# Evaluating Reclamation Success at Three AML Sites in North Dakota[1]

Presented by
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## ABSTRACT

Lignite coal mining has been an important part of North Dakota's economy for over a century. The Abandoned Mine Lands (AML) Division of the North Dakota Public Service Commission has been charged with the reclamation of hazardous abandoned coal mine sites in North Dakota since 1981. Approximately 80 primary reclamation projects have been completed at surface and underground AML sites in North Dakota. The objective of reclamation at these sites has been hazard abatement. For surface mined sites, reclamation has usually included backsloping or backfilling dangerous highwalls, replacement of any available topsoil materials and seeding. Other reclamation design considerations have included disposal of hazardous materials, restoration of degraded land and water resources and improvements in land utility.

Reclamation of AML sites in North Dakota is usually considered complete when the hazards associated with an abandoned mine site have been reduced or eliminated and the area is stable. Quantitative assessments of the success of reclamation, other than with regard to hazard elimination, have not generally been attempted.

In the summer of 1998, evaluations of the success of reclamation were made at three representative reclaimed surface mined sites: Hazen-West, Noonan and Fritz. Evaluation criteria focused on restoration of degraded land and water resources and restoration of degraded land utility. Sampling was conducted to evaluate soil materials, wetland and stockpond water quality and vegetative species composition, cover and production. Ocular surveys of plant and animal species were also conducted at each site.

Additional Key Words: Surface Mine Reclamation, Revegetation, Reclaimed Soils, Recreational Land Use, Fish and Wildlife Habit

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## Introduction

Approximately 80 primary abandoned mine land reclamation projects, at a cost of over $22 million, have been completed North Dakota since 1981. In addition many more secondary (maintenance) and several more emergency projects have been completed. Reclamation is usually considered complete when the hazards associated with an AML site are reduced or eliminated.

In the summer of 1998 comprehensive evaluations of the success of reclamation were made at three AML sites in North Dakota: Hazen-West, Noonan, and Fritz. In addition to hazard abatement these evaluations considered such factors as slope reduction, soil development, erosion control, revegetation success, wildlife use, wetland and stockpond quality, and improvements in land use capability. The remainder of this paper will be divided into the following sections:

A. Importance of Lignite Mining in North Dakota and Establishment of AML Program

B. Site Characterizations

C. Sampling materials and methods

D. Discussion and conclusions

E. Figures and Tables

### A. Importance of Lignite Mining In North Dakota and Establishment of AML Program

North Dakota has the largest reserve of lignite coal in the United States, estimated at 600 billion tons (Burr 1954). The recoverable reserves are estimated at 35 billion tons (Lignite Energy Council 1998). These coal reserves are mainly in the western part of the state in the Tongue River and Sentinel Butte formations. The lignite bearing area in North Dakota covers about 28,000 square miles.

Lignite is a dark brown low-grade coal that is softer than bituminous or sub-bituminous coal. It is characterized by its relatively high moisture content, fairly low heating value (approximately 6-7000 BTU), moderate ash and generally low sulfur content. Lignite has been mined commercially in North Dakota since 1873. Underground, room and pillar mining was the predominant method of coal extraction in North Dakota until the 1930s. Large equipment and construction of coal-fired electrical generating plants created a shift from small underground mines to large strip mines since the 1940s. Today North Dakota lignite is used almost exclusively for electrical generation and coal gasification.

Approximately 30 million tons of lignite is mined annually in North Dakota, making it the ninth leading coal producer in the nation. In 1997, the industry employed more than 3075 people and had an annual payroll of over $155 million (Lignite Energy Council 1998).

Although the importance of lignite mining in North Dakota is unquestionable, the effects of past mining prior to environmental regulation has resulted in significant hazards to the public and the environment of the state. Past underground mining has resulted in dangerous collapse features, or sinkholes, and surface mining has left dangerous steep pits, waste piles and structures. Title IV of the Surface Mining Control and Reclamation Act of

1977(SMCRA) established an Abandoned mine land (AML) fund to be used to reclaim abandoned coal mines. Money for this fund comes from a 10 cents per ton federal tax levied by the Office of Surface Mining Reclamation and Enforcement (OSMRE) on active lignite coal mining in North Dakota.

