WOODLAND RECLAMATION WITHIN THE MISSOURI BREAKS IN WEST CENTRAL NORTH DAKOTA[1]

by

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Abstract. Surface mining in the Missouri Breaks requires the removal of deciduous woodlands associated with drainages that flow intermittently toward the Missouri River. Reestablishing these woodlands requires the use of reclamation techniques that maximize plant available water. Grading, soil handling, site selection, plant material and condition, and proper installation and management operations are important to woodland establishment and survival. Survival data and reproductive capabilities of reestablished woodlands provide some insight into whether or not a stand will become self-perpetuating woodland system. Data collected from tall shrub reclamation study sites established between 1982 and 1984 show initial survival has varied from 54 to 78 percent. However, mean stem densities of shrubs increased 150-375 percent by the end of the third growing season. During the 1988 field season, mean stem densities were within 25 percent of the mean recorded in undisturbed sites.

Additional key words: Woodland reclamation, hardwood draws, reforestation.

Introduction

Surface mining in the Missouri Breaks in west central North Dakota requires the removal of native woodlands known locally as "woody draws" and prairie woodland thickets. These woodlands are associated with mesic sites along drainages that flow intermittently toward the Missouri River. Woody draws are important, not only to a variety of wildlife species, but also to livestock where they provide protection during periods of extreme weather.

Data presented in this paper are from the Glenharold Mine (GHM) which is owned and operated by Basin Cooperative Services, a subsidiary of Basin Electric Power Cooperative. For evaluation and permitting purposes, native woodlands are grouped according to lifeform as low shrub, tall shrub, and mixed deciduous plant communities. These woodlands are distributed across the mine covering approximately 10 percent of the coal reserve area. Although most woodlands have developed along drainages, woody vegetation is not

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limited to this site. Prairie woodland thickets containing a few or several species, including trees, are distributed across the landscape primarily on north and east facing slopes. Shrub species in order of abundance include chokecherry (Prunus virginiana), silver buffaloberry (Shepherdia argentea), serviceberry (Amelanchier alnifolia), hawthorn (Crataegus rotundifolia) and American plum (Prunus americana). The dominant low shrub species is western snowberry (Symphoricarpos albus) Other common low shrub species include woods rose (Rosa woodsii) and silverberry (Elaeagnus argentea).

Where trees are present, green ash (Fraxinus pennsylvanica) is common followed by American elm (Ulmus americana) and to a lesser extent box elder (Acer negundo). Cottonwood (Populus deltoides) and willow (Salix spp.) occur sporadically adding to structural diversity. Aspen (Populus tremuloides) are site specific occurring in clumps or thickets in the vicinity of water bearing strata.

Soil

Soil resources typical of wooded draws were described by Richardson (1979) and summarized below. In general, these soils are representative of non-wooded prairie soils in the region. Richardson described uplands as Typic and Pachic Haploborolls where Amor, Temvik, Parshall and Sen soil series are common. These soils are some of the most productive on the mine. Where concave landforms are present, upland prairie thickets of snowberry, woods rose, silver buffaloberry and silverberry are common. The shoulder and upper backslope soils of wooded draws are Ustorthents and typically represented by the Cabba soil series. Further downslope where soil depths increase and landform is more concave, soils were classified as Lithic and Entic Haploborolls. At this location the Werner soil series is common.

History

Following the enactment of the Surface Mining Control and Reclamation Act in 1977 (SMCRA, P.L. 95-87), opposition to mining wooded draws increased. Woodland reclamation plans in existing permits consisted of the installation of shelterbelts and the use of traditional shelterbelt technology. This was considered inadequate from a wildlife habitat standpoint. Approval of permit applications became contingent on mining plans that avoided woodlands of exceptional quality as they were considered irreplaceable. Additionally, the ability to replace woodlands with a diverse self-perpetuating woodland system capable of sustaining comparable wildlife populations was vigorously contested. Without resolution, this conflict threatened the coal supply to the Leland Olds Power Station. To resolve this conflict, it was necessary to develop and evaluate new reclamation technology and demonstrate its capability to mitigate woodland/wildlife losses. Concurrently, it was necessary to initiate a wooded draw ecological study to develop a better understanding about "woody draw" ecosystems. This required a multi-disciplinary approach involving biologists, ecologists, soil scientists and hydrogeologists, as well as oversight by the Public Service Commission and by state and federal wildlife agencies. The results of this two pronged approach was used to develop a new reclamation plan for areas mined following the enactment of SMCRA.

