# HIGH INTENSITY, SHORT DURATION ROTATIONAL GRAZING ON RECLAIMED COOL SEASON FESCUE/LEGUME PASTURES: I. SYSTEM DEVELOPMENT[1]

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**Abstract:** The Pittsburg & Midway Coal Mining Co.'s ("P&M") Midway Mine lies 50 miles south of Kansas City, Kansas, straddling the border of Kansas and Missouri. P&M actively mined the area until 1989, when the mine was closed and reclaimed. Approximately 3,750 acres of surface mined land were topsoiled and revegetated to cool season fescue/legume pasture. Various pasture management methods are being utilized to meet reclamation success standards and achieve final bond release. The effectiveness and costs of various cool season fescue/legume pasture management methods are evaluated and contrasted. These methods include sharecropping, bush hogging, burning and livestock grazing. It presents guidelines used to develop a site specific rotational livestock grazing programs with land owners or contractors, and local, state and federal agencies. Rotational grazing uses both cow/calf or feeder livestock operations. Key managerial elements used to control grazing activities, either by the landowner or a contractor, are reviewed. Methods used to determine stocking levels for successful rotational grazing on this type of pasture are presented. Rotational grazing of livestock has proven to be the most effective method for managing established cool season fescue/legume pastures at this site. Initial stocking rates of 1 A.U.M. per 5 acres have been modified to a current stocking rate of 1 A.U.M. per 2.5 acres. Supporting physical and chemical data are presented and discussed in **Part II. Forage Production, Soil and Plant Tissue Comparisons between Grazed and Ungrazed Pastures** of this paper.

**Additional Key Words:** Reclaimed Land Management, Rotational Grazing, Grazing Agreements-Landowner/ Contractor, Grazing Program Development, Stocking Rates for Rotational Grazing; Midwest, Kansas, Missouri.

## Introduction

The Pittsburg & Midway Coal Mining Co.'s ("P&M") Midway Mine is located approximately 50 miles south of Kansas City, KS on State Highway 69 (Figure 1). The mine varies in elevation from 780 to 1,000 feet above MSL. Average annual precipitation for the region is 39 inches (NOAA, 1980). The mine is located in the Continental Climatic Zone. Frequent changes of weather occur, both from day to day and from season to season, due to the influence of the following three air flow regimes, cold Canadian, moist Gulf of Mexico, and dry western air masses.

Precipitation is spread fairly homogeneously throughout the mine area and its distribution is not significantly influenced by topography. The winter months, mid-November through mid-March, are comparatively dry with precipitation averaging between one and two inches per month. Winter precipitation may be received as either rain or snow. Annual average snowfall for the area is 20 inches. May through September are the wettest months, with precipitation averaging between four and five inches per month. Precipitation occurs mainly in the form of showers and thunderstorms, with infrequent hailstorms. A daily minimum precipitation of at least 0.01 inches or more occurs on an annual mean of 62 days. The mean number of days with 0.05 inches or more of precipitation is 25.

Midway Mine experiences large annual (January-July 40° F) and diurnal temperature fluctuations (23° F). Average daily temperatures range from 79° F during the summer to 30 F in the winter months. Mean annual temperature is 59°F, with a mean annual high of 67°F and a mean annual low of 44° F. January is the coldest month and July is the hottest month. The frost-free season is about six months, occurring from mid-April through mid-

