ANL/LRP-TM-9

LAND RECLAMATION PROGRAM

ARGONNE NATIONAL LABORATORY

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LAND RECLAMATION LABORATORY

JIM BRIDGER MINE SITE
DESCRIPTION OF RESEARCH

Becky B. Green: Site Coordinator

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ABSTRACT

Four subprojects have been developed for the Jim Bridger Mine near Rock Springs, Wyoming. This research addresses the problems associated with vegetative response to stressed environments, water availability in reclaimed spoils, refaunation dynamics, and snowpack management for reclamation. A fifth project, soil microbiota recovery dynamics, will also be done at the mine site.

Research on vegetative adaptations to stressed ecosystems concentrates on productivity, population dynamics and energy allocation strategies as indicators of plant response to stress. Water availability studies address erosion and spoil moisture characteristics of the native ecosystem and selected reclamation treatments. Design snowfence systems studies will develop methodologies to maximize the amount of the precipitation which is available to vegetation.

Animal species composition and density on revegetated areas are also being examined. Wildlife studies are also investigating the impacts of small mammals on revegetation. The microbiological component of topsoil is being investigated in stored and native topsoil. These experiments are designed to provide insight into the reclamation of communities, not just revegetation of mine spoils.

1. INTRODUCTION

Mining for coal is obviously on the increase in the United States, and some states, of which Wyoming is one, are scheduled to double or triple their coal production over the next 5 years. Due to its high potential production, therefore, Wyoming has been identified by the Land Reclamation staff as a high priority research area, and 3 sites have been selected in the state. Two of the sites, the Big Horn Mine near Sheridan and the Black Butte, will be discussed by Drs. Richard Olsen and Michael Miller, respectively, in other proposals. A third site, the Jim Bridger Mine near Point of Rocks, is the subject of this proposal.

The Jim Bridger Mine is located in the Green River Region 5 miles north of Point of Rocks and is operated by the Pacific Power and Idaho Energy Resource

Company. Production, which began in 1975, rose to 2.5 million tons in 1975; it is expected to reach 6.5 million tons annually by 1979. Two seams of low sulfur bituminous coal (9,350 Btu/lb) provide coal for three 250 megawatt generators operating on site. Currently, the mine disturbs approximately 100 ac/yr.

Precipitation varies between 6" and 8" annually. The topography is rolling with draws and buttes, typical of southwestern Wyoming. The average slope is approximately 30%. Current land use is winter range for sheep and wild horses. Vegetation is sparse, and consists mainly of brush species (*Atriplex* spp. and *Artemisia* spp.) and some native grasses. The Jim Bridger site is of particular interest because it is a mine-mouth operation and will provide an opportunity to examine a broad range of health and environmental impacts from the combined cycle operation. In addition, waste products can be examined for their potential use as soil amendments during reclamation.

2. DESCRIPTION OF SUBPROJECTS

There are four subprojects which have been initiated at the Jim Bridger Mine. These efforts address the problems associated with vegetative response to stressed environments, water availability in reclaimed spoils, refaunation dynamics, and snowpack management for reclamation. The first two projects were initiated during the 1976 growing season; the third and fourth will be initiated in the winter and spring 1976-1977. A fifth project which will examine spoil microbiota is also discussed. All of these subprojects will be implemented in the same treatments, making the data gathered in one applicable to any other. A native and a reclaimed site have been selected which have similar slope and aspect. The treatments in the reclaimed area include stored topsoil applied directly over minespoils, direct applied topsoil over minespoils (i.e. no storage period), and straw mulch applied over direct applied topsoil over minespoils. A bare spoils treatment was planned, but initial observations made by Argonne scientists indicated that revegetation was unsuccessful on untreated spoils. The snowfence subproject which will be discussed will be used as another minespoils treatment.

2.1 SUBPROJECT: VEGETATIVE ADAPTATIONS TO STRESSED ECOSYSTEMS (Principal Investigator: Becky B. Green)

Introduction

Ecologically, the greatest concern over the development of the United

States' coal reserves has been with the feasibility of restoring biota on mine spoils. Most recently, this concern has manifested itself in vegetation trials: growing species under selected treatments to determine which is the most effective. This research (e.g., Hodder, Sindelar, and Buckholz 1972; Sindelar, Hodder, and Majerus 1973; Balzer, et al. 1975; Vogel 1973; etc.) has shown that mine spoils can be reclaimed. It has emphasized overburden management, soil amendments, irrigation, and species selection. There has been far less work, however, in understanding the dynamics of plant response to the stressed conditions found on mine spoils.

With the development of trophic level theory and the concept of community dynamics (Lindeman 1942) the importance of primary productivity in maintaining community diversity and equilibrium has been recognized. Information on seasonal increments and biomass accumulation has led to a better understanding of organic turnover, mineral cycling and energy flow (Kucera, Dahlman, and Koelling 1967). Research of this type, while it has not yet been applied to stressed systems, is basic to our understanding of the dynamics of establishing and maintaining reproducing communities on toxic materials.

Researchers in England and the eastern United States have been studying the genetics and population dynamics of plants on spoils contaminated by heavy metals (e.g., McNeilly and Bradshaw 1968; Antonovics 1972) and have shown definite selective responses by the stressed populations. Three major indicators of stress in plant populations appear to be reproductive patterns, productivity, and energy allocation. The first and last of these are genetically controlled and are subject to natural selection. Changes in productivity and yield are generally phenological responses that indicate stress but are not necessarily the result of genotypic alteration. This proposal will address vegetation response to stressed conditions as measured by the above three characteristics: reproductive patterns (population dynamics), productivity, and energy allocation. Although the research performed under this proposal will be limited to studies on communities affected by coal mining, the principles of plant response under these conditions will be applicable to other stressed environments. This research is aimed at identifying basic principles of adaptation and survival of native species under stressed conditions.