One of the first woodland reclamation study areas established under this plan was the Glenharold Mine Wooded Draw Demonstration Site (WDDS) in 1978. In addition to the development and application of operational procedures, other factors were evaluated including potted versus bare-root stock, vermeer spade transplants, soil depth effect, slope, aspect and stand position importance. Initial growth and survival data were reported by Williamson and Wangerud (1980).

The results of the wooded draw ecological study were compiled by Williamson et al. (1982) in an unpublished report submitted to the North Dakota Public Service Commission. In summary, three environmental factors emerged from this study that were important to the presence of woody vegetation. These included:

1. Landform/shape (geomorphology).
2. Aspect.
3. Shallow water table outcrops.

Of these, geomorphology and aspect directly affect the amount of plant available water and consequently the presence or absence of woody species. The most advantageous combination of these factors for both woodland establishment and development is a north, northeast or east facing slope with a concave surface profile. Of these two variables, landform is the most important for two reasons. First, although woodland areas are more common on north and east facing slopes, some shrub species are present on drier south and west facing slopes where the surface configuration is suitable (Richardson 1979, Mack 1981). Second, north and east facing slopes with convex surfaces do not have woodland plants unless underlain by a shallow water table, or fed by a spring or seep from a higher elevation. Generally, where site factors altered the moisture regime, native woodlands were likely to occur.

Woodland Reclamation Plan

The GHM woodland reclamation plan evolved from the installation of shelterbelts using traditional tree planting equipment and bare root stock in the mid 70's to the use of containerized stock and hand-held motorized coring equipment in 1980. Planting densities were increased from approximately 1,500 plants/ha (600/ac) to 12,000/ha (4,800/ac) to compensate for expected losses during the first few years. These densities were later changed, however, as ongoing monitoring studies in the wooded draw demonstration site indicated that reproduction of major shrubs, via suckering, tripled and in some cases quadrupled stem densities from the number initially planted. American plum suckers, for example, were found up to 1.5 m from the parent plant after 5 growing seasons (Nilson 1983). Because of this reproductive capability, a lesser number could be installed and still meet density standards. Also, it was obvious that the cost of containerized stock combined with labor intensive planting methods needed to be re-evaluated. In 1982, a revised reclamation plan was developed which mechanized the planting process and radically reduced reclamation costs without sacrificing reclamation quality. This plan called for the installation of bare root stock using a conventional tree planter and crew contracted through the Soil Conservation Service. Using this equipment, all shrubs are installed on approximately 1.25m centers (4 ft.) for a total planting density of 6,670 plants/ha (2,700/ac). Following shrub establishment, tree species are installed by hand in the most favorable microclimates. Using this method, planting and plant material costs were reduced by 75 percent. Also, it allowed for the installation of 8,000 to 10,000 plants per day using a 3 man crew (one tractor operator and two planters). At this rate, an annual replacement acreage of 10 ha (25 ac) could be planted in 7-9 days.

Planting Mixtures

Three planting mixtures listed in Table 1 are typical of those used to replace deciduous woodland, tall shrub and low shrub plant communities. Extant species do not occur in the area but are present along the Missouri River or have the capability to inhabit the area. These species are added as an experimental component to enhance wildlife habitat characteristics.

Planting Sites

Based on research conducted at the Glenharold Mine, and data collected from reestablished woodlands, it was concluded that those factors important to the success of native woodlands are also important to reclamation woodlands. Proper surface configuration and aspect are major factors to consider in planning and developing a post-mine topography. At the GHM, prime woodland sites are selected following the normal grading process. If a sufficient number and acreage do not occur, special grading operations are conducted. These include the excavation of concave surfaces on slopes that face north, east or northeast. Typically, planting sites vary from .1 to 4 ha (.25-10 ac) depending on surface configuration and general topography. The majority of planting sites are along drainage bottoms, side-slopes or sites simulating natural escarpments.

