RECLAMATION RESEARCH IN NORTH DAKOTA

PART B

RESEARCH PUBLICATION BRIEFS

REVEGETATION AND VEGETATION (RV)

Title: **PROGRESS REPORT OF REVEGETATION STUDIES ON COAL MINE SPOILS OF NORTH DAKOTA**

Authors: J.J. Bond, F.M. Sandoval, J.F. Power and W.O. Willis

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

Format: Report

Reference: USDA-ARS, SWC Research Report No. 427, 1971

Key Index Words: Spoil Properties, Water Management, Revegetation

Brief Description

Results of field investigations and laboratory analyses are included in this progress report of reclamation efforts conducted in North Dakota. The research discussed was carried out during 1970 and 1971 primarily at the Consolidated Coal Company's Glenharold Mine at Stanton, ND and in the laboratories of the Northern Great Plains Agricultural Research Center.

Analysis of Conclusions

These investigations were conducted mainly with the spoil materials, because there were no topsoiling requirements in force then. However, studies showed that even very small amount of respread topsoil was good for vegetation establishment.

Title: **ECOLOGY OF SOME MINED AREAS IN NORTH DAKOTA**

Authors: M.K. Wali and P.G. Freeman

Organization: Biology Department, University of North Dakota, and US Bureau of Mines Energy Research Laboratory, Grand Forks, ND

Format: Paper

Reference: Some Environmental Aspects of Strip Mining in North Dakota (M.K. Wali, ed), North Dakota Geological Survey Educational Series 5, 1973

Key Index Words: Revegetation, Spoil Properties, Topsoil, Trace Elements

Brief Description

Spoil materials and undisturbed soils were sampled from several mine sites in North Dakota in the summers of 1972 and 1973. The samples were analyzed for a number of parameters, and the vegetation surrounding the sample sites was inventoried. The authors compared the results to determine the spoil characteristics hindering revegetation.

Analysis of Conclusions

This study is particularly useful for reclamation of abandoned mine lands as it provides considerable data on physical and chemical properties of spoil and soil materials collected from a number of abandoned mines.

Title: **REGIONAL SITE FACTORS AND REVEGETATION STUDIES IN WESTERN NORTH DAKOTA**

Authors: M.K. Wali and F.M. Sandoval

Organization: Project Reclamation, University of North Dakota, Grand Forks, ND, and USDA-ARS, Northern Great Plains Research Center, Mandan, ND

Format: Paper

Reference: Practices and Problems of Land Reclamation in Western North Dakota, (M.K. Wali, ed), University of North Dakota Press, Grand Forks, ND, 1975

Key Index Words Revegetation, Environmental Factors, Land Use, Spoil Properties

Brief Description

This paper provides information on regionally important site factors and their effects on reclamation. The revegetation potential of mined lands in North Dakota is considered in the light of experiments conducted by various research groups working in this state.

Analysis of Conclusions

This is a paper of general as well as specific importance: the revegetation potential of typical sites is discussed in terms of geological, climatic, topographic, and edaphic factors. The research conducted in the early 70's is reviewed.

Title: **ESTABLISHMENT OF WESTERN WHEAT GRASS ON SURFACE MINED COAL SPOILS UNDER CONTROLLED ENVIRONMENTAL CONDITIONS**

Authors: E.J. Finck and M.K. Wali

Organization: Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Paper

Reference: Proceedings of North Dakota Academy of Science 30(1):13, 1976

Key Index Words Revegetation, Plant Responses, Productivity, Amendments, Leonardite

Brief Description

Growth chamber and laboratory experiments were conducted to study the effects of slack and leonardite on the establishment and growth of western wheatgrass on Glenharold coal mine spoil. The effects of these materials on the physical and chemical spoil were also studied. Both materials tended to decrease the growth of western wheatgrass, particularly when supplied in the absence of NPK fertilizers.

Analysis of Conclusions

This is only a preliminary study on the use of oxidized lignite products (slack and leonardite) as possible reclamation agents.

Title: **SOME CHRONOSEQUENCES OF VEGETATION IN THE SURFACE MINED AREAS OF WESTERN NORTH DAKOTA**

Authors: R.H. Pemble and M.K. Wali

Organization: Moorhead State University, Moorhead, MN and University of North Dakota, Grand Forks, ND.

Format: Paper

Reference: Proceedings of North Dakota Academy of Science 30(1):37, 1976

Key Index Words AML, Revegetation, Succession, Soil Development

Brief Description

During the summer of 1975 a study was conducted to determine the relationship between vegetation pattern and local site conditions on mined and unmined areas in southeastern Ward County, North Dakota. The vegetation from a range of topographic positions was examined in the field on both unmined sites and spoils material belonging to five different age classes. The preliminary results of this investigation were discussed.

Analysis of Conclusions

The conclusions of this study are discussed elsewhere in this inventory.

Title: **POTENTIAL USE OF SUPPLEMENTAL IRRIGATION FOR ESTABLISHMENTS OF REVEGETATION ON SURFACE MINED LANDS**

Authors: R.E. Ries, J.F. Power, 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(2): 21-22, 1976

Key Index Words Revegetation, Irrigation

Brief Description

This study emphasizes the importance of supplemental irrigation as a potential tool in reestablishing vegetation, especially perennial rangeland vegetation, on surface mined lands.

Analysis of Conclusions

Additional research would be needed to better define the technique and the benefits of supplemental irrigation as a reclamation tool.

Title: **PERENNIAL FORAGE SPECIES RESPONSE TO SODIUM AND MAGNESIUM SULFATE MINE SPOILS**

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

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

Format: Paper

Reference: Proceeding of the Fourth Symposium on Surface Mining and Reclamation, NCA, pp. 173-183, Louisville, KY, 1976

Key Index Words Revegetation, Plant Responses, Salinity

Brief Description

This paper describes the results of some growth chamber experiments in which the effects of sodium and magnesium sulfate on the germination, emergence/establishment and growth of eight (8) perennial forage species were studied. For the emergence/establishment and growth portion of this study, the salts were applied to mine spoils of two different textures from a mine near Colstrip, MT. Results showed that plant species responded differently to similar kinds or concentrations of salt and that individual species responded differently to a given salt at different developmental stages. In general, three types of plant responses were observed: 1) No effect of kind or concentration of salt, 2) sensitive to salt concentration but not to specific kind of salt, and 3) sensitive to both kind and concentration of salt. Growth of some species was affected by soil texture.

Analysis of Conclusions

This study reinforces the current thinking that selective use of plants based on their tolerance or adaptability to the prevailing edaphic stress(es) is important in revegetation of mined lands. It is therefore essential that the relative adaptability of the regional plants to various stresses and conditions are properly understood.

Title: **EFFECTS OF LEONARDITE ON THE GERMINATION OF SOME PRAIRIE GRASS AND LEGUME SPECIES**

Authors: N.M. Safaya and M.K. Wali

Organization: Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Paper

Reference: Proceedings of North Dakota Academy of Science 31(10:27, 1976

Key Index Words Revegetation, Amendments, Plant Responses

Brief Description

In this laboratory study, the germination of some grass and legume species on a sodic mine spoil was tested in the presence or absence of two types of leonardite material. Most of the species whose germination was poor on the spoil material responded favorably to leonardite treatment. However, a differential response of the species to leonardite types was observed.

Analysis of Conclusions

This study indicated that the germination of some plant species can be enhanced by the use of leonardite as soil amendment. However, different types of leonardite may have altogether different effects on the same species.

Title: **FORAGE SPECIES ESTABLISHMENT AND PRODUCTIVITY ON MINED LAND**

Authors: R.E. Barker, R.E. Ries, and P.E. Byron

Organization: USDA-ARS, Northern Great Plains Research Center, Mandan, and North Dakota State University, Fargo, ND

Format: Paper

Reference: North Dakota Agricultural Experiment Station Farm Research vol. 34(6):8-12, 1977

Key Index Words Revegetation, Plant Adaptability, Species Selection, Productivity

Brief Description

The objective of this study was to determine which forage species work best for reclamation and how they compare in establishment and productivity. A site established at the Glenharold mine represented the reclaimed area and a site established at the Mandan ARS station represented an undisturbed area. Only preliminary results were provided with the recommendation that the ability of each species to establish, survive and produce be carefully considered when selecting the composition of a species mix for seeding.

Analysis of Conclusions

A preliminary study on which there has been a large amount of subsequent work by the SCS.

Title: **EFFECTS OF GRAZING INTENSITY ON VEGETATION AND ANIMAL PERFORMANCE ON RECLAIMED STRIP MINED LAND**

Authors: L. Hofmann, R.E. Ries, J.F. Power, and R.J. Lorenz

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

Format: Paper

Reference Proceedings of the Fifth Symposium on Surface Mining and Reclamation, pp. 306-310, Louisville, KY, October 1977

Key Index Words Revegetation, Grazing, Erosion, Animal Performance, Productivity

Brief Description

The effects of grazing intensity on forage production and animal performance over a two-year period on a reclaimed (under ND 1969 law) piece of land near Center, ND, are discussed in this paper. The area was seeded with a mixture of cool season grasses and legume in 1973 and the grazing study began in 1976. Pastures were stocked at 0, 0.6, 1.2, and 1.8 acres/yearling steer to obtain control, heavy, moderate and light grazing intensities, respectively. During 1976, the ungrazed control pastures produced 3,331 lbs/acre dry matter, and 80, 44, and 32 percent of the forage was grazed at the heavy, moderate and light grazing intensities, respectively. When grazing was stopped in 1977, no harvestable forage remained on the heavily grazed pastures, and beef production equaled 49, 52, and 36 lbs/acre for the heavily, moderately and lightly grazed areas, respectively.

Analysis of Conclusions

From these preliminary data, it was concluded that reclaimed mined land should be suitable for grazing, but additional research would be required to establish good grazing management guideline for reclaimed land. Research of this type should also be conducted on lands reclaimed under recent reclamation laws.

Title: **AN ECOLOGICAL - LEGAL ASSESSMENT OF LAND RECLAMATION LAWS**

Authors: A.C. Imes, and M.K. Wali

Organization Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Paper

Reference: North Dakota Law Review 53:359-399, 1977

Key Index Words Revegetation, Legislation, Reclamation Law

Brief Description

In this paper the reclamation laws are reviewed and discussed as passed by the federal government and the states of Colorado, Montana, New Mexico, North Dakota, South Dakota, Utah, and Wyoming. Analysis of the reclamation laws has been made from an ecological standpoint, and their implications on reclamation and revegetation performance standards have been examined.

