EFFECTS OF GRAZING ON DIVERSITY AND SEASONAL BALANCE ON RECLAIMED GRASSLANDS IN NORTH DAKOTA[1]

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Abstract. The purpose of this study was to evaluate the influence of prescribed seasonal grazing on diversity and seasonal balance of 2-yr old, 3-yr old and 4-yr old reclaimed grasslands in western North Dakota. Research was conducted on the Glenharold Mine in Oliver County, which is located in the Missouri Slope Physiographic Region of North Dakota. The 55 ha study area was comprised of adjoining 22, 24, and 9 ha areas reclaimed in 1994, 1995, and 1996, respectively. The seed mixture used contained 71 to 77% warm-season grasses. Grazing by 20 cow/calf pairs was implemented on the 55 ha site from May 26 to August 1, 1998 utilizing approximately 50% of aboveground biomass. In 1999 and 2000, grazing was conducted by 30 cow/calf pairs from May 8 to July 29 and May 7 to July 29, respectively. In 2001 and 2002, grazing by 45 cow/calf pairs was deferred until mid-July (July 15 to October 16) in efforts to maintain green needlegrass (*Stipa viridula*), a declining species on each site. Each site was randomly sampled for basal cover and species composition using a 10-pin point-frame. Alpha (intra-community) diversity fluctuated between sites early in the study; however, diversity trended higher on reclaimed sites in the last two years of the study. Total basal cover throughout the five year study ranged from 3.65 to 7.20%, 4.00 to 8.60% and 4.90 to 9.30% for the 1994, 1995 and 1996 reclaimed grasslands, respectively. Herbaceous biomass was estimated from 0.25 m^2 quadrats by clipping at ground level, separating by grass species, forbs, and shrubs, and drying and weighing samples. Yields on reclaimed sites were highest in the early stages of research when compared to the reference site but trended similar in later stages. Seasonal balance of cool- and warm-season grasses on the 1994, 1995 and 1996 reclaimed grasslands shifted from 73:27, 70:30 and 28:72 in 1998 to 65:35, 24:76 and 38:62 in 2002, respectively.

Additional Key Words: North Dakota, reclamation, prescribed grazing

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Introduction

Following enacting of the Federal Surface Mining Control and Reclamation Acts of 1977 and 1979, great emphasis has been placed on the restoration of post-mined lands to conditions resembling those of pre-mining activities. Although mandated by these acts, reestablishment of plant communities is often difficult to achieve and much research has been undertaken on this subject.

The Great Plains region is a mixed grass prairie consisting of both cool- and warm-season species and is utilized for season-long grazing (Hofmann and Ries 1988). The outcome of reclamation in this region is to redevelop both components to allow for the intended grazing use. However, these lands often tend to become dominated by cool-season species. Advantages such as early-season seeding in which soil temperatures are cooler have allowed for cool-season species to become dominant, complicating the reestablishment of a warm-season component to the rangeland (Williamson 1984). Suitable species diversity is another criteria deemed necessary by federal mandates for bond release of a reclaimed site. A site must be found to contain appropriate species diversity in order to sustain the intended use of the site and again, resemble conditions prior to disturbance.

The objective of this research on 2-, 3- and 4-year old reestablished grass lands in western North Dakota was to develop information regarding the effects of livestock grazing on seasonal balance and species diversity. The data presented from this research will assist in the implementation and utilization of grazing as a management tool in grassland reclamation of this region following surface mining activities.

Study Area and Methods

The reclamation research was conducted on the Glenharold Mine in Oliver county of west-central North Dakota. The physiographic region of North Dakota which encompasses this mine is the Missouri Slope (Bluemle 2000).

The topographic features and local relief occurring within this region is primarily rolling to hilly plains with gentle slopes characterizing 50 to 80 percent of the area. Local relief may range from

91 to 152 feet in some areas (Bluemle 2000). The region as a whole is situated on the western edge of an area where soils were formed from glacial deposits and residuums from weathered bedrock (Carlson 1973).