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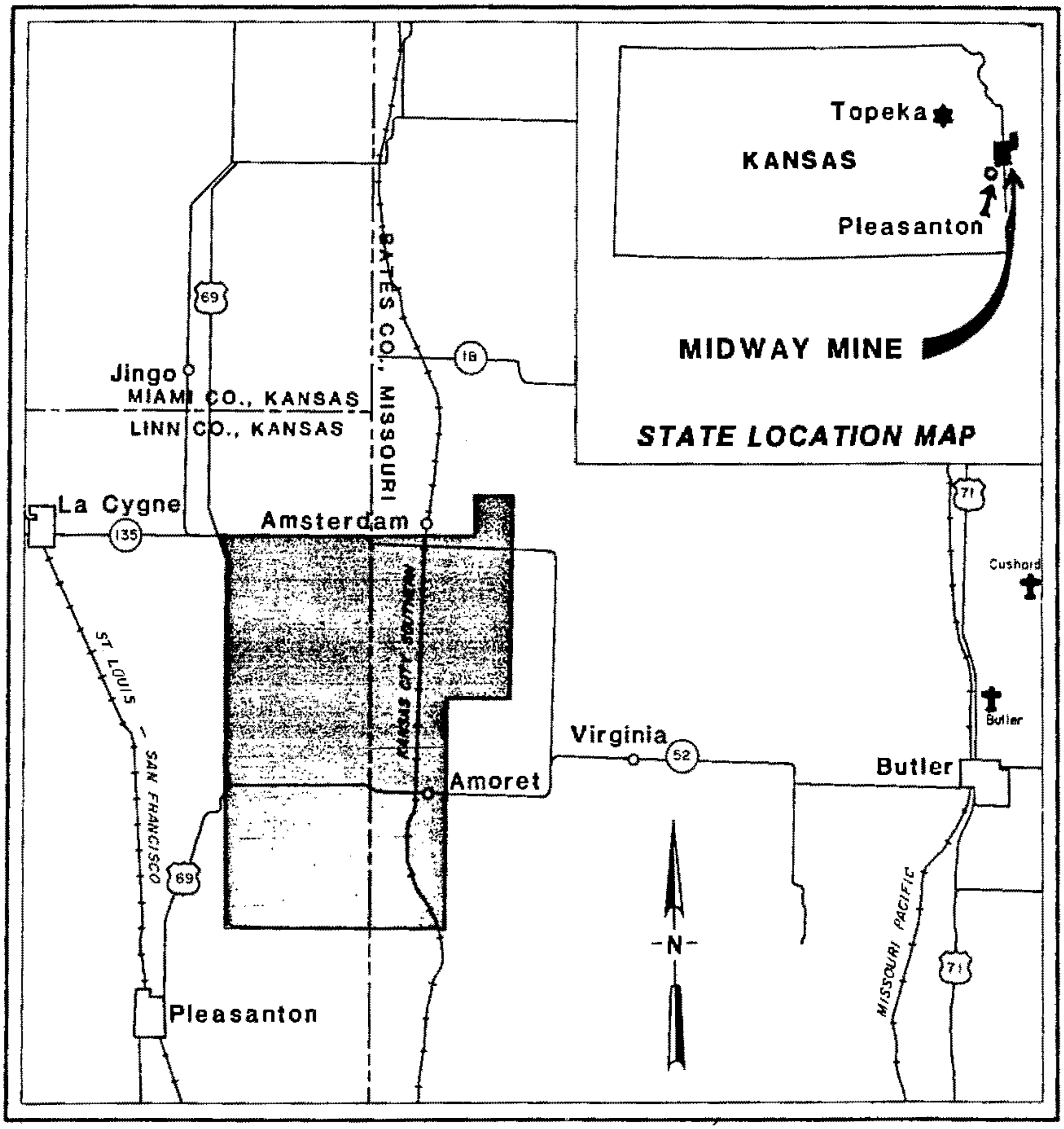
**FIGURE 1**

The Pittsburg & Midway Coal Mining Co.

ENGINEERING DEPARTMENT

**MIDWAY MINE**

## *GENERAL LOCATION MAP*




5 0 5

*SCALE IN MILES*

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October. The mean number of days with temperatures below 32° F is 56. There is an average of 114 days per year in which temperatures are 90° F or above.

Prevailing winds are southerly, occurring during the spring, summer and fall. Cold winter winds are generally from the north to northwest. The average annual wind speed is 11 miles per hour.

Coal was mined at this facility from 1972 until 1989 when it was permanently closed. Eight permanent program Surface Mining Control and Reclamation Act ("SMCRA") permits were issued for coal mining and reclamation activities at the Midway Mine by the Kansas Department of Health and Environment-Surface Mining Section ("KDHE-SMS") and the Missouri Land Reclamation Program ("MLRP"). These permits contained approximately 5,967 acres of land disturbed by mining and reclamation activities. All reclamation involving large scale earthmoving equipment was completed by 1991. The mine was reclaimed to multiple land uses including Pastureland (cool season grass), Cropland (both prime farmland and nonprime farmland soils), Wildlife, Water Resources and Industrial/Commercial. Approximately 3,750 acres of Pastureland and Cropland were topsoiled and revegetated with cool season fescue/legume seed mixes.

The primary soil series salvaged and used for topdressing on Pastureland and Cropland included Parsons sil (fine, mixed, thermic Mollic Albaqualf), Dennis sil (fine, mixed, thermic Aquic Paleudoll) and Summit sicl (fine, montmorillonitic, thermic Vertic Argiudoll) (USDA-SCS, 1981). Soils were salvaged to a depth of 24 inches and stockpiled separately. Soils were reconstructed to a minimum depth of 24 inches following final backfilling and grading.