Analysis of Conclusions

The information presented in this paper is useful for understanding the complex relationship between the legal and ecological aspects of reclamation.

Title: **THE ROLE OF PIONEERING VEGETATION IN ECOLOGICAL SUCCESSION OF SURFACE MINED AREAS IN NORTH DAKOTA**

Authors: L.R. Iverson and M.K. Wali

Organization Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Paper

Reference: Proceedings of North Dakota Academy of Science 32(1):3, 1977

Key Index Words Revegetation, Allelopathy, Competition, Succession

Brief Description

Preliminary results of growth chamber, laboratory and field studies on the role of kochia, a weedy species, in the revegetation of mined lands were discussed. Complete results of this investigation were published later, and are discussed in this inventory elsewhere.

Analysis of Conclusions

This ecophysicological study is very interesting and instructive of our lack of complete knowledge about the role of pioneering species in the early succession of vegetation on mined lands. Additional work in this area would be desirable.

Title: **POTENTIAL USE OF NATIVE SHRUBS FOR STRIP MINE RECLAMATION**

Author: K.E. Kissel

Organization North Dakota State University, Fargo, ND

Format: Thesis

Reference: M.S. Thesis, North Dakota State University Botany Dept., 1977

Key Index Words Revegetation, Plant Adaptability, Planting Techniques, Shrub Establishment

Brief Description

Field plot studies at Dickinson and greenhouse studies at Fargo were conducted to determine best methods for propagation of 15 shrub species in different planting media. A preliminary study which shows most species can be successfully established as transplants, but each species has special requirements for successful establishment from seed or cuttings.

Analysis of Conclusions

The results of the study are very preliminary. Further work needs to be conducted on individual species.

Title: **RESPONSE OF A GRASS - LEGUME MIXTURE TO VARIOUS AMENDMENTS AND NUTRIENTS ON A SODIC SPOIL MATERIAL**

Authors: N.M. Safaya and A. Kollman

Organization Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Paper

Reference: Reclamation Review, p. 14, 1977

Key Index Words Revegetation, Fertilizer Use, Plant Responses, Amendments, Nutrient Requirements

Brief Description

Discussed in this presentation were the preliminary results of some laboratory and growth chamber experiments conducted to study the effects of some fertilizers and amendments on a grass - legume mixture grown on a calcareous sodic mine spoil from Glenharold mine. The effects of fertilizers and amendments on the properties of the spoil material were also discussed.

Analysis of Conclusions

This study indicated that phosphorus was predominantly deficient in the soil; and that leonardite had a beneficial effect on the legume but an adverse effect on the grass species.

Title: **GROWTH AND NUTRIENT RELATIONS OF SOME GRASS AND LEGUME SPECIES ON A SODIC MINE SPOIL AS AFFECTED BY DIFFERENT AMENDMENTS AND NUTRIENT APPLICATIONS**

Authors: N.M. Safaya and M.K. Wali

Organization Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Paper

Reference: Agronomy Abstracts, p. 130, 1977

Key Index Words Revegetation, Fertilizer Use, Plant Responses, Amendments, Nutrient Requirements

Brief Description

In this presentation, the nutrient deficiencies and imbalances characterizing the sodic mine spoils and their detection by soil test and plant growth response studies were discussed. The effects of fertilizers and different types of amendments on the spoil properties and plant growth were also discussed.

Analysis of Conclusions

This investigation demonstrated the occurrence of some major and micronutrient deficiencies in the mine spoils from western North Dakota mines. Also the use of sulfuric acid as a suitable amendment for calcareous sodic spoils was established.

Title: **MOLYBDENOSIS: A POTENTIAL PROBLEM IN RUMINATS GRAZING ON COAL MINE SPOILS**

Authors: J.A. Erdman, R.J. Ebens and A.A. Case

Organization USGS, Denver, CO, and University of Missouri, Columbia, MO

Format: Paper

Reference: Journal of Range Management 31(1):34-36, 1978

Key Index Words Revegetation, Trace Elements, Animal Performance, Grazing

Brief Description

This paper reports the results of analyses conducted on sweet clover plants collected from eight surface mines in North Dakota, Montana and Wyoming. Copper to molybdenum ratios in all but two sweet clover samples ranged from 0.44:1 to 5:1. Ratios of 5:1 or less in forage are reported to cause molybdenosis, a nutritional disease occurring in molybdic regions of the world. Therefore, if the major forage on coal mine spoils is sweet clover or other species with similar Cu:Mo ratios, molybdenosis may be expected to occur in cattle and sheep grazing in these areas.

Analysis of Conclusions

A very important study, revealing for the first time that sweet clover growing on some coal mine spoil banks may be sufficiently high in molybdenum which can induce metabolic imbalances in cattle and possibly other ruminants fed predominately on this or similar legumes. Further investigations in this area of research are necessary. Indeed, not much work has been done in determining the nutritional quality of forages grown on mined lands.

Title: **INFLUENCE OF POINT FRAME QUADRAT ORIENTATION ON VEGETATIVE ANALYSES OBTAINED ON DISTURBED LAND RESEEDED IN ROWS**

Authors: L. Hofmann, R.E. Ries, J.F. Power, and R.J. Lorenz

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

Format: Paper

Reference: Proceedings of the First International Rangeland Congress (Donald Hyder, ed), pp. 521-523, Denver, CO, August, 1978

Key Index Words Revegetation, Cover

Brief Description

This study was conducted at the Baukol-Noonan Center Mine on reclaimed areas to determine if orientation of a point frame quadrat in relation to vegetation occurring in rows influences the results of cover estimation. Plant cover was measured under four grazing intensities using point-frame quadrats that were oriented diagonally, parallel or perpendicular to the seeded row, or randomly located. The conclusion was that there is no significant difference in estimation of plant cover due to quadrat orientation.

Analysis of Conclusions

A very interesting and informative study which will be useful when sampling for the determination of reclamation success.

Title: **GRAZING RECLAIMED STRIP MINED SITES**

Authors: L. Hofmann, R.E. Ries, J.F. Power, and R.J. Lorenz

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

Format: Paper

Reference: North Dakota Agricultural Experiment Station Farm Research 36(1):3-5, 1978

Key Index Words Revegetation, Grazing, Animal Performance, Cover, Erosion

Brief Description

This paper presents some preliminary results obtained in an initial grazing study on a reclaimed site at Baukol-Noonan's Center Mine. The effects of grazing management on soil and vegetation were being studied in this ongoing long-term study. For details see Hofmann et al 1977.

Analysis of Conclusions

This long-term study has provided important data useful for developing grazing management technique for reclaimed lands.

Title: **PRAIRIE HAY AS A SEED SOURCE FOR STRIP MINED LAND REVEGETATION**

Author: R.E. Ries

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

Format: Paper

Reference: Ecological Society of America Bulletin 59(2):51, 1978

Key Index Words Revegetation, Prairie Hay, Seed Source, Mulch

Brief Description

Earlier research in North Dakota had shown that mature prairie hay can serve as a seed source for native prairie species when revegetating strip mined land. This paper presents information on how harvest date of the prairie hay may affect the seed source available in the prairie hay. Prairie hay was harvested from a range community in fair range condition at 5 monthly intervals during the 1977 growing season. Species composition of the hay material was determined and the material was air-dried and stored. In mid-November, the hay material was mulched over sterilized soil in flats in the greenhouse at a rate of 3,360 kg/ha. Results showed the October 1 harvest date to have the seeds of mostly weedy species.

Analysis of Conclusions

More research is needed to determine the use of prairie hay as seed source for reclamation purposes.

Title: **USE OF IRRIGATION IN RECLAMATION IN DRY REGIONS**

Authors: R.E. Ries and A.D. Day

Organization USDA-ARS, Mandan, ND

Format: Paper (Chapter)

Reference: Reclamation of Drastically Disturbed Lands Schaller and P. Sutton, eds.), pp. 505-520, ASA, CSSA, SSSA, Madison, WI, 1978

Key Index Words Revegetation, Irrigation

Brief Description

This article presents an overview of the use of irrigation in revegetation efforts of surface mined land in the western United States. The reasons for irrigation are presented and the development of specific methods and techniques is described. The future use of irrigation for reclamation is also discussed. It is contended that supplemental irrigation might improve deteriorated rangeland communities by establishing new communities with more desirable species.

Analysis of Conclusions

It is a good source of information on the use of supplemental irrigation in reclamation. Additional work in this area of research would be desirable.

Title: **RE-ESTABLISHMENT OF GRASSES ON LAND DISTURBED BY MINING IN THE NORTH GREAT PLAINS.**

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

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

Format: Paper

Reference: Proceedings of the First International Rangeland Congress, pp. 700-703, Denver, CO, August 1978

Key Index Words Revegetation, Soil Requirements, Fertilizer Use, Topsoil

Brief Description

Field studies were conducted to determine the effects of topsoil thickness and fertilization on introduced and native grass species. Topsoil replacement was found to be essential to vegetative stand establishment and productivity on mine spoil. Fertilizer increased stand production, but did not influence stand density. Selection of grass species that are readily established is essential to establishing fully stocked initial stands.

Analysis of Conclusions

A good study which provides documentation on the need of topsoil for grassland reclamation and the potential uses of fertilizer in reclamation.

Title: **EFFECTS OF FOLIAR APPLICATION OF NUTRIENTS ON BARLEY AND ALFALFA GROWTH ON COAL MINE SPOILS**

Authors: N. Malakondaiah, N.M. Safaya, and M.K. Wali

Organization Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Paper

Reference: Agronomy Abstract p. 157, 1978

Key Index Words Revegetation, Plant Responses, Nutrient Requirements, Fertilizer Use, Foliar Fertilization

Brief Description

In this presentation, the results of experiments conducted to determine the efficacy of foliar versus soil applications of N and P fertilizers to plants grown on a calcareous mine spoil were discussed. The complete results of this study were published in a full length paper in 1981, the details of which are included in this research inventory.

Analysis of Conclusions

The results of this investigation demonstrated that foliar applications of N and P fertilizers to plants grown on nutrient deficient spoil materials can be as or more effective than supplying these nutrients to the spoil.