Scope

In order to draw conclusions about plant responses to stressed conditions in general, specific information on the comparative response of selected species under stressed and nonstressed conditions is required. This study will compare the responses of selected native species at the Jim Bridger mine in Wyoming. The research will be coordinated with other efforts in the ERDA-funded Land Reclamation Laboratory to take advantage of data from ongoing studies.

Studies performed under this proposal will include productivity, population dynamics and energy allocation research. Since grazing by big game and livestock is the primary land use in the area, the species studied will be selected with bias toward range requirements. Species will be selected from sites that are currently being mined. Concurrent studies on spoil manipulation and hydrologic relationships will provide sites for the study. Valuable data on species response to mining and reclamation practices can be gathered from these sites.

The objectives of this study are to:

1. Identify and quantify the adaptations of plant species to stressed environments through studies on productivity and population dynamics.
2. Identify and quantify energy allocation strategies in stressed and nonstressed plant populations.

This research will be, of necessity, long-term. The proposed length of time is six years. Most of the plants which are important to a sound reclamation program are perennials, which require at least three years to reach reproductive maturity. In addition, there is another critical question which must be addressed by a long-term study. Reclamation bonds are based on a one- to two-year test period. During this time, none of the perennial species will have reached maturity, and no judgments can be made on whether or not the community will reproduce itself. Studies on population dynamics and productivity which are conducted as part of the proposed research will yield valuable information in this area.

Implementation

The study will be divided into four parts: (1) monitoring, (2) productivity analysis, (3) population dynamics studies, and (4) energy allocation strategies.

The site for the proposed research has been identified. The native plant communities, both shrub and grass, are located on a southwest-facing slope at the Jim Bridger Mine. Directly behind them about 700 m are regraded spoils which have similar slope and aspect. These spoils were seeded in the spring of 1976 with an assortment of surface treatments including straw mulch, pitting and topsoil.

Monitoring. This phase of the proposed research includes the installation of the necessary monitoring equipment. A precipitation gage has been installed with a long-term event recorder to measure snow- and rainfall. Temperature is currently being monitored only by a maximum-minimum thermometer. In the spring of 1977, double-junction soil psychrometers will be installed at 10 and 30 cm to monitor moisture availability. These instruments will be attached to a long-term data logger which will also monitor air temperature and net radiation. The research will also examine the relationship between soil temperature and albedo, two important parameters on mine spoils. These factors are of particular concern on bare spoils.

Tasks -- The following tasks will be performed under this phase of the research:

1. Identify equipment required for a monitoring program.
2. Install monitoring equipment.
3. Monitor selected environmental parameters.

Productivity Analyses. Productivity analyses are used as a measure of the amount of biomass produced by the primary producers in an ecosystem. They provide a baseline from which to examine the functional aspect of a community (Wiegert and Evans 1964). This reseach will use productivity analyses to compare biomass production, which is a measure of energy fixation, of stressed and nonstressed communities. Since the amount of energy available to consumers is dependent upon primary productivity, this is an important factor.

Methods. Quadrat size for productivity sampling was determined to be 1 m^2 following Wiegert (1962), and baseline samples have been collected from the native grassland community. Mine spoil productivity will be sampled twice a year beginning in the spring of 1977 concurrently with the native ecosystem. There are 2 replications of 3 samples in each treatment. The standing crop is clipped at ground level in each quadrat; all other material is collected as litter. Biomass is separated into three classes: (1) standing live, (2) standing dead, and (3) litter. Shrub biomass will be sampled along transects using a size/biomass curve developed for each species. These curves will be determined in the spring of 1977 following Ludwig and Reynolds (1975).

Root biomass is measured by placing a 0.05 m^2 quadrat at four locations in each treatment. All surface herbage will be removed. Soil and roots will then be excavated to a depth of 60 cm. Roots will be separated from soil by washing and floatation; they will then be dried and weighed. Root biomass samples will be taken twice, once in the spring and once in the fall.

Paired plots will be placed in each treatment to measure the disappearance rate of dead material (Wiegert and Evans 1964). There will be 8 locations in each treatment for each sampling interval. Sampling intervals will be April 12 - June 14 (63 days), June 14 - September 9 (87 days), September 9 - October 7 (28 days), and October 7 overwinter.

Tasks. The following tasks will be performed under this phase of the research:

1. Sample Site Selection. Sample sites will be selected on mine spoils and in native vegetation. Completed task 9/76.
2. Sample Size Determinations. Quadrat size for the clipping studies will be determined for each research site after the method of Wiegert (1962). Completed task 6/76.
3. Set up Dead Material Disappearance Plots. Sample areas with similar community composition and similar amount of dead material will be selected. Samples will be taken as described above.
4. Standing Crop Measurements. All above ground biomass will be removed from the sample quadrats and separated into living and dead material. Roots will be removed from a predetermined amount of soil. Biomass estimates will be made on dried material.

Population Dynamics Studies. Population dynamics studies were orginally designed by zoologists and wildlife managers to study animal populations. In most cases, stress will appear in the form of increased mortality and a skewed population structure. Recently, population studies have been applied to plants to better understand their longevity and reproduction dynamics (Tamm 1948, 1956; White and Harper 1970; Antonovics 1972; Sharitz and McCormick 1973).

