MINED-LAND REVEGETATION STUDIES AND DESCRIPTIVE PREDICTION MODELS

by

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DEDICATION

To Dick, Julie and Leslie for love, faith and support

Chapter 1

INTRODUCTION

> In altering his environment in order to overcome its limitations to him, man learns that he is often faced with the undesirable consequences of environmental change. In manipulating his environment seldom has he foreseen the full consequences of his action. (Van Dyne, 1979, p.73)

Some of the major causes of plant growth failures -- unpredictable precipitation, droughty or impermiable soils, wind and water erosion, toxic or deficient levels of soil components and plant nutrients -- are even more critical on mined lands. Disruptions in plant communities that had previously reached a stage of equilibrium can result in a return to earlier, more unstable, successional stages of community development (Law, 1984). Particularly in arid and semi-arid climates, it can take many years to return to a stable climax community, where the plants can survive cyclical environmental extremes and disruptions. The mined-land revegetation specialist's task is to shorten the time it takes to establish a stable community (Law, 1984) and mitigate the processes that can lead to revegetation failures.

The impetus of recent governmental regulations and an awareness of the importance of preserving natural systems, have focused attention on the special requirements of revegetating mined lands. However, much work needs to be done to determine effective combinations of plant species and cultural practices required for successful revegetation.

Mining, Models and Landscape Architecture

Through the creation of a reclamation committee dedicated to promoting the involvement of landscape architects in the area of surface mining, the American Society of Landscape Architects has recognized the importance of mined-land rehabilitation (American Society of Landscape Architects, 1984). As a member of a rehabilitation team or as a specialist in revegetation, the landscape architect should be aware of the processes of post-mining revegetation; a successful revegetation effort is one of the best measurements of the quality of all of the preceding rehabilitation efforts (Steward, 1984), including regulatory procedures, mining methods, and land configuration.

Mathematical prediction models have proven useful in evaluating post-mining potentials and management alternatives. An understanding of the purpose, structure and processes of creating these models, and a recognition of their advantages and limitations, will make them useful to the landscape architect involved in the revegetation of disturbed lands. However, lack of proper documentation, faulty interpretation and failure to understand the parameters of model building and use can limit their appropriate applications.

Landscape architects, by training and necessity, are users and creators of models. C.T. deWit and J. Goudriaan (1978), in their book Simulation of Ecological Processes, theorized that "a work of art is a model of a conception in the artist's mind." (p.2) If this is true, then all of the essentially "visionary" processes used in the profession of landscape architecture are based upon the principles of modeling. From the first "vision" to the actual completion of a project, landscape architects use prediction models.

The landscape architect is familiar with many types of prediction models, including:

> Physical Models to analyze and use inventoried data -- from bubble diagrams to complex overlay maps, to sophisticated computerized geographical information systems; from corrugated cardboard three-dimensional representations to detailed models that miniaturize reality.

> Mathematical models, based on physical laws, to answer questions about the properties of proposed construction elements -- the strength of a retaining wall to resist natural forces; the ability of a deck to support its intended load; the degree of superelevation for a highway curve; the

amount of water pressure needed for an irrigation system; the correct configuration for a drainage swale.

Models based on experience to help choose alternatives -- lists of plant materials for selected areas; amount of light required for certain activities; percentage of acceptable slope for a ramp.

Physical models, drawings, formulas, nomagraphs, correlation charts, and sorted lists are all forms of models used by landscape architects. Each type of model is based on an analysis of similar factors: climate, soil conditions, intended use, the properties of available materials, design and management factors imposed by the client or the landscape architect. These same factors come into play repeatedly in all models that are related to ecological processes.

The goal of most prediction modeling activities is to provide the best possible solution given the constraints of the project at hand. As optimizers, landscape architects are of the "best fit" mind set; their goals parallel the goals of modeling.

Thesis Objectives

The objectives of this thesis are to develop an understanding of descriptive predictive modeling and investigate the application of modeling to the study of mined-land revegetation. These objectives will be met by researching modeling theory, analyzing a set of prediction models for mined-land revegetation, and testing the usefulness of these models on an existing mined site. The insights and strategies presented should also be relevant to related ecological studies and revegetation programs where the impacts are less severe.