Soil Management

Generally, no special soil removal or replacement operations are included in the woodland reclamation plan. As part of the overall reclamation plan however, special soil removal operations are conducted to salvage subsoils that are physically superior and capable of improving chemical and physical characteristics across an entire tract. Chemical criteria set by the PSC to determine whether or not topsoil and subsoil is suitable are well within the tolerances for establishment and growth of native trees and shrubs used in reclamation. Also, no special surface field operations such as deep tillage or ripping, are conducted to minimize compaction and improve soil water storage capabilities.

Soil Amendments

Site preparation includes the incorporation of two types of fertilizer. The first is a slow release nitrogen (38-0-0) which is applied at a bulk rate of 280 kg/ha (250 lbs/ac). This fertilizer is slow to react with water and is included to provide a source of nitrate nitrogen over a period of several years. The second fertilizer application includes phosphorus and soluble nitrate nitrogen. Both fertilizers are tilled into the soil to a depth of 15-20 cm (6-8 in). Where the topsoil or first lift material is less than 15 cm, fertilizer is spread following the distribution of subsoil. Application rates are based on soil tests and historical soil test data to ensure minimum nitrogen/phosphorus levels of 56 and 168 kg/ha (50-150 lbs/ac) respectively.

Table 1. Typical reclamation planting mixtures used to replace mixed deciduous, tall shrub and low shrub plant communities.

	Deciduous Woodlands		Tall Shrub		Low Shrub	
Species	Plants/ha	% Comp.	Plants/ha	% Comp.	Plants/ha	% Comp.
Tree Layer (TL)						
Willow	62	5				
Boxelder	198	15				
Green ash	802	60				
Cottonwood	198	15				
Bur oak (ES)	37	3				
Hackberry (ES)	37	3				
TOTAL TL	1,334	100				
Tall Shrub Layer (TS)						
Native plum	1,062	25	1,087	20		
Silver buffaloberry	556	13	1,087	20		
Serviceberry	803	19	543	10		
Chokecherry	1,062	25	1,198	22		
Round-leaved hawthorn	531	12	1,087	20		
Red osier dogwood	247	6	272	5		
Bristly gooseberry	0		161	3		
TOTAL TS	4,261	100	5,435	100		
Low Shrub Layer (LS)						
Silverberry	531	50	371	30	1,335	20
Woods rose	272	25	494	40	1,335	20
Snowberry	272	25	371	30	4,000	60
TOTAL LS	1,075	100	1,236	100	6,670	100

ES - Extant Species

Planting Schedule

All shrub species are installed in the early spring as soon as field conditions permit. Dates have varied over the past nine years from mid-April to early June, depending on the advent of spring conditions. Generally, planting is done into sites prepared the previous year to take advantage of soil water recharge over winter. If spring soil temperatures warm sufficiently to germinate a weed crop prior to planting, areas are sprayed with a non-selective herbicide (glyphosate). Tree species are installed by hand following mulching operations but in most cases they are installed the following year to facilitate weed control operations during the first year.

Erosion Control

To avoid competition for soil moisture, neither a temporary nor permanent herbaceous cover is seeded. Instead, all woodland sites are mulched at a rate of 11,200 kg/ha (5 ton/ac) to control erosion and to preserve soil moisture levels. A slough hay mulch is spread over the area to depths of 5 to 10 cm (2-4 inches) using a big bale mulcher. To avoid vehicle rutting and to maintain operational stability, a four-wheel drive tractor with dual wheels is used to power the mulcher. If over winter soil water recharge is deficient, mulching may be delayed until after the first sufficient rain following planting.