Methods. The first 2 growing seasons emphasize species selection for population dynamics studies. Phenological measurements are being made, and a phenological index (West and Wien 1970) will be constructed for species which have been seeded on the mine spoils. Native populations will be used in constructing the indices. Twenty individuals of each species selected have been marked in each treatment; their phenological stage will be noted monthly. The above data will be used to construct life tables (Sharitz and McCormick 1973).

Tasks. The following tasks will be performed under this phase of the proposal:

1. Make Phenological Measurements. Selected grass and shrub species will be analyzed for phenology. Phenology indices will be constructed for these species.
2. Select Species. Two species, one grass and one shrub will be selected from those studied under Task 1 above.
3. Mark and Locate Individuals. Individuals in established and newly seeded populations will be marked and located on a transect. Several samples will be taken throughout the growing season for at least four years. Estimates will be made on density and seed production at the same time.
4. Construct Life Table. Using information gathered from the above tasks and from other research in this proposal, a life table will be constructed. Life table components will be estimated following Sharitz and McCormick (1973).

Energy Allocation Strategies. Studies on energy allocation strategies and their evolutionary significance are of recent origin. Given the discreet amount of energy fixed by the plant, this amount must be sufficient for growth, reproduction, and defense. In a stressed system, an individual may be required to expend more effort for defense or growth and less on reproduction, for example. Studies on energy allocation in plants can give an excellent indication of plant responses to stressed environments.

Methods. Calorimetric measurements will be performed on the material collected for biomass determinations. Plant materials will be divided into inflorescense, fruit, seed, vegetative, root, and litter fractions. These fractions will be dried and weighed separately. After biomass has been determined (see above "Productivity Analyses"), the caloric content of each fraction will be determined using a bomb calorimeter. Total ash content will be determined as well.

Tasks. The following tasks will be performed under this phase of the research:

1. Select Species. The species selected under this task will be those used in the productivity studies discussed above.

2. Determine Caloric Content. Caloric content of different plant parts will be determined.

3. Determine Allocation. Using caloric measurements and morphological characteristics (e.g., number seeds, number vegetative progagules, number stems), energy allocation strategies will be determined.

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2.2 SUBPROJECT: ASSESSMENT OF WATER AVAILABILITY THROUGH SELECTED SOIL AMENDEMENTS AND SURFACE MANIPULATIONS (Principal Investigator: Stanley D. Zellmer)

Introduction

Fresh spoils, even though they are topsoiled and regraded to the original topography, can be expected to have different physical and chemical characteristics than the original soils. The heavy equipment used in the final reshaping of spoils not only creates new slopes, but also changes water infiltration and percolation rates. These factors, combined with the lack of vegetation, accelerate erosion and surface runoff. Any increase in mining activities must therefore be accompanied by the development of reclamation techniques which will reduce environmental impacts and return the mined area to a productive use.

One of the biggest problems in reestablishing vegetation in arid regions is the limited amount of available soil moisture for plant growth (May 1975). Other investigators (e.g., Hodder, Sindelar, Buckholz, and Ryerson 1972); Sindelar, Hodder, and Majerus 1973) have shown that revegetation of surface mined spoils is possible. Their work has included various surface manipulations and selected species in an area which receives 11 to 13 inches of annual precipitation. These methods of surface manipulation, as well as alternative soil amendments (including mulches of various types), must be evaluated in areas with low (6 to 8 inches) amounts of annual precipitation.

Scope

The evaluation of various surface manipulations and soil amendments can only be done under field conditions. The Jim Bridger Mine, located near Point of Rocks, Wyoming, is well suited for such field evaluations. Annual precipitation averages 7.1 inches; 60% of this is in the form of snow.

Research performed under this proposal will evaluate the effects of various surface treatments on physical soil factors and erosion rates. Surface treatments tested will include hay mulch and pitting and harrowing. An automated system of soil psychrometers will be installed to monitor daily changes in soil moisture and temperature at various depths within the root zone. Erosion measurement plots will determine relative rates of erosion and runoff water quality and quantity form each study area.

The objectives of the study are to:

1. Evaluate various soil amendments and surface manipulation treatments as to the effectiveness in controlling erosion and surface runoff.

2. Determine the changes occurring in soil temperature and soil moisture as a result of various surface manipulation and soil amendments.

The research proposed here will be long-term and monitoring programs will be maintained for a minimum of four years. This length of time will be necessary to determine if erosion rates are minimized.

Research Plans

The research efforts will be divided into two phases. Phase I will include: the selection of a study area, initial field testing and sampling, the installation of erosion, soil moisture and temperature monitoring equipment, and the laboratory analyses of field samples.

Phase II of the program will consist of: yearly field testing and sampling, laboratory analysis of samples, maintenance of monitoring systems, and the evaluation of data collected. At the end of each growing season, data will be summarized and a progress report issued.

Phase I. The following tasks will be completed under Phase I:

1. Study Site Selection. An area will be selected, within the study site and a mined or spoil study site. Important factors which will be considered in the selection of the area include: slope angle, slope aspect, overburden characteristics, and availability of the area to range stock. It is important that differences in slope angle and slope aspect be kept at a minimum. Large differences in these factors will have a profound effect on soil moisture and soil temperature as well as the vegetative aspects of the study. The unmined area will provide a study site with native vegetative cover, as well as an area which has had the topsoil removed. This topsoil will be transported to the nearby spoil area and used as one of the surface treatments on the spoil or mined study site. Other treatments and amendments tested will include: coal as a mulch worked into the spoil surface, hay mulch, spoils pitted and harrowed. Each study site will be a minimum of one half acre. Study sites will be arranged to run the length of the slope, with no study site above another

on the slope. The reclamation coordinator of the Bridger Coal Company will determine the type of treatment and location of study sites. Only treatments which he feels can be used on mine scale operations will be tested. Grading, seeding, and any other reclamation operations will be done under the supervision of the reclamation coordinator of the Bridger Coal Company.

