2000 Billings Land Reclamation Symposium

LIVESTOCK GRAZING EFFECTS ON RECLAIMED GRASSLANDS

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ABSTRACT

Prescribed livestock grazing of reclaimed grasslands was evaluated to determine the effects on plant species diversity and seasonality. The study was conducted between 1989 and 1998 on the BNI, Freedom and Indian Head coal mines in Mercer and Oliver counties of west-central North Dakota. The grasslands were reclaimed between 1983 and 1989 and grazing began four to eight years after seeding. Grazing was conducted mid to late May through early to mid July each year to decrease the competitiveness of cool season grass species. Live basal cover and species composition were estimated using the ten-point frame method. From these data alpha, beta and mosaic diversities and cool:warm season grass ratios were determined and compared across years for each mine. On the BNI mine, grazing significantly increased alpha (small scale) diversity but beta (gradient) and mosaic (landscape) remained similar. No changes in species composition were evident. At the Freedom mine, alpha diversity was significantly higher after four years of grazing despite no changes in beta and mosaic diversities. Seasonality of species improved with warm season grasses increasing from 6% to 42% of the composition between 1995 and 1998. Diversity at any scale did not change following grazing on the Indian Head mine. However, positive species composition trends were evident following grazing including an increase in warm season grass composition from 26% to 55% and a decline in composition of introduced grass species from 47% to 6%. In summary, prescribed livestock grazing produced positive trends in plant species diversity, seasonality and composition of reclaimed mixed grasslands.

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INTRODUCTION

Re-establishment of diverse and seasonally balanced grassland plant communities following surface coal mining in the Northern Great Plains is difficult to achieve due to the competitiveness of cool season grass species. Despite seed mixes using a warm to cool season grass ratio of 3:1 or greater, diverse and seasonally balanced grasslands are not easily established and maintained. Cool season grass species establish easier and have the advantage of making most of their growth in early spring when soil moisture is advantageous for plant growth. Warm season species grow most rapidly in summer when soil moisture is often inadequate to sustain plant growth. The result is that reclaimed grasslands often become heavily dominated by cool season grass species, especially during the first few growing seasons following their establishment (Williamson 1984, Nilson et al. 1985, Krabbenhoft et al. 1993).

The objective of this study was to evaluate early season livestock grazing effects on plant species diversity and seasonality of established reclaimed grasslands (5-10 years after re-establishment) in western North Dakota. The results of this study will provide information needed to make recommendations concerning grazing management to improve diversity and seasonal balance, while maintaining productivity and ground cover of re-established native grasslands.

STUDY AREA and METHODS

The research was conducted on the BNI, Freedom, and Indian Head coal mines in Mercer and Oliver Counties of west central North Dakota. The mines are located in the Missouri Plateau Physiographic Region of North Dakota. This region lays on the western edge of an area where soils are formed from glacial deposits and residuum weathered bedrock of the sedimentary Sentinel Butte formation. The mines lie within an area used primarily for agriculture. The principal vegetative community of mixed grass prairie is dominated by grasses and grasslike plants.

In 1989, five transects were established at the BNI Mine on soils that were considered silty site types. Two transects were located on a reference area (undisturbed) and three transects were on a 65-hectare reclaimed area. Basal cover and species composition were estimated each year using the ten-pin point-frame method (Arny and Schmid 1942). Ten frame (100 points) readings were taken randomly at each sampling location (10 per transect) along transects.

The 65-hectare pasture was seeded in May, 1983, and 1984. Grazing was implemented in the fall of 1992 at 1.39 animal unit months per ha (AUM/ha). Thereafter the pasture was grazed in the springs of 1994 to 1998 at an average stocking rate of 1.46 AUM/ha.

In 1995, three transects were established on both reference and reclaimed sites at the Freedom Mine on soils that were considered silty site types. Vegetative cover was estimated each year using the ten-pin point-frame method. On the reclaimed site an average of 150 frame readings were taken between 1995 and 1998. On the two reference areas, 200 frame readings were taken each year between 1995 and 1998.

The 32.4 hectare reclaimed area was seeded and fertilized in the fall of 1989. Grazing was implemented in April, 1993. Each year (1994-1998) grazing began in mid-May and terminated the beginning of July. Stocking rate averaged 2.97 AUM/ha over the five years of grazing.

In 1989, four and two transects, each containing ten sampling points, were established in reclaimed and reference sites, respectively, on the Indian Head Mine. The sites contained clay loam soils before mining. Vegetative cover was estimated each year using the ten-pin point-frame method. Ten frame (100 points) readings were taken randomly at each sampling location (10 per transect) along transects.

The 26.7 hectare reclaimed area was seeded, mulched and crimped in 1986 and hayed in 1987. Grazing was implemented in 1994 and continued annually through 1998 with an annual stocking rate of 0.74 to 0.84 AUM/ha. Grazing began each year in mid-May and continued to late July.

Statistical Methods

Vegetation diversity can be observed and quantified at three scales, alpha, beta, and mosaic. Alpha diversity was estimated using the Shannon-Wiener index (Shannon and Weaver 1973). Beta (inter-community) diversity was estimated from presence/absence data using affinity analysis (Scheiner and Istock 1987). Using presence/absence data, mosaic diversity was estimated as the variation and degree of structuring around the mean similarity (Istock and Scheiner 1987). Mosaic diversity values were standardized and analyzed using the bootstrap technique outlined by Scheiner and Istock (1987). Beta and mosaic diversities were similar between reclaimed and reference sites each year at all three mines so will not be discussed further. The multiresponse permutation procedure (MRPP), as described by Biondini et al. (1988), was used to determine if reclaimed and reference areas of the same mine differed between years at the alpha diversity level.

RESULTS

BNI Mine

Total plant species basal cover ranged between 3.2 and 6.4% over the study period (Table 1). Basal cover of native and introduced cool season grasses remained similar, while basal cover of native warm season grasses increased during the study period. On a species level, basal cover of *Bouteloua gracilis*, *Poa* spp. and *Schizachyrium scoparium* increased, while *Stipa viridula* decreased during the same study period (data not presented).

A positive trend in plant species seasonality occurred during the study as evidenced by an increase in warm season grass relative to total basal cover (Table 1). Between 1989 and 1991, warm season grass species averaged 41% of the total basal cover. For the period 1992-1993 and 1997-1998, warm season grasses comprised 58% of the total basal cover of the study site.

Despite annual fluctuation, alpha diversity of the reclaimed grassland appeared to be increasing following grazing (Fig. 1). Alpha diversity was greater ($p<0.05$) on the reclaimed grassland in 1997 and 1998 compared to the pre-grazing years of 1990 and 1991.

Table 1. Basal cover (%) by plant class observed on a reclaimed grassland on the BNI Mine, Center, North Dakota.

Plant Class	Idle			Grazed			
	1989	1990	1991	1992	1993	1997	1998
	……………………%……………………						
Native cool season grasses	2.3	1.7	2.9	2.1	0.6	1.7	2.6
Native warm season grasses	1.4	1.2	2.8	3.4	3.8	2.0	3.1
Native forb	0	0	0.1	0	0.3	0.4	0.3
Introduced cool season grasses	0.3	0.3	0.4	0.3	0.2	0.4	0.4
Total basal cover	4.0	3.2	6.2	5.8	4.9	4.5	6.4

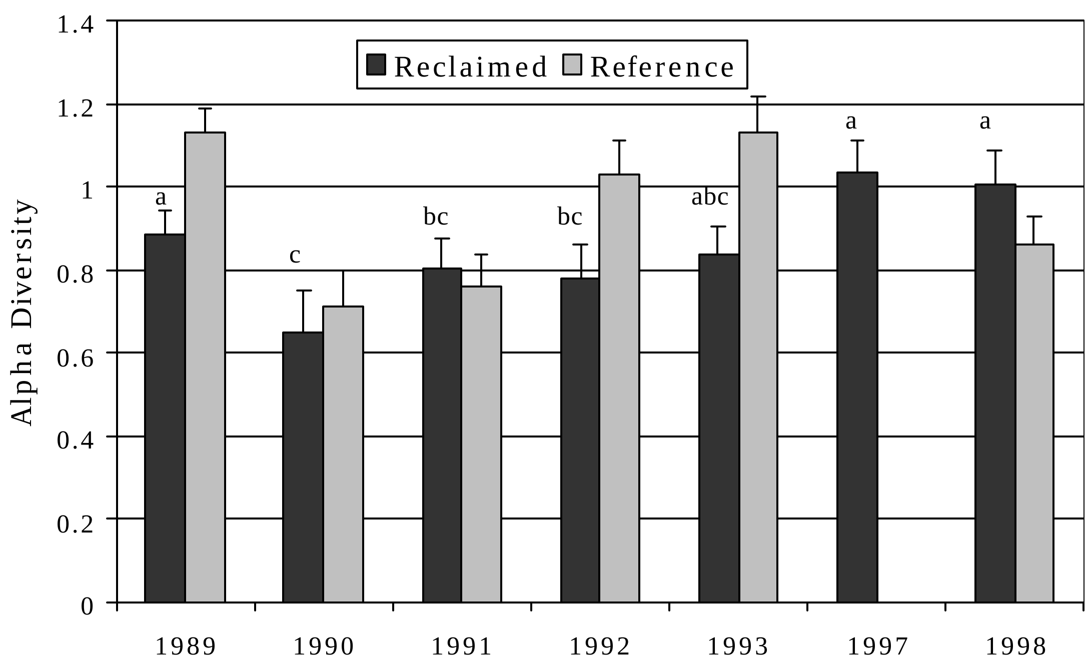

Figure 1. Alpha diversity for reclaimed and reference sites on the BNI Mine, Center, North Dakota. Annual means for reclaimed sites with the same letter were not significantly different (p>0.05).