Title: **DELINEATION OF MINERAL STRESSES IN MINE SPOILS AND SCREENING PLANTS FOR ADAPTABILILTY**

Authors: N.M. Safaya

Organization Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Paper

Key Index Words Ecology and Coal Resource Development (M.K. Wali, ed.), pp. 830-849, Pergamon Press, NY 1978

Key Index Words Revegetation, Nutrient Requirements, Amendments, Plant Adaptability

Brief Description

Edaphic stresses resulting from mineral deficiencies, toxicities and imbalances are among the important plant growth limiting factors encountered in surface mined lands. This paper emphasizes the synchronized approach of identifying the site specific nature of these stresses, and screening plants for their tolerances to specific stresses. The advantages and practical feasibility of this approach in mined land revegetation have been discussed in the light of current knowledge pertaining to both of these aspects.

Analysis of Conclusions

The conclusions drawn in this paper are based on the review of literature as well as the data obtained by the author from experiments conducted by him. It is being increasingly realized that revegetation of drastically disturbed areas must follow an approach which combines soil improvement on one hand and use of adapted species on the other.

Title: PLANT RESPONSES TO NUTRIENT APPLICATIONS IN COAL MINE SPOILS OF NORTH DAKOTA

Authors: N.M. Safaya and M.K. Wali

Organization Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Paper

Reference: 144th National Meeting of the American Association for the Advancement of Science, Washington, Abstract No. 204, p. 130, 1978

Key Index Words Spoil Properties, Nutrient Requirements, Fertilizer Use, Revegetation

Brief Description

In this paper the nutrient availability problems of calcareous, sodic mine spoils from western North Dakota were discussed. Growth chamber experiments were conducted with oats, slender wheatgrass and alfalfa as test crops. Nitrogen fertilization, under adequate supply of phosphorous, increased the dry matter yields of oats and slender wheatgrass 4 to 8 times, but that of alfalfa by only 46%. However, nitrogen fertilization decreased the manganese concentration in all the three species, and phosphate fertilization decreased the concentration of zinc in plants. Addition of manganese increased the yield response of alfalfa to 85% and with manganese plus zinc to 99%. Oats and slender wheatgrass did not show any growth response to manganese or zinc. The response to manganese was related to high iron/manganese ration in this species.

Analysis of Conclusions

This study has shown that some North Dakota spoils are generally deficient in plant available nitrogen and phosphorous, and for some species the availability of manganese and zinc may also be low. Moreover, conventional soil tests do not necessarily indicate these deficiencies.

Title: **SOME NUTRIENT DEFICIENCY AND TOXICITY SYMPTOMS IN SLENDER WHEAT GRASS**

Authors: P.A. Schwartz and N.M. Safaya

Organization Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Paper

Reference: Proceedings of North Dakota Academy of Science 31(II):50-57, 1978

Key Index Words Nutrient Requirements, Plant Responses, Revegetation

Brief Description

This paper reports the results of growth chamber and laboratory experiments which were conducted to study the effects of various nutrient deficiencies and toxicities on the growth and nutrient composition of slender wheatgrass. The study was designed to provide a visual diagnostic criteria for recognizing nutrient deficiencies in the filed using this species as an indicator plant. Growth of slender wheatgrass was severely retarded by depleting nitrogen, phosphorus, or potassium from the growth medium but this species seemed to be most sensitive to potassium deficiency. Its requirement for zinc appeared to be relatively low. Potassium deficient plants were found to contain extremely high amounts of iron.

Analysis of Conclusions

Though not directly related to mined land reclamation and revegetation, this study has shown that there is a great need for understanding the nutritional requirements of many forage species which are generally used for revegetation of mined lands.

Title: **FIELD EVALUATION PLANTING**

Authors: USDA-SCS, Bismarck Plant Material Center Staff

Organization USDA-SCS, Bismarck Plant Materials Center, Bismarck, ND

Format: Report

Reference: 1976 Annual Technical Report, pp. 119-168, 1978

Key Index Words Revegetation, Plant Adaptability, Species Selection, Reclamation

Brief Description

This report presents the results of the mine spoil reclamation efforts of the Bismarck Plant Materials Center for the years 1975 to 1977. The reclamation work was conducted at four mine sites in western North Dakota, namely: Baukol-Noonan's, Center Mine (Oliver County); North American Coal Corporation's, Indian Head Mine (Mercer County); Wilton Mine Game Management Area, (Burleigh and McLean Counties); and North Beulah Mine Game Management Area (Mercer County). The work involved a variety of techniques including: plot preparation with leveling, planting of grasses, legumes, forbs and woodland vegetation, vegetation management, and the evaluation of the survival success of the vegetation.

Analysis of Conclusions

This report provides information on revegetation techniques which may be useful for reclamation of abandoned as well as currently mined areas.

Title: **ALLELOPATHIC POTENTIAL OF *SALSOLA KALI* L. AND ITS POSSIBLE ROLE IN RAPID DISAPPEARANCE OF WEEDY STAGE DURING REVEGETATION**

Author: M.A.K. Lodhi

Organization Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Paper

Reference: Journal of Chemical Ecology 5(30):429-437, 1979

Key Index Words Revegetation, Succession, Allelopathy, Pioneer Species

Brief Description

This paper describes the results of a laboratory growth chamber study which was conducted to determine the factors which control the rapid disappearance of the weedy stage in surface mine spoils. Decaying leaves of *Salsola* in soil significantly reduced the root, shoot, and seedling growth of *Kochia* and *Salsola*. Several phytotoxins were identified which accumulate in the soil.

Analysis of Conclusions

The cause of the rapid disappearance of the weedy stage was identified. This is useful information for the management of reclaimed areas.

Title: **PLANTING DATE AND WATER AFFECT INITIAL ESTABLISHMENT OF PERENNIAL VEGETATIVE COMMUNITIES**

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

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

Format: Paper

Reference: Ecology and Coal Resource Development; Volume 2, (M.K. Wali, ed.), pp. 899-905, Pergamon Press, New York, NY, 1979

Key Index Words Revegetation, Irrigation, Planting Techniques

Brief Description

The objectives of this study were to determine if initial stand development is enhanced by additional water, does planting date affect stand establishment, and what interacting effects does additional water have. It is possible to successfully establish perennial vegetation on disturbed land. Planting date affected composition but not overall vegetation establishment.

Analysis of Conclusions

An important study which is applicable to all perennial species used for revegetation in the state.

Title: **RELEVANCE OF FLOW CULTURE STUDIES IN IDENTIFYING P-EFFICIENT SPECIES FOR MINE SPOILS**

Authors: N.M. Safaya, N. Malakondaiah, and M.K. Wali

Organization Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Paper

Reference Agronomy Abstracts, p. 180, 1979

Key Index Words Plant Adaptability, Species Selection, Nutrient Requirements

Brief Description

In this study a number of plant species were screened for their relative susceptibility or tolerance to phosphorus deficiency, using continuous flow culture and spoil culture techniques. The two screening techniques yielded similar results. The grass species tested were found to have lower requirements for phosphorus than the legumes, but two weedy species (Kochia and Russian thistle) were found to be most tolerant to phosphorus deficiency.

Analysis of Conclusions

This study indicated that continuous flow culture system provides a rapid method of screening plant species for their adaptability to mineral stresses characterizing mine soils. The high capacity and low intensity type of situation prevailing in mine spoils or soils with respect to phosphorus availability can be easily simulated in continuous flow culture system. Moreover, this study has shown that some plants can tolerate extremely low levels of phosphorus in the growing medium better than others. Using nutritionally efficient plants on mined lands with nutrient availability problems should prove advantageous.

Title: **GROWTH AND NUTRIENT RELATIONS OF A GRASS - LEGUME MIXTURE ON SODIC COAL MINE SPOIL AS AFFECTED BY SOME AMENDMENTS**

Authors: N.M. Safaya and M.K. Wali

Organization Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Paper

Reference: Soil Science Society of America Journal 43:747-753, 1979

Key Index Words Revegetation, Spoil Properties, Amendments, Fertilizer Use

Brief Description

Laboratory and growth chamber experiments were conducted to study the effects of fertilizers, gypsum, sulfuric acid, and leonardite on the growth and nutrient relations of a mixed crop of thickspike wheatgrass and yellow sweetclover on a calcareous sodic coal mine spoil. Application of NPK increased the dry matter yield of the two species by 10 and 37 times, respectively. However, sweet clover required P only but wheatgrass yields almost doubled when N was included with P. The two species exhibited differential response to leonardite, which was correlated with K^+/Na^+ ratios in the plants and their calcium uptake efficiency. Leonardite increased Na concentration in wheatgrass (ca inefficient species) and decreased its growth, but caused a reverse effect on sweetclover (ca efficient species). Sulfuric acid proved more effective than gypsum in releasing Na from the exchange sites in the spoil, and improved the P status of the plants.

Analysis of Conclusions

This is an important study which demonstrated that the effects of leonardite can vary with species, and that sulfuric acid is more effective than gypsum as a reclamation agent for calcareous sodic mine spoils. The importance of nitrogen and phosphorus fertilization for mine spoils was established.

Title: **FIELD EVALUATION PLANTING**

Authors: USDA-SCS, Bismarck Plant Materials Center Staff

Organization USDA-SCS, Bismarck Plant Materials Center, Bismarck, ND

Format: Report

Reference: 1977 Annual Technical Report, 1979

Key Index Words Revegetation, Plant Adaptability, Species Selection

Brief Description

This report presents the results of the mine spoil reclamation efforts of the Bismarck Plant Materials Center for the years 1975 to 1977. The reclamation work was conducted at four mine sites in western North Dakota, namely: Baukol-Noonan's, Center Mine (Oliver County); North American Coal Corporation's, Indian Head Mine (Mercer County); Wilton Mine Game Management Area, (Burleigh and McLean Counties); and North Beulah Mine Game Management Area (Mercer County). The work involved a variety of techniques including: plot preparation with leveling, planting of grasses, legumes, forbs and woodland vegetation, vegetation management, and the evaluation of the survival success of the vegetation.

Analysis of Conclusions

This report provides information on revegetation techniques which may be useful for reclamation of abandoned as well as currently mined areas.