Management

Broadleaf weeds and perennial grass control may be necessary for 2 to 3 years following installation. The heavy mulch application can reduce weed populations the first growing season and has at times precluded the need for any weed control. Weed control in subsequent years is accomplished using both pre-emergent and post-emergent herbicides. Glyphosate is used prior to and following planting if necessary. After installation, it is applied using a hand held nozzle and hose attached to a mobile spray unit. Chemical is applied under low pressure during days of very little wind. Since windy days are the rule rather than the exception in North Dakota, more areas are being treated with dichlobenil (Casoron 4-G) which inhibits herbaceous root and shoot growth. Dichlobenil is a granular herbicide applied during late fall at a rate of 140-170 kg/ha (125-150 lbs/ac) using a broadcast fertilizer spreader.

Woodland Reclamation Success

As of the end of 1988, approximately 60 ha (@150 ac) of woodlands have been reestablished on reclaimed land at the Glenharold Mine. To facilitate advancement in woodland reclamation design and ensure performance standards are met, reclamation areas are monitored on an annual basis. Changes in survival, diversity and density, have been observed over the past 10 years. Data in this paper are presented for study sites WDDS2, Section 16 and Section 19. The first two were planted in 1982 while the latter was planted in 1984. The relative composition based on 1988 data are presented in Table 2.

Table 2. Relative composition of major species on woodland reclamation study sites in 1988.

Species	WDDS2	Sec.16	Sec.19
	------Relative %-------		
Serviceberry	0.0	0.0	3.3
Red-osier dogwood	10.1	1.4	7.6
Silverberry	0.0	9.6	0.0
Amer. plum	28.7	29.0	18.2
Chokecherry	30.4	19.4	5.6
Woods rose	11.3	13.9	64.8
Silver buffaloberry	17.0	24.5	0.0
Green ash	2.2	2.0	0.0
Other	.3	.2	.5
	-------Stems/ha--------		
Total	31,125	28,100	33,500

Although trees are present, both WDDS2 and Section 16 resemble tall shrub plant communities because of their age. Also, these areas have similar species composition and stem densities. Plant community comparisons using similarity coefficients show stem densities of species common to both areas to be 78% in 1983, the year following establishment. This similarity declined to 57% in 1984 but increased to 79% by the end of 1988. When compared to study site

Section 19, WDDS2 and Section 16 had similarity coefficients of 36 and 47% respectively.

Reproductive capabilities of tall and low shrub species on these sites provide encouraging evidence that self-perpetuating woodlands are possible. Stem density data collected between 1983 and 1988 show a mean annual growth rate of approximately 45% through 1988 for study sites WDDS2 and Section 16 (Figure 1). The Section 19 site had an annual density growth rate of 57%. This is attributed to the dominance of woods rose which suckers prolifically. As a consequence of these growth rates, the number of stems per hectare ranged from 28,100 (11,375/ac) in Section 16 to 33,500 (13,550/ac) in Section 19 by the end of 1988. These densities are within 25 to 30% of the mean stem density of tall shrub species in native tall shrub communities across the mine.

Topographic and surface variability, aspect and soil water differentials all contribute to wooded draws that are non-uniform and structurally complex. This vertical and horizontal diversity contributes significantly to wildlife diversity and are attributes that are real in terms of designing and developing replacement woodlands. As observed in undisturbed sites, woodland reclamation areas developed since 1978, show density and height variation depending on site characteristics. Figure 2 demonstrates mean stem density differences between lower, middle and upper slope positions over time on WDDS2. Height data of major species collected in 1985 show similar differences (Figure 3).