Freedom Mine

Total plant species basal cover ranged between 2.6 and 8.2% over the study period (Table 2). Basal cover of native and introduced cool season grasses declined, while basal cover of native warm season grasses increased during the study period. On a species level, basal cover of *Bouteloua curtipendula*, *Panicum virgatum*, and *Poa* spp. increased following grazing (data not presented). Basal cover of the cool season grasses, *Agropyron smithii* and *Stipa viridula*, decreased during the same time period.

As on the BNI Mine, a positive trend in plant species seasonality occurred during the study as evidenced by an increase in warm season grasses relative to total basal cover (Table 2). In 1995 and 1996, warm season grass species accounted for 7% of the total basal cover. This increased to 25% in 1997 and by 1998 warm season grasses comprised 42% of the live total basal cover of the study site.

Table 2. Basal cover (%) by plant class observed on a reclaimed grassland on the Freedom Mine, Beulah, North Dakota.

Plant Class	**Grazed**			
	1995	1996	1997	1998
	……………………………%…………………………			
Native cool season grasses	6.3	2.2	3.3	2.8
Native warm season grasses	0.6	0.2	1.2	2.3
Native forb	0.7	0.2	0	0.1
Introduced cool season grasses	0.6	0	0.2	0.3
Total basal cover	8.2	2.6	4.7	5.5

Alpha diversity on the Freedom Mine study area exhibited significant changes ($p<0.05$) annually during the study period (Fig. 2). Between 1996 and 1998 alpha diversity significantly increased each year.

Indian Head Mine

Total plant species basal cover ranged between 3.1 and 6.6% over the study period (Table 3). Basal cover of native cool and warm season grasses increased, while the basal cover of introduced cool season species decreased (Table 3). On a species level, percentage basal cover of *Agropyron smithii*, *Bouteloua curtipendula*, *Bouteloua gracilis,* and *Bromus inermis* increased over the study period (data not presented). *Stipa viridula* and *Agropyron intermedium* cover decreased during the same period.

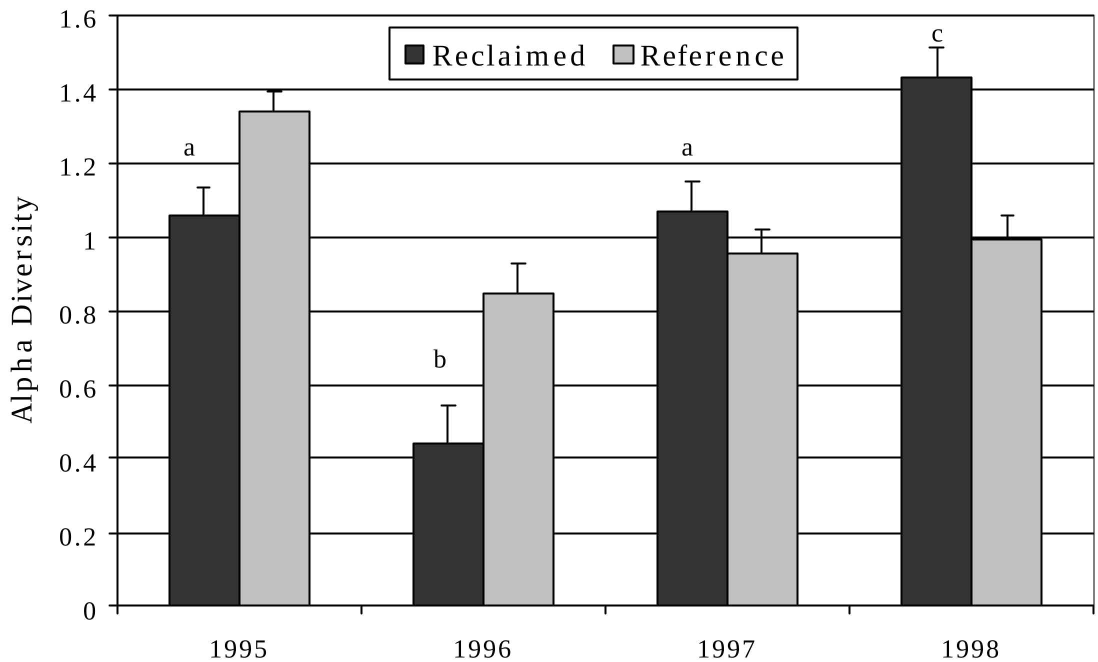

Figure 2. Alpha diversity for reclaimed and reference sites on the Freedom Mine, Beulah, North Dakota. Annual means for reclaimed sites with the same letter were not significantly different (p>0.05).

A positive trend in plant species seasonality occurred during the study as evidenced by an increase in warm season grass relative to total basal cover (Table 3). Between 1989 and 1990, warm season grass species averaged 29% of the total basal cover. For the period 1996 to 1998, warm season grasses averaged 54% of the total basal cover of the study site.

Alpha diversity on the reclaimed area was significantly lower (p<0.05) in 1989 and 1996 compared to 1990, 1997 and 1998 (Fig. 3). Alpha diversity appeared to be trending higher following the initiation of grazing on the reclaimed grassland.

CONCLUSIONS

Early season grazing increased the basal cover of warm season grasses at all three mines during the study. Basal cover of introduced cool season grasses declined at two mines while remaining similar at the third. At the species level, the warm season grasses, *Bouteloua curtipendula* and *B. gracilis* increased at three and two mines, respectively. *Stipa viridula*, a desirable cool season grass species, decreased at all three mines. This plant species may need to be monitered closely under early season grazing to be maintained at an acceptable level in grazed stands.

Table 3. Basal cover (%) by plant class observed on a reclaimed grassland on the Indian Head Mine, Zap, North Dakota.

Plant Class	**Idle**		**Grazed**		
	1989	1990	1996	1997	1998
	……………………%……………………				
Native cool season grasses	0.9	0.8	1.8	1.9	1.8
Native warm season grasses	0.9	1.1	2.1	2.3	4.1
Native forb	0	0	0	0	0.3
Introduced cool season grasses	2.2	1.2	0.3	0.3	0.4
Total basal cover	4.0	3.1	4.2	4.5	6.6

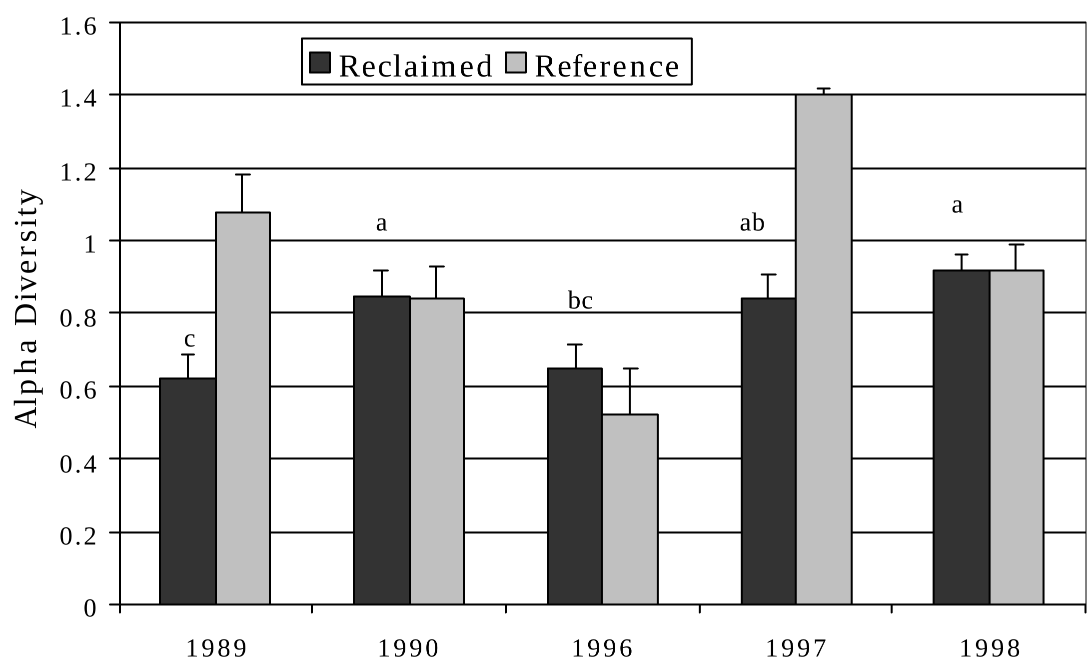

Figure 3. Alpha diversity for reclaimed and reference sites on the Indian Head Mine, Zap, North Dakota. Annual means for reclaimed sites with the same letter were not significantly different (p>0.05).