North Dakota Century Code Chapter 38-14.2, passed in 1979, established a state AML program to be administered by the North Dakota Public Service Commission. This program is funded by grants from OSMRE drawn from the AML Fund. The state's AML Reclamation Plan was approved by OSMRE in 1981. This plan contained an inventory of 616 known mines, abandoned prior to SMCRA, in the state. Of these, 87 were deemed potentially hazardous to the public health, safety, and welfare (Ogaard 1992). Several more abandoned mines have been added to the inventory since then.

**B. Site Selection and Characterizations**

The three sites chosen for this study, Hazen-West, Noonan, and Fritz, are relatively large representative reclaimed surface-mined AML sites in North Dakota. Each was characterized by dangerous steep highwalls and water filled pits. Each site represents a different geographical area within the coal mining region of North Dakota. Hazen-West is in the east-central portion, Noonan in the northwest and Fritz in the southwest.

Hazen-West

The Hazen-West site is located in the N1/2 of Section 17, T144N, R897W, Mercer County, approximately four miles west of the city of Hazen and 75 miles northwest of Bismarck (figure 1). This site is located on the historic Knife River Coal Mining Company North Beulah strip mine. This mine operated from 1952 to 1974 and produced coal for electrical generation, domestic and industrial use. The mine covered approximately 960 acres and about 185 acres was reclaimed under North Dakota's AML program.

The Hazen-West project was conducted during the summer of 1991, under Contract No. 195, by Lindemann Construction Company. The contract cost for this project was $531,569.73.

The objective of this project was to backfill a dangerous pit highwall located near a major U.S. highway. The highwall of this pit was approximately 60-70 feet deep and was very steep with slopes of approximately 1.3h:1v or 75%. This pit was located within 100' of U.S. Highway 200 and erosion along the highwall was intruding into the south road ditch. This site was a part of the North Beulah Wildlife Management Area, owned by the North Dakota Game and Fish Department. The reclamation plan was developed in consultation with the land owner to enhance the wildlife value of the site while eliminating the hazardous pit. Two ponds and two wetlands were constructed for waterfowl habitat. The seed mix planted on the reclaimed site (see table 1) was a mixture of tall grasses and forbs to provide cover for nesting waterfowl and other wildlife.

No topsoil was available at this site but approximately 10,000 cubic yards of good quality spoil material was identified and salvaged from about 70 acres. Spoil at this site was mostly glacial till material and was fairly good quality plant growth material. Dirt work consisted of moving 1,022,050 cubic yards of material from nearby dragline-cast spoil piles to backfill the pit to maximum slopes of 5h:1v, or 25%. After backfilling and grading and construction of the water management structures, the salvaged good quality spoil was respread on the site. Coal fines were also used to supplement this topsoil substitute material. Subsequently the area was fertilized with approximately 200 lbs. per acre 35-18-0 fertilizer, seeded, and mulched with 2 tons per acre straw mulch.

Noonan

Four major AML reclamation projects have been conducted at the historic Noonan Mine. However, for the purposes of this study only the final two project sites were used. These two are contiguous and were treated as one area. The Noonan site is located in Sections 3, 10, 11, and 12, T162N, R95W, Divide County, approximately one mile southwest of the city of Noonan and 240 miles northwest of Bismarck (figure 1). This site is located on the historic Baukol-Noonan strip mine. This mine operated from 1930 to 1963 and produced coal that was shipped by rail for industrial and commercial use and sold locally for domestic use. The mine covered over 1400 acres and about 500 acres were reclaimed (this area only) in under North Dakota's AML program.

This project was conducted in 1994 and 95, under Contracts No. 254904 and 283905, by American Contracting, Inc. and Hexom Earth Construction, Inc., respectively. The combined contract costs for this project was $1,206,663. The entire site was seeded under a separate contract in 1995.