This task was completed in 6/76.

2. Installation of Monitoring Equipment. A remote recording gage will be installed near the study sites to measure the intensity and duration of rainfall. Three erosion measurement devices will be constructed in each study treatment. These devices consist of a low sheet metal frame, a collector made of sheet metal at the downslope end, and a storage tank. The area enclosed is 4' x 10.89' (43.56 ft^2 or .001 ac). The storage tank is a 32 gal steel GI can with a plastic liner. All runoff and sediment from the enclosed area is directed to the storage tank where the volume will be measured and samples taken for laboratory analysis. Care will be taken to coordinate these devices with the vegetation sampling but to not interfere with the effort. A system of soil psychrometers will be installed in each treatment. Soil temperature and water potential will be monitored every 12 hours at two levels within the root zone (10 and 30 cm). Air temperature above the soil surface will be monitored on all study treatments. Three psychrometers will be placed at each depth on each treatment to provide replicated measurements.

   Additional monitoring sensors (net radiometers) will be added to this system for the vegetative portion of the study. All monitoring equipment and its installation will be provided by Argonne National Laboratory.

   The precipitation gage has been installed as have runoff plots on the native sites. Additional equipment and runoff plots will be installed in spring 1977.

3. Field Testing and Sampling. Water infiltration rates and bulk density will be determined for each study site. Standard methods, as described by Bertrand and Blake (1965) will be used. A minimum of three determinations will be made for each test on each study treatment.

   Samples of surface material and at selected levels within the root zone will be collected for later laboratory analysis. A minimum of three samples will be taken from each study treatment.

4. Laboratory Analyses. Various physical properties of the samples collected in the field will be determined in the laboratory. Physical properties measured will include particle size distribution and particle density using

method described by Day (1965) and Blake (1956). Soil moisture retention curves (.3 atm to 15 atm) will be developed using a pressure membrane extractor.

For each surface and for selected subsurface samples, the following chemical characteristics will be determined: pH, NO_3, P, K, Ca, Na, Mg, percent organic matter and soluble salts by electrical conductivity. One surface sample from each treatment area will be subjected to detailed analysis for all essential plant nutrients, heavy metals, and other potential pollutants. Additional samples may be chemically analyzed for elements which appear to have high concentration in the initial study. Surface samples may be analyzed for phyto-toxic elements if the vegetation studies indicate the need.

Phase II. The second phase of the study will include the long-term monitoring, yearly field testing and sampling, laboratory analysis of samples and evaluation of data collected. The following tasks will be performed under this phase.

1. Erosion Monitoring. The volume of runoff water and sediment collected by the erosion monitoring equipment will be determined after each storm event which produces runoff. Samples will be taken from the storage tanks and a detailed chemical analysis will be made on the first few samples from each study treatment. Particle size distribution will be made on sediment collected. The results of these determinations will define the type and extent of chemical analyses done on future runoff samples. These data will be used to evaluate each treatment's effectiveness in controlling erosion and general runoff quality. This monitoring will be done over a four-year period to determine changes over time.

2. Soil Moisture/Temperature Monitoring. As stated in Phase I, Task 2, daily measurements of soil moisture and temperature will be taken at various levels within the root zone at the treatment sites. The soil psychrometers will be cleaned and calibrated before the start of each growing season. The data collected will be used to evaluate the effect each treatment has on soil temperature and soil moisture. This information will also be used, when combined with runoff and precipitation data, to determine the fate of water which infiltrates the surface of the study treatments.

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2.3 SUBPROJECT: DESIGNED SNOWFENCE SYSTEMS FOR INCREASED SEEDLING ESTABLISHMENT ON STRIPMINE SPOILS (Principal Investigator: Dennis T. Cleaves and Becky B. Green)

Introduction

With the increased activity of surface coal mining to meet the U.S. energy demands, it is becoming more imperative to find rapid and efficient methods to reestablish vegetation on the resultant minespoils, especially in the arid and semi-arid regions of the western United States. The single most limiting natural resource and thus the greatest obstacle to revegetation is water. Several difference procedures are being tested or have been suggested to increase soil moisture on newly seeded spoil material. These include catchments, irrigation with pit water (when available), and surface manipulations. Catchments and surface manipulations are of minimal value in areas that receive 10 inches of precipitation a year or less. Pit water (and blow down water) is generally of such poor quality that only small amounts can be used and for only a short period of time. Irrigation equipment and labor costs are also prohibitive.

In the western states (Wyoming, parts of Montana, Colorado, Idaho, Utah, North and South Dakota) from 35 to 65% of the annual precipitation occurs as snow. Winds that accompany these snows cause significant relocation and sublimation resulting in a serious decrease in the amount of spring moisture available for plant growth. Use of precipitation in the form of snow may well be a partial answer to the problem of plant establishment on minespoils (May

1970). It is essential to consider all parameters and provide accurate baseline data before specifically designed snowfence systems can be proven effective (Tabler 1971a, 1971b, 1972).

This project will investigate the effectiveness of designed snowfence systems for control of snow that would normally be blown over mine spoils and subsequently be lost to plant growth.