Seasonality and alpha diversity of the reclaimed grasslands improved on all three mines following initiation of grazing. Beta and mosaic diversity remained similar during the study across the three mines. Warm season grass species basal cover increased to comprise >50% of the cover on the reclaimed grasslands by the end of the study. This positive trend in warm season grass cover occurred during an usually wet climatic cycle during the growing season, which tends to favor cool season grass dominance. Introduced cool season grasses decreased with early season grazing.

Management of diverse grasslands following re-establishment should be aggressive and initiated soon after stand establishment. Grazing to improve species composition should commence 2-3 years after seeding reclaimed grasslands to prevent cool-season grass species from becoming too dominant. In addition, grazing cool-season species early in the spring of the year on reclaimed grasslands and removing animals from pastures by July 1 should also improve the competitiveness of warm season grass species.

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IMPROVING THE HEALTH OF RECLAIMED LAND THROUGH PROPER GRAZING MANAGEMENT

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ABSTRACT

For years reclamation of mined lands has focused on revegetation techniques such as types of seed, seeding practices, mulching, etc. Kennecott Energy's Jacobs Ranch Mine in the Powder River Basin of Wyoming has taken the next step in managing the reclaimed land to improve the health of the land and progress towards the goal of release of the reclamation bond. Jacobs Ranch Mine has approximately 1,400 hectares of permanently reclaimed land. Of that area, over 90% of it is being grazed.

A holistic approach is used to determine grazing management practices. Decisions are made depending on several factors ranging from the rate of plant growth to the long-term land use of the area. The management plan generally consists of utilizing large groups of animals for short periods of time with the goal of reducing the overgrazing of plants and improving the health of the land.

The holistic grazing approach was initiated in 1998 with 646 head of yearling steers grazing the reclaimed areas for the summer. The stocking rate was double that of adjacent undisturbed lands. Livestock weight gains were slightly over 1 kg/day. In 1999 a total of 955 yearling steers were grazed on the reclaimed areas for the summer. Signs are already visible of improved health of the reclaimed areas. New seedlings are evident, ground cover and litter has increased, plant health has improved and erosion is decreasing.

In addition to improving the health of the reclaimed land, the grazing program is established to provide a monetary return for Jacobs Ranch Mine. This is accomplished while meeting the challenges of grazing a large number of livestock in the middle of a large active surface coal mine.

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1.0. INTRODUCTION

Jacobs Ranch Mine is a surface coal mine in the Powder River Basin of northeast Wyoming. Construction began at the mine in 1975. The first coal was shipped and reclamation began in 1978. Jacobs Ranch Mine currently ships approximately 29 million tons of coal per year. As of year-end 1999 approximately 2,430 hectares have been disturbed, while 1,494 hectares have been permanently reclaimed (61% of disturbance). Jacobs Ranch Mine has received full bond release on 28 hectares and partial bond release on approximately 200 hectares of reclamation to date.

Grazing began on reclaimed areas in 1985 with a local rancher responsible for the livestock being grazed. Generally the grazing pattern was small numbers of livestock for long periods of time. Timing of grazing was somewhat dependent on the requirements of the rancher. This continued through the 1997 grazing season. In 1998 Jacobs Ranch Mine entered into an agreement with Reclamation Technologies LLP to graze 650 yearling steers on the reclaimed area.

2.0. RECLAMATION TECHNOLOGIES, LLP. AGREEMENT

The agreement between Jacobs Ranch Mine and Reclamation Technologies LLP is a reclaimed land management agreement with common goals. The agreement was written in an effort to create a win-win situation for both parties and is described below:

2.1. Goals of the Agreement

The goals of the agreement were determined jointly between the two companies. The goals include:

- Obtain reclamation bond release;
- Realize a monetary profit from the reclamation (for both Jacobs Ranch Mine and Reclamation Technologies, LLP);
- Improve the health of the land;
- Provide a high quality wildlife habitat through biological diversity.

2.2. Terms of the Agreement

The terms of the agreement were written to facilitate accomplishment of the goals.

Jacobs Ranch Mine provides:

- The reclaimed land;
- Long-term exterior fencing;
- Water at each major grazing area.

Reclamation Technologies provides:

- The livestock, owned by a third party, delivered to and from the minesite;

- Temporary electric fencing and all labor as needed to move the fence;
- All labor and equipment for watering the livestock (portable tanks and piping);
- All labor required for the management of the livestock;
- Technical knowledge and skill for managing livestock. This includes providing a season long grazing plan prior to grazing followed up with results of grazing including animal performance, levels of utilization and monitoring data as collected on plant growth and plant recovery.

Payment is determined by the yearling steer weight gains. Reclamation Technologies LLP is paid by the owners of the steers on the basis of weight gain. Jacobs Ranch Mine receives a portion of that payment. Upon bond release Reclamation Technologies LLP receives 100% of the payment from that piece of land for a predetermined number of years.

This agreement provides Reclamation Technologies LLP with a monetary incentive to obtain bond release and it allows Jacobs Ranch Mine to provide that incentive with no out-of-pocket expenditures as the land pays the incentive. Land that is healthy with vigorously growing plants produces higher livestock weight gains than land that is deteriorating; therefore, there is an additional incentive for the livestock to be managed in a manner than improves the health of the land. All of this contributes towards the common goal of bond release.

3.0. GRAZING MANAGEMENT PLAN

A planned and controlled grazing system is utilized. The steps to utilize the system are to plan, monitor, control and replan.

The grazing management plan includes a detailed day-by-day plan for the entire grazing season. The plan focuses on utilizing large numbers of animals for short periods of time. Multiple factors are considered in the development and implementation of the plan. The grazing plan is critical, as managing livestock grazing without a detailed plan is similar to driving a car by looking in the rearview mirror – all you know is where you have been!

A detailed grazing plan allows the operator to know at all times if the land is being utilized properly. The grazing plan was developed in the spring of 1998 with historical information as available. It was decided to graze the reclaimed areas with 500 head of yearling steers. Three days into the grazing program we realized we had underestimated the amount of forage. The number of steers was then increased by approximately 150 head. Without a grazing plan, we would not have realized we were understocked until much later in the grazing season. Additionally, during a drought a detailed grazing plan also allows you to realize early in the grazing season if the number of grazing animals needs to be reduced.

3.1. Definition of Overgrazing

Document research has concluded overgrazing of plants is a result of the time plants are exposed to grazing rather than the number of animals present (Voisin 1988). Overgrazing has been defined as grazing during active growth that is both severe and frequent. Generally, this results in the eventual death of the plant. In intermediate stages it results in reduced production. Overgrazing damages plants to varying degrees by utilizing energy temporarily obtained by the plant from roots sacrificed for that purpose (Savory 1988).

3.2. Development of the Grazing Plan

Development of a detailed day-by-day grazing plan requires input from several factors. The number of pastures to be grazed, the size of each pasture, the estimated amount of forage in each pasture and the quality of that forage are determined to calculate the number of animal units of grazing available. The amount of time planned to graze each pasture depends on the amount of forage available, the number of livestock to be grazed and the grazing management decision factors listed in a following section.

3.3. Implementation of the Grazing Plan

Although a detailed grazing plan is in place prior to the start of grazing, it is assumed the plan will change as environmental factors such as rainfall, temperature, insects, and etc change during the course of the grazing season. How to actually move the steers from one pasture to another with the least amount of stress on the steers and people and with the least effect on the mining operation is also taken into consideration.

3.3.1. Fencing

One goal of the grazing plan is to mimic what large herds of buffalo did for centuries in the past. Instead of using very active animals like buffalo and predators like wolves and bears, we now use yearling steers and electric fences. High tensile electric fence is used for temporary perimeter fences. Poly wire electric fence is used to sub-divide pastures into smaller units. The poly wire fences utilize lightweight plastic step-in posts that are set in the ground by simply stepping on a notch in the post. Fences are intentionally placed in different locations each time a pasture is grazed in order to avoid damage to the plants from livestock trailing along the fence lines. The temporary fences are also intentionally built crooked in order to further reduce trailing along the fence lines.

3.3.2. Water

With several small pastures and the continual changes associated with a large surface coal mining operation, it was decided to utilize a portable water system. Jacobs Ranch Mine provides water at three strategic locations on the minesite. Reclamation Technologies LLP then uses portable aboveground 5 centimeter plastic pipe to get the water to a 10,000 gallon portable storage tank. The water flows from the storage tank to portable livestock watering troughs. This allows reclaimed areas to be grazed that had previously not been considered feasible to graze due to remote location or small size.

This water system provides a continual source of fresh water to the livestock, which is critical to good weight gains. Reclaimed ponds are fenced from livestock grazing to allow development of wildlife habitat around the pond shoreline.

3.3.3. Additional Undisturbed Pastures

Since topsoil on newly reclaimed land is unconsolidated, the impact of grazing during wet periods is greater on reclaimed areas than on native undisturbed areas. It is helpful to have an area of undisturbed pasture available for grazing during prolonged wet periods in order to avoid impacting the reclaimed areas more than desired. The need for this will vary depending on the number of animals grazed and the level of management. When grazing large numbers of animals on wet reclaimed areas, the time in a pasture may be determined by the number of hours in the pasture, not the number of days.

3.4. Grazing Management Decision Factors

The following factors are all considered when developing the grazing plan and when determining when to actually move the steers from one pasture to the next.