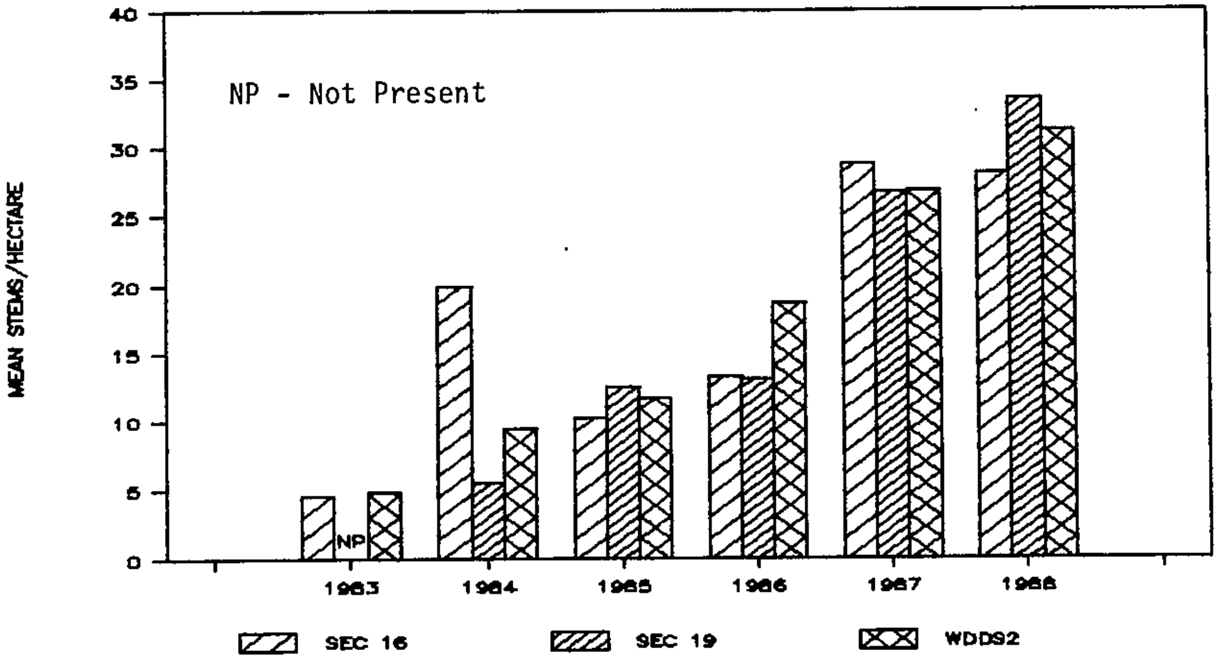

Figure 1. Changes in mean stem densities (thousands) over time on 3 woodland reclamation study sites on the Glenharold Mine.

