth phase of warm season grasses, mid July to August 1. Fall grazing following warm season grass growth

will also be evaluated. Stocking rates will be prescribed to remove 40 to 50% of the annual cool season grass growth and monitored with clipping 0.25 m^2 quadrats inside (non-grazed) and outside (grazed) portable exclosures established in each grazed unit. Cover, diversity and seasonality of plant species will be evaluated annually on permanent transects in each grazed unit using the 10-point frame. Comparison will be made to annually monitored reclaimed area exclosures and reference areas of similar range sites. Changes in measured characteristics of these grazed re-established grasslands will be tested using multivariate analyses (principal components, cluster, and discriminate analyses).

Haying will be conducted on a time-specific basis in order to analyze its effect on the competitiveness of cool season grasses in reclaimed native grasslands. Haying is an alternative post-establishment management technique that could be more universally applied by the mining industry and may have similar results on reclaimed native grasslands. Haying would be conducted by cooperators or simulated by cutting and baling portions of re-established grasslands that are also receiving the livestock grazing treatment. Haying would be conducted approximately July 1 each year when cool season grasses are headed out. This treatment will also be evaluated using 0.25 m^2 quadrats and 10-point frames to collect production and cover data on permanently established transects for each unit. Results from this study will be compared and analyzed similar to the grazed treatments.

Standards of Success

The standards for success for this research effort will be a final report with

recommendations of grazing management strategies and haying opportunities to maintain production and cover of reclaimed grasslands while improving diversity and seasonal balance of cool and warm season grasses. Grazing recommendations will specify season and intensity (stocking rates) for grazing use. Optimum date of haying favoring warm season grass maintenance and growth will also be evaluated.

Background

The principal investigators in this proposal have been working in reclamation research since 1988. The main focus of the research has been in evaluating soil depth and quality relationships for successful reclamation of grasslands (1988-1995). This research was funded by the North Dakota Industrial Commission, Lignite Energy Council and North Dakota State University (LRRC and the Animal and Range Sciences Department). Other funded research has included the study of reclaimed wetlands, plant diversity levels and indices for reclaimed grasslands, recolonization of vesicular-arbuscular micorrhizae, drought effects on reclaimed grasslands, improving the use of Range Site Guides for reclamation evaluation, and establishment techniques for successful grassland reclamation. A total of 12 reports have been written for various local, regional and national publications.

Two recent research efforts of the principal investigators pertaining to this proposal are in evaluating plant diversity patterns and indices for reclaimed grasslands and establishment techniques effects on successful grassland reclamation. Concerning plant diversity, the principal investigators recommended

that more than one diversity index be utilized in evaluating reclamation success, and that trend is a better evaluation technique than the final two years of monitoring presently required to determine success (Krabbenhoft et al. 1991). In a second study, the principal investigators reported that later seeding dates and a seed mix heavily favoring warm season grass species generally established diverse stands of reclaimed grasslands (Krabbenhoft et al. 1993). However, they recommended that annual management such as haying would be necessary to manage competition from cool season grasses and maintain the diversity and seasonal balance of reclaimed grasslands.

Prior reports by other researchers have discussed the need for post-establishment management of reclaimed grasslands to improve species diversity and seasonal balance (Nilson et al. 1985, Nilson and Hirsch 1989, Hirsch and Nilson 1990). They suggested that spraying glyphosate, burning or prescription mowing be conducted on reclaimed grasslands to reduce cool season grass competitiveness. Livestock grazing has not been examined for maintaining reclaimed native grasslands but has been reported for limited mixture seedings of cool season grasses (Ries and Hofmann 1984, Hofmann and Ries 1988), In these, the authors reported that wheatgrasses decreased under moderate and heavy grazing intensities. In addition, many plant species including native grasses and forbs had to a limited extent (10%) invaded the grazed reclaimed grasslands. This trend in desirable plant species invasion would appear promising for livestock grazing as a post-establishment management tool for reclaimed native grasslands.

Qualifications

Principal Investigators:

Donald R. Kirby

Present Position: Professor, Animal and Range Sciences Department, North Dakota State University, Fargo, ND 58105

Education: B.S. Range and Wildlife Management, Humboldt State University, 1974

M.S. Natural Resources Management, Humboldt State University, 1976

Ph.D. Range Science, Texas A&M University, 1980

Experience: 1976-1980 Research Assistant, Texas A&M University
1980-1986 Assistant Professor, NDSU
1986-1992 Associate Professor, NDSU
1992-present Professor, NDSU

Research Experience:
1988-1996 Conducted competitive funded research in grassland and wetland reclamation, noxious weed control and grazing management strategies
1980-1996 Completed 18 graduate research programs
1980-1996 Published over 50 research articles
1980-1996 Received over $650,000 in grants

Mario E. Biondini

Present Position: Professor, Animal and Range Sciences Department, North Dakota State University, Fargo, ND 58105

Education: B.S. Agronomy, Universidad Nacional del Sur, 1975

M.S. Range Ecology, Texas Tech University, 1980

Ph.D. Range Science - Statistics, Colorado State University, 1984

Experience: 1984-1986 Consultant, Winrock International
Morrillton, Arkansas
1986-1989 Assistant Professor, NDSU
1989-1996 Associate Professor, NDSU
1996-present Professor, NDSU

Research Experience:
1986-1996 Conducted competitive funded research in mined land reclamation, ecological and grazing processes on mineral cycles and plant competition
1990-1996 Completed 4 graduate research programs
1984-1996 Published over 50 research articles
1984-1996 Received over $1.54 million in grants

Value to North Dakota

The research results from this project will be used by the members of the Lignite Energy Council, North Dakota Public Service Commission, western mined-land reclamation specialists, and private and public land managers throughout western North and South Dakota and eastern Montana. The mining industry should benefit from this research by receiving recommendations on management of reclaimed grasslands to maintain productivity and cover, and improve diversity and seasonal balance of plant species. Additionally, the results from this research should prove the permanence of reclaimed mined-lands under the typical post-bond land use, livestock grazing.