- Length of time in current pasture – as previously described, the length of time the plants are exposed to grazing must be considered to avoid overgrazing plants;
- Rate of plant growth – during spring when plants are growing rapidly, the length of time the plant is exposed to grazing must be less than when the plants are growing slowly in order to avoid overgrazing plants;
- Amount or quantity of grass available for consumption – if too much grass is removed, the performance of the animals will be sacrificed. Also, the more of the grass sward removed during grazing the longer the recovery time for the plant;
- Type of vegetation available –when grazing vegetation such as annual weeds or annual grain crops, the amount and time grazed will be different than when grazing perennial grasses since the purpose of grazing and the desired outcome is different;
- Soil factors – soil texture and soil moisture must be considered as the goal is to increase water infiltration by reducing soil capping and increasing litter and mulch on the soil surface (reduce bare ground);
- Wildlife factors – a diverse wildlife habitat is a primary goal of the grazing program; therefore, wildlife factors are continually taken into account during the course of the grazing program. For example, the presence of nesting birds or denning mammals can influence the timing of grazing certain pastures. Future forage requirements of wildlife such as winter forage for big game are taken into account. Livestock watering around ponds is controlled to allow riparian wildlife habitat to develop;

- Total area and pastures available – pasture moves must also consider the plant growth in future pastures, as the goal is to graze areas when the grass is in a palatable stage of growth;
- Mining operations – moving livestock from one pasture to another may interfere with the mining operation. When possible, crossing of haul roads is done between shifts, at lunch or during crew meetings in order to minimize interference.

3.5. Grazing as a Management Tool

Livestock grazing is considered one of several tools used to accomplish successful reclamation. Since the livestock generate income as opposed to being an expense, the goal is to utilize the livestock as much as possible as a management tool. In addition to grazing established reclaimed areas, the livestock are also used in the following manners:

- Weed Control – as previously mentioned, the livestock are used for weed control by grazing annual weeds for short periods of time on newly reclaimed areas. The timing of grazing is determined by the stage of growth of the annual weeds and the stage of growth of the perennial grasses, shrubs and forbs. The duration of grazing is generally very short, again depending on the stage of growth of the various plants and the utilization of each type of plant.
- Stubble Mulch Control – frequently annual grain crops are seeded to provide stubble mulch prior to interseeding the permanent reclamation seed mixtures. In order to avoid excessive volunteer growth of the grain the following year, the stubble mulch areas are grazed. This provides high quality forage for the livestock while avoiding the traditional expense of mowing.
- Wildlife Habitat Enhancement – When grazing stubble mulch areas, the late fall regrowth of the annual grains provides very desirable wildlife forage for big game animals. As discussed, grazing of established reclaimed areas is also timed around wildlife needs. Some areas are left with tall forage for wildlife use in times of heavy winter snow cover while other areas are grazed later in the season to provide fresh regrowth of plants for wildlife use.
- Erosion Control and Repair – Grazing during wet periods can result in considerable impact from the hoof action of the livestock. This can be utilized on steep hillsides to control erosion. Each hoof print becomes a miniature dam that holds water and reduces movement of water down the slope; therefore, reducing runoff and erosion. In areas where erosion has already created gullies, straw bales are placed in the gullies prior to grazing to repair the erosion. The steers very effectively incorporate the straw into the soil and break down the sides of the gully. The end result is a smoothed-over gully with considerable organic matter in the soil that provides good infiltration. The straw also provides a seed source for a quick growing stand of vegetation to help repair the gully.

4.0. GRAZING PROGRAMS

4.1. 1998 Grazing Program

During 1998 a total of 646 head of yearling steers were grazed on 1,300 hectares of reclamation from May 7 to August 29. The reclaimed area was split into 21 pastures with the average pasture size approximately 60 hectares. The largest pasture was 110 hectares while the smallest was 6 hectares.

All pastures were grazed twice during the summer. Each pasture was grazed an average of 3 days each time (the 6 hectare pasture was grazed for 18 hours). The stock density averaged approximately 1 animal per 0.1 hectare for each 3-day period. Steer weight gains averaged 1.0 kg/day.

4.2. 1999 Grazing Program

Yearling steers were again utilized for grazing in 1999. A total of 955 steers were grazed on the reclaimed area and on adjacent areas. The goal was to have more steers, but they were not available under favorable terms due to livestock market conditions. The area received very good moisture in early 1999 so there was abundant forage. Due to this several pastures were grazed only once during the summer. Steer weight gains were less than 1998 primarily due to hot dry conditions at the end of the summer. Also, the livestock market conditions resulted in multiple third party owners of the steers, ranging in locations from Montana to Oregon. This also had an adverse effect on weight gains.

The increased number of steers allowed the use of slightly larger pastures. Also, some areas grazed under wet conditions were grazed as larger pastures to avoid excessive hoof impact. A set of corrals was constructed to allow safe and efficient handling of the livestock. Improvements were also made to the watering system.

4.3. Future Grazing Programs

During the year 2000 we anticipate again increasing the number of steers to be grazed. Approximately 200 hectares of additional reclamation will be available for first-time grazing (approximately half will be established permanent reclamation and half will be newly seeded reclamation), bringing the total reclaimed area to almost 1,500 hectares.

Grazing larger numbers of animals and increasing the total amount of land to graze has several advantages:

- More impact is achieved in a shorter period of time. We are trying to impact these areas. The impact is needed to break up capping of soils and knock down standing dead material and incorporate it into the surface of the soil.
- Pasture sizes can be larger and/or grazing periods can be shorter.
- There may possibly be fewer disruptions to the mining operation due to less haul road crossings and possibly less total time spent on the reclaimed area.

- Large herds more closely replicate the herds of buffalo from centuries ago, which is how the grasslands evolved.

Since reclaimed mine land was previously disturbed by the mining process, the impact desired from the grazing animals is much less than similar undisturbed land. Soil capping is much less developed than on undisturbed land and the reclaimed area vegetation is very new compared to undisturbed land. As the planning and monitoring of the reclaimed area grazing program continues, we may decide to split the steers into multiple herds. Some reclaimed areas may be grazed primarily during drier periods of the year. Some areas may be grazed with small numbers of animals for longer periods of time (i.e. areas managed for shrubs). The continual process of planning the grazing, monitoring the effects of grazing, making changes to control future effects, and replanning will be used to make decisions on reclaimed area management practices.

5.0. SUMMARY

Overall the health of the reclaimed land is improving. We are seeing new seedlings in old stands of reclamation. There is increased litter and organic matter on the soil surface with less standing dead plant material. The health of the plants has improved and soil erosion has decreased. Numerous species of wildlife utilize the reclamation. The number of livestock grazing the reclaimed land is greater per area than the number grazing similar undisturbed land. This is critical for the economic sustainability of the reclamation.

The primary postmining land use of the area is livestock grazing. This means the primary postmining land **user** will likely be a family trying to make a living off the land; therefore, the real postmining land use is supporting families and communities. Our decisions should always keep that in mind.

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2000 Billings Land Reclamation Symposium

CONTROL OF LEAFY SPURGE BY SHEEP GRAZING

R.E. Ries and J.F. Karn[1]

ABSTRACT

Leafy spurge is a serious invasive plant problem on native rangelands and some reclaimed mined land across the Northern Great Plains and northwestern United States. This plant has been difficult to control with herbicides because of expense and collateral damage to other plants and water supplies. Sheep will graze leafy spurge and sheep grazing has been used with varying degrees of success to control leafy spurge. We studied the use of sheep as a biological control measure for leafy spurge infested rangeland on the Heart River in central North Dakota. Prior to sheep grazing, 10 locations within 4 range sites (overflow, silty, shallow, and woody draw) were identified and caged. Leafy spurge stem density and leafy spurge and other forage dry matter production were monitored for 3 growing seasons prior to sheep grazing. After 1 year of grazing with Rambouillet sheep, leafy spurge stem density and dry matter production were measured inside and outside the cages. Data were analyzed by unequal subplot, mixed model analysis of variance. Leafy spurge density and production had a significant range site x year interaction. After 1 grazing season, leafy spurge densities were the same on ungrazed and grazed rangeland. Leafy spurge dry matter remaining after one season of sheep grazing was significantly less on grazed than ungrazed areas but the effect was not uniform for all range sites. Range sites (silty, shallow, and woody draw) that were at higher elevations, with significant air movement, were more intensively grazed by the sheep than the overflow range site along a stream bank and in protected areas. Sheep grazing can be an important leafy spurge control option on infested rangelands or reclaimed native grasslands while providing marketable products for the land owner. Understanding sheep behavior is important when managing a flock for optimum leafy spurge control.

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INTRODUCTION

Leafy spurge (*Euphorbia esula* L.) is a perennial noxious weed introduced from Europe which currently infests many hectares of range and pasture land in the Northern Great Plains of the United States and southern Canada. Sheep have been recognized for their ability to graze leafy spurge and reduce its abundance on pasture and range land (Helgeson and Thompson 1939, Johnston and Peake 1960). Sheep consume significant amounts of leafy spurge while suffering neither harmful internal effects nor a significant loss in body weight and therefore, may be an effective biological control agent for leafy spurge (Landgraf et al. 1984). Incorporating sheep grazing into ranching operations in Montana can result in positive economic returns when as little as 4% of the ranch land was infested with leafy spurge (Williams et al. 1996). Kronberg and Walker (1999) found that sheep grazed Idaho and North Dakota leafy spurge differently. Sheep preferred leafy spurge from North Dakota in a fresh or dried hay form more than Idaho spurge and also preferred fertilized leafy spurge compared to unfertilized spurge. They suggest that preference of leafy spurge by sheep may depend on the site where it was grown and that control of leafy spurge by sheep may be more successful on soils with relatively high fertility.