The Pastureland revegetation seed mix species included tall fescue (*Festuca arundinacea*), orchardgrass (*Dactylis glomerata*), Korean lespedeza (*Lespedeza stipulacea*) and alfalfa (*Medicago sativa*). This mixture was drilled into the reconstructed soils during revegetation operations. The cool season pasture soils require periodic fertilization in order to be capable of meeting SMCRA productivity standards. An annual hay productivity target of 2.5 to 3.0 tons per acre was used together with annual soil testing to develop nutrient requirements and appropriate fertilizer blends. Fertilizer was applied in split spring and fall applications to maximize its benefits in the following blends: 1989 through 1991, 40-45-60; 1992, 71-72-62; 1993, 66-54-93 and 1994, 50-30-30 (N-P-K). Agricultural lime was applied in 1991 at a rate of two tons per acre. Periodically legumes have been seeded in conjunction with fertilizer applications for pasture improvement purposes.

## Postmining Pasture Management

The cool season pasture was initially harvested with various methods including sharecropping (2/3, 1/3 split cropper/P&M), brush hogging, burning and limited non-rotational livestock grazing. Sharecropping was the preferred harvesting method while the mine was operating. This method was chosen because third party interaction with the ongoing mining operations was controllable and minimal, the arrangement allowed owners of lands leased for mining the opportunity to realize productivity from them while still under lease, and in a good year the company's share of the hay crop helped offset part of the pasture management cost. Unfortunately, weather patterns were not always optimal for hay production. Sharecroppers naturally looked out after their own interests and harvested their own lands first. When hay crops were either high or low the reclaimed lands frequently went unharvested, since sharecroppers either did not need the additional hay or the low yield amounts were not worth the effort.

Brush hogging was used on lands where hay harvesting was either physically impossible (equipment limitations, ground conditions, etc.) or when harvesting was simply not performed. The obvious drawback with brush hogging is that it adds additional operational costs and generates no offsetting revenue. A benefit is that significant amounts of organic material are added to the brush hogged which is readily incorporated into the soil.

Burning cool season pasture is not universally accepted as an agricultural practice in the Midway Mine region. Nonetheless, burning was used to remove excessive accumulations of growth, particularly when it was perceived that weed control benefits might be derived from use. The problem with burning is that it is difficult to control burn rate and heat, which often results in damage to the pasture. In the event that containment control is lost, damage may extend to structures or other improvements. Grass moisture and growth conditions, and weather conditions must be ideal to safely use burning as a management tool. As a result, its application was extremely limited.

Immediately following mine closure, short duration winter grazing was used on limited areas of reclaimed pastures. Cattle were removed from the pastures before spring growth began and proved valuable in removing accumulated vegetation and preparing the pastures for the next season's growth period. Environmental and management benefits realized by this limited grazing helped in the setting up of commercial scale, high intensity, short duration rotational grazing at the mine.

After the mine was permanently closed and active reclamation completed, responsibility for management of the mine was transferred to environmental personnel at P&M's corporate office in Englewood, Colorado. One full time employee was locally retained to oversee contractor activities, monitor the mine site's progress toward reclamation liability release, interface during regulatory inspections and perform miscellaneous management activities.

Following mine closure P&M's Land Department marketed and sold the mine property to several private parties and the U.S. Fish and Wildlife Service. P&M retained an exclusive use lease-back for all reclaimed lands sold which were still under reclamation bond. This lease-back provision aided in development of acceptable grazing agreements with the new owners on their newly acquired property.

Besides postmining pasture management problems, the repair of rills and gullies at the mine site was proving to be a difficult undertaking. The inventory and repair of significant erosion structures was lagging behind their ongoing formation. Despite concentrated efforts, the contractor responsible for on-site reclamation activities was falling farther behind. These problems were compounded by the above-average moisture received at the mine site during 1992 and 1993. Due to the above-listed problems, it clearly was necessary to adjust postmining pasture management paradigms and adopt new, or modify traditionally accepted, postmining reclamation management practices.

## Grazing Plan Requirements And Development

An evaluation of short duration, high intensity rotational grazing of livestock as a potentially viable reclamation management tool for these pastures was performed. It was concluded that high intensity rotational grazing as a management method had potential benefits over other traditional agricultural methods currently being employed. It was also determined that to successfully establish a grazing system the following requirements would have to be met:

1) Regulatory Approval-Plans would require approval by Kansas and Missouri regulatory agencies. Acceptable plans would contain sufficient detail to satisfy them, while retaining the latitude to adjust to ongoing operational needs and variations in environmental conditions;

2) Regulatory Compliance-Requirements contained in approved plans will be met by the grazer. P&M would have the ability to terminate the agreement at its discretion in the event of serious default or environmental harm resulting from contractor neglect or mismanagement;

3) Grazing Program Goals-Reclamation liability release is the primary focus and concern. Therefore, adequate checks and balances capable of fostering and benefiting reclamation goals should be incorporated. Such items include determining grazing duration within cells by monitoring grass height and condition, avoiding excessive trampling, maintaining or improving pasture productivity, and supplemental mowing performed by the grazer following livestock rotation out of a grazing cell to remove excess vegetation (>12 inches in height);