Chapter Summary

Following the introduction, discussion of the relationship of the thesis topic to the profession of landscape architecture, and the statement of objectives in Chapter 1, is a summary of the methods used to develop this thesis. Specific procedures that were used to develop an understanding of the processes of mined-land revegetation and modeling are explained in the applicable chapters. An overview of modeling, including definition of terms, a discussion of the differences between descriptive and theoretical models, modeling procedures and applications, are presented in Chapter 2. Chapter 3 describes a set of descriptive models developed for predicting mined-land revegetation based on a comparison of pre- and post-mining potentials. Belle Ayr Mine, in northeastern Wyoming, was chosen as a test site for the revegetation models. Chapter 4 provides the background information on mining operations, environmental conditions, and the revegetation policies and programs at Belle Ayr needed to evaluate the vegetative cover predictions generated by the models.

Chapter 5 includes a summary of the data collection techniques and data interpretation required to test the models and to investigate the revegetation efforts at Belle Ayr. On the basis of an analysis of the models and the tests on the Belle Ayr data, the determination was made that the models for mined lands were too generalized to provide accurate predictions for the revegetation test plots at Belle Ayr. Examples of other factors, which might have influenced the percentage of vegetative cover, are discussed and analyzed in Chapter 6. Suggestions are presented for developing appropriate site-specific models. Chapter 7 contains a summary of the findings and conclusions derived from the preceding chapters. Recommendations for the development and use of descriptive prediction models are included.

Methodology

Course work in mined-land rehabilitation, resource systems analysis, ecological processes and computer applications provided the impetus and background for this thesis. The initial focus was a review of the Forest Service Surface Mining and Environment (SEAM) report Models to Estimate the Revegetation Potential of Land Surface Mined for Coal in the West (Packer, Jensen, Noble and Marshall, 1982). To better understand the models developed with this report, the version of the models, written in FORTRAN for mainframe computers, were translated to BASICA for use on an IBM-compatible microcomputer system.

A visit to the Belle Ayr Mine in northeastern Wyoming (one of the original test sites in the SEAM report), provided an opportunity to learn about mined-land revegetation techniques. The revegetation specialists at Belle Ayr had just completed a vegetation inventory, which included measurements of percentage of plant cover for all of the permanent reclamation units within the Belle Ayr mine site booundaries. This data included most of the information that would be needed to test the SEAM models. They were interested in the possibility of using models to help predict and evaluate revegetation results. A grant proposal was accepted by the AMAX Coal Company to test the SEAM models using data from Belle Ayr, and to determine if prediction models could be used successfully in their operation. The data had not yet been collated, and soil samples had not been sent to the laboratory for evaluation. Soil sample evaluations required for the models were added to the list of specified soil tests.

A second trip was made to Belle Ayr, for a week of data gathering and background research. This included field investigations, reviewing the history of Belle Ayr mining operations and standard practices, reconstructing the methods used and problems encountered on each of the 58 tested reclamation units, locating baseline vegetation studies; and collecting maps, soil test results, climatic reports, and field reports and summaries of the data collected for the 445 individual test sites within the 58 revegetated reclamation units.

Several months were spent sorting the data, deciding how it would be organized and recorded, and establishing a set of computer databases to provide a method of relating all of the disparate types of information. One of the major decisions at this time was to include as much of the information obtained at the mine as possible, even though most of this would not be used in testing the SEAM models. It had become obvious that the data presented many opportunities for more extensive site-specific studies to investigate the effects of environmental and management factors. The categorized data was sent to Belle Ayr headquarters on computer disk, where it was converted to a form that could be loaded directly into their mainframe computer system. They checked the data, added several more categories, and decided to use the format for their long-range reclamation monitoring project, and for immediate use for statistical testing of established research projects.

After the data had been organized, procedures established and initial statistical evaluations performed for testing the SEAM models, Belle Ayr discovered that several sets of data has been misrecorded when the original field tests where done. They made the corrections, sent the computerized data to their computer headquarters in Indianapolis for conversion to a format that could be directly loaded into a microcomputer system. Although this saved time that would have been spent re-recording data, almost all of the tests and procedures had to be redone.

To develop a background for understanding the model construction and appropriate applications, sources directly related to the SEAM project and more generalized sources of model development were researched. Paul Packer, the coordinator of the SEAM model project was contacted, and he provided useful information that was not included in the original report, including copies of data collection forms from a number of the mine sites tested for developing the models.