Scope

Snowfences have been used on native and agricultural ecosystems in the past for a longer snowpack or to supplement late summer streamflow. May, et al. (1971) discuss the use of snowfences for increased water to reclamation plots and noted that numbers of seedlings were higher on sites where snow had accumulated than on sites where it did not. The proposed research will investigate the efficency of snowfence systems designed specifically for a given site in increasing moisture content and seedling establishment on mine spoils. Studies will include baseline weather monitoring, soil and vegetation studies. Estimates will be made on the cost-effectiveness of snowfences systems for reclamation in the semi-arid West.

The objectives of the proposed research are:

1. To develop usuable methods for site-specific design of snowfence water accumulation and distribution systems for use in reclamation,
2. To determine whether snow accumulated by snowfences can significantly increase seedling establishment and soil moisture on mine spoils, and
3. To evaluate the cost-effectiveness of snowfences in aiding reclamation.

Implementation

The study will be divided into 3 phases: (1) site selection and systems design, (2) establishment and production studies, and (3) surface manipulation and sedimentation/runoff research.

Site Selection and System Design. This phase on site selection and system design includes one winter of baseline weather data which will be used to select an appropriate test site and to design the system. Tasks which will be performed under this phase include the following:

1. Determine on-site prevailing wind direction and velocity. Wind direction and speed will be measured during the snow months (November through March) using a long-term event

recorder in conjunction with a three-cup anemometer and a vane.

2. Monitor precipitation and snow accumulation. Precipitation will be monitored as discussed in preceeding subprojects. Snow accumulation transects will be laid out to the windward of the site and monitored monthly to determine snow storage.

3. Select study site and design snowfence system. Based on the above data a site will be selected for snowfence installation. The fence will be designed to provide maximum snowpack for the site.

4. Construct snowfence system. The snowfence will be constructed in the fall of 1977 according to the design in Task 3.

Establishment and Production Studies. First-year comparisons of seedling survival and establishment will be made between the snowfence treated site and other reclamation treatments. Soil moisture will be monitored on snowfenced sites and will be compared with soil moisture data gathered from other reclaimed and native sites for the preceeding subprojects. At the end of each growing season, annual biomass production will be measured following clipping procedures outlined in the subproject on vegetative establishment. The tasks which will be performed under this phase are as follows:

1. Measure seedling establishment. A minimum of fifteen 1 m^2 quadrats (2m x .5m) will be used on reclaimed, snowfenced and native sites to count seedling establishment. These plots will be monitored monthly.

2. Monitor soil moisture. Soil moisture will be monitored gravimetrically every 2 weeks from 15 March through September 30 on the snowfenced site. These data will be compared, using a conversion coefficient, with soil moisture data gathered on reclaimed and native areas for concurrent subprojects.

3. Measure total yearly biomass. Biomass will be clipped from the snowfenced site following procedures outlined under the subproject on vegetative response to stress. The data gathered from the snowfenced site will be compared to those data gathered from other reclaimed and native sites to determine differences in biomass production between treatments.

Surface Manipulation and Sedimentation/Runoff Studies. This research on sedimentation/runoff and surface manipulation is designed to complement the subproject on water availability. Identical surface treatments will be used to test for increased infiltration into the spoils. Runoff and sedimentation plots, as described in the preceeding subproject, will be installed. The following tasks will be performed during this phase:

1. Perform surface manipulations. This task will be completed by mine personnel and will include contour furrowing and ripping.

2. Install runoff/sedimentation plots. Runoff/sedimentation plots will be installed as described in the preceeding subproject.

3. Monitor runoff/sedimentation plots. Runoff/sedimentation plots will be monitored and used in conjunction with the preceeding subproject.

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2.4 SUBPROJECT: WILDLIFE STUDIES ON RECLAIMED LANDS AND NATIVE ECOSYSTEMS (Principal Investigator: Ed Pentecost)

Introduction

Although the initial interest in reclaiming strip-mined lands is to establish a vegetative cover, it is also important to determine the suitability of reclaimed areas to wildlife. Few studies have dealt with responses of animals to coal surface mining. For the most part, these studies were concerned with vertebrate populations inhabitating strip-mine overburden in the eastern United States (Yeager 1942, Verts 1957, Brewer 1953, Myers and Klimstra 1963, Kirkland 1976, Sly 1976). Research on the impacts of coal mining and reclamation in the western U.S. is still in its infancy. The U.S. Fish and Wildlife Service is currently funding several multi-year studies in the Northern Great Plains to provide new knowledge and methods to minimize the adverse effects of coal development on fish and wildlife resources (Arron 1976). Many of these investigations will be attempts to quantitatively and qualitatively characterize the wildlife of areas proposed for coal mining.

Scope

The main focus of the research outlined below is to determine the use of reclaimed mine overburden by wildlife at the Jim Bridger mine. Natural vegetation in the vicinity of the mine is sparse and consists primarily of saltbush (*Atriplex* sp.), sagebrush (*Artemisia* sp.) and some native grasses. In addition to the natural fauna expected in an ecosystem of this type the area also provides winter range for sheep and wild horses.

The objectives of this research are:

1. To determine wildlife species composition and density on reclaimed mined lands and adjacent native ecosystems.

2. To determine the impact of small mammals on the early success of vegetation establishment of surface-mined lands.

Implementation

The tasks presented here are concerned primarily with a characterization of the fauna presently occupying reclaimed and natural vegetation at the Jim Bridger Mine. Problems concerning reclamation success relative to particular taxonomic faunal groups will be identified from the results of the FY 77 effort and examined more closely in FY 78.