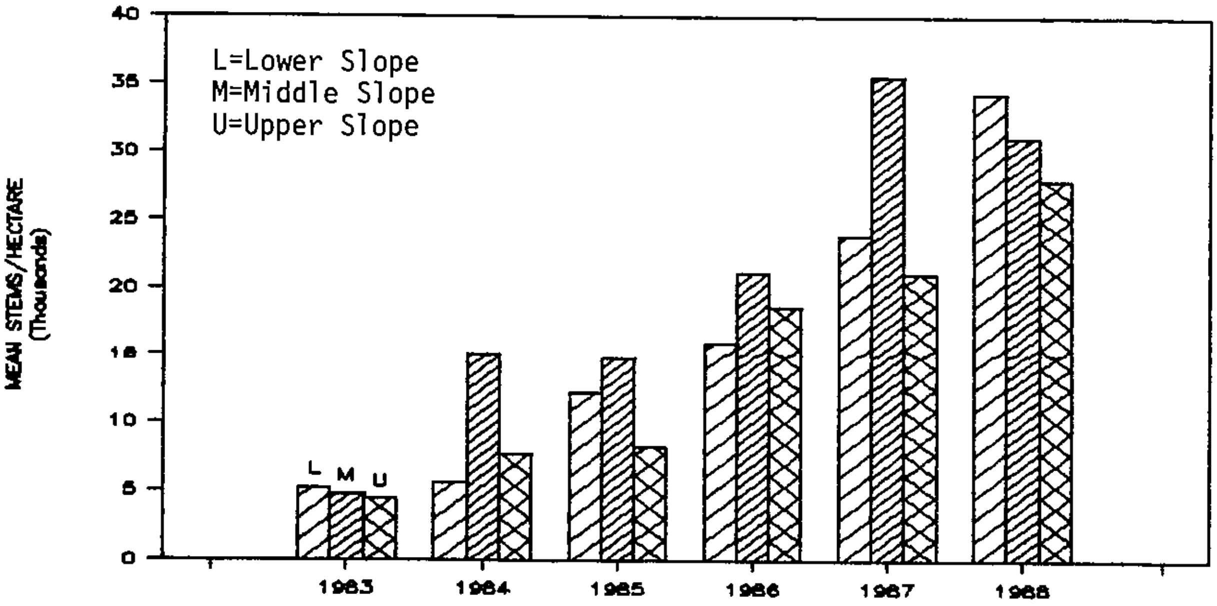

Figure 2. Changes in mean stem densities over time by slope position in the Glenharold Mine Wooded Draw Demonstration Site 2.

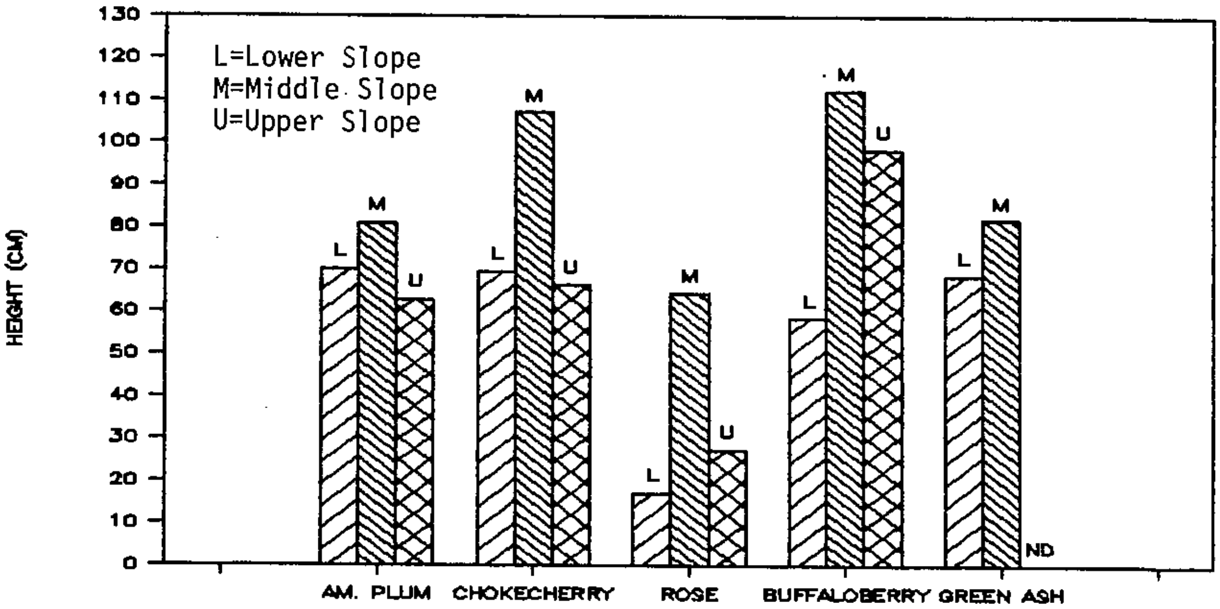

Figure 3. Effects of slope position on mean height of major species on study site WDDS2 (1985 data).

Effect of Soils on Woody Vegetation

Native woodlands occur over a wide variety of soils with often adverse physical and chemical soil characteristics. Shrub communities have been observed on shallow Cabba soils underlain by scoria to sodium affected Daglum and Rhoades soils in drainage bottoms and foot slopes. Richardson (1979) recognized the lack of correlation between soil type and properties and the presence of woody vegetation except with respect to landscape position and shape. Woodland vegetation can be present or absent from the same soil series and slope position depending on whether or not the surface is concave or convex.