The soils pertinent to this research, those of the northeast edge of the Missouri Slope Upland, were developed by pre- and early-Wisconsinian glacial processes occurring 40 to 100 thousand years ago (Bluemle 2000). The study area is dominated by soils of the Williams Series and thus classified as silty range sites (Weiser 1975).

The 55 hectare study area was comprised of three adjacent grasslands. The grasslands were 22, 24 and 9 hectares in size and reclaimed in 1994, 1995 and 1996, respectively. Seeding of these areas took place in early June utilizing a ratio of 3:1 warm- to cool-season grass species. A silty native reference grassland was also sampled as a standard.

The 1994 seeding was rotary mowed in 1994, hayed from 1995 to 1997 and grazed from 1998 to 2002. The 1995 seeding was rotary mowed in 1995, hayed in 1996 and 1997, and grazed from 1998 to 2002. The 1996 seeding was rotary mowed in 1996 and 1997 then grazed from 1998 to 2002. The seedings were grazed as one cell with 20 cow/calf pairs from May 15 to July 31, 1998. In 1999, due to grazing distribution problems, the 1996 seeding was separated from adjacent seedings by an electric fence and cattle restricted from this area following approximately 50% removal of the current herbage growth. In 1999, the study area was grazed by 30 cow/calf pairs from May 8 to July 29. The electric fence was removed in 2000 and the study grazed from May 7 to July 29 by 30 cow/calf pairs. In 2001 and 2002, grazing by 45 cow/calf pairs was deferred until late in the growing season (July 31 to October 16) due to the decline in green needlegrass (*Stipa viridula*), an important cool season component for the achievement of reclamation standards. The decrease in green needlegrass from early season grazing was also experienced in western North Dakota by Kirby et al. (2000).

Transects were established on each reclaimed site and one reference site. Basal cover and species composition were estimated each year using the ten-pin point-frame method (Arny and Schmid 1942). Two hundred frame (2000 points) readings were taken randomly along transects. Herbaceous yield was estimated from thirty 0.25 m^2 quadrats by clipping at ground level, separating by grass species, forbs, and shrubs and drying and weighing samples.

Statistical Methods

When comparing vegetational diversity among reclaimed and reference sites, alpha, beta and mosaic diversity indices are the three most often used classifications. The Shannon-Weiner index was used to analyze alpha, or intra-community diversity (Shannon and Weaver 1973), and the values were further analyzed using multi-response permutation procedure (MRPP) to a significance of $p<0.05$ (Biondini et al. 1988). Presence and absence data was used in the determination of both beta and mosaic diversity; however, beta diversity utilizes affinity analysis alone in its estimation while mosaic diversity must then be standardized using the Bootstrap technique (Scheiner and Istock 1987, Istock and Scheiner 1987). As beta and mosaic diversities were similar on both the reclaimed and reference sites, only alpha diversity will be discussed.

Results and Discussion

Throughout the study, plant basal cover ranged from 3.9 to 7.2%, 4.1 to 8.6%, 3.7 to 9.3% and 4.6 to 9.8% for the 1994, 1995, 1996 seedings and silty reference area, respectively (Tables 1-4). The basal cover for the 1994 and 1995 seeded areas experienced a noticeable decline in the dominance of cool-season species during the first three years (80 to 53% and 64 to 44%) (Tables 1 and 2). Basal cover in the 1996 seeded area was dominated by warm-season species during all five years of the study (Table 3). On all three reclaimed sites, the basal cover of green needlegrass (*Stipa viridula*), a cool-season species was consistently low during the first three years then showed an increasing trend the last two years on two of the three reclaimed sites (data not presented). Similar trends were also noted by Kirby et al. (2000) following grazing on 4-year old reclaimed mined lands.

In 1998, alpha diversity of the 1994 seeding was less ($p<0.05$) than that of the other two reclaimed areas (no data taken on reference area in 1998)(Fig. 1). In 1999, alpha diversity of the 1994 and 1995 seeded areas was less ($p<0.05$) than the 1996 seeded area as well as the reference area, while, in 2000, the alpha diversity on the 1994 seeding was less ($p<0.05$) than each of the other

Table 1. Basal cover (%) by plant class for a grassland reclaimed in 1994 in section 9, Glenharold Mine, Stanton, North Dakota.