Title: **RECLAMATION RESEARCH STUDY IN SLOPE COUNTY**

Author: J. Van Deussen

Organization USDA-FS, Rock Mountain Forest and Range Experiment Station, Bottineau, ND

Format: Report

Reference: USDA-FS, Unpublished Report (no date)

Key Index Words Revegetation, AML, Species Selection

Brief Description

This study focuses on the reclamation of an unleveled, abandoned uranium mine about 40 acres in size in north central Slope County. The study was initiated during the summer of 1975, and attempted to reclaim the area with several woody species. Data were collected on the percentage of survival of plantings. The survival of bare root versus containerized plantings was compared. Planting was discontinued in the summer of 1979 and the final evaluation and report was to be completed in the fall of 1979.

Analysis of Conclusions

The results of this study may be useful in the reclamation of abandoned mined lands.

Title: **COMPARISON OF VEGETATIVE COMPOSITION, COVER, AND PRODUCTION ON RECLAIMED AND NONMINED GRAZED LANDS**

Authors: L. Hofmann and R.E. Ries

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

Format: Paper

Reference: Proceedings of the Symposium on Adequate Reclamation of Mined Lands?, pp. 27-1 to 27-10, Billings, MT, 1980

Key Index Words Revegetation, Grazing, Cover, Animal Performance

Brief Description

This paper discusses the results of a long term grazing study in which animal performance and vegetative production, composition, and cover on reclaimed strip mined land and unmined grazing land near Center, ND, were compared. Dry matter yields harvested from moderately, lightly, and ungrazed reclaimed pastures were equal to or better than yields from two adjacent unmined range sites. Performance of yearling steers grazing reclaimed pastures at moderate or light intensities, equaled steer performance from unmined pastures at Mandan, ND, during spring and early summer. Four cool season, introduced plant species made up about 90 percent of the vegetation on the reclaimed site, and four native species made up over 75 percent of plant cover on native sites. Except for ungrazed controls, live plant cover was less on reclaimed land than on native range, as measured by foliage hits with a point frame. However, live vegetation plus litter was equal or better on reclaimed sites than on native sites, and cover was sufficient to prevent soil loss on both reclaimed pastures and native range, as predicted by the Universal Soil Loss Equation. If only live plant basal hits were used to estimate cover, neither the reclaimed nor native sites had sufficient cover to prevent unacceptable soil loss. The reclaimed area had equal or better vegetative production, equal animal performance.

Analysis of Conclusions

The observations and conclusions made in this study are very important in developing grazing management strategies for reclaimed and revegetated mined lands. Continued observations on these experimental plots would be highly desirable.

Title: **PRODUCTIVITY POTENTIAL OF SOME STOCKPILED TOPSOILS FROM COAL MINED LANDS IN WESTERN NORTH DAKOTA**

Authors: N. Malakondaiah, N.M. Safaya, and M.K. Wali

Organization Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Paper

Reference: Agronomy Abstracts, p. 171, 1980

Key Index Words Productivity, Stockpiled Soil, Fertilizer Use, Nutrient Requirements

Brief Description

In this study stockpiled topsoils from Center, Glenharold, and South Beulah mines in North Dakota were evaluated for their fertility status and productivity potential by growth chamber experiments and soil and plant analyses. Effects of 10 fertilizer treatments consisting of various combinations of N, P, K, Mn, Cu, and B on slender wheatgrass and yellow sweetclover were studied. Plants showed little response to N, some response to P, but a strong response to N+P. Responses to Zn occurred on Glenharold topsoil, and to B on South Beulah topsoil.

Analysis of Conclusions

This study has indicated that the availability of plant nutrients, especially N and P, in stockpiled topsoils can be extremely low. This can result in poor plant growth when such stockpiled soil materials are spread on reshaped spoils without proper fertilization.

Title: **POTENTIAL CONTROL AND VALUE OF SEEDS IN PRAIRIE HAY FOR REVEGETATION**

Authors: R.E. Ries, L. Hofmann, and W.C. Whitman

Organization USDA-ARS, Northern Great Plains Research Center, Mandan, and North Dakota State University, Fargo, ND

Format: Paper

Reference: Reclamation Review, 3:149-160, 1980

Key Index Words Revegetation, Prairie Hay, Mulch

Brief Description

This paper describes the results of a greenhouse study conducted at the ARS Station, Mandan. The objective of the study was to determine the relationship of amount and kinds of seeds available in prairie hay with range condition and harvest date of prairie hay. Prairie hay was found to be a seed source with potential to increase the diversity of native species on reseeded areas. However, excessive amount of certain species may result from prairie hay. By careful selection of range condition and harvest dates and the mixing of specific harvests the potential seedlings available from prairie hay may be matched to the intended use of the areas reclaimed.

Analysis of Conclusions

This was an excellent study which advanced the knowledge on the use of native hay mulch as a seed source. Follow-up studies should be conducted to see if seed dormancy or yearly climatic effects on potential seedling in hay are factors which need to be considered when harvesting or using native hay mulch.

Title: **SUPPLEMENTAL IRRIGATION WITH DIFFERENT WATER QUALITIES AND QUANTITIES TO INSURE REVEGETATION ESTABLISHMENT AFTER MINING**

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

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

Format: Report

Reference: Final Report, M-76-5, March, 1980

Key Index Words Revegetation, Irrigation

Brief Description

The study was conducted at the Knife River Gascoyne Mine. The objectives were to evaluate vegetation response during establishment and growth to supplemental water of different qualities and in different quantities, to evaluate soil salinity during and after application of irrigation and as a waste water disposal technique. The conclusions were that there are no detrimental effects on vegetative establishment and growth from the application of poor quality water. Soil quality was not adversely affected by the use of poor quality water. The use of poor quality water has potential for water disposal while benefiting the establishing of vegetation and having only moderate increases of the salt content in the root zone on permeable soil/spoil areas.

Analysis of Conclusions

A good study with results that can be applied to all reclamation areas which have moderate to high permeability. This study should be extended to fine textured materials.

Title: **RE-ESTABLISHING WOODY DRAWS ON THE NORTHERN GREAT PLAINS AFTER MINING: THE FIRST STEPS**

Authors: R.L. Williamson and K.W. Wangerud

Organization Consolidation Coal Company

Format: Paper

Reference: Adequate reclamation of mined lands? A Symposium, pp. 17-1 to 17-12, Soil Conservation Society of America and LRRC-1, Billings, MT, March, 1980

Key Index Words Revegetation, Woody Draws, Planting Techniques, Irrigation

Brief Description

The study was conducted at the Glenharold mine to determine which planting, bed preparation, and management techniques are most suitable for the establishment of woody vegetation. Results reported were preliminary and the only conclusion drawn was that irrigation enhances establishment as all plots exhibited good survival rates.

Analysis of Conclusions

This is one of the first studies conducted on North Dakota mine lands regarding the re-establishment of woody vegetation in the drainages. This study needs to be followed up and additional studies need to be conducted on woody draw establishment.

Title: **LIVESTOCK AND VEGETATIVE PERFORMANCE ON RECLAIMED AND NONMINED RANGELAND IN NORTH DAKOTA**

Authors: L. Hofmann, R.E. Ries, and R.J. Lorenz

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

Format: Paper

Reference: Journal of Soil and Water Conversation 36(1):41-44, 1981

Key Index Words Revegetation, Grazing, Animal Performance, Cover, Erosion

Brief Description

The study was conducted to determine the effect of grazing intensity on growth and persistence of vegetation, the ability of reclaimed lands to remain productive, and to compare livestock and vegetation performance on mined and unmined areas. The study was conducted at the Baukol-Noonan Center Mine. The results show that animal performance on reclaimed areas did not change significantly due to grazing, and the cover of the reclaimed area was adequate to control erosion, though both composition and cover varied from that found on unmined areas.

Analysis of Conclusions

This is an excellent study and is applicable to all reclaimed cool season pasture lands in the state. New grazing research should be conducted on a seasonally balanced cool/warm season with season long or deferred rest rotation grazing evaluated.

Title: **ECOLOGY OF *KOCHIA SCOPARIA* ON SURFACE MINED LANDS**

Authors: L.R. Iverson and M.K. Wali

Organization Project Reclamation, University North Dakota, Grand Forks, ND

Format: Paper

Reference: North Dakota Academy of Science 35:7, 1981

Key Index Words Revegetation, Succession, Pioneer Species, Allelopathy

Brief Description

The objective of this study was to increase the knowledge available on the ecology of *Kochia scoparia* and determine its role in revegetation of mined lands. A series of reclaimed areas near Beulah were studied. *Kochia* flourishes on newly reclaimed sites for a number of reasons; however, interspecific and intraspecific competition, loss of good germination sites, and the phenomenon of autotoxicity in *Kochia* all combine to decrease it the second and third years after reclamation. Some speculation were made as to why *Kochia* would produce phytotoxins.

Analysis of Conclusions

This paper presents a good summary on the traits of *Kochia* which allows it to flourish on newly reclaimed areas and why it decreases the following years. The study advanced the knowledge on *Kochia scoparia*, a common weed species which invades reclaimed areas. Understanding the ecology of and physiology of weedy species which invade and thrive on disturbed lands will be greatly helpful in controlling such species as well as in selection and breeding of desirable species with similar mechanisms for adaptability to impoverished soil conditions.

Title: **GROWTH AND CHEMICAL COMPOSITION OF SLENDER WHEATGRASS AND YELLOW SWEET CLOVER AS AFFECTED BY NUTRIENT APPLICATIONS TO COAL MINE SPOILS.**

Authors: N. Malakondaiah, N.M. Safaya and M.K. Wali

Organization Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Paper

Reference: Agronomy Abstract p. 183, 1981

Key Index Words Spoil Properties, Fertilizer Use, Nutrient Requirements, Revegetation

Brief Description

Laboratory and growth chamber studies were conducted to assess the fertility status and productivity potential of spoil materials collected from the Center, Glenharold and South Beulah Coal mines in western North Dakota. Slender wheatgrass and yellow sweetclover, used as test plants, produced less than 6% of maximum dry matter yield when the spoils were not fertilized. Responses to nitrogen and phosphorous, when applied singly, were nil to slight, respectively. However, near maximum yields were obtained when nitrogen and phosphorous were applied together. Some slight responses to potassium, zinc and manganese fertilization were also observed.

Analysis of Conclusions

This is one of the many studies conducted at the University of North Dakota, which have elucidated that mine spoils and soils are deficient in plant available phosphorus and nitrogen. In some cases manganese and zinc deficiencies are also evident in plants though conventional soil tests may show the levels of these nutrients in the spoil or soil materials in a seemingly adequate range. Moreover, these nutrient deficiencies are often masked in the field because of overriding water stress.