4) Pre-existing Reclamation Problem Areas-Inventory and correction of any revegetation problem areas will be performed by P&M prior to introducing livestock;

5) Provision of Livestock-Adequate numbers will be supplied by the grazer at his expense to provide high intensity, short duration grazing of the grazing area per P&M and regulatory direction;

6) Removal of Livestock-Accomplished promptly if the regulatory agencies or P&M determines their presence represents a serious threat to the reclamation. Dead livestock will be promptly removed from the grazing area and properly disposed of;

7) Livestock Damage Prevention and Repair-Activities which may negatively affect P&M's ability to meet reclamation success standards would need to be reduced or eliminated, and a plan set out for repair of livestock damages should they occur;

8) Fencing-Perimeter and interior fencing will be timely constructed and maintained by the grazer;

9) Water Supply Access Stability and Alternate Sources-Suitable soil stabilization measures will be placed along watering access routes to ponds. If needed, alternate watering methods necessary to prevent damage to the grazing area will be supplied with equal cost sharing;

10) Fertilizer Application-Purchased partially or totally by the grazer per P&M's soil testing recommendations;

11) Pasture Improvement-Interseeding for pasture improvement purposes will be performed by the grazer according to regulatory specifications;

12) Harvesting Hay or Seed Crops-Performed at the expense of the grazer after obtaining P&M approval. Harvested crops will be promptly removed from pastures and stockpiled in designated areas;

13) Equipment Maintenance-Servicing of farm equipment having the potential to negatively impact the grazing area will not be performed in the grazing area. Release of potentially hazardous materials on reclaimed lands would be minimized by servicing farm equipment off bonded land areas; and

14) Third Party Liabilities-Claims resulting from livestock activities are the responsibility of the grazer;

Clearly, the ability to negotiate agreements and plans with potential grazers and regulatory agencies which satisfactorily meet these requirements on a prioritized basis would determine whether or not rotational grazing could be used for pasture management.

Development of grazing agreements and plans was conducted simultaneously with potential grazers and regulatory agencies. Meetings were held with personnel from the Kansas Department of Health and Environment-Surface Mining Section, the Missouri Land Reclamation Program, Kansas and Missouri Soil Conservation Service and University Extension Services (Borland, 1993, Briggs, 1993 and Decker 1993), and potential grazers to develop grazing plans. Site specific productivity data was used to evaluate and determine initial stocking rates. The size and permanency of water resources was evaluated, as well as acceptable access routes. Fencing requirements were reviewed and paddock arrangements evaluated to reduce costs.

Short duration, high intensity grazing plans were approved and agreements executed for 4,065 acres of cool season pasture, of which 3,750 acres were mined and reclaimed (Figure 2). Either feeder or cow/calf livestock operations were allowed throughout the year. The grazing area was divided into 34 paddocks or grazing cells, 31 were specified for grazing and three for hay harvesting or grazing. Hay harvesting in cells was provided to supply supplemental forage for livestock during the winter in the event that stockpiled grass was depleted. Fences were