Plant class	1998	1999	2000	2001	2002
	---------- % ----------				
Native cool-season grasses	4.90	3.05	1.90	3.10	3.50
Native warm-season grasses	1.80	1.05	1.70	3.70	1.90
Native forbs	0.00	0.00	0.05	0.40	0.50
Introduced forbs	0.00	0.00	0.00	0.00	0.00
Introduced cool-season grasses	0.00	0.10	0.00	0.00	0.30
Total basal cover	6.70	4.20	3.65	7.20	6.20

Table 2. Basal cover (%) by plant class for a grassland reclaimed in 1995 in section 9, Glenharold Mine, Stanton, North Dakota.

Plant class	1998	1999	2000	2001	2002
	---------- % ----------				
Native cool-season grasses	4.80	2.80	2.20	4.40	0.90
Native warm-season grasses	2.10	1.10	2.75	3.80	2.90
Native forbs	0.05	0.00	0.05	0.20	0.10
Introduced forbs	0.00	0.00	0.00	0.00	0.00
Introduced cool-season grasses	0.05	0.10	0.00	0.20	0.40
Total basal cover	7.00	4.00	5.00	8.60	4.30

Table 3. Basal cover (%) by plant class for a grassland reclaimed in 1996 in section 9, Glenharold Mine, Stanton, North Dakota.

Plant class	1998	1999	2000	2001	2002
	---------- % ----------				
Native cool-season grasses	1.45	2.20	1.55	2.30	1.80
Native warm-season grasses	3.70	3.30	5.60	6.80	2.90
Native forbs	0.10	0.00	0.10	0.10	0.10
Introduced forbs	0.45	0.00	0.00	0.10	0.00
Introduced cool-season grasses	0.00	0.00	0.00	0.00	0.10
Total basal cover	5.70	5.50	7.25	9.30	4.90

Table 4. Basal cover (%) by plant class for a silty reference site in section 27, Glenharold Mine, Stanton, North Dakota.

Plant class	1998	1999	2000	2001	2002
	---------- % ----------				
Native cool-season grasses	5.10	3.60	4.55	6.40	5.20
Native warm-season grasses	2.90	0.70	3.25	2.70	1.50
Native forbs	0.40	0.30	0.30	0.70	0.40
Introduced forbs	0.00	0.00	0.00	0.00	0.00
Introduced cool-season grasses	0.00	0.00	0.00	0.00	0.00
Total basal cover	7.40	4.60	8.10	9.80	7.10

three areas. No differences were observed in 2001; however, in 2002, alpha diversity of all three reclaimed areas was greater ($p<0.05$) than that of the reference area. This increasing trend in alpha diversity following grazing on reclaimed sites support data reported by Kirby et al. (2000).