A recent survey of ranchers and local decision makers in 4 counties in western North Dakota and eastern Montana found leafy spurge was a major weed problem. The main reason ranchers and local decision makers did not use sheep grazing as a control mechanism was a lack of equipment and expertise to include sheep in their grazing strategies (Sell et al. 1999). However, some farmers and ranchers have successfully incorporated sheep into cow operations and have controlled leafy spurge while maintaining an economically viable ranching operation. Information from four farm and ranch operators on the Heart River Drainage in North Dakota provides some producer information on using sheep to control leafy spurge while providing a cash crop for the farm or ranch (Ries and Sedivec 1998).

In 1996, 130 ha of leafy spurge infested rangeland on the Heart River was purchased by an adjacent farmer/rancher. This rangeland had a history of cattle and horse grazing. The goal of this operator was to use this rangeland for sheep/cattle grazing. Research plots were established on this rangeland and leafy spurge was monitored before and after sheep/cattle grazing. The purpose of our study was to document the density and dry matter production of leafy spurge on the rangeland and monitor change in leafy spurge following sheep grazing.

STUDY AREA AND METHODS

In June of 1996, 10 research plots were located on 130 ha of land situated in the Heart River Breaks, 29 kilometers southwest of Mandan. The rangeland was diverse and included several range sites. Three research plots were on an overflow range site along a small intermittent stream with deep soils which received run on water from the adjacent area. Three other research plots were located on a silty range site, with good soils but little run on water. Two other research plots were on a shallow range site with limited soil resources and the final two research plots were in a woody draw range site with the potential for extra water from winter snow catch.

A cage (0.9 by 4.3-m and 1 m high) was secured at each research plot to protect the leafy spurge and other forage from being grazed by sheep or cattle. The pasture was grazed with sheep and cattle, with sheep grazing early in the season and cattle added after the sheep had reduced the leafy spurge canopy. The 130 ha of rangeland on our study area was part of a 891 ha pasture with cattle tight boundary fences. In 1996 and 1997, sheep grazing was minimal because boundary fences were not sheep tight. Before the 1998 grazing season, a boundary fence consisting of 5 barbed wires was built. During the 1998 grazing season, about 280 Rambouillet ewes with 280 lambs grazed the newly purchased 130 ha of leafy spurge infested rangeland. Sheep remained on the pasture from June until early November.

Leafy spurge stem density was counted and leafy spurge and other forage species dry matter production was clipped on 4 1/8th m^2 quadrats at each research plot. Data were collected in June 1996, 1997, and 1998 before sheep grazing and provided a 3-year record of the amount of ungrazed leafy spurge and other forage. In September 1998, 4 1/8 m^2 quadrats were clipped inside the cages and along a grazed transect outside the cages. Leafy spurge and the other forage species were separated in the laboratory before drying. Leafy spurge stems were counted and then vegetation samples were oven dried for 48 hours at 49EC and weighed.

Data were analyzed by unequal subplot, mixed model analysis of variance. Data from June 1996-98 provided an evaluation of leafy spurge density and dry matter production in relationship to each range site and growing season. Data from inside and outside the cages in September of 1998 provided information on leafy spurge removal by sheep at the different range sites.

RESULTS

There was a significant range site x year interaction for leafy spurge density (Fig. 1) because density did not respond the same among range sites in different years. A summary of weather conditions during each season and year (Table 1) provides some insight into the interactions in Fig. 1. There was a significantly higher number of leafy spurge stems on the overflow and woody draw sites in 1997 than on the silty or shallow sites. This may be explained by the amount of precipitation received as snow over the winter of 1996-97. Snow accumulated in the woody draws and on areas adjacent to the overflow range sites. Future snow melt provided more water than usual for leafy spurge seedling germination. In 1998, stem density was greatest on the silty range site. Conditions were favorable for leafy spurge germination on the silty range site because of a cool spring and less evapo-transpiration. Leafy spurge stem density varied more than leafy spurge dry matter between sites and years; however, dry matter production also responded significantly different among range sites and years (Fig. 2).

There was also a significant range site x year interaction for grass dry matter production with responses differing at the same range site in different years (Fig. 2). Forb dry matter was similar each year and was not significantly different among range sites. Forb dry matter averaged over 3 years was 168, 56, 40, and 8 kg/ha, respectively, for the overflow, silty, shallow, and woody draw range sites. Shrubs were only found in significant amounts on the

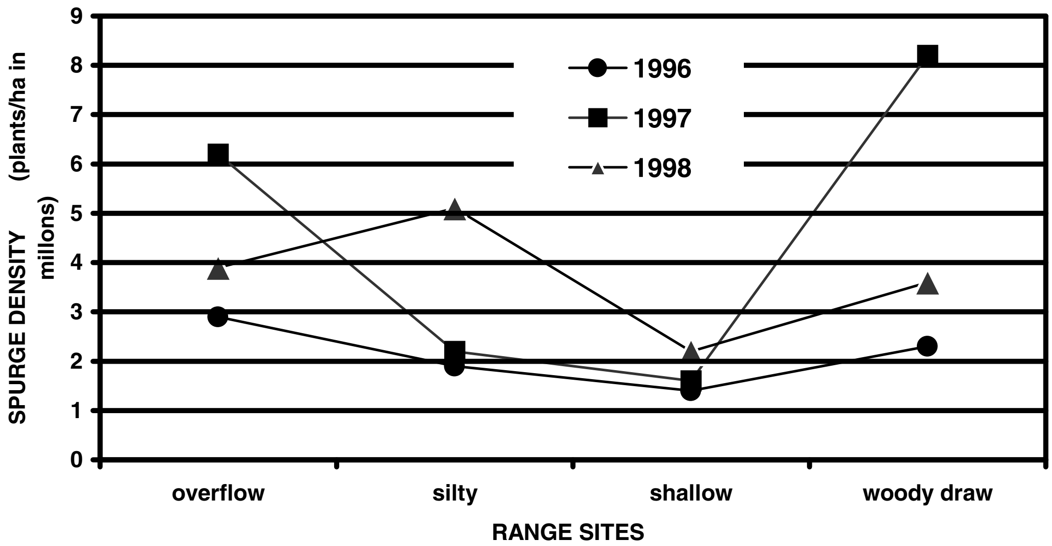

Figure 1. Significant year x range site interaction for leafy spurge density

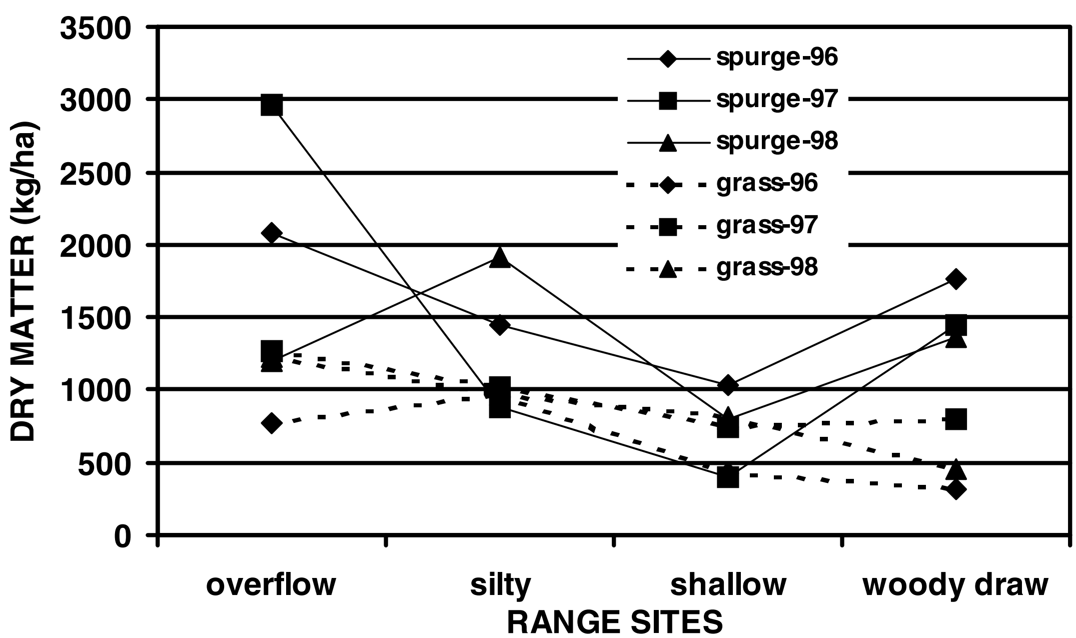

Figure 2. Significant year x range site interaction for leafy spurge and grass dry matter

woody draw range site where shrub dry matter averaged 2656 kg/ha.