The objective of this project was to backfill more than two miles of dangerous pit highwall located along a trail used extensively by sportsmen. The highwall of this pit was approximately 60-70 feet deep and was very steep with slopes of approximately 1.3h:1v or 75%. This pit was located immediately west of the trail and also near a county highway. This site was a part of the Harris M. Baukol Wildlife Management Area, owned by the North Dakota Game and Fish Department. The reclamation plan was developed in consultation with the owner to enhance the wildlife value of the site while eliminating the hazardous pit. Several large wetlands, diversions and a concrete weir structure were constructed for surface water management and to facilitate wildlife use. A portion of the water-filled pit was preserved and is used as a fishing pond. The seed mix planted on the reclaimed site (see table 1) was a mixture of tall grasses and forbs to provide cover for nesting waterfowl and other wildlife.

No topsoil was available at this site but approximately 15,000 cubic yards of good quality spoil material was identified and salvaged. Spoil at this site was generally poor quality sodic clay material. Dirt work consisted of moving about 2.5 million cubic yards of material from nearby dragline-cast spoil piles to backfill the pit to maximum slopes of 5h:1v, or 25%. After backfilling and grading and construction of the water management structures, the salvaged good quality spoil was respread on the site. Coal fines were also used to supplement this topsoil substitute material but most of the surface material was spoil. Subsequently the area was fertilized with approximately 200 lbs. per acre 35-18-0 fertilizer, seeded, and mulched with one or two tons per acre straw mulch, depending on the slope.

Fritz

The Fritz site is located in the N1/2 of Section 5, T136N, R100W, Slope County, approximately seventeen miles southwest of the city of Belfield and 140 miles southwest of Bismarck (figure 1). The Church and Hurick pits were located at this site. These were open pit mines operated from the late 1950s until about 1967 for the purpose of extracting uraniferous lignite coal. After extraction, the coal was either burned in the pit or hauled to nearby kilns and burned to concentrate the uranium it its ash (Karsmizki 1990). The uraniferous ash was sold to the Atomic Energy Commission and hauled out of state to be processed. Before reclamation this site was characterized by large water filled pits and acid forming spoil materials. The land was a wasteland and virtually unusable. It was nearly barren except for a few prickly pear cactus and water quality was poor due to acidity.

In addition, surface materials were contaminated with heavy metals such as uranium, cadmium and molybdenum. Approximately 155 acres were reclaimed at this site.

This project was conducted in 1992, under Contract No. 208, by American Contracting Inc. The contract cost for this project was $457,147.10. The objective of this project was to reclaim contaminated spoils and acidic water filled pits. Because of the hazards presented by radioactive dust, workers were required to wear radiation film badges, dust respirators and were required to leave clothing on-site after working hours. No smoking or eating was allowed on the work site. The reclamation plan was developed in consultation with the owner, Rocky Fritz, with the goal of establishing a native grassland prairie capable of supporting grazing cattle.

One stockpond, 5 wetland sumps, and two terraces were constructed for surface water management and to support the post-reclamation land use. The seed mix planted on the reclaimed site (see table 1) was composed of both cool and warm season native grassland species. Topsoil and other non-contaminated materials were identified and salvaged. Dirt work consisted of moving about 905,334 cubic yards of material to backfill pits and grade to a gently rolling topography. Approximately 500,000 cubic yards of contaminated material were covered with a minimum of three feet of non-contaminated spoil. Identification of contaminated and non-contaminated materials was vital. Assistance in this effort was provided by the State Department of Health, the Geological Survey and other agencies.

After backfilling and grading and construction of the water management structures, the salvaged topsoil and good quality spoil was respread on the site. Subsequently the area was fertilized with approximately 200 lbs. per acre 35-18-0 fertilizer, seeded with a cover crop of oats, and mulched with two tons per acre straw mulch.

**C. Sampling materials and methods**

Sampling for evaluation of reclamation success was conducted at the three sites, Hazen-West, Noonan, and Fritz on June 30-July1, July 7-8, and July 10, 1998, respectively. Components of the evaluation process included an ocular survey of plant and animal species, soil and surface water samples from each site, and vegetation sampling for species composition, cover and production.

A wildlife survey was conducted at each site in the early morning hours and species observed were recorded. In addition, plant and animal species were observed and recorded opportunistically during the remainder of the site evaluations.