Title: **RESPONSES OF ALFALFA AND BARLEY TO FOLIAR APPLICATIONS OF N AND P ON A COAL MINE SPOIL**

Authors: N. Malakondaiah, N.M. Safaya, and M.K. Wali

Organization Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Paper

Reference: Plant and Soil 59:441-453, 1981

Key Index Words Nutrient Requirements, Fertilizer Use, Foliar Fertilization, Revegetation, Plant Responses

Brief Description

This paper discusses the results of several growth chamber experiments conducted to determine the effects of foliar fertilization with NaH_2PO_4, H_3PO_4, and urea on the growth and nutrient composition of alfalfa and barley grown on a calcareous, moderately saline and sodic mine spoil from South Beulah mine. The effects of various concentrations and frequencies of foliar fertilization were tested and compared with those obtained with soil applications of N and P.

Analysis of Conclusions

The results of these experiments have demonstrated that foliar applications of N and P to barley and that of P to alfalfa, grown on a freshly exposed mine spoil, can increase their growth significantly, and in some cases more effectively than do the applications of these nutrients to the spoil.

Title: **IMPROVING SPECIES COMPOSITION AND SEASONAL VARIETY ON RECLAIMED STRIP MINED GRASSLANDS THROUGH SELECTIVE GRAZING INTENSITIES AND TIME PERIODS**

Author: R.L. Williamson

Organization Consolidation Coal Company

Format: Paper

Reference: North Dakota Academy of Science Proceeding 35:5, 1981

Key Index Words Revegetation, Grazing, Grassland

Brief Description

The objectives of the study were to determine if grazing could be used as a management tool in improving species composition and seasonal variety of reclaimed grasslands and what levels of grazing could reclaimed grasslands withstand. The study was conducted at the Glenharold Mine. Three pastures were established, along with a control, and each pasture was grazed at a different intensity. The results indicated that grazing improved the seasonal variety and species diversity of the reclaimed grasslands. The more intense the grazing, the more the change. Good beef gains were obtained from all pastures. The control declined in condition.

Analysis of Conclusions

The study yielded excellent information about using grazing to manipulate vegetation. This is applicable to all mines reclaiming natural grasslands. The scale at which this study was conducted, was sufficient to provide the desired information. However, a large scale study should be conducted for several years to see how the vegetation withstands long term grazing in a season long grazing system.

Title: **RECLAIMING SEASONALLY BALANCED NATIVE GRASSLAND AFTER STRIP MINING**

Author: R.L. Williamson

Organization Consolidation Coal Company

Format: Paper

Reference: North Dakota Academy of Science Proceeding 35:3, 1981

Key Index Words Revegetation, Seeds, Grassland

Brief Description

The objective of this study was to see the effect of using different seed mixtures in reestablished at the Glenharold mine. Each site was mined, reshaped, respread with soil materials, and seeded. The seed mixture used differed between sites, one favoring sideoats grama (*Bouteloua gracilis*) and the other favoring little bluestem (*Schizachyrium scoparium*); the other species in the mixture were seeded at the same rate on both sites. The preliminary results reported were that by using specific reclamation techniques (delaying seeding until June, using irrigation, and weighting the seed mixture toward warm season species, a native seasonally balanced grassland can be established.

Analysis of Conclusions

This is an important study, the results of which are applicable to all mines where native grasslands are being reclaimed. However, the results of this study are only preliminary. This study should be continued to see what the long term requirements are for establishing native grassland. Also, this study looked at only a few of the techniques which may be usable for establishing a seasonally balanced native grassland. Additional work on management techniques would be desirable.

Title: **PHYSICAL AND ENVIRONMENTAL FACTORS OF WOODLAND ECOSYSTEMS ON THE GLENHAROLD MINE RESERVE IN WESTERN NORTH DAKOTA**

Authors: R.L. Williamson, J.L. Richardson, G. Clambey, B.J. Bermes, and W. Keammerer

Organization Consolidation Coal Company

Format: Paper

Reference: North Dakota Academy of Science Proceeding 35:8, 1981

Key Index Words Woody Draws, Environmental Factors, Land Use

Brief Description

The objective of this study was to identify the physical and vegetative characteristics of woody draws at the Glenharold Mine. Botanical, soils, landscape, and hydrogeologic investigations were conducted at six sites. Three main factors were identified as being important for the presence of woody vegetation and three vegetation types were described. The three factors are landform, slope aspect, and shallow water table outcrops. The three vegetation types are low shrublands, tall shurblands, and deciduous woodlands.

Analysis of Conclusions

This study is important in that it is the first time an analysis was conducted of woody draws to determine what physical factors contribute to the establishment and survival of woody vegetation in coulee and escarpment areas.

Title: **ECOLOGICAL STUDIES ON THE REVEGETATION PROCESS OF SURFACE COAL MINED AREAS IN NORTH DAKOTA: 3. SOIL AND VEGETATION DEVELOPMENT OF ABANDONED MINES**

Authors: M.K. Wali and R.H. Pemble

Organization Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Report

Reference: A minerals research contract report to USDI-Bureau of Mines, 1982

Key Index Words Revegetation, Soil Development, Spoil Properties, AML, Succession

Brief Description

A field study conducted at the Velva Mine, with laboratory work completed at UND. The objective was to analyze soil and vegetation development on abandoned mine sites from 1 to 45 years old and compare these sites to an unmined site. Species diversity was highest at the unmined site and lowest at the 1 year old site. Site ages were found to be the most important in influencing species diversity and composition based on stand ordinations. Stand environmental complex ordinations showed topographic variables the most important. Nutrient accumulation and carbon-nitrogen ratios data are provided.

Analysis of Conclusions

A good study on vegetation development on abandoned mine areas with good spoil conditions.

Title: **RECLAMATION OF COAL MINED LANDS: THE ROLE OF *KOCHIA SCOPARIA* AND OTHER PIONEERS IN EARLY SUCCESSION**

Authors: L.R. Iverson and M.K. Wali

Organization Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Paper

Reference: Reclamation and Revegetation Research, 1 :123-160, 1982

Key Index Words Revegetation, Succession, Pioneer Species, Allelopathy, Competition

Brief Description

This study was conducted on mined and unmined areas south of Beulah, and in the growth chambers and laboratories of UND. The objective was to determine the role of Kochia and other pioneer species early in succession. The authors found that *Kochia* dominated the first couple of years after mining, then declined and the seeded *Agropyron sp.* increased. Other pioneers showed a similar but less abrupt decline. Chemical changes in the soil also occurred during this time. *Kochia* was found to act as a nurse crop for *Agropyron sp.* the first year, but later shaded them. Autotoxicity in *Kochia* appeared to be the major factor in its decline.

Analysis of Conclusions

An informative study on the role of Kochia in early succession.

Title: **ECOLOGICAL STUDIES ON THE REVEGETATION PROCESS OF SURFACE COAL MINED AREAS IN NORTH DAKOTA: 9. VIABILITY AND DIVERSITY OF THE SEED BANK.**

Authors: L.R. Iverson and L. Brophy

Organization Project Reclamation, University of North Dakota, Grand Forks, ND.

Format: Report

Reference: A minerals research contract report to USDI-Bureau of Mines, 1982

Key Index Words Seed Source, Topsoil, Germination

Brief Description

Results of a laboratory and growth chamber study designed to determine the amounts and kinds of viable seeds in natural topsoil and stockpiled topsoil are discussed. The conclusions were that the top 7.5 cm of topsoil contains by far the highest quantity and quality of seeds, grazing of a site increases the seeds, stockpiled topsoil contained very few seeds, and there is a definite seasonality to the quality and quantity of the seed bank.

Analysis of Conclusions

An important study which if furthered should improve the reclamation technology.

Title: **ECOLOGICAL STUDIES ON THE REVEGETATION PROCESS OF SURFACE COAL MINED AREAS IN NORTH DAKOTA: 11. EFFECT OF AMENDMENTS ON SOIL - PLANT NUTRIENT RELATIONS UNDER CONTROLLED CONDITIONS**

Authors: N. Malakondaiah and N.M. Safaya

Organization Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Report

Reference: A mineral research contract report to USDI-Bureau of Mines 62 p., 1982

Key Index Words Revegetation, Amendments, Fertilizer Use, Nutrient Requirements, Productivity

Brief Description

This report discusses the results of a number of growth chamber and laboratory experiments which were conducted to study the effects of various amendments and nutrient applications on the germination, growth, and nutrient uptake of several grass and legume species grown on spoils and topsoils collected from various mining areas in North Dakota. Germination and growth responses to leonardite varied with species; sulfuric acid was found to be a better amendment than gypsum; plant growth on spoils and topsoils was greatly increased by nitrogen plus phosphorus applications, and in some cases responses to manganese and zinc were also observed.

Analysis of Conclusions

This report provides very useful information about the productivity and fertility characteristics of mine spoils and soils. The problems of nutrient availability in these materials have been examined in great detail, and the requirements for specific nutrients established. It is important to recognize, however, that any possible responses to fertilizer applications on mine spoils and soils can be completely masked by the overriding effect of moisture shortage.

Title: **ECOLOGICAL STUDIES ON THE REVEGETATION PROCESS OF SURFACE COAL MINED AREAS IN NORTH DAKOTA: 12. SCREENING PLANTS FOR PHOSPHORUS REQUIREMENTS.**

Authors: N.M. Safaya and N. Malakondaiah

Organization Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Report

Reference A minerals research contract report to USDI, Bureau of Mines, 46 p., 1982

Key Index Words Plant Adaptability, Nutrient Requirements, Species Selection

Brief Description

This report provides a review of literature on the adaptability of plants to mineral stresses (deficiencies and toxicities), and discusses the results of continuous flow culture and soil culture techniques used for screening some plant species and varieties for their relative susceptibility to phosphorus deficiency. Legumes were found to be the most susceptible to phosphorus deficiency and weedy species such as Russian thistle and kochia the least. The phosphorus uptake efficiency of the weedy species was three to five times higher than that of the legumes. The rating of species with respect to their susceptibility to phosphorus deficiency was more or less similar under both screening procedures.