The following tasks will be performed to characterize the fauna on reclaimed and native sites:

1. Establish small mammal live-trap grid. A live-trap grid will be established in the native and one of the reclaimed treatments. Trapping will occur for 5-7 days at monthly intervals beginning in May and ending in September.

2. Conduct bird census. Birds will be censused in native and reclaimed sites using the Emlen (1971) line transect method. Sampling will be carried out for 7-10 days each month from May to September.

3. Establish pit trap grids. Pit traps will be constructed along 10m x 10m grids in reclaimed and undisturbed sites. Samples will be taken monthly for a 3-5 day period from May to September.

Initial observations by site personnel have indicated that small mammals do impact reseeded areas by consuming seed. In order to better understand the impacts of small mammals on reclaimed systems, the following tasks will be performed:

1. Construct enclosures. Three, $25m^2$ enclosures will be constructed on reseeded surface-mine overburden prior immediately following seeding.

2. Obtain plant production data. Plant productivity will be sampled using methods developed in Subproject I. Samples will be taken from the enclosures and from the reseeded area adjacent to the enclosures. Seedling emergence will also be followed.

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2.5 SUBPROJECT: ASSESSMENT OF VARIOUS RECLAMATION TECHNOLOGIES ON THE RECOVERY DYNAMICS OF THE SOIL MICROBIOTA (Principal Investigator: R. Michael Miller)

Introduction

Reclamation efforts in the Green River Basin are restricted by various environmental factors, the major of which is low annual precipitation (15-25 cm), much of which comes in the form of snow. This factor, along with the short growing season and the high evapo-transpiration rate, make revegetation a formidable challenge. At the same time an effort must be made to identify problems occurring below the soil surface as well. In arid environs the soil microbiota play a very important role in nutrient availability since much of the NH_4-N comes directly from autotrophic nitrogen fixers. Also of major consideration is the fate of the natural fungal populations in the soil, specifically the mycorrhizal fungi which are essential for plant growth. The success of any reclamation technique must reflect the fate of the soil microflora in conjunction with the revegetation process.

The strategy to date in reclaiming spoils has been to cover spoils with soil surface material, fertilize with abundant nitrogen (N) and phosphorus (P), and plant with native species which are presumably already adapted to the environment. Many times, however, proper soil surface material or "topsoil" is lacking. Other times the topsoil may actually be toxic due to salt accumulation. In these cases, different amelioration techniques are necessary. Some success at revegetation has been achieved, however, long-term questions as to stability have not been answered.

The undisturbed natural soils are not sterile; there is, however, a definite vertical decrease in the number and kinds of microorganisms encountered. Thus, it is possible to plant a seed and the seedling will grow because the fungi necessary to form mycorrhizal relationships with the plant are normally in the soil (Gerdemann 1968, Mosse 1973). However, when the origin of the spoil material is from deep within the earth or where the mycorrhizal fungi have died there is no potential mycorrhizal inoculum and the plants cannot develop this association.

This subproject is part of a separate project concerned with microbial development at mine sites in the West and Midwest. It is included here since the data are applicable to the Jim Bridger Project.

Implementation

The microbiota subproject will be concerned with the identification and isolation of bacteria. The roles of nitrogen transformers, specifically the autotrophic nitrogen fixers, will be examined as will the producing power of N and its other forms in soils and spoils. Mycorrhizae are also important components of the ecosystem; their fate and occurrance will also be examined. Soil/spoil physical and chemical analyses required by this subproject will be obtained from Subproject 2.

The tasks performed to meet the objectives of this subproject are as follows:

1. Isolate and identify bacteria. Bacteria will be isolated and identified including plate counts for different numbers of groups of bacteria determined aerobically, anaerobically, and for salt tolerance and temperature optima. The fungi will be isolated and plate counts made. A trapping technique will also be employed. Soil algae, and protozoans will be isolated by incubation of soil in a mineral salt solution (Allen 1957).

2. Identify the role of nitrogen-transformers. The role of autotrophic nitrogen fixers will be examined. Also to be determined for the soils/spoils are NO_3-N producing power and total soil N.

3. Assess mychorrhizae occurance. The fate and reoccurrance of mychorrhizae will be assessed. Roots from plant species encountered will be examined microscopically (Phillips and Hayman 1970). A flotation technique will be utilized to determine the presence of the mycorrhizal propagules in soil samples (Sutton and Barron 1972).

4. Analyze physical and chemical characteristics of the spoils/ soils. Analyses will follow predetermined proceedures (Black 1965a, Black 1965b, U.S. Salinity Laboratory 1954). These analyses will compliment, not duplicate, those performed under Subproject 2.

5. Analyze data. Multivariate analysis techniques will be utilized for statistical analysis of the experimental data. The factors considered important for each sample are soil/ spoil physical, chemical, and microbiological, as well as the faunal and floristic makeup of each of the treatment sites from which samples are collected.

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3. RESULTS

The research performed at the Jim Bridger Mine is designed to provide insight into the problem of reclaiming, not just revegetating, mine spoils. Successful reclamation implies a productive, reproducing ecosystem which requires only management for a specific land use, not continual restoration. As mentioned in the Introduction, previous research has emphasized revegetation trials and spoils manipulation to permit plant establishment. Little attention has been given to the establishment of an ecosystem.

Research at the Bridger mine will also be useful to mining personnel in providing valuable information on reclaiming spoils most efficiently. The snowfence design system in particular is intended to provide efficent water use and reduce the necessity for irrigation.

The establishment of shrubs on western mined lands has also been a problem without irrigation or extensive pretreatment. A better understanding of the responses of forage species (e.g. *Atriplex spp.*) to stressed environments will enable more realistic treatment of these species in the revegetation process.