Leafy spurge stem density after one season of grazing with sheep was not significantly reduced (139 stems/m^2 for ungrazed vs. 116 stems/m^2 on grazed; P>F = 0.0956). This was expected because any portion of a leafy spurge stem remaining after grazing was counted unless the stem was totally removed. There was a significant range site x grazing interaction for leafy spurge dry matter removed indicating that leafy spurge was not grazed equally on all range sites (Fig. 3). On the overflow site, leafy spurge plants were big and after grazing slightly more leafy spurge dry matter remained outside than inside the cages (+112 kg/ha). Leafy spurge dry matter was lower outside the cages at all other range sites. Sheep preferred grazing the shallow, silty, and woody draw areas because they were higher in elevation and more open. These range sites are less confining, with greater air movement resulting in cooler temperatures and fewer insects for the sheep. Preference for these 3 range sites compared to the overflow sites is also reflected in leafy spurge dry matter removal. On the silty and woody draw range sites in 1998, sheep removed 680 and 696 kg/ha of leafy spurge, respectively. At the shallow range site, sheep removed 320 kg/ha of leafy spurge in 1998. We expect leafy spurge dry matter use to also increase on the overflow range site with continued sheep grazing in future years.

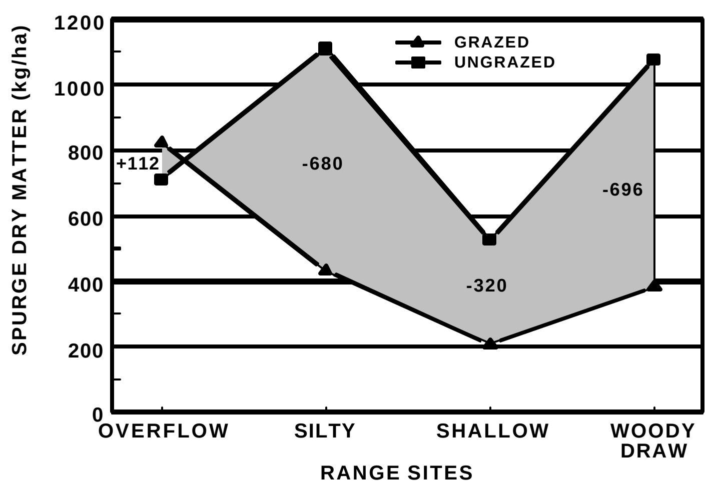

Fig. 3. Significant grazing treatment x range site interaction for leafy spurge dry matter removed during the 1998 grazing season.

Table 1. Weather data during the 3 year leafy spurge study on Heart River rangeland.

Seasons [1]	Precipitation (mm)	Temperature (C)	Evaporation (mm)
Winter '95-'96	68 [2]	-8.3 [3]	–
Winter '96-'97	110	-1.9	–
Winter '97-'98	64	-7.4	–
Spring '96	138	11.4	311
Spring '97	171	20.3	413
Spring '98	103	13.0	320
Summer '96	104	20.2	403
Summer '97	110	12.6	376
Summer '98	232	22.2	422
Fall '96	126	10.2	114
Fall '97	36	-3.0	147
Fall '98	150	12.6	141

[1] Winter – Nov thru Mar; Spring – Apr thru Jun; Summer – Jul & Aug; and Fall – Sep & Oct

[2] Snowfall ('95-'96 = 1466 mm; '96-'97 = 2200 mm; and '97-'98 = 554 mm)

[3] Growing Season ('96 - 5/13-9/11 - 121 days; '97 - 5/20-9/20 - 123 days; and '98 - 6/4-9/2 - 109 days)

DISCUSSION

Some research results reflect differences in degree of leafy spurge utilization by sheep because of possible differences in leafy spurge ecotypes and growing sites. Our data did not reflect this difference and further indicated that sheep can control leafy spurge by grazing and provide a cash product which is important to the economic viability of the farm/ranch operation. In our study on 130 ha of leafy spurge infested rangeland, sheep grazed significant amounts of leafy spurge from the study area even though it was part of a 891 ha pasture. The tight flock behavior and the tendencies to trail into the wind resulted in excellent utilization of the total pasture by the sheep. However, integration of sheep into a primarily cow/calf operation is not without difficulty. Fencing, timing of work, capital, and lack of experience with integration of sheep into cattle operations are often given as problems. However, there are several farm/ranch operators that have successfully integrated sheep into their operations for leafy spurge control and additional income. Including sheep in a ranching operation has often been dictated by loss of cattle forage because of leafy spurge infestation. Sheep grazing will not eradicate leafy spurge but they can control it, permitting more grass to grow for use by cattle. Sheep can play an important part in leafy spurge control on pasture and range lands of the Northern Great Plains and northwestern United States. Sheep should also be readily considered a proper biological control measure for leafy spurge infestations on reclaimed mined land.

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MANAGING A *BROMUS JAPONICUS* INFESTED RECLAIMED SITE

K. Krabbenhoft[1], D. Kirby[1] and D. Nilson[2]

ABSTRACT

A 14.7 ha area was reclaimed in 1989 on the Glenharold Mine in west central North Dakota. An extensive infestation of Japanese brome (*Bromus japonicus*) was present. Left unmanaged, the site would most likely fail to meet bond-release requirements. The site was rotary mowed in 1990, 1991, 1993 and 1995. The site was grazed by 47 cow/calf pairs from May 24th – June 22nd in 1997. During 1998, 48 cow/calf pairs grazed from May 16th – June 17th. Live basal cover was estimated using the ten-point frame method. Two thousand points in 1992, 1995 and 1998 were taken to record the abundance of Japanese brome, perennial species, annual litter and perennial litter. In 1995 and 1998, aboveground herbaceous yields were estimated by clipping 0.25m^2 quadrats. These were randomly located on transects in 1995 and 1998. Cover data in 1992 estimated that 66% was Japanese brome and annual litter. In 1995, these cover components were 50%. Japanese brome and annual litter cover was less than 1% in 1998. Yields of Japanese brome averaged 264 kg/ha (10% of the total) in 1995 and 52 kg/ha (3% of the total) in 1998. Japanese brome was present in 40% of the clipped plots in 1995 and 15% in 1998. Live basal and litter cover of Japanese brome was nearly eliminated following one year of early season intensive grazing. Yields were reduced by approximately 70% from 1995 to 1998. Japanese brome is quite palatable early in the growing season and readily grazed by cattle. By preventing seed set, the plant decreased in coverage allowing native perennials to inhabit the site. Infestations of annual grasses, such as Japanese brome, on reclaimed grasslands can be reduced through early season grazing management.

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INTRODUCTION

The Surface Mining Control and Reclamation Act of 1977 requires that a reclaimed native grassland have a diverse, effective and permanent vegetation cover of the same seasonal variety native to the region. Experience has shown that regardless of how well revegetation plans are designed and implemented, re-established native grassland stands can vary considerably. This nonpredictability is due to the inability to control certain variables in the reclamation process such as soil depth and quality, weather and weedy plant competition from species such as quackgrass (*Agropyron repens*), Kentucky bluegrass (*Poa pratensis*), smooth brome (*Bromus inermis*) and annual bromes such as Japanese brome (*Bromus japonicus*) (Nilson et al. 1985). Because of these variables, it may be necessary to employ management techniques, such as livestock grazing, to maintain or modify the seasonal balance of reclaimed native grasslands (Cline et al. 1999).

Grazing management and systems have been the most important management practices implemented for improving rangelands (Kothmann 1980). Most land disturbed by surface mining in the western United States is rangeland used by domestic livestock and wildlife (Schuman et al. 1990). If the post-mining land use is to be grazing, then a stand must sustain grazing without detrimental effects to the ecosystem. Much of the early literature dealt with grazing introduced forage species. Recent publications and abstracts often report seasonal balance shifts when dealing with grazing reclaimed land using native species. Limited information is available describing management techniques to reduce aggressive introduced annual or perennial species within a native mixture.

The objective of this study was to evaluate early season livestock grazing effects on a Japanese brome infested reclaimed grassland in western North Dakota. The results of this study should provide information necessary to make grazing recommendations for similar areas to achieve bond-release requirements.

STUDY AREA and METHODS

The research was conducted on the Glenharold coal mine in Oliver County of west central North Dakota. The mine is located in the Missouri Plateau Physiographic Region of North Dakota. This region lays on the western edge of an area where soils are formed from glacial deposits and residuum weathered bedrock of the sedimentary Sentinel Butte formation. Agriculture is the primary land use in the area adjoining the mine. Grasses and grasslike plants dominate the native vegetative communities in the surrounding mixed grass prairie.

In 1992, randomly located transects were sampled on the west pasture of Section 8 at the Glenharold Mine. Sampling continued in 1995 and 1998. The soils of the area were considered silty site types. Concurrently, data was taken from a nearby silty reference site during each of the respective years. Transects and portable grazing exclosures were randomly located across the 14.7 ha reclaimed area which was associated with an approximately equal amount (11 ha) of undisturbed rangeland and woodlands. Basal cover and species composition were estimated each year using the ten-pin point-frame method (Arny and Schmid 1942). During each sampling year, 2000 points were taken along two randomly located transects. In 1995 and 1998, aboveground herbaceous yields were estimated by clipping 0.25 m^2 quadrats. Two quadrats were clipped at each of ten grazing exclosures in 1995, while three were clipped during 1998.