A poor relationship between growth and survival and soil depth also is evident on reclamation woodlands established since 1978. Williamson and Wangerud (1980) found survival and growth on 30, 75 and 150 cm (12, 30 and 60 in) soil depths to be highest on 30 cm deep plots. Also soil depth did not cause total stem densities to differ in WDDS2 and Section 16 study sites. Approximately 45 cm (18 in) of soil was respread over sodic spoil (SAR > 25) in WDDS2. In contrast, over 90 cm (36 in) was respread over good quality spoil (SAR < 10) in the Section 16 site. Despite this difference, total stem densities were similar over the past four growing seasons (Figure 1).

Weather Effects & Survival Notes

Precipitation and temperature data are collected from on-site weather stations and compared with long term (20 years) data from the National Oceanic and Atmospheric Administration (NOAA). The long term average annual precipitation is 42.9 cm (16.9 in) varying from 29.9 cm (11.8 in) to 61.2 cm (24.1 in). Approximately 70% falls during May through September and almost half of this occurs during a period from May through July (Figure 4). GHM records show the mean May through September precipitation to be 25.6 cm (10.1 in) slightly less than the 20 year mean of 29.7 cm (11.7 in). Mean precipitation over the last 5 years is also less than the long term average.

Long term data from NOAA show years of high precipitation are often characterized by below average temperatures while years of low precipitation have higher temperatures. Figure 5 illustrates the relationship between total May through July precipitation, relative to long term averages and the number of days temperatures exceeded 32° C (90° F). In 1980 and 1988 when total May through July rainfall was 54 and 63% of normal, first year survival was generally less than 50% and as low as 14% on some sites. In 1981 and 1984 when May-July precipitation was similar, overall survival was well over 70%. Where the 1980 and 1988 years differ from 1981 and 1984 is that temperatures were higher during the critical spring and early summer period. Also, the lack of fall moisture left subsoil moisture levels in short to very short supply prior to planting.

In comparison, these periods demonstrate the role of temperature in ameliorating precipitation deficiencies. It also points out the importance of selecting slopes of a north, northeast or east aspect where total day time exposure to direct sunlight is less. In 1984 and 1988, stem densities on these study sites increased even when May-July precipitation was below normal.