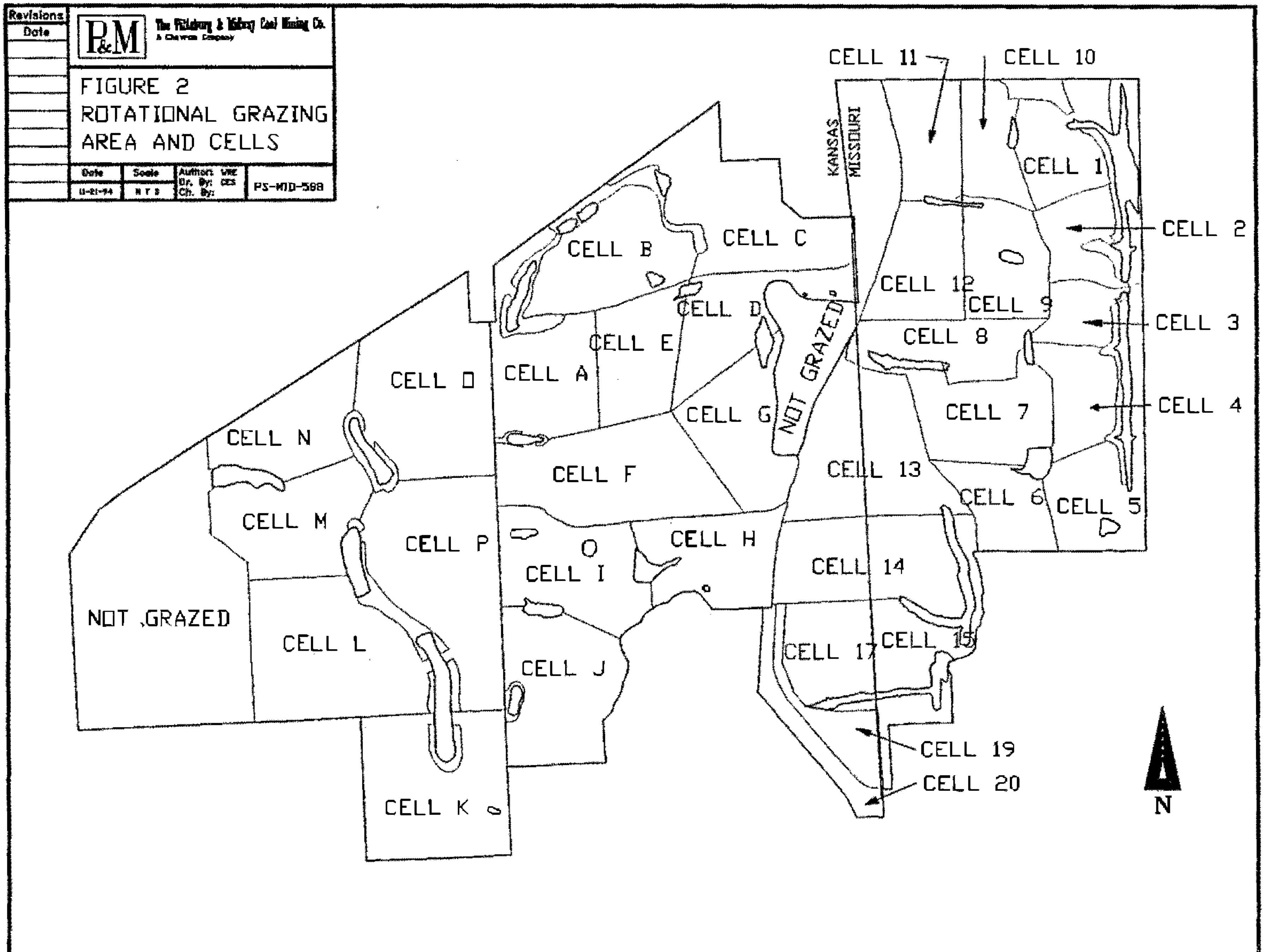

FIGURE 2
ROTATIONAL GRAZING
AREA AND CELLS

constructed around the perimeter of developing riparian and wetland habitats to exclude livestock. Corridors through wildlife/riparian areas were provided into ponds to allow watering access.

## Stocking Rates

Animal size influences the maximum stocking rate for either cow/calf or feeder operations. Exclusive use of feeder operations makes stocking relatively easy, since the desired number is determined by animal size and projected growth for the anticipated grazing duration. Cow/calf operations must also consider:

1) Number of open cows;

2) Ratio of spring calves and fall calves and their timing of removal;

3) Birthing and calf mortality rates; and

4) Bull number and time in grazing area for cow fertilization purposes.

Considering these factors, the required numbers of animals required to approach maximum stocking levels can be calculated (Tables 1 through 4). Calculations and assumptions for determining stocking rates are detailed at the bottom of each table.

For 1993 grazing the maximum stocking rate was simply determined by dividing the pasture acreage by 4.5 acres resulting in 903 Animal Units or 1,806 animals. This stocking level did not adequately remove the available forage crop. During 1994 the maximum stocking rate was determined using the methods contained in Tables 1 through 4. In 1994 maximum stocking levels were modified to three acres per Animal Unit. This increased stocking maximums to a monthly average of 1,397 and a monthly maximum of 1,612 animals. This stocking rate represents a calculated grazing duration of 452 days with a 39% forage surplus.

## Pasture Management Methods Cost Comparisons

Comparing costs of hay harvesting (by contractor and sharecropping), brush hogging, burning and livestock grazing demonstrates the economic advantages of grazing (Table 5). Brush hogging is the most expensive management method ($65.92/acre), since the crop value is totally lost and additional costs are incurred to perform this operation. The same is true for burning ($52.23/acre), although additional costs to perform this removal method are usually less than brush hogging. Harvesting hay using a contractor is preferred over the first two removal methods which destroy the crop ($37.92/acre). Hay harvesting through sharecropping is the second least expensive pasture management method ($25.42/acre ). Livestock grazing is the most economical method for pasture management ($0/acre). Monitoring pastures during livestock grazing and ensuring that livestock are timely rotated may require additional manpower. At the most one day per week, 52 weeks per year would be required to perform the additional work (Table 5 Annual Cost column). Even with this additional cost ($2.52/acre), grazing is the pasture management method of economic choice.