Analysis of Conclusions

The importance of selecting plants for revegetation of mined lands on the basis of their tolerance to edaphic stresses, such as mineral deficiencies and toxicities, is emphasized. The relatively high phosphorus uptake efficiency of Russian thistle and kochia, as reported in this study, may perhaps be one of the reasons for their ability to grow well on the highly impoverished mine spoils and other disturbed areas. This study also indicated that screening of plants conducted in continuous flow culture system does not greatly differ from that conducted in the spoil system, and therefore continuous flow culture technique can be of much use in rapid screening of species for mined land use.

Title: **ECOLOGICAL STUDIES ON THE REVEGETATION PROCESS OF SURFACE COAL MINED AREAS IN NORTH DAKOTA: 6. RELATIONSHIP BETWEEN COVER AND ABOVEGROUND BIOMASS**

Author: D.K. Schemmelpfennig

Organization Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Report

Reference A minerals research contract report to USDI-Bureau of Mines, 1982

Key Index Words Revegetation, Productivity, Cover, Topsoil

Brief Description

A field study was conducted on both native and reclaimed grasslands to determine plant cover estimates by species, biomass estimates by species, the relationship between cover and biomass, the predictability of the relationship, and evaluate factors affecting the relationship. Correlations for individual species and native grassland sites were significant. Rough estimates of biomass of major species can be obtained by using aerial cover on these sites.

Analysis of Conclusions

A good study with some interesting possibilities for application. Accurate estimates of biomass from cover data would reduce determination of reclamation success. Further work should be done to see if correlations can be improved for reclaimed areas.

Title: **WARM-SEASON GRASSES FOR REVEGETATION IN THE NORTHERN GREAT PLAINS**

Authors: R.E. Ries

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

Format: Paper

Reference: Proceedings, Symposium on Surface Coal Mining and Reclamation in the Northern Great Plains, Mont. Ag. Exp. Stat. Res. Rep. No. 194, 1982

Key Index Word: Revegetation, Grassland

Brief Description:

Literature pertaining to the ecology of warm-season grasses and their establishment on mined land is reviewed. Warm-season grasses, such as blue grama and buffalo grass are recognized for their value as forage and for erosion control. Difficulties in obtaining seeds and establishing them from seed have limited the use of warm-season species. Warm-season grasses require optimum seed placement depth and moisture conditions which are difficult to obtain.

Analysis of Conclusions

This paper is a good review of literature on warm-season grasses for establishment on reclaimed lands. Proper seeding techniques, including rate, depth, and date are given.

Title: **PLANT ROOT DISTRIBUTION IN UNDISTURBED AND RECLAIMED STRIPMINE SOILS IN WESTERN NORTH DAKOTA**

Authors: J.E. Gilley, D.D. Schlenker, and E.C. Doll

Organization NDSU-Land Reclamation Research Center, Mandan, ND

Format: Report

Reference: NDSU-Agricultural Experiment Station Research Report No. 92, October 1982

Key Index Words Root Growth, Sodicity, Topsoil

Brief Description:

This study, conducted at the Indian Head Mine, compared root growth in an undisturbed soil to that in reclaimed soils with underlain sodic or nonsodic spoils. It also evaluated the effects of topsoil thickness on root growth; the effects of tilling the spoil surface prior to topsoil replacement on root growth in the spoil were also studied. Similar root growth patterns were found for perennial grasses grown on the undisturbed soil, the reclaimed nonsodic spoil site, and the reclaimed sites with varying depths of topsoil over sodic spoil. However, the total amount of roots produced varied greatly at the 3 sites. Tillage of the spoil surface prior to topsoil replacement did not appear to improve root penetration into the spoil. Total depth of root penetration appeared to be independent of topsoil depth.

Analysis of Conclusions

Additional research should be conducted to further determine those factors which affect root growth and development in reclaimed soils. The research should also include mined lands that have been reclaimed with both topsoil and subsoil.

Title: **SURFACE MINE RECLAMATION PLANT MATERIALS STUDIES**

Authors: USDA-SCS, Bismarck Plant Materials Center Staff

Organization USDA-SCS, Plant Materials Center, Bismarck, ND

Format: Report

Reference: Progress Reports, June 1982 and December 1983

Key Index Words Revegetation, Plant Adaptability, Erosion, Species Selection

Brief Description

These progress reports provide information on studies which were conducted to: 1) determine plants best suited for mine spoil reclamation, 2) develop techniques for successful establishment of plants for erosion control and surface mined land reclamation, 3) determine equipment modification needed for seed collection and processing, and 4) propagate and provide for increase of seed and other plant materials. All studies are currently underway. No conclusions or findings have been provided.

Analysis of Conclusions

These are ongoing studies on the selection and evaluation of plant materials suitable for strip mine land reclamation. These studies need to be continued.

Title: **LIABILITY PERIOD AND MANAGEMENT OF RECLAIMED LANDS**

Authors: J.D. Friedlander

Organization The North American Coal Corp., Western Division, Bismarck, ND.

Format: Paper

Reference: Symposium on Western Coal Mining Regulatory Issues: Land use, Revegetation, & Management, (E. F. Redente, W. E. Sowards, D. G. Steward, Terry L. Ruiter, eds.). pp.103-4, Fort Collins, CO, 1983.

Key Index Word: Liability Period, Bond Release, Land Use, Management Practices

Brief Description:

The author contends that a 10-year liability period, imposed by the 1977 Surface Mining Control and Reclamation Act, for assessing reclamation success in the western states does not meet the site specific management needs because of the extreme variability in climate and land use in this region. Good arguments have been presented to underscore the importance of management practices in relation to the liability period and the degree of difficulty in establishing vegetation in different parts of the Western United States.

Analysis of Conclusions

There may be some truth in the author's contention that restarting the liability clock for instituting certain management practices actually penalizes operators, and discourages effective reclamation and postmining land use.

Title: **RE-ESTABLISHING NORTH DAKOTA GRASSLANDS AFTER MINING WITH EMPHASIS ON SEASONALITY AND USE OF NATIVE SPECIES**

Authors: R. L. Williamson

Organization Consolidation Coal Company

Format: Paper

Reference: Journal of Soil and Water Conservation 39(6):387-391. 1984

Key Index Word: Seasonality, Grassland, Planting Techniques

Brief Description:

This study was designed to demonstrate on large-scale pastures that a seasonally balanced grassland can be re-established with native species following mining. Techniques including seeding in late spring, irrigation during the first growing season, and weighting the seed plan to heavily favor native warm season species were evaluated to determine their necessity to insure a seasonal stand and to compare to traditional practices.

Analysis of Conclusions

Alternative methods of establishing grasslands that are seasonally balanced with native warm season grass species are more successful than traditional North Dakota grassland establishment practices. Particularly significant was a combination of seeding date and irrigation, although seed plan ratios were also important. Seeding later in the spring gives warm season species a more equal establishment chance. Irrigation, in the first growing season only, appears to be most helpful in late spring and early summer for establishing warm season species. Sideoats grama was especially responsive to first growing season irrigation. Seed plans for establishing grasslands that emphasize dual seasonality should include in excess of 70% perennial warm season grass varieties.

Title: **PASTURE AND HAYLAND: MEASURES OF RECLAMATION SUCCESS**

Authors: R.E. Ries and L. Hofmann

Organization ARS, Northern Great Plains Research, Laboratory, Mandan, ND

Format: Paper

Reference: Minerals and the Environment 6: 85-90, 1984.

Key Index Word: Vegetation, Cover, Pasture, Reclamation Success

Brief Description

Several characteristics of reclaimed tame pastureland were quantified and evaluated as a measure of determining reclamation success on surface mined lands. These include productivity (vegetation and animal), ground cover and soil loss, species composition and species numbers, and seasonality of use.

Analysis of Conclusions

Measurement of reclaimed grassland characteristics including beef gains, plant species numbers, soil loss, and seasonality of use are useful in evaluating reclaimed grassland from a research standpoint. However, these characteristics do not appear necessary for making management - oriented determinations of reclamation success. Important measures are vegetative productivity and ground cover. Measure of vegetation productivity translates into quantity of forage or hay produced following reclamation, while it also provides an evaluation of the effectiveness and permanence of the reclaimed grassland. Ground cover (vegetation and litter cover) provides a measure of soil protection from water erosion. Reclaimed grassland with a total surface ground cover of 73% or more (bare soil amount less than 27%) had soil loss similar to native non-mined grassland.

Title: **FACTORS AFFECTING REVEGETATION OF ABANDONED MINE LANDS IN THE NORTHERN GREAT PLAINS**

Authors: S. A. Nicholson

Organization Project Reclamation, University of North Dakota, Grand Forks, ND

Format: Paper

Reference: Proceedings of the National Sympoisum and Workshops on Abandoned Mine Land Reclamation) L.L. Schloesser, G.S. Anderson, N.M. Safaya, D.J. Thompson, eds.) pp. 548-561, Bismarck, ND 1984

Key Index Words AML, Microorganisms, Salinity, Sodicity, Water Stress

Brief Description

This paper discusses the key environmental and biotic factors that restrict or affect the revegetation of abandoned mine lands in the Northern Great Plains, with particular emphasis on those found in North Dakota. The reclamation problems caused by sodicity, salinity, acidity, nutrient deficiencies, instability caused by subsidence, and susceptibility to wind and water are discussed.

Analysis of Conclusions

The information provided in this paper will help to identify the problems encountered in revegetating abandoned mine lands in North Dakota. The discussion on the role of micro-organisms in the reclamation process enlarges the scope of this paper.

Title: **YIELD AND BOTANICAL COMPOSITION OF A GRASS-LEGUME MIXTURE ON RECLAIMED LAND AS AFFECTED BY N AND P FERTILIZER**

Authors: G.A. Halvorson and A. Bauer

Organization NDSU - Land Reclamation Research Center, Mandan, and Soils Science Department, Fargo, ND

Format: Paper

Reference: Agronomy Journal 76:355-358, 1984

Key Index Words Revegetation, Fertilizer Use, Plant Responses, Species Selection, Landuse Management

Brief Description:

The objective of this study was to determine the effect of N and P fertilizers on a grass-legume mixture consisting of alfalfa, yellow sweetclover, intermediate wheatgrass, crested wheatgrass and smooth bromegrass grown on reclaimed land at the Center Mine. Eleven P and three N treatments were applied in a split-plot design. Annual N applications increased total forage yield, by increasing the relative composition of smooth bromegrass and wheatgrasses. Alfalfa yields were reduced by N application. P applications did not increase total forage yields. Yield and percent composition of wheatgrass increased with increasing additions of P, but the percent composition of smooth bromegrass decreased. Yields of smooth bromegrass and wheatgrass were highly correlated with the cumulative P applications. The authors concluded that application of fertilizer P can be used as a management tool to influence species composition on reclaimed pasture.