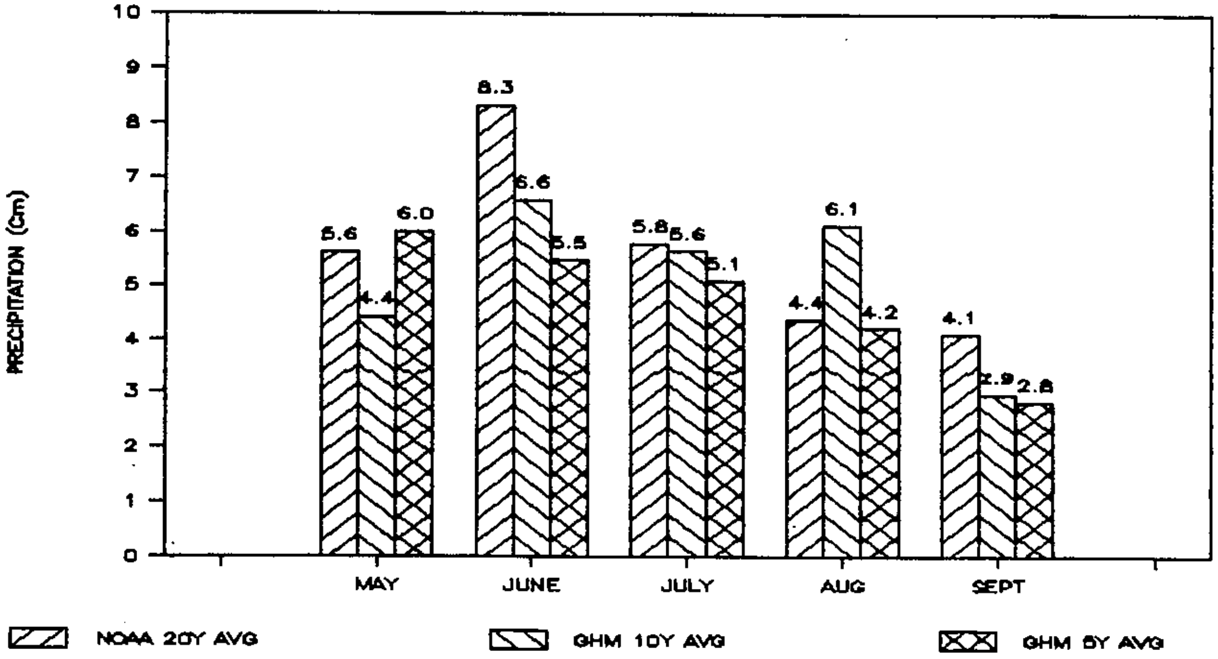

Figure 4. Five and ten year average May-September precipitation received at the Glenharold Mine relative to the long term average.

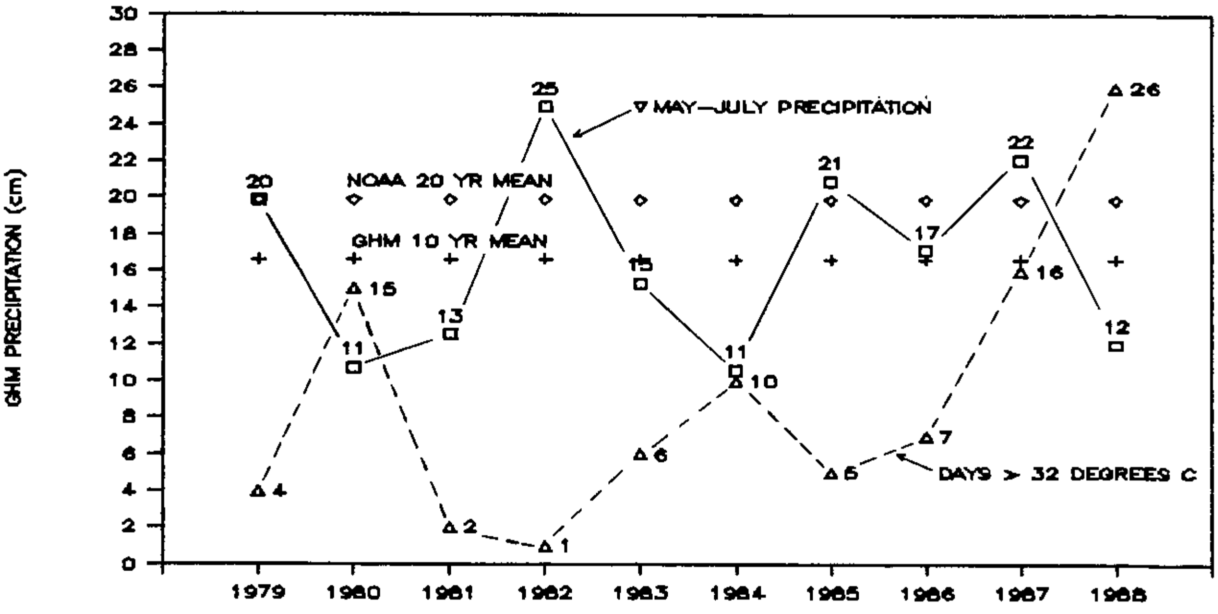

Figure 5. Changes in total May-July precipitation relative to the number of days where temperatures exceeded 32 degrees C (90 degrees F).

Summary

Colonization of native grasslands by pioneer shrub species such as snowberry and silverberry are initial stages of a successional pattern leading to a climax plant community. If conditions develop which create a more mesic microclimate, then tall shrub and tree species will become established.

Many environmental factors important in ecological succession in native woodlands are also important to restored woodlands. Basic to woodland reclamation success is the selection and development of sites where soils water levels are augmented by landform and aspect. On these sites, a high density woodland planting can insure adequate survival numbers and reproductive capabilities of remaining plants can quickly increase stem densities. This in turn alters the microclimate providing more favorable conditions for successional processes to occur. The final product is a self-perpetuating woodland system with many attributes important to wildlife inhabiting the Missouri Breaks.

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