Many public land management agencies in North Dakota may be interested in the results from this study. Agencies and groups such as the U.S. Fish and Wildlife Service, Bureau of Reclamation, North Dakota Game and Fish, State Land Department, Ducks Unlimited, The Nature Conservancy, etc. all manage grasslands in the state. These agencies are often involved in reclaiming grassland

tracts especially for wildlife habitat and erosion control. The results from this research may improve land management decisions for lands administered by these agencies or groups.

The productivity and permanence of these grassland stands is also of primary concern to the livestock industry of the state. Cattle sales approach $500 million annually in North Dakota. Over 80% of the diets of cattle come from grazed or hayed forages, mainly grass. Results from this study will be used to make recommendations for the appropriate use of reclaimed grasslands for grazing livestock including stocking rates, season of use, grazing systems, etc.

Management

The co-principal investigators in conjunction with the cooperating reclamation specialists will personally supervise the project to completion. Annual reports will be filed with the funding agencies each year.

Timetable

This research project has short-term and long-term objectives. The short-term objective is to evaluate previously grazed reclaimed grasslands and describe the changes that have occurred and the management techniques utilized in the grazing process. This objective will be completed with a final report in year 3. The long-term objective will be to begin grazing and haying research on previously untreated reclaimed grasslands. This part of the research will be initiated in year 1 and evaluated each year thereafter. Although this proposal requests only three years to funding, the long-term objective should require five to six years of evaluation to detect trends and changes in plant community characteristics.

May 1, 1997 - April 30, 1998

a. Review of existing literature and related research currently in progress.

b. Data on previously grazed reclaimed grasslands will be collected and synthesized. Analyses of change in productivity, cover, diversity and seasonality will be conducted. Additional annual data will be collected.

c. Sites will be selected for the long-term study. Preliminary grassland stand data will be collected in order to compare trend and treatment effects. Haying and grazing treatments will then be implemented.

d. Write annual report.

May 1, 1998 - April 30, 1999

a. & b. (above) will be continued.

c. Annual vegetation data will continue to be collected on treatments.

d. Write annual report.

May 1, 1999 - April 30, 2000

a. Collect annual vegetation data.

b. Complete data analysis.

c. Write final report.

Budget: Year 1.

Budget for May 1, 1997 - April 30, 1998

	Hours	Matching Lignite Research Council	Matching Lignite Energy Council	NDSU	Total
A. Salary					
Principal Investigators	240			7,200	7,200
Research Specialist	520			9,400	9,400
Graduate Student	1,000	5,000	5,000		10,000
Undergraduate Students	1,040	5,200	5,200		10,400
B. Employee Benefits		570	570	4,480	5,620
(27% of salary, 10% for under. students, 1% for grad. students)					
C. Field, Laboratory and Office Supplies		1,700	1,700		3,400
D. Travel and Housing		3,500	3,500		7,000
E. Indirect Costs		0	0	0	0
TOTAL		$15,970	$15,970	$21,080	$53,020

The level of funding as presented in this budget is the amount necessary to meet the objectives. The research will not be initiated without this funding.

Matching Funds

These funds are identified in the budget as **Matching** from the Lignite Energy Council and North Dakota State University.

Tax Liability

The applicants of this proposed research are employees of North Dakota State University and the State of North Dakota; therefore, this section does not apply.

Budget: Year 2.

Budget for May 1, 1998 - April

	Hours	Matching Lignite Research Council	Matching Lignite Energy Council	NDSU	Total
A. Salary					
Principal Investigators	240			7,200	7,200
Research Specialist	520			9,400	9,400
Graduate Student	1,000	5,000	5,000		10,000
Undergraduate Students	1,040	5,200	5,200		10,400
B. Employee Benefits		570	570	4,480	5,620
(27% of salary, 10% for under. students, 1% for grad. students)					
C. Field, Laboratory and Office Supplies		950	950		1,900
D. Travel and Housing		3,500	3,500		7,000
E. Indirect Costs		0	0	0	0
TOTAL		$15,220	$15,220	$21,080	$51,520

Budget: Year 3.

Budget for May 1, 1999 - April 30, 2000

	Hours	Matching Lignite Research Council	Matching Lignite Energy Council	NDSU	Total
A. Salary					
Principal Investigators	240			7,200	7,200
Research Specialist	520			9,400	9,400
Graduate Student	1,000	5,000	5,000		10,000
Undergraduate Students	1,040	5,200	5,200		10,400
B. Employee Benefits (27% of salary, 10% for under. students, 1% for grad. students)		570	570	4,480	5,620
C. Field, Laboratory and Office Supplies		950	950		1,900
D. Travel and Housing		3,500	3,500		7,000
E. Indirect Costs		0	0	0	0
TOTAL		$15,220	$15,220	$21,080	$51,520

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