## Results And Discussion

The livestock industry is cyclic and its profitability is highly variable. For these reasons, investing significant amounts of capital in livestock to manage reclaimed pastures by grazing is difficult to justify to mine management. There are also a number of additional liabilities and expenses that must be addressed when using a biological management method that are not inherent in conventional management methods. Nonetheless, if suitable

**Table 1: Rotational Grazing Duration For Cow/Calf And Feeder Operation At 3 Acres Per AUM**

| A | B | C | D | E | F | G |
|---|---|---|---|---|---|---|
| Paddock Area | Acres | Estimated Annual Production (# per acre) | Estimated Total Production (pounds) | Estimated Stocking Rate (# of Units) | Estimated Consumption (# hay/day/unit) | Calculated Duration (days) |
| TS. Pasture | 2,683 | 5,500 | 14,756,690 | 894 | 30 | |
| NTS. Pasture | 837 | 3,000 | 2,509,567 | 279 | 30 | |
| Undist. Pasture | 546 | 2,000 | 1,091,725 | 182 | 30 | |
| Totals | 4,065 | | 18,357,982 | 1,355 | 30 | 452 |

Calculation Descriptions:
D=B*C
E=B/3 Acres per Animal Unit
F=1000 lbs. Per Animal Unit * 3%
G Total=D/(E*F)

**Table 2: Livestock Population Dynamics: 1,084 Desired A.U.M. And 858 Adjusted A.U.M.**

| A | B | C | D | E | F | G | H |
|---|---|---|---|---|---|---|---|
| Month | Max. Animals | Cows | Spring Calves | Fall Calves | Bulls | Feeders | Avg. A.U.M.s |
| January | 933 | 764 | 0 | 130 | 38 | 0 | 874 |
| February | 933 | 764 | 0 | 130 | 38 | 0 | 874 |
| March | 1,452 | 764 | 520 | 130 | 38 | 0 | 1,082 |
| April | 1,452 | 764 | 520 | 130 | 38 | 0 | 1,082 |
| May | 1,612 | 764 | 520 | 130 | 38 | 160 | 1,183 |
| June | 1,612 | 764 | 520 | 130 | 38 | 160 | 1,183 |
| July | 1,612 | 764 | 520 | 130 | 38 | 160 | 1,183 |
| August | 1,482 | 764 | 520 | 0 | 38 | 160 | 1,131 |
| September | 1,482 | 764 | 520 | 0 | 38 | 160 | 1,131 |
| October | 1,482 | 764 | 520 | 0 | 38 | 160 | 1,131 |
| November | 1,612 | 764 | 520 | 130 | 38 | 160 | 1,183 |
| December | 1,093 | 764 | 0 | 130 | 38 | 160 | 975 |
| Monthly Avg. | 1,397 | 764 | 390 | 97 | 38 | 107 | 1,084 |

Calculation Descriptions:
B=C+D+E+F+G
C=(Table 1 E Total-(G Monthly Avg. Total/2))-((Table 1 E Total-(G Monthly Avg. Total/2))/20)
D=C*80%*85%
E=C*20%*85%
F=C/20 Cows per Bull
G=Input Desired Number
H=(C*1 AU)+((D+E)*40%AU)+(F*1.5 AU)+((G/2*(Table 3 F Total*2)/1000))

**Table 3: Animal Weight Dynamics**

| A | B | C | D | E | F |
|---|---|---|---|---|---|
| Month | Weight/ Cow | Weight/ Spring Calf | Weight/ Fall Calf | Weight/ Bull | Weight/ Feeder |
| February | 1,000 | 0 | 227 | 1,500 | 0 |
| March | 1,000 | 90 | 272 | 1,500 | 0 |
| April | 1,000 | 136 | 318 | 1,500 | 450 |
| May | 1,000 | 181 | 364 | 1,500 | 496 |
| June | 1,000 | 227 | 409 | 1,500 | 541 |
| July | 1,000 | 272 | 455 | 1,500 | 587 |
| August | 1,000 | 318 | 0 | 1,500 | 632 |
| September | 1,000 | 364 | 0 | 1,500 | 678 |
| October | 1,000 | 409 | 0 | 1,500 | 724 |
| November | 1,000 | 455 | 90 | 1,500 | 769 |
| December | 1,000 | 0 | 136 | 1,500 | 815 |
| Avg. Monthly Wt. | 1,000 | 204 | 204 | 1,500 | 632 |

NOTE: Bull and cow weights are held constant; calf and feeder weights are adjusted for growth on a monthly basis.