The reclaimed pasture was seeded in early June of 1989. The site was rotary mowed during four of its first 8 years of establishment. Grazing was implemented during year nine in the spring of 1997. The site was grazed by 47 cow/calf pairs from May 24th- June 22nd. During 1998, 48 cow/calf pairs grazed from May 16th- June 17th. The average stocking rate during these years was 1.9 animal unit months per ha (AUM/ha).

RESULTS

Live basal cover data in 1992 estimated that 66% of the total cover was Japanese brome and annual litter from previous year's growth (Fig. 1). Little change was seen in 1995 with levels of these two components still at 50%. However, following two seasons of intensive early season grazing the levels fell below 1% of the total cover in 1998 (Fig. 1).

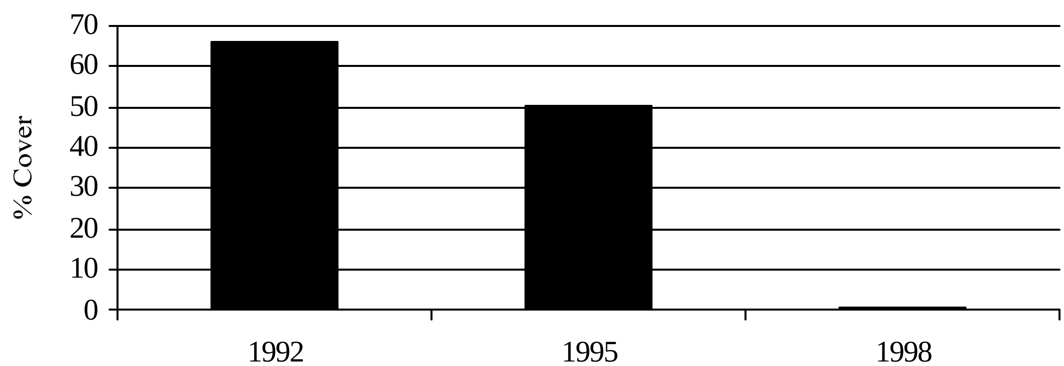

Figure 1. Basal cover (%) of Japanese brome and annual litter on the Glenharold Mine, Stanton, North Dakota.

Japanese brome yields averaged 264 kg/ha (10% of the total) in 1995 (Fig. 2). These levels dropped to 52 kg/ha (3% of the total) in 1998. Due to the use of grazing exclosures, this 70% relative decrease was seen following only one grazing season. Japanese brome was present in 40% of the clipped plots in 1995 and 15% in 1998 (data not presented).

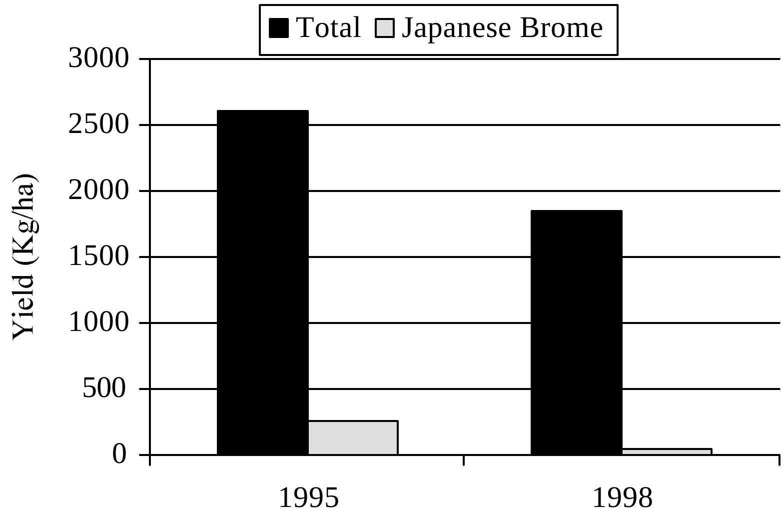

Figure 2. Total herbaceous and Japanese brome yields (kg/ha) on the Glenharold Mine, Stanton, North Dakota.

A positive trend in plant species seasonality occurred during the study. An increase in the relative amount of warm season grasses occurred for both cover and yield measurements. For live basal cover, the warm season relative percentage went from 17% in 1995 to 42% in 1998 (Fig. 3). Warm season grass yields exhibited an equally dramatic increase going from 8% to 28% during the same time frame (Fig. 4).

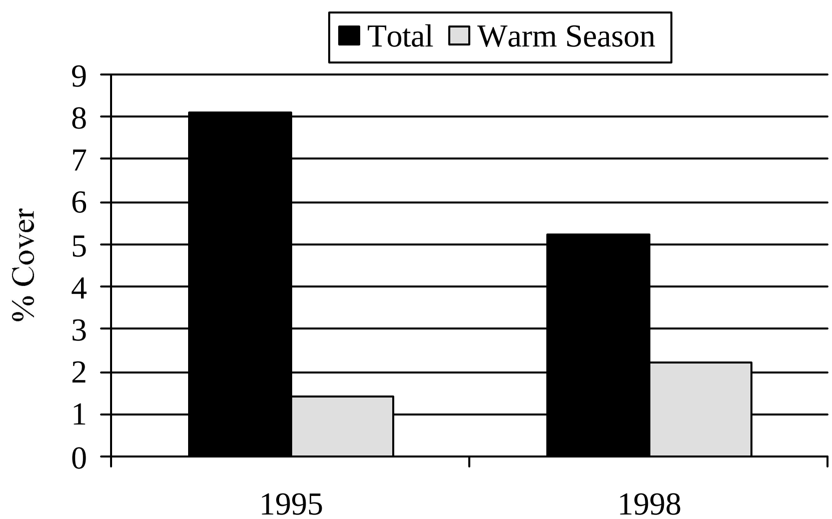

Figure 3. Total and warm season basal cover (%) on the Glenharold Mine, Stanton, North Dakota.

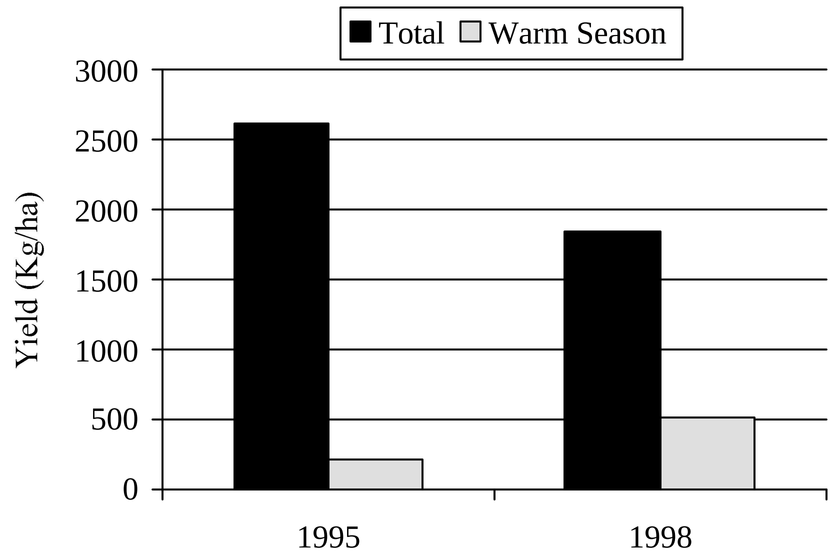

Figure 4. Total herbaceous and warm season yields (kg/ha) on the Glenharold Mine, Stanton, North Dakota.

CONCLUSIONS

Early season grazing decreased the abundance of Japanese brome based on basal cover and yield estimations to a manageable level two years following implementation. Concomitant with this observation was the positive relative composition shift in the native perennial species to that of a more seasonally balanced stand.

Japanese brome is quite palatable early in the growing season and readily grazed by cattle. By preventing seed set, the plant decreased in coverage allowing native perennials to inhabit the site. Infestations of annual grasses, such as Japanese brome, on reclaimed grasslands can be reduced through early season grazing management.

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2000 Billings Land Reclamation Symposium

DETERMINING RECLAMATION SUCCESS FROM A WILDLIFE PERSPECTIVE

Chris Yde[1], Bruce Waage[2], Patrick Farmer[3]

ABSTRACT

Montana's coal program provides for two post-mine land uses: livestock grazing and wildlife habitat. The majority of coal mine lands reclaimed under the Montana Strip and Underground Mine Reclamation Act are classified as both livestock grazing lands and wildlife habitat. In addition to vegetation and hydrology standards, fish and wildlife habitats and related environmental values must be restored, reclaimed or protected before a mining company may receive Phase IV (final) bond release. In order to evaluate reclamation success for wildlife, pre-mine baseline studies are completed and wildlife monitoring is subsequently conducted annually at all active Montana coal mines. To the extent possible, sampling methods are consistent between mines. The data collected to date have identified the pre-mine wildlife communities and documented generalized trends in species invasion and use of reclaimed areas. Reclaimed areas vary in size from small to relatively large, are often irregular in shape, and may be scattered throughout the mine area. Consequently, when sampling wildlife populations in reclaimed areas, it is difficult at best and usually not feasible to sample intensively enough to make statistically significant determinations. However, annual wildlife monitoring using consistent sampling methods, can establish general population trends for individual mine sites. Implications regarding long-term regional trends can also be made for selected species. These trends can be used as a tool to assess the success of reclamation and whether or not reclamation qualifies for final bond release.