A composite soil sample was collected from several areas at each site, mixed together and taken to Minnesota Valley Testing, Inc., Bismarck, for analysis. A single water sample was taken from one of the wetlands or stockponds at each site. These were also taken to the Minnesota Valley Testing for water quality analysis. Testing parameters for the soil samples included, pH, Nitrogen, Phosphorous, Potassium, Sodium Adsorbtion Ratio, Heavy Metals (Fritz only) and Electrical Conductivity. Water quality testing parameters included Field pH, Total Suspended Solids (TSS), Total Dissolved Solids (TSS), Nitrates, Iron, Heavy Metals (Fritz only) and Nutrient Load. Soil and Water test analyses are included in Table 2.

Procedures for sampling and measurement of vegetation parameters were intended to conform generally with those required for reclaimed sites at active mines in North Dakota (North Dakota Public Service Commission 1995). The point quadrat method was utilized for quantitative analysis of vegetative cover at each site. This method is recommended because it is the most commonly used technique for Northern Great Plains vegetation (North Dakota Public Service Commission 1995). A vertical ten-point frame was utilized. In this method, ten

sharpened pins are lowered through a frame until each comes in contact with a portion of a live plant, bare ground, rock or vegetative litter. Frames were placed every fifty paces across randomly located transects across each reclaimed site. Vegetation sampling was also conducted, for purposes of comparison, on unreclaimed spoils at the Hazen-West and Noonan sites but not at the Fritz site because it was entirely reclaimed.

Species composition and above ground cover was recorded using the first-hit method, in which each pin is lowered until it hits a live plant, vegetative litter, rock or bare ground. Basal ground cover was evaluated by continuing to lower each pin through the vegetative canopy to the ground surface and recording whether each hit was live, litter, or bare ground. Results of point frame analysis are summarized in Table 3.

Vegetative productivity and weight of ground cover (litter) was sampled by randomly placing a one-quarter square quadrat and clipping at ground level all vegetation within it. The square quadrat was placed at every other location that was sampled with the point frame (i.e. the first, third, fifth, etc.). Clipped samples were separated by growth forms – grasses, forbs, and litter – and were placed in paper bags. Each sample was air dried to a constant weight. In this case five days of air drying was required. Based on dry weights of the replicated samples, average production and average weight of litter was determined for each site. This data is summarized in Table 4.

**D. Discussion and conclusions**

Success of Reclamation at Abandoned Mine Land Sites can be evaluated in several ways. From the most basic viewpoint, hazard abatement, all three sites have certainly been successfully reclaimed. The Hazen-West and Noonan sites had dangerous steeply sloped highwalls at or near public-use areas. These were eliminated. The Fritz site was a virtual wasteland characterized by toxic spoils and acidic water filled pits. The toxic spoils and ash were a wind-borne health hazard to people and animals. This site was graded to a rolling topography, toxic surface materials were covered, and wetland sumps and a stock pond were constructed. All three sites have been stabilized with permanent vegetation including grass and forb species.

From the standpoint of restoration or improvement of degraded land utility, this study has demonstrated that each site is capable of supporting its intended post-reclamation land use. In addition, the data could be used to suggest that several alternate land uses may be feasible at each site.

Table 2 provides information on soil and water quality. The soils at each site, while less than high quality, should be adequate to sustain the species seeded. Water quality at the wetlands sampled at the Hazen-West and Noonan Sites compares favorably with established wetland standards (N.D. State Dept. of Health 1991). The water quality at the stock pond at the Fritz site is within established parameters for stock watering impoundments in North Dakota (N.D. State Dept. of Health 1991).

The Fritz site, reclaimed in 1992, was the one acidic uraniferous site documented in North Dakota. A limited amount of topsoil was recovered through the process of segregating materials deemed acidic and radioactive. The seed mix chosen was based on an analysis of range sites described for this portion of the county. The mix used was in large part the climax vegetation described for the soils endemic to the area.

A comparison of the mix with the extant vegetation yields some interesting results. First, the dominant species of the site, six years after planting, are for the most part the species originally planted. The only species not encountered or observed that was part of the mix is sideoats grama (Bouteloua curtipendula), a warm season grass that is difficult to establish under good edaphic conditions. The limited amount of topsoil respread and

the high clay content of the spoil are not conducive to revegetation of any kind in this semi-arid portion of the State.