Calculation Descriptions:
B=1,000 Lbs./Cow Avg.
C=90 Lbs./Calf Avg. @ Birth; Increase Each Month 1.5 Lbs./Day*30.4 Avg. Days/Month
D=90 Lbs./Calf Avg. @ Birth; Increase Each Month 1.5 Lbs./Day*30.4 Avg. Days/Month
E=1,500 Lbs./Bull Avg.
F=Enter Lbs./Feeder Avg. @ Introduction; Increase Each Month 1.5 Lbs./Day*30.4 Avg. Days/Month

**Table 4: Estimated Grass Production vs. Consumption**

| A | B | C | D | E | F |
|---|---|---|---|---|---|
| Month | Percent Production | Monthly Production (lbs. Forage) | Total A.U.M.s by Month | Monthly Consumption/ Wastage (lbs. forage) | Cumulative Production (lbs. Forage) |
| January | 0.0% | 0 | 874 | 770,926 | -770,926 |
| February | 0.0% | 0 | 874 | 776,330 | -1,547,256 |
| March | 12.5% | 2,294,748 | 1,082 | 824,401 | -76,909 |
| April | 25.0% | 4,589,496 | 1,082 | 851,423 | 3,661,163 |
| May | 25.0% | 4,589,496 | 1,183 | 950,763 | 7,299,895 |
| June | 12.5% | 2,294,748 | 1,183 | 984,439 | 8,610,204 |
| July | 0.0% | 0 | 1,183 | 1,018,115 | 7,592,089 |
| August | 0.0% | 0 | 1,131 | 992,485 | 6,599,604 |
| September | 12.5% | 2,294,748 | 1,131 | 1,020,756 | 7,873,595 |
| October | 12.5% | 2,294,748 | 1,131 | 1,049,028 | 9,119,315 |
| November | 0.0% | 0 | 1,183 | 1,087,966 | 8,031,349 |
| December | 0.0% | 0 | 975 | 884,417 | 7,146,932 |
| Annual Totals | 100.0% | 18,357,982 | 13,010 | 11,211,050 | 7,146,932 |

Calculation Descriptions:
B=% of Vegetation Production Prorated by Growing Season
C=B*Table 1 D Total
D=Monthly Value from Table 2 H
E=(Table 2 C*Table 3 B*3%*30.4 Avg. Days/Month)+(Table 2 D*Table 3 C*3%*30.4 Avg. Days/Month)+(Table 2 E*Table 3 D*3%*30.4 Avg. Days/Month)+(Table 2 F*Table 3 E*3%*30.4 Avg. Days/Month)+(Table 2 G*Table 3 F*3%*30.4 Avg. Days/Month); 3%=2% Consumption+1% Wastage per Day
F=C-E

## Table 5: Pasture Management Methods Cost Comparison

| Pasture Management Method | Fertilizing | Liming | Cut/Bale/ Stack | Bush Hogging | Burning | Pasture Improvement Interseeding | Cost/ Acre | Grazing Area Estimated Annual Cost |
|---|---|---|---|---|---|---|---|---|
| Hay Harvesting | ($40.00) | ($8.75) | $12.50 | n.a. | n.a. | ($1.67) | ($37.92) | ($142,188) |
| Hay Harvesting (Sharecropper) | ($40.00) | ($8.75) | $25.00 | n.a. | n.a. | ($1.67) | ($25.42) | ($95,313) |
| Brush Hogging | ($40.00) | ($8.75) | n.a. | ($15.50) | n.a. | ($1.67) | ($65.92) | ($247,188) |
| Burning | ($40.00) | ($8.75) | n.a. | n.a. | ($1.82) | ($1.67) | ($52.23) | ($195,881) |
| Grazing | n.a. | n.a. | n.a. | n.a. | n.a. | n.a. | $0.00 | ($10,400) |

Notes:
1) An average hay production of 2.5 tons per acre per year was used.
2) The grazing area included 3,750 acres.
3) Burning costs are highly variable depending upon the size of the burn area, fire control equipment available, and local labor rates.
4) Hay costs $25.00 per ton to harvest and sells for $30.00 per ton.
5) The estimated annual cost for grazing allows one day per week of employee time to monitor grazing that would not otherwise be required.

grazing partnerships can be formed with qualified participants, cost effective management of cool season fescue/legume pastures can be realized. Compared with conventional reclaimed pasture management methods used at Midway Mine, high intensity, short duration rotational grazing is now preferred.

Properly managed rotational livestock grazing improves pasture management efficiency and timeliness. Improvement is realized because livestock will consume the grazing cell's vegetation, whereas third party human harvesters may not be motivated or prepared to timely harvest hay crops. Removal of vegetation is controlled directly by the company through timing and selection of grazing cell rotation. The influence of inclement weather and associated ground conditions has less influence on the timeliness of or ability to harvest hay crops. Livestock stocking levels may be varied to retard or accelerate harvesting, thus ensuring that the entire crop is harvested while allowing protection against potential adverse site impacts. The grazer is also responsible for mowing weedy areas or other areas that are not adequately grazed, which ensures that these areas are properly managed and improved.