Additional Key Words: Bond release, reclamation, wildlife, wildlife monitoring

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INTRODUCTION

The Montana Strip and Underground Mine Reclamation Act [82-4-233(1)(a)] and the Administrative Rules of Montana [ARM 17.24.762(1)] provide for two post-mine land uses: livestock grazing and wildlife. Additionally, ARM 17.24.1116(7)(d)(ii) provides that Phase IV (final) bond release can not be completed until, "fish and wildlife habitats and related environmental values have been restored, reclaimed, or protected in accordance with the Act, the rules, and the approved permit." Montana has established a comprehensive wildlife assessment program to ensure that coal companies appropriately and adequately meet these responsibilities. Initially, coal companies are required to determine pre-mine wildlife communities. These efforts provide baseline data used both for pre-mine impact analysis, and to assess the re-establishment of a viable wildlife communities on reclaimed mine lands. Wildlife monitoring is then required [ARM 17.24.723] to determine wildlife use of mine sites during mining and reclamation, as well as wildlife use of reclaimed habitats prior to Phase IV bond release. Annual wildlife monitoring provides these data, including long-term trends needed for final bond release evaluations.

Until the early 1990's, wildlife monitoring programs at active Montana coal mines were developed without guidelines for target species or species groups, methodology or sampling intensity. In the early1990's, however, the Montana Department of State Lands, Coal and Uranium Bureau (now Department of Environmental Quality, Industrial and Energy Minerals Bureau), in cooperation with the coal companies, evaluated the past results and determined that some species and/or species groups appeared to be more reliable indicators of habitat conditions then others. Furthermore, because of the difficulty in observing animals and replicating methods, some methods (e.g., spring and summer big game aerial surveys and fawning/calving area surveys) were providing information of limited value. Therefore, wildlife-monitoring programs were modified to emphasize species groups that are effective indicators of habitat conditions while reducing the emphasis on or totally eliminating surveys for other groups. Today, annual wildlife monitoring focuses on surveys for landbirds (song birds), upland game birds (lek surveys), raptors (nest and concentration areas), small mammals (including bats), amphibians and reptiles (pond, wetland and special feature surveys), and big game winter distribution.

Surveys for upland game bird leks, raptor nests and concentration areas, and big game winter distribution are conducted on a mine-wide basis to determine annual changes in both animal numbers and distribution. Surveys for amphibians and reptiles are centered primarily on ponds and wetlands, with selected upland habitats surveyed for species such as the northern sagebrush lizard *Sceloporus gracious* and the short-horned lizard *Phrynosoma hernandesi*. While these surveys document the occurrence of amphibians and reptiles in selected habitats no population trends can be determined from these data. Thus, these surveys provide very general information indicating some forms of wildlife responses to reclamation, including seasonal habitat use and presence or absence of a variety of species.

Surveys for landbirds and small mammals are conducted in selected reclaimed habitats and representative reference areas. These surveys are more comprehensive and provide long-term population trend information, and compare use or important native and reclaimed habitats. Depending on the species, landbirds and small mammals select certain habitat conditions (vegetative species, vertical structure, ground cover, amount of litter, etc.), are good indicators of habitat quality and, therefore, have been chosen as indicators to determine reclamation success.

DISCUSSION

In this paper, we are concerned with three basic coal mining steps: (1) overburden and coal removal; (2) backfilling and regrading the disturbed area; and, (3) successfully completing reclamation and obtaining bond release. To provide guidance and help ensure survey consistency at each mine over time, as well as between the different mines, the Montana coal program has adopted Fish and Wildlife Guidelines (MDSL 1994). Since the re-establishment of a wildlife community comparable to the pre-mine situation is prerequisite for final bond release, development of a logical, econmic, consitent and defensible wildlife monitoring program is a paramount challenge for the coal mining companies. Such a program must be sound, with clear objectives, consistent and repeatable methods, and must operate within the economic and logistical constraints inherent to coal mining.

In an academic and/or research scenario, conclusions from wildlife surveys would commonly require a degree of statistical significance, such as a 90 percent confidence level. Due to the high variance often encountered when sampling wildlife populations, large sample sizes are usually required to obtain the necessary level of statistical confidence. In the "real world" scenario of coal mine wildlife monitoring, however, this intensity of sampling effort is seldom logistically or economically feasible, particularly because mining disturbs comparatively small amounts of area (e.g., less than the home ranges of individual big game animals) reducing the potential sample size, and because the life of a mine may exceed often exceed thirty years, reducing the applicability of data that represent a brief "moment in time," such as a single season of year. Indeed, depending on a number of variables that might influence the success of an intense sampling effort (e.g., weather, population size), it may be impossible to collect statistically valid samples on some mines or some reclaimed areas. Therefore, a defendable alternative monitoring strategy must be used

As discussed earlier, Montana's wildlife monitoring approach relies on implementing consistent methods that are applied every year. This approach yields two types of data: generalized trends in numbers, distribution and habitat use of certain species or species groups (including big game, upland game birds and raptors) in the mine area and a larger surrounding buffer that contains undisturbed (by mining) habitat conditions; and comparisons of species richness (for species groups such as landbirds, small mammals, reptiles and amphibians) between reclaimed habitats and appropriate unmined reference areas. The first type of data addresses the problem of small study areas for highly mobile species groups, while the second type of data addresses the issue of habitat quality restored through reclamation. Both types of data are comparatively easy to collect, meeting the objective of a study approach that is logistically feasible. Both types of data also contribute to the overall goal of determining reclamation success and suitability for Phase IV (final) bond release.

Annual monitoring over the life of the mine reduces the potential for either type of data to be dramatically influenced by variability in wildlife numbers or diversity that might be encountered in a single year, which could occur if monitoring took place on a more sporadic schedule (such as every third or fourth year). For example, in Montana there appear to be "cycles" in mule deer numbers, seasonal or annual fluctuations in small mammal numbers, and years in which amphibian reproduction may be greater (or lower). If wildlife monitoring is conducted on a sporadic schedule, there is an increased probability that such peaks or troughs in wildlife numbers or diversity could present a distorted picture of the success or failure of reclamation. In order to compensate for such variability in wildlife numbers and diversity, sampling in any given year would have to be considerably more intensive than is needed under an annual monitoring approach. As a result, the sum of annual monitoring costs would intuitively appear to be lower than the sum of greater costs incurred through more intensive monitoring in fewer years, thus meeting the objective of providing a study approach that is economically feasible, particularly over the potentially long life of a mine.

Montana's program recognizes that, because of annual climatic variability as well as annual variability in habitat conditions such as vegetative composition, cover and structure, there may be annual variability in wildlife numbers, diversity, distribution and habitat use. Over the long term, however, a general trend will become evident and conclusions regarding the success of reclamation, in terms of Phase IV (final) bond release, can be drawn.

Montana's program also recognizes that vegetative diversity (i.e., composition, cover, structure, litter, substrate) influences the wildlife species that utilize a particular site, and that these characteristics will gradually change as reclamation matures. For example, some species such as western meadowlark (*Sturnella neglecta*) and deer mouse (*Peromyscus maniculatus*) may be considered to be habitat generalists and will often be present throughout both reclaimed habitats and undisturbed reference areas, regardless of habitat conditions. Other species prefer tall, uniform stands of grass; some, such as voles (*Microtus* spp.) favor dense accumulation of ground litter; while others like the grasshopper sparrow (*Ammodramus savannarum*) prefer short grass prairies. Over time, habitat conditions in a maturing reclaimed area will be expected to change to a greater degree than would be expected in an unmined reference area. Consequently, while wildlife species richness in a reclaimed area and its associated reference may be similar, the species composition of the wildlife communities inhabiting the two areas may be very dissimilar. Therefore, a species similarity index is a useful tool to determine the overlap of species occurring in the two habitats. As the index increases toward 1.0, the species overlap approaches 100 percent.

SUMMARY

In the 1990's, MDEQ in cooperation with the coal mining companies, has developed an effective strategy to measure the success of reclamation tin terms of Phase IV (final) bond release. The strategy is based on the comparatively intense collection of pre-mine wildlife baseline data, followed by less intense annual monitoring through the life of the mine. Annual monitoring provides a long-term trend with limited data gaps, accommodating naturally occurring fluctuations in wildlife diversity, numbers and distribution, and also allowing for change in habitat conditions in maturing reclaimed areas. Wildlife communities in reclaimed habitats can be compared with those occurring in unmined reference areas, both annually and over the long term. The development of a species richness trend, combined with a similarity index, is an effective method to determine if the wildlife communities within reclaimed habitat eventually approximate the communities found in adjacent unmined areas. While this method undoubtedly provides lower levels of statistical confidence than more intensive, large-scale sampling efforts, it does provide a very worthwhile method within the economic and logistical constraints normally imposed on coal mining companies.

REFERENCES

Montana Department of State Lands. 1994. Fish and Wildlife Guidelines for The Montana Strip and Underground Mine Reclamation Act. Coal and Uranium Bureau. Helena, MT. 48 p.