The diversity of vegetation, over and above the dominant species, suggests the area is indeed returning to a condition similar to the climax vegetation described for the soils originally found prior to mining. The productivity of live vegetation and the litter component, while the lowest of the three sites evaluated, still provides adequate erosion control. The number of forbs encountered is remarkable. Even cactus (Opuntia polycantha) was clipped, reflecting the xeric conditions of the area. Mature cactus were present prior to reclamation.

The Hazen-West site, reclaimed in 1991, had no topsoil. The spoil quality is relatively good due to effects from glaciation and was enhanced through the use of coal fines as an amendment. The seed mix used was requested by the landowner, the North Dakota Game and Fish Department, as a mix of utility to wildlife. The dominant species, after seven years, again reflect species originally planted. The road ditch was seeded by the North Dakota Department of Transportation with the introduced species, brome grass (Bromis inermis). This is a very aggressive and ecologically tolerant species that has invaded the site. Tall wheatgrass (Agropyron elongatum), while not clipped, was present in small inclusions.

The diversity of this site is considerably less than Fritz, where the planting of climax vegetation was used. Nevertheless, erosion control is excellent due not only to a vigorous plant community but also a good litter component (Table 4.). The site has several wetlands used by waterfowl, and deer were observed during our sampling effort.

The Noonan A(3) and Noonan A(4) sites were reclaimed in 1994 and 1995, respectively. The two sites are contiguous and represent a two-phased effort to eliminate a long stretch of dangerous highwall proximal to agricultural activity. While the seed mixes planted are a little different, wheatgrass species were used on both due to their ecological tolerance to saline conditions. There again were small inclusions of tall wheatgrass not encountered in either first hit or clipped quadrats. However, the dominance of both thickspike (Agropyron dasystachyum) and slender (Agropyron trachycaulum) wheatgrasses amply reflects what was originally seeded. Note that smooth brome grass was the dominant species found on spoil as well as an invader on reclaimed areas.

North Dakota Public Service Commission (1995) provided expected production values of native grasslands by range site. Values for very shallow to shallow range sites were expected to be 700-1400 pounds per acre in a normal year. Sampling data for the Fritz site indicated above ground production of 960 pounds per acre (Table 4). Expected median pasture/hayland yields for shallow to thin upland soils ranged from 0.5 to 1 ton per acre (NDPSC 1995). Sampling data for Hazen-West and Noonan indicated above ground production of 1562 and 1010 pounds per acre, respectively (Table 4). North Dakota Public Service Commission (1995) also established a cover standard for reclaimed mine lands based on previous studies that indicated 73% basal cover is required to adequately protect grassland areas from erosion. Sampling data indicated total basal cover for Hazen-West, Noonan, and Fritz reclaimed sites was 78%, 82% and 67%, respectively (Table 3).

## E. Figures and Tables

| Table 1 Seed Mixtures Used at Reclaimed Sites | | |
|---|---|---|
| **Site (year reclaimed)** | **Common Name (Species 'variety')** | **Lbs. PLS** |
| Hazen-West (1991) | Yellow Sweetclover (Melilotus officianalis) | 2 |
| | Alfalfa (Medicago sativa - 'Trevois') | 2.5 |
| | Intermediate Wheatgrass (Agropyron cristatum - 'Oahe') | 6 |
| | Tall Wheatgrass (Agropyron elongatum 'Alkar') | 7 |
| | Total | 17.5 |
| Noonan (1994-5) | Western Wheatgrass (Agropyron smithii – 'Rodan') | 10 |
| | Slender Wheatgrass (Agropyron trachycaulum - Primar') | 3.5 |
| | Thickspike Wheatgrass (Agropyron dasystachum - Critana') | 2 |
| | Yellow Sweetclover (Melilotus officianalis) | 1 |
| | Total | 16.5 |
| Fritz (1992) | Buffalograss (Buchloe Dactyloides – native harvest) | 0.25 |
| | Blue Grama (Bouteloua gracilis – native harvest) | 1.5 |
| | Sideoats Grama (Bouteloua cirtipenula –'Pierre') | 3 |
| | Western Wheatgrass (Agropyron smithii – 'Rodan') | 3.5 |
| | Prairie Sandreed (Calamovilfa longifolia – 'Goshen') | 2 |
| | Needle and Thread (Stipa comata – native harvest) | 4 |
| | Total | 14.25 |