Grazing costs are about one-tenth that of the second best economic choice, sharecrop hay harvesting. Costs of harvesting, storing and selling the hay crop are avoided. Destructive crop harvesting methods (brush hogging and burning) are as much as 25 times the cost of grazing on a per acre basis. The grazer assuming the cost of pasture fertilization removes a significant annual operating expenditure. The cost of repairing small rills and gullies has also decreased significantly. The herd tramping effect has filled in or reduced these features. The hoofing action described above has also served to establish vegetation in these features that in many cases should prove capable of stabilizing them against further excessive erosion. In some cases, big round hay bales have been placed along larger rills and gullies for feeding purposes, effectively serving to repair these features.

There are resource considerations associated with using rotational grazing as a pasture management tool. Management demands additional labor, since time is required to monitor livestock impacts on grazing cells to ensure proper livestock management and grazing cell rotation. Significant amounts of time may be spent performing management activities, particularly during periods of inclement weather, when smaller sized grazing cells are used or when stocking rates are elevated. These manpower requirements usually do not represent significant costs, but need to be considered when developing grazing programs.

Regular periodic inspections of the grazing area have been conducted allowing a qualitative review of rotational grazing effects. Qualitative observations suggest, and evaluation of data contained in Part II of this paper documents, that grazing has benefited the reclaimed cool season pasture physically and biologically. Qualitative observations correlate with the quantitative information and reinforce the biological and environmental desirability of this management method. Qualitative observations are also an important aid in evaluating the overall success of using grazing as a reclaimed pasture management tool.

Livestock wastes return nutrients to the soil and represent a significant source for reintroduction of soil microorganisms. Increased microbial activity serves to accelerate decomposition of livestock wastes and plant litter. Increased organic matter is thereby incorporated in the topsoil which in turn improves its ability to promote vegetative growth. Soil fertility and nutrients available for plant uptake are increased. The value of forage is improved with increased nutrient content.

Vegetation productivity and cover, and weed control are improved. Livestock trampling creates small surface depressions similar to a land imprinter, particularly when the soil is moist or wet (Savory 1987). These serve to harvest precipitation runoff, improving infiltration and increasing soil moisture. Increased soil moisture promotes the growth of vegetation. Seed germination has benefited by livestock activity, with seeds being firmed into the soil, thus improving germination and survival. Additionally, trampling acts to break apart perennial grass rhizomes and stimulate new growth in overly mature grass plants. The number of mature plants to seedlings and new vegetative growth occurring from asexual vegetative mechanisms has increased and improved vegetative cover and production. Increased rhizomatous growth of grass plants reduces the presence of weeds which invade when pastures are not regularly harvested.

Livestock grazing has also introduced some new problems into the management of reclaimed lands. The largest of these stems from the fact that grazing has worked well and land owners are anxious to regain use of leased or newly acquired lands. P&M has had difficulty in keeping up with requests to set up additional grazing programs. Ongoing land sales within the mine area have also exacerbated this situation. Education of the landowners regarding the requirements of grazing on lands regulated under primacy SMCRA programs is time intensive. Regulatory approval processes and requirements often appear unresponsive and excessive to potential grazers who are unfamiliar with SMCRA. Rotational grazing realizes greater management and economic benefits on a larger rather than smaller scale. Many landowners requesting grazing programs own acreage too small for P&M to realize rotational grazing's economic benefits. The additional costs of developing and overseeing grazing plans on small acreage are not justifiable to P&M and difficult for some landowners to accept.

Significant physical problems have not occurred. Some excessive trampling of limited extent, resulting in temporary removal of vegetation cover, has occurred around water sources, mineral supplement licks and along fencelines. Water corridors frequently are temporarily denuded, particularly when soil moisture is higher and the ground is soft. Spreading mulch during corridor use and immediately after usually results in rapid regrowth of grass in these areas. To date it has not been necessary to gravel any of these corridors to achieve stable slopes. Vegetation denuded around nutrient licks rapidly recovers when the lick is either depleted or moved. Cattle trails along perimeter fencing and frequently traveled routes have been established. Evidence of these trails remains long after the livestock has been removed. Vegetation in these areas usually regrows, but is usually less vigorous than surrounding areas, probably due to soil compaction. In a few limited instances it has been permanently denuded. Cattle trails are small in area and are inevitable features in the postmining landscape where livestock are to be introduced. Regulatory acceptance of these features has proven difficult to obtain although 100 percent ground cover is not required for these pastures. A side benefit of introducing livestock before final bond release is that corrective measures may be undertaken to repair problem areas created by the livestock. This helps to ensure the long term stability of reclaimed lands where the landowner plans to graze livestock.

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