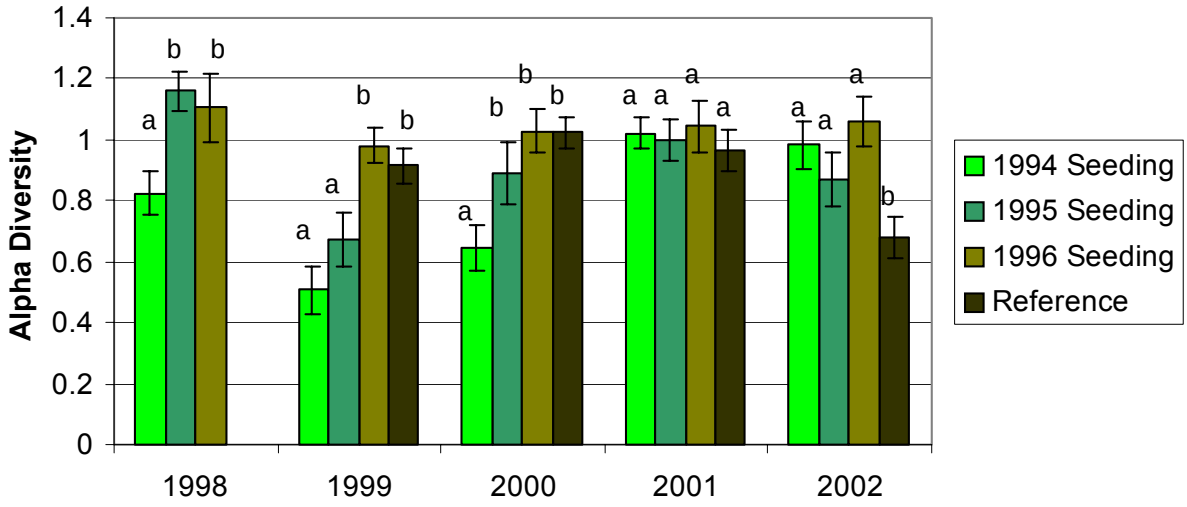

Figure 1. Alpha diversity for reclaimed and reference sites on the Glenharold Mine, Stanton, North Dakota. Annual means for sites with the same letter are not different ($p>0.05$).

Total herbaceous yield on the reclaimed sites was higher than the reference area for the first three years of the study (Fig. 2). This phenomena was to be expected due to the high vigor of newly developing plant communities on reclaimed grasslands. Above ground biomass for the 1994 and 1995 seeded areas was dominated by cool-season species in the first three years, but became more evenly balanced and comparable to the reference area during the last two years. The data presented in this paper on 2- to 4-year old reclaimed grasslands support Kirby et al. (2000) research on 4- to 7-yr old reclaimed grasslands in western North Dakota. Both studies reported no negative effects from the stresses of grazing reclaimed grasslands ranging from 2- to 7-yrs in age. Kirby et al. (2000) did report that grazing had no positive influence on the ratio of cool- to warm-season grasses on grasslands where grazing was initiated ten years after re-establishment.

Total herbaceous yield on the 2-yr old seeded area was similar to the reference area during the first two years of the study but became skewed to favor warm-season species during the last three years (Fig. 2). Williamson (1984) experienced similar results when warm-season species rebounded