4. DELIVERABLES

Yearly progress reports beginning in January 1978 will contain data analyses and preliminary observations. The final reports anticipated at this time are:

Subproject 1: Vegetative Adaptations to Stressed Ecosystems.

- Plant productivity in ecosystems stressed by mining coal.

  Final Report - FY 1980

- Plant population dynamics in ecosystems stressed by mining coal.

  Final Report - FY 1981

- Energy allocation by plants in ecosystems stressed by mining coal.

  Final Report - FY 1980

Subproject 2: Assessment of Soil Water Availability

- Assessment of water availability in coal strip-mine spoils in semi-arid ecosystems.

  Final Report - FY 1980

Subproject 3: Design Snowfence Systems for Increased Seedling Establishment on Strip-Mine Spoils

- Snowfence Design for Maximum Moisture Retention in Strip Mine Spoils.

  Final Report - FY 1978

- Effects of snowfence systems on seed germination and seedling survival in semi-arid strip-mine spoils.

  Final Report - FY 1978

Subproject 4: Wildlife Studies on Reclaimed Lands and Native Ecosystems

- Invasion of strip-mine spoils by wildlife in southwestern Wyoming.

  Final Report - FY 1980

- Impact of small mammals on strip-mine reclamation in southwestern Wyoming.

  Final Report - FY 1979

Subproject 5: Assessment of Various Reclamation Technologies on the Recovery Dynamics of the Soil Microbiota.

Output from this research will be discussed by Dr. R.M. Miller in a separate work statement.

Milestones

A. Vegetative Adaptations to Stressed Ecosystems

Monitoring:

a. Identify equipment required for a monitoring program.
b. Install monitoring equipment.
c. Monitor environmental parameters.

Production Analyses

d. Sample site selection
e. Determine sample size
f. Set up dead material disappearance plots
g. Measure standing crop.

Population Dynamics Studies

h. Make phenological measurements.
i. Select species.
j. Mark and locate individuals
k. Construct life tables

Energy Allocation Strategies

l. Determine caloric content
m. Determine allocation

B. Assessment of Water Availability Through Selected Soil Amendments and Surface Manipulations

n. Selection and preparation of experimental area.
o. Installation of monitoring equipment.
p. Field testing and sampling
r. Laboratory analysis of soil samples.
s. Monitor soil moisture/temperature.
t. Monitor erosion and runoff.

C. Refaunation of Ecosystems on Lands Disturbed by Mining

v. Perform wildlife sampling.
w. Compare species composition of reclaimed and native areas.

D. Site Selection and System Design

x. Determine on-site prevailing wind direction and velocity.
y. Monitor precipitation and snow accumulation.
z. Select study site and design snowfence system.
a'. Construct snowfence system.

Milestones (Contd.)