Analysis of Conclusions

Vegetation responses to N and P fertilizers obtained in this study on reclaimed land are similar to those that would be expected on undisturbed lands. The observation that P fertilization can change the botanical composition of grasslands provides yet another method of managing reclaimed lands for meeting diversity and seasonality requirements.

Title: **GRAZING RECLAIMED MINED LAND: ANIMAL PERFORMANCE**

Authors: L. Hofmann and R.E. Ries

Organization ARS, Northern Great Plains Research, Laboratory, Mandan, ND

Format: Proceedings

Reference: American Society of Agronomy 76th Annual Meeting, 76:158. 1984.

Key Index Word: Animal Performance, Grazing

Brief Description

Yearling steers were grazed on fertilized surface-mined land-reclaimed to cool-season forage species for a six year period to determine animal gains. Steers were grazed at rates of 0.73, 0.49, and 0.24 ha/steer/season to determine effects of light, moderate, and heavy grazing intensities, respectively. Grazing occurred between late May and early July: 38 days for light and moderate intensities and 30 days for the heavy intensity. Surface soil compaction was estimated using a cone-tip penetrometer.

Analysis of Conclusions

Heavily grazed pastures produced significantly less (P=0.05) beef (31 kg/ha) than moderate or light grazing intensities (86 and 64 kg/ha respectively). Average daily gains were 0.3, 1.1, and 1.3 kg/ha for heavy, moderate and light grazing intensities, respectively. Overgrazing was especially detrimental in stressed years. In 1980, a drought year, steers grazed at the heavy intensity for 18 days lost weight, while steers at moderate and light grazing intensities gained. Increased grazing intensity increased soil compaction but had no effect on soil bulk density. There were no animal health problems. Animal gain and performance were comparable to long-term research experience on unmined lands.

Title: **GRAZING RESEARCH AND WATER-USE-EFFICIENCY ON RECLAIMED PASTURES IN NORTH DAKOTA**

Authors: R.E. Ries and L. Hofmann

Organization ARS, Northern Great Plains Research, Laboratory Mandan, ND

Format: Paper

Reference: Symposium on Reclamation of Lands Disturbed by Surface Mining: A Cornerstone for Communication and Understanding, pp. 151-163. 1984 National meeting, American Society for Surface Mining and Reclamation. Science Reviews Limited. Northwood, Middlesex, England. 1985.

Key Index Word: Revegetation, Performance Standards

Brief Description

This paper presents a review of grazing research on reclaimed, cool-season pastures in North Dakota and a comparison of water-use-efficiency of forage grown on unmined and mined land.

Analysis of Conclusions

Data has shown that vegetation and animal production from reclaimed pastures is similar to that from unmined pastures. Soil loss on reclaimed pastures was similar to soil loss from native rangeland providing reclaimed areas were not heavily grazed. Production of vegetation and surface ground cover (vegetation and litter) provide appropriate and adequate documentation to evaluate reclamation success of tame pastureland. Forage water use efficiency as effected by maximum air temperature and free water evaporation indicated water was more efficiently used in producing forage under cooler climatic conditions. Light and moderately grazed pastures produced more forage per unit water used as compared to ungrazed and heavily grazed pastures. Forage water use efficiency on reclaimed pastures was comparable to forage water use efficiency of non-irrigated unmined land.

Title: **TECHNIQUES USED TO ESTABLISH, MAINTAIN, AND ENHANCE GRASSLAND SEASONAL VARIETY ON THE GLENHAROLD MINE IN NORTH DAKOTA**

Authors: D.J. Nilson, R.L. Williamson, J.C. Thompson, and J.E. Shultz

Organization Consolidation Coal Company

Format: Paper

Reference: Proceedings, Second Annual Meeting, American Society for Surface Mining and Reclamation, Denver, Colorado, October 8-10, 1985

Key Index Word: Revegetation, Seasonality, Cover, Productivity

Brief Description

Establishment and management techniques which have enhanced seasonal variety on reclaimed native grasslands are described. Three reclaimed areas which were seeded with different mixes and managed differently were compared for cover, productivity, and frequency. Practices which enhanced seasonality are late spring seeding, irrigation, larger amounts of warm-season species in seed mixes, herbicide control of cool-season species, controlled burning in late spring, and interseeding.

Analysis of Conclusions

This paper presents state-of-the-art techniques used to establish seasonally balanced native grassland on reclaimed lands.

Title: **PRESCRIBED BURNING OF RE-ESTABLISHED GRASSLANDS ON RECLAIMED GRASSLANDS IN WESTERN NORTH DAKOTA**

Authors: M. Haupt

Organization Department of Botany, North Dakota State University, Fargo, ND

Format: Thesis

Reference: M.S. Thesis. North Dakota State University, Fargo, ND, 1985

Key Index Word Management Practices, Grassland

Brief Description:

Prescribed burning was conducted on three re-established grassland sites at the Glenharold Mine to determine the effect of fire on the diversity, cover and production of several reseeded grass species. Pre-burn physical and biological conditions were recorded in order to evaluate their influence on post-burn vegetation response. Six plots, approximately 0.10 ha in size, were located on each north and south exposure of each site. Burning date was chosen based on growth stages of western wheatgrass and sideoats grama. Burning dates included May 1, May 23, June 30, August 1, and October 23, 1983. A non-burned plot was included as a control. Basal cover, production and frequency of seeded and nonseeded species were recorded.

Analysis of Conclusions

Post-burn vegetation measurements in 1984 revealed total live basal cover, production and frequency of seeded species was the same or higher, compared to control plots, on all but August 1 burn-plots. Evaluation of pre-burn physical and biological conditions, and post-burn vegetation response, revealed that prescribed burn treatments on May 1 and May 23 produced the optimum response in vegetation cover, production and frequency while protecting topsoil from erosion.

Title: **MARGINAL WATER FOR VEGETATION ESTABLISHMENT**

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

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

Format: Abstract

Reference: Abstracts, 38th Annual Meeting, Society for Range Management, Salt Lake City, UT Feb. 11-15, 1986

Key Index Word: Irrigation, Grassland, Salinity, Sodicity

Brief Description

Medium and low quality water were applied as irrigation supplements to natural precipitation during initial establishment of perennial grass species. Response of seeded and weed species and changes in soil salinity and SAR were monitored. Production of seeded species increased while that of weed species decreased with increased amounts of water, regardless of quality. Soil salinity and SAR were minimal when water was applied for one growing season. After two growing seasons, low quality water had increased salinity and SAR; however, no adverse effects on vegetation production were observed.

Analysis of Conclusions

This study indicates the potential for supplemental irrigation with low quality water to enhance initial vegetation establishment.

Title: **SEASONALITY OF GRAZING RECLAIMED PASTURES: ANIMAL PERFORMANCE**

Authors: L. Hofmann and R.E. Ries

Organization ARS, Northern Great Plains Research, Laboratory,
Mandan, ND

Format: Proceedings

Reference: Society for Range Management 39th Annual Meeting, 1986

Key Index Word: Grazing, Animal Performance

Brief Description

Live weight gains of yearling steers grazing reclaimed pastures, dominated by smooth bromegrass and alfalfa, were compared to weight gains on adjacent unmined rangelands. Pastures were stocked at 0.93 ha/steer.

Analysis of Conclusions

Live weight gains from reclaimed pasture and native rangeland were, respectively: 65 and 64 kg/steer from June 15 to September 20; 75 and 61 kg/steer from May 25 to September 28; and 65 and 57 kg/steer from May 30 to October 3. Weight gains were equal or better on reclaimed introduced pasture as compared to native rangeland when identical stocking intensities, grazing dates, and management practices were used. Data suggest that cool-season species may be used to revegetate disturbed land designated for grazing without sacrificing animal performance.

Title: **IMPROVED PASTURE**

Authors: R.E. Ries and W.L. Stout

Organization USDA-ARS, Northern Great Plains Research Laboratory, Mandan, ND and Forage and Pasture Laboratory, University Park, PA

Format: Paper (Chapter)

Reference: Reclamation of Surface-Mined Lands, Volume II (L.R. Hossner, ed.), pp. 157-173, CRC Press, Inc., Boca Raton, FL 1988

Key Index Words Pasture, Rangeland, Revegetation, Animal Performance, Erosion, Land Use

Brief Description

This paper provides a brief review of the importance, management, and the present status of forage and animal production of improved pastures in the eastern and western U.S. Emphasis has been given on the development and management of improved pastures on reclaimed lands. Critical factors for successful establishment of pastures on mined lands have been discussed in relation to both reclamation and revegetation strategies.

Analysis of Conclusions

The information contained in this review is of much value to the coal mining industry, regulatory agencies, and plant and animal scientists. The authors have shown that forage and animal production from improved pastures established on mined lands can be equal to and in some case greater than, that from those on unmined lands, under similar management and climatic conditions. However, to establish productive pastures on reclaimed land requires that "mining and reclamation must be planned together and thought of as one goal".

Title: **IRRIGATION WATER FOR VEGETATION ESTABLISHMENT**

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

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

Format: Paper

Reference: Journal of Range Management 41(3): 210-215, 1988

Key Index Words Revegetation, Irrigation, Sodicity, Salinity, Plant Responses, Productivity

Brief Description:

In this study, conducted at the Gascoyne Mine, the effects of supplemental irrigation with marginal quality water on the establishment of perennial forage on reclaimed land and changes in soil salinity and sodicity were evaluated. Nine combinations of various quantities of medium (EC 1; SAR 6.5) and low (EC 3.2 - 3.8; SAR 11.6 - 18.2) quality water were applied to augment soil moisture resulting from natural precipitation. The production of seeded species increased with all types of supplemental irrigation, and weed infestation decreased. Changes in soil salinity or sodicity were minimal following one season's irrigation, but when low quality water was applied for two seasons, an increase in these parameters was noted.

Analysis of Conclusions

The authors concluded that marginal quality water can be used for establishing perennial forage communities on reclaimed lands without any significant soil deterioration. This finding has practical application in the reclamation of semi-arid lands. However, research on the irrigation uses of marginal quality waters should include testing under more than one soil-plant condition and an assessment of trace elements, particularly boron, in such waters and their accumulation in the soil.