**Table 2. Soil and Water Sample Analysis**

| | Site/Type | | | | | |
|---|---|---|---|---|---|---|
| **Parameter** | Hazen W./Soil | Hazen W./Water | Noonan/Soil | Noonan/Water | Fritz/Soil* | Fritz/Water* |
| Organic Matter (%) | 2.7 | | 1.8 | | 3.1 | |
| Nitrogen (lbs/a) | 1 | | 3 | | 1 | |
| Phosphorous (ppm) | 3 | | 4 | | 13 | |
| Potassium (ppm) | 180 | | 200 | | 160 | |
| Salts (mmhos/cm) | 1 | | 0.7 | | 0.4 | |
| Texture | med/fine | | med/fine | | med/fine | |
| Calcium (meq/l) | 3.8 | | 1.5 | | 2.6 | |
| Magnesum (meq/l) | 2.4 | | 0.6 | | 1.6 | |
| Sodium (meq/l) | 11.9 | | 9.7 | | 6.6 | |
| Sodium Adsorbtion Ratio | 6.76 | | 9.47 | | 4.55 | |
| pH | 7.3 | | 7.8 | | 5.2 | |
| Total Alkalinity (mg/l CaCO3) | | 136 | | 145 | | 31 |
| Phenolphtalein Alk. (mg/l CaCO3) | | 42 | | 17 | | <1 |
| Bicarbonate (mg/l CaCO3) | | 51 | | 111 | | 31 |
| Carbonate (mg/l CaCO3) | | 85 | | 34 | | <1 |
| Hydroxide (mg/l CaCO3) | | 0 | | 0 | | 0 |
| Specific Conductance (umhos/cm) | | 385 | | 1010 | | 128 |
| Fluoride (mg/l) | | 0.38 | | 0.3 | | 0.3 |
| Sulfate (mg/l) | | 80.6 | | 349 | | 125 |
| Chloride (mg/l) | | 1.2 | | 8.6 | | 8.9 |
| Nitrate-Nitrite as N (mg/l) | | <1 | | <1 | | <1 |
| Ammonia-Nitrogen as N (mg/l) | | <0.1 | | <0.1 | | 0.42 |
| Total Suspended Solids (mg/l) | | 10 | | 4 | | 58 |
| Calcium-Total (mg/l) | | 15.5 | | 48.6 | | 10.1 |
| Magnesum-Total (mg/l) | | 9.7 | | 35.2 | | 8.1 |
| Sodium-Total (mg/l) | | 63.2 | | 120 | | 25.9 |
| Potassium-Total (mg/l) | | 5.9 | | 11.2 | | 3.9 |
| Iron-Total (mg/l) | | 0.32 | | 0.32 | | 39 |
| Manganese-Total (mg/l) | | <0.05 | | <0.05 | | 0.25 |
| Total Dissolved Solids (mg/l) | | 258 | | 660 | | 200 |
| Total Hardness as CaCO3 (mg/l) | | 78.6 | | 266 | | 58.6 |
| Hardness (grains/gallon) | | 4.6 | | 15.6 | | 3.43 |
| Cation Summation | | 4.48 | | 10.8 | | 3.83 |
| Anion Summation | | 4.43 | | 10.4 | | 3.47 |
| Sodium Adsorbtion Ratio | | 3.1 | | 3.2 | | 1.47 |

- Fritz soil – Uranium 10.1ug/g, Cadmium <1.45 ug/g, Molybdenum 42 ug/g
- Fritz water – Uranium 0.018 mg/l, Cadmium <0.01mg/l, Molybdenum <0.01g/l