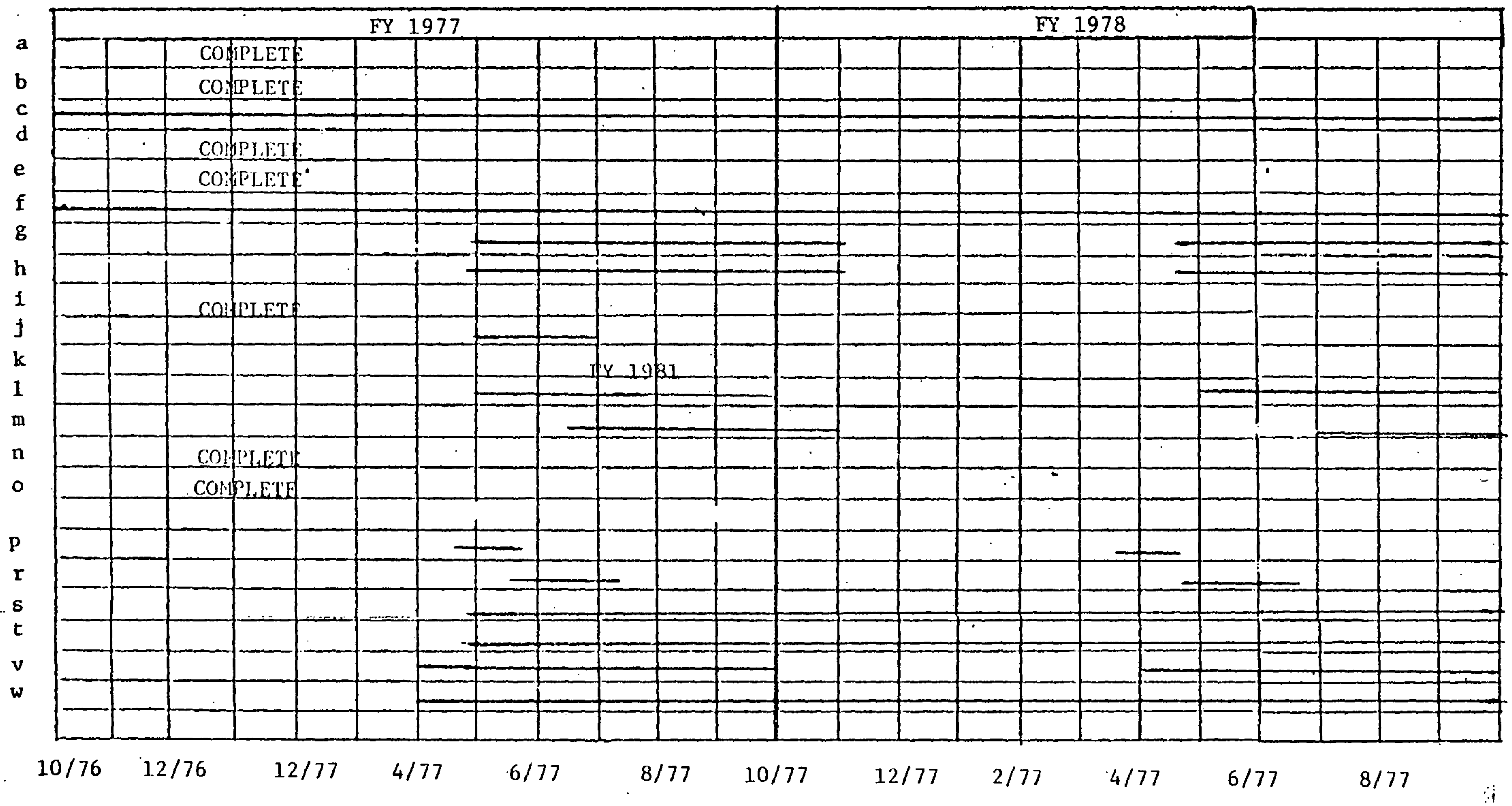
E. Establishment and Production Studies

b'. Measure seedling establishment.
c'. Monitor soil moisture.
d'. Measure total yearly biomass

F. Surface Manipulation and Sedimentation/Runoff Studies

e'. Perform surface manipulations
f'. Install runoff/sedimentation plots.
g'. Monitor runoff/sedimentation plots.

MILESTONES



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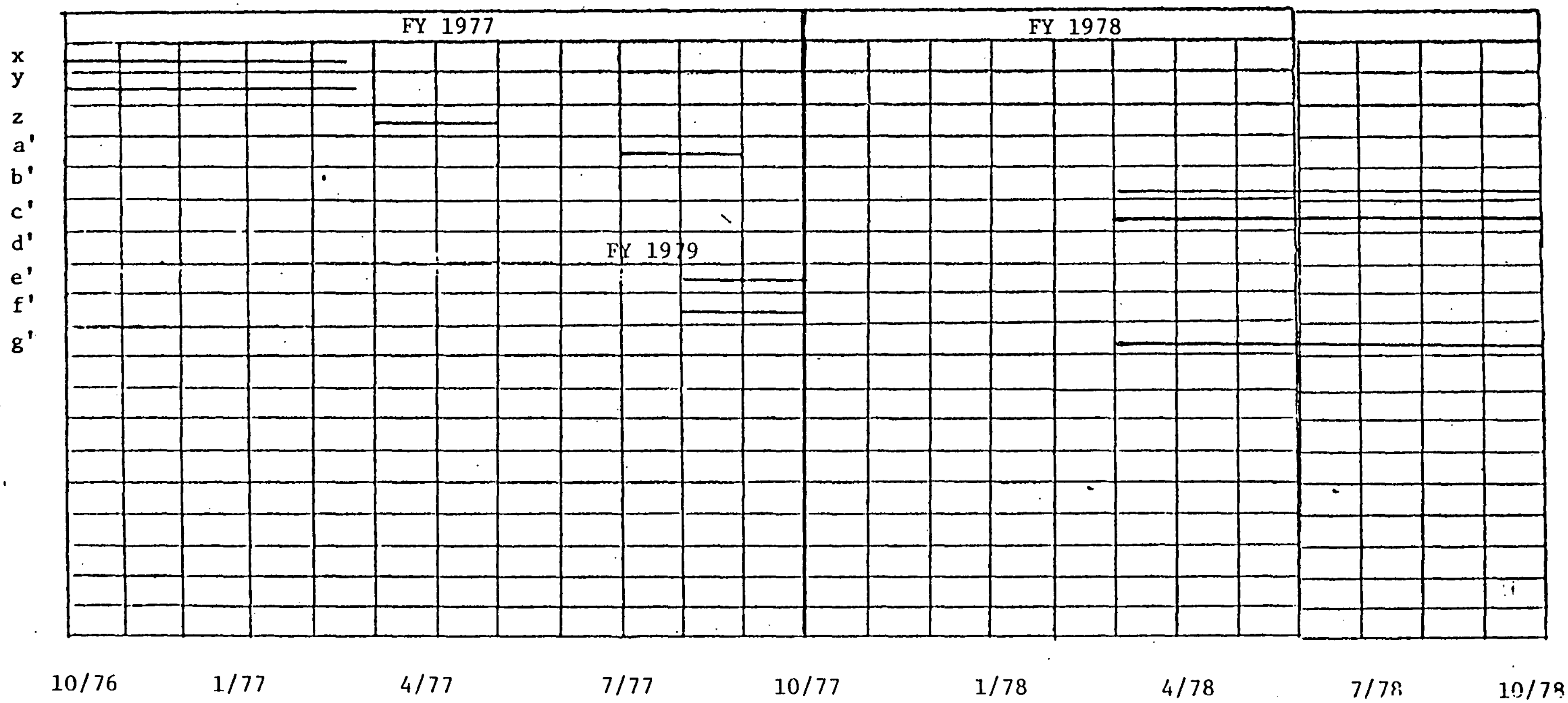
MILESTONES



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BUDGET -- FY. 78

	MY	Dollars (X1000)
Staff		
Green	0.5	25
Zellmer	0.1	4
Technician (Taylor)	0.4	18
Contracted Services		
Cleaves		10
Undergraduate Assistance		9
Travel and per diem		4
Supplies and equipment		4.5
Analyses (M. Master)		2
		76.5