Title: **VEGETATION AND ANIMAL PRODUCTION FROM RECLAIMED MINED LAND PASTURES**

Authors: L. Hofmann and R.E. Ries

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

Format: Paper

Reference: Agronomy Journal 80:40-44, 1988

Key Index Words Grazing, Vegetation, Cover, Compaction, Land Use, Management Practices

Brief Description:

The objectives of this research were to study the effects of grazing intensity on standing crop vegetation, steer performance, and soil compaction; and to determine which vegetation measurement method would best reflect the response of cool-season pastures to grazing. Research was conducted near Center, North Dakota over a 5-year period. Pastures were divided into ungrazed, lightly grazed, moderately grazed and heavily grazed treatments. Reclaimed grasslands did not deteriorate with 50% or less total vegetation removal in early summer. Vegetation production and steer gain were highest on lightly grazed plots. Heavily grazed areas resulted in an increase in invader species. Grazing did not measurably affect soil bulk density in the top 150 mm, however, soil compaction increased with grazing intensity. Ground cover was effectively measured using either basal or aerial hits with the ten-point frame.

Analysis of Conclusions

This 5-year study of the effects of grazing intensities on steer performance, vegetation, and soil compaction provides much valuable data on the management and productive use of reclaimed lands in North Dakota. The study showed that assessment of ground cover adequacy for erosion control by point frame method can be made as reliably by using surface hit bar-ground cover estimates as by the first hit estimates of vegetation itself.

Title: **DIVERSITY AND SEASONAL VARIETY IN RECLAIMED NATIVE GRASSLANDS**

Authors: D.J. Nilson and K.J. Hirsch

Organization Basin Electric Power Cooperative, Glenharold Mine, Stanton, ND, and Public Service Commission, Bismarck, ND

Format: Paper

Reference: Proceedings of the Conference "Reclamation, A Global Perspective," (D.G.Walker, C.B.Powter and M.W. Pole, eds.) pp. 263-277, Calgary, Alberta, August 1989

Key Index Words Grassland, Seasonality, Revegetation Management Practices

Brief Description:

Production and cover data from a 216 ha reclamation area were collected between 1982 and 1988 to determine revegetation success and evaluate several grassland establishment and management practices. Data presented in this paper show that choice of seed mixture, seeding date, glyphosate (Roundup) herbicide treatments, and use of native hay mulch can affect species composition, diversity and productivity of reclaimed grasslands.

Analysis of Conclusions

North Dakota reclamation laws and rules require that reclaimed native grasslands be diverse, effective and permanent and of the same seasonal variety native to the area. This paper presents innovative management techniques that have been effective in achieving those standards.

Title: **WOODLAND RECLAMATION WITHIN THE MISSOURI BREAKS IN WEST CENTRAL NORTH DAKOTA**

Authors: D.J. Nilson

Organization Basin Electric Power Cooperative, Glenharold Mine, Stanton, ND

Format: Paper

Reference: Proceedings of the Conference "Reclamation, A Global Perspective," (D.G.Walker, C.B.Powter and M.W. Pole, eds.) pp. 345-355, Calgary, Alberta, August 1989

Key Index Words Woody Draws, Shrub Establishment

Brief Description:

This paper discusses the restoration of woody draws along the Missouri breaks at the Glenharold Mine. Natural woody draws in this geographic area usually occur in the drainages and hillsides and consist of shrub and mixed deciduous communities. Restoration of these sites requires reclamation techniques to create areas with geomorphology and slope aspect that maximize plant available water necessary for establishing woody vegetation. All the management methods that have led to the establishment of self perpetuating woodland systems at this mine are discussed.

Analysis of Conclusions

Woody draws are critical wildlife habitat in western North Dakota. This paper presents valuable reclamation and management strategies that have proven successful in reestablishing these woodland areas.

Title: **PROMISING NATIVE FORBS FOR SEEDING ON MINE SPOILS**

Authors: A.J. Bjugstad and W.C. Whitman

Organization USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Rapid City, SD and North Dakota State University, Fargo, ND

Format: Paper

Reference: Proceedings of the Conference "Reclamation, A Global Perspective," (D.G. Walker, C.B. Powter and M.W. Pole, eds.) pp. 255-262, Calgary, Alberta, August 1989

Key Index Words Revegetation, Shrub Establishment, Species Selection, Plant Responses, Pioneer Species

Brief Description:

Thirty one forb species were planted into minespoil near Dickinson, ND to determine which species would be most successful. Seed germination was tested using several different storage treatments. Plant height comparisons were made between seeded and transplanted plants. Several species showed exceptionally good emergence and vigorous growth.

Analysis of Conclusions

Although grazing systems are usually focused around grassy species, the forb component is also important, especially for wildlife. This paper gives valuable information on the pioneer species that can rehabitate mine spoils during early successional stages.

Title: **ANIMAL PERFORMANCE AND PLANT PRODUCTION FROM CONTINUOUSLY GRAZED COOL-SEASON RECLAIMED AND NATIVE PASTURES**

Authors: L. Hofmann and R.E. Ries

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

Format: Paper

Reference: Journal of Range Management 42: 248-251, 1989

Key Index Words Revegetation, Pasture, Seasonality, Species Selection, Land Use

Brief Description

The objective of this study was to compare season-of-grazing use of reclaimed pastures comprised of introduced cool-season species with undisturbed rangeland pastures supporting native warm- and cool-season species. The study was conducted at the Center Mine over a period of 5 years, and data on vegetation cover and production and live weight gain of steers under various grazing intensities were collected. No differences were noted in the season-of-grazing use between the reclaimed cool-season pastures and the native mixed prairie. There was no evidence that species with the same growing season as those native to the area were necessary to provide season-long grazing use.

Analysis of Conclusions

The authors claim that since cool-season species are readily established, easier to seed, less expensive, and provide similar season-long grazing use as a mixture of warm- and cool-season species, there is no need to have a warm-season species component or prairie type of species diversity on reclaimed lands to provide comparable seasonal grazing. This conclusion has a significant bearing on some of the regulatory requirements for revegetation.

Title: **DROUGHT EFFECTS ON PLANT DIVERSITY OF RECLAIMED GRASSLANDS IN WESTERN NORTH DAKOTA**

Author: L. Frarck, K. Krabbenhoft, D. Kirby, and D. Nilson

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

Format: Paper

Reference: In: Proceedings of the 9th Annual National Meeting of the American Society for Surface Mining and Reclamation. pp 304-313, Duluth, Minnesota, June 1992

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

Brief Description

Effects of drought on plant diversity of reclaimed and undisturbed grasslands at the Glenharold Mine were studied. Species diversity of a reclaimed silty site was determined over a period of 1983-90. The period of 1988-90 was droughty. Drought had no effect on species diversity. However, on reclaimed grasslands, drought tended to diminish localized plant diversity. Effects on alpha-, beta-, and mosaic diversity are discussed

Analysis of Conclusions

This study is important in that it addresses the question of plant diversity on reclaimed lands in a broader context, namely alpha-, beta-, and mosaic diversity, and informs us as to what might happen to vegetation diversity during droughty periods. This type of study needs to be conducted at other mine sites as well.

Title: **IMPORTANCE OF POST-DISTURBANCE LAND USES TO RECLAMATION/RESTORATION SUCCESS**

Author: R.E. Ries

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

Format: Paper

Reference: Proceedings of the 9th Annual National Meeting of the American Society for Surface Mining and Reclamation. pp 651-656, Duluth, Minnesota, June 1992

Key Index Words: Revegetation, Environmental Factors, Reclamation Success

Brief Description

In this scholarly presentation the author emphasizes that the potential, long term success of any reclamation or restoration is limited by the purported end use of the disturbed ecosystem. And the end use must be in harmony with the topographic, climatic and edaphic characteristics of that ecosystem. However, outside resource inputs may to an extent sustain uses that are not in total harmony with the ecosystem. If the natural ecological process is allowed to reclaim/rehabilitate a disturbed site, then there is little need to define when and what constitutes successful reclamation. But, where success of reclamation must be evaluated, the parameters of evaluation are determined by the end use.

Analysis of Conclusions

The thoughts expressed in this paper are worth taking into account when formulating a policy and methodology for evaluation of reclamation success. To a large extent this has been done. Also, the aptness of the argument: success need not be evaluated if reclamation has been allowed by natural ecological process, is clear when considering the reclamation of abandoned mines.

Title: **TRANSPLANTING AND ESTABLISHMENT OF WESTERN SNOWBERRY (*Symphoricarpos occidentalis* Hook.) ON RECLAIMED LAND**

Authors: J.D. Friedlander

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

Format: Paper

Reference: Decades Later: A Time for Reassessment, Proceedings of 12th National ASSMR Meeting, pp. 779-795, Laramie, WY, 1995

Key Index Words Revegetation, Shrub Establishment, Soil Moisture

Brief Description:

Described are the results of an attempt to reestablish western snowberry on reclaimed prairie grassland at the Freedom Mine. Shrub patches from an undisturbed area were removed with tractor and placed in two low drainage landscape sites. No management treatments were applied. Establishment and success of the replanted shrubs was most affected by October-July precipitation.

Analysis of Conclusions

The author cautions that special consideration should be given to site location and moisture conditions when transplanting western snowberry. This study may prove useful to other mines also.

Title: **EVALUATING THE SUCCESS OF RECLAIMED GRASSLANDS**

Author: D.R. Kirby

Organization: NDSU-Animal & Range Science Department, Fargo, ND

Format: Executive Summary

Reference: Report on Contract No. LRC-X-37, 12p, February 1, 1996

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

Brief Description

The stated objective of this research was to "provide a long-term data base upon which to evaluate grassland reclamation success and the regulations determining that success." Reclaimed and undisturbed grasslands at the Glenharold, Center, Indian Head, and Freedom were sampled for soil and vegetation characterization. The discussion in the report is focused on silty sites only. Soil characteristics studied included topographic position, soil depth, bulk density, SP, SAR, and EC. Vegetation analyses included yield, cover and alpha diversity. Herbaceous yield, cover, or diversity were found poorly correlated to the replaced soil depth. 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 adequate for meeting the required revegetation standards. Replacement of 24 inches of SPGM over average quality spoil was considered as adequate for all topographic locations.

Analysis of Conclusions

The assumption made in this report that meeting 90 percent of the standard (as required by the federal rules and not the state 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.

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