## Table 3. Point Frame Data

### A. First Hit

| Site | Date Sampled | Species | Percent Absolute Cover | Relative Composition |
|---|---|---|---|---|
| Fritz | 7-10-98 | Agropyron smithii | 30.33% | 40.27% |
| | | Meidcago sativa | 6.33% | 11.06% |
| | | Calamovilfa longifolia | 6.33% | 8.41% |
| | | Stipa comata | 6.00% | 8.41% |
| | | Panicum virgatum | 2.67% | 7.96% |
| | | Buchloe dactyloides | 4.00% | 5.31% |
| | | Bouteloua gracilis | 2.67% | 3.54% |
| | | Sporobolus cryptandrus | 2.00% | 3.10% |
| | | Spartina pectinata | 1.33% | 2.65% |
| | | Achillea lanulosa | 1.33% | 1.77% |
| | | Carex sp. | 1.00% | 1.77% |
| | | Koeleria pyrimida | 1.00% | 1.33% |
| | | Stipa viridula | 0.67% | 1.33% |
| | | Hordeum jubatum | 0.67% | 0.88% |
| | | Bromus inermis | 0.67% | 0.88% |
| | | Artemesia frigida | 0.67% | 0.88% |
| | | Artemesia ludoviciana | 0.33% | 0.44% |
| | | Kochia scoparia | 0.33% | 0.00% |
| | | Melilotus officinalis | 14.33% | 0.00% |
| Hazen-West - Recl. | 7-1-98 | Agropyron intermedium | 30.63% | 47.57% |
| | | Medicago sativa | 21.88% | 33.98% |
| | | Bromus inermis | 8.13% | 12.62% |
| | | Convolvulus arvensis | 2.50% | 3.88% |
| | | Hordeum jubatum | 1.25% | 1.94% |
| Hazen-West - Spoil | 7-1-98 | Bromus inermis | 61.67% | 97.37% |
| | | Unknown Forb | 1.67% | 2.63% |
| Noonan A(3) & A(4) Reclaimed | 7-7 -7-8-98 | Agropyron trachycaulum | 29.38% | 46.31% |
| | | Bromus inermis | 10.94% | 17.24% |
| | | Agropyron dasystachyum | 10.63% | 16.75% |
| | | Melilotus officinalis | 2.81% | 4.43% |
| | | Artemesia caudata | 2.81% | 4.43% |
| | | Kochia scoparia | 2.50% | 3.94% |
| | | Polygonum aviculare | 1.56% | 2.46% |
| | | Agropyron smithii | 1.25% | 1.97% |
| | | Hordeum jubatum | 0.63% | 0.99% |
| | | Poa pratensis | 0.31% | 0.49% |
| | | Descurainia pinnata | 0.31% | 0.49% |
| Noonan A(3) & A(4) Spoil | 7-7 -7-8-98 | Bromus inermis | 30.67% | 57.50% |
| | | Symphoricarpos occidentalis | 5.33% | 10.00% |
| | | Euphorbia esula | 4.67% | 8.75% |
| | | Stipa viridula | 3.33% | 6.25% |
| | | Kochia scoparia | 2.67% | 5.00% |
| | | Atriplex argentea | 1.33% | 2.50% |
| | | Poa pratensis | 1.33% | 2.50% |
| | | Populus detoides | 1.33% | 2.50% |
| | | Sporoblous heterolepis | 1.33% | 2.50% |
| | | Lactuca serriola | 0.67% | 1.25% |
| | | Lygodesmia juncea | 0.67% | 1.25% |

### B. Basal Cover

| Site | Date Sampled | Vegetation Type | Percent Absolute Cover |
|---|---|---|---|
| Fritz | 7-10-98 | Grasses | 18.67% |
| | | Forbes | 1.67% |
| | | Litter | 47.00% |
| Hazen-West - Recl. | | Grasses | 7.50% |
| | | Forbes | 3.13% |
| | | Litter | 67.50% |
| Hazen-West - Spoil | | Grasses | 3.33% |
| | | Forbes | 0.00% |
| | | Litter | 83.33% |
| Noonan A(3) & A(4) - Recl. | 7-7-98 | Grasses | 7.81% |
| | | Forbes | 0.94% |
| | | Litter | 73.75% |
| Noonan A(3) & A(4) - Spoil | | Grasses | 4.00% |
| | | Forbes | 0.00% |
| | | Litter | 53.33% |