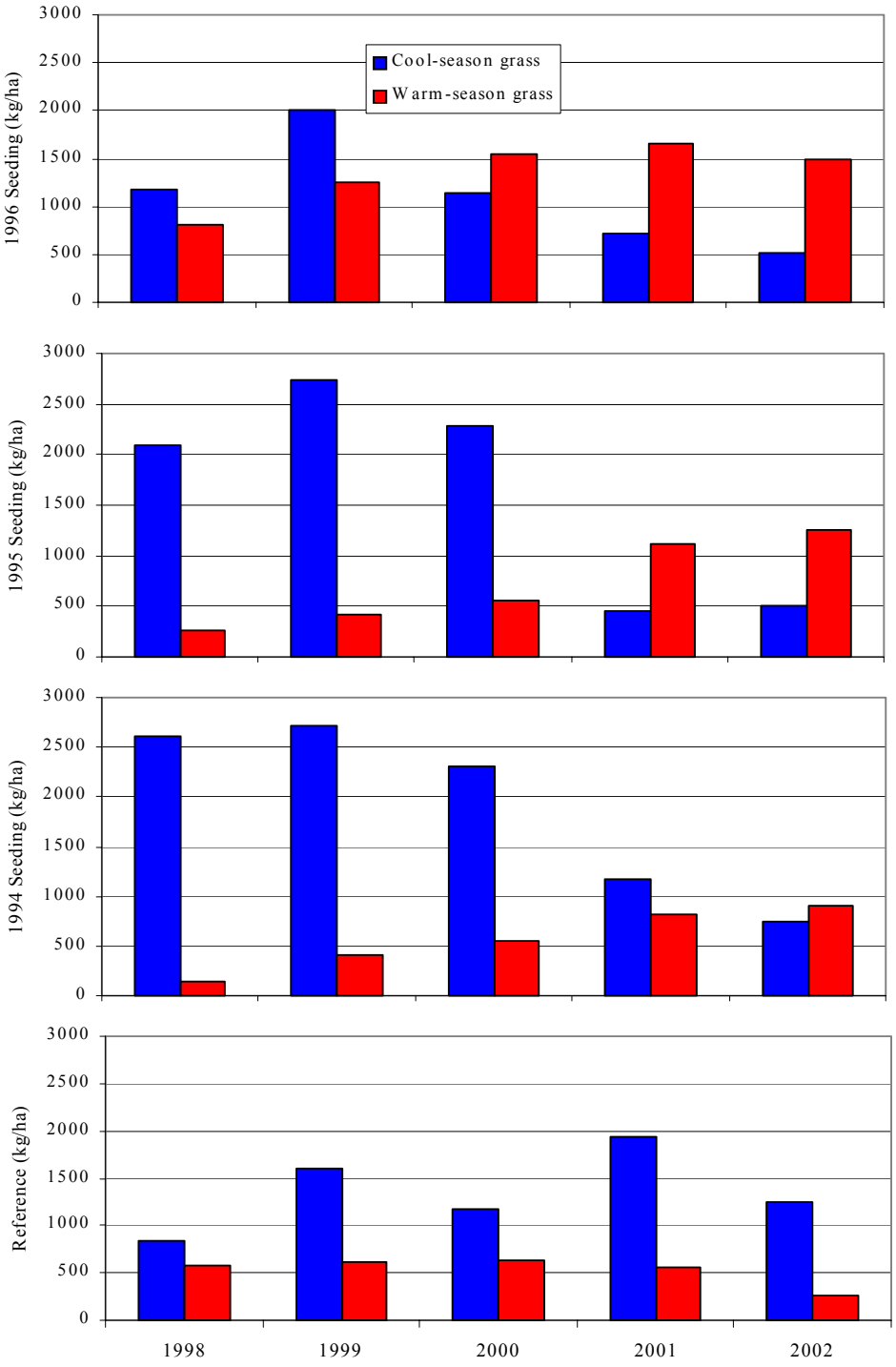

Figure 2. Average annual herbaceous yield of cool- and warm-season grasses (kg/ha) for all sites on the Glenharold Mine, Stanton, North Dakota.
after one season of high intensity (84.9% removal of annual above ground biomass) early-summer

grazing followed by one year of rest on a 4-yr old reclaimed grassland.

Conclusions

Grazing of reclaimed grasslands may be initiated 2- to 4-yrs following seeding. In this study 2- to 4-yr old re-established grasslands demonstrated positive results in both seasonal balance and species diversity from prescribed grazing. Following early season grazing, the basal cover of cool-season grasses decreased and was in balance with the warm-season species on two of the reclaimed areas. The basal cover of green needlegrass, an important cool-season grass, increased on two sites following late season grazing.

Herbaceous yield of cool-season species declined on all three grazed reclaimed sites. The 1994 and 1995 seeded areas closely resembled the seasonal balance of the reference area. The ratio of cool- to warm-season species shifted in year three of this study on the 1996 seeded area to favor warm-season species. The change in herbaceous yield on all three sites is directly related to the grazing by domestic herbivores during key establishment periods of cool- and warm-season grass species.

Beta and mosaic diversities of the three seeded areas were not observed to be dissimilar when compared to the reference site of this study. However, alpha diversity demonstrated a significant improvement ($p<0.05$) on all three reclaimed sites in the fifth year of the research with values greater than that of the reference area. The increase in small scale diversity favoring reclaimed areas over the reference area at the end of the five year study supports the use of grazing to improve species diversity soon after establishment of plant communities on mined lands.

Previous reports and the research findings in this study suggest a window for grazing re-established grasslands of 2- to 7-yrs post-establishment. Grazing early in the growing season at a rate of 50% removal of annual biomass production for the first two years to allow developing warm-season species a competitive advantage followed by rotational grazing system in later years may provide the best results for increasing diversity and improving seasonal balance of North Dakota reclaimed grasslands. A reclaimed rangeland grazed soon after seeding is also supporting evidence for the permanence criteria of bond release. Thus prescribed grazing appears to be a land use treatment for reclaimed grasslands to achieve reclamation success.

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