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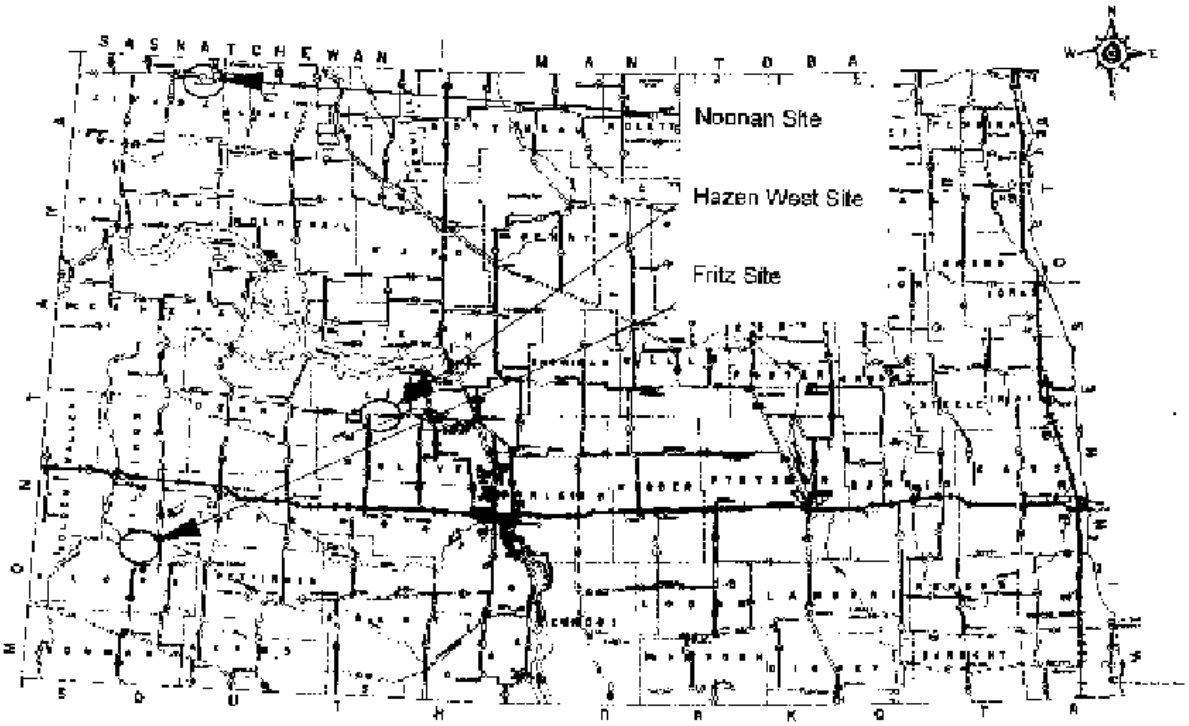
**Table 4. Vegetative Productivity at Reclaimed Sites and Unreclaimed Spoils**

| Site | Status | Date Sampled | Type | Average Dry Weight g/0.25m2 | Range lbs/acre | Lbs./Acre |
|---|---|---|---|---|---|---|
| Fritz | Reclaimed | July 10, 1998 | Live | 26.9 | 136 - 2223 | 960 |
| Fritz | Reclaimed | July 10, 1998 | Litter | 17.7 | 0 - 1574 | 632 |
| Hazen-West | Reclaimed | July 1, 1998 | Live | 43.8 | 832 - 2541 | 1562 |
| Hazen-West | Reclaimed | July 1, 1998 | Litter | 45.2 | 64 - 3176 | 1614 |
| Hazen-West | Spoil | July 1, 1998 | Live | 31.4 | 985 - 1199 | 1119 |
| Hazen-West | Spoil | July 1, 1998 | Litter | 46.8 | 1567 - 1742 | 1669 |
| Noonan | Reclaimed | July 7-8, 1998 | Live | 28.3 | 268 - 1920 | 1010 |
| Noonan | Reclaimed | July 7-8, 1998 | Litter | 31.4 | 328 - 2930 | 1120 |
| Noonan | Spoil | July 7-8, 1998 | Live | 19.7 | 385 - 1181 | 703 |
| Noonan | Spoil | July 7-8, 1998 | Litter | 55.7 | 0 - 3419 | 1989 |

## Figure 1 General Site Locations



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