Analyzing and testing the Belle Ayr data required background investigation and synthesis of information on climate, soils, plant materials and management strategies. Range scientists and specialists knowledgeable in these areas were contacted. Research was done to determine appropriate statistical and non-statistical tests for evaluating the Belle Ayr data.

Chapter 2

MODELS AND MODELING PROCESSES

> An experiment, even with a physical model, provides a foundation that can be built upon soundly, unlike opinion that is merely a degree in the endless circle of debate. (Waggoner, 1977, p.79)

Models are abstractions of real world systems based on simplifications of reality, and represented by limited interactions and distinctly defined boundaries (deWit, 1978). Models can be expressed quantitatively (the relation of velocity and distance), graphicly (mapped isobars showing patterns of equal rainfall), or physically (an experiment in a wind tunnel) (Waggoner, 1977).

Many models are based on the assumption that natural laws govern the interactions and interdependencies within a system. If all of the biological, physical and chemical phenomena of a system were understood, an ideal model could be created which incorporated all of this knowledge. Unfortunately, such models do not exist (deWit, 1982b). In actual models, certain aspects of the processes within a system might be well represented. If the purposes of model use are carefully defined, and if the model is based on relevant measurable information, the results are often representative of the system.

Ecological Systems

The focus of this thesis is the model that simulates an ecological system. Living organisms and their related environments form definable ecosystems which have structures based on the relationships of all of the elements within the systems. Some of these have scientifically defined limits or boundaries: a cell, a plant, an animal. Others are defined by arbitrary boundaries: a field with a crop, a farm, a forest (deWit & Goudriaan, 1978). Unless interrupted by catastrophic events or imposed changes, ecosystems are continuous systems; they change gradually over time in response to changes in internal and external factors (deWit, 1982b), such as the competitiveness among plant species or the changing of the seasons.

The elements within an ecosystem may be biological components (producers, consumers, decomposers) or abiotic components (climate, geology, inert materials). Since much of the study of ecosystems deals with the impact of human intervention, perhaps a separate category should be added -- that of meddlers and disrupters. These components, through interaction, function together to carry on such processes as transformation (growth, death), circulation (intake and output of air, water, nutrients and chemical elements), and energy flow (Van Dyne, 1979). Although the elements and the processes are often highly interactive, it is important to note that their relationships are internalized and their influences on the larger environment are slight (Penning de Vries, 1982).

As an ecosystem matures, the processes stabilize over time and a balanced state is reached. If this stabilization occurs naturally, it is called a climax. If it is maintained by human intervention, it is called a disclimax. Van Dyne (1979) calls this the "essence of renewable resource management: maintaining disclimaxes at equilibrium for the benefit of man." (p.73)

There has been a gradual change in the direction of ecological studies, from a concern with exhaustive inventory and description of systems to a growing interest in understanding how ecological systems work. Energy flow, nutrient cycles, and productivity mechanisms are topics that are now the basis of extensive research (Van Dyne, 1979).

Systems Ecology

Systems Ecology refers to the discipline concerned with the development of methods for understanding ecosystem dynamics and the impact of stresses upon these systems. It is based on "the assumption that the state of an ecosystem at any particular time can be expressed quantitatively and that changes in the system can be described in mathematical terms." (deWit & Goudriaan, 1978, p.1) The beginnings of Systems Ecology can be traced to the early 1960's when the

International Biome Programme (IBP) proposed the establishment of major interdisciplinary studies. This included input from engineers, physicists, statisticians, zoologists, botanists and dozens of other related professionals. IBP provided financial support and served as one of the major organizers of the movement.

When the National Environmental Protection Act (NEPA) was passed in 1969, requiring the assessment of long and short term environmental impacts, more ecologists became involved in Systems Ecology to complete the analysis and synthesis of environmental data required to prepare the required impact statements (Reichle & Auerback, 1979). The interdisciplinary activities, especially the processes involved in the construction of ecosystem models, have served to increase communication among diverse specialties (Holt, 1977), and have had a synergistic effect on a wide range of research projects (DeMichele, 1973). The subdiscipline of Systems Ecology originally referred to the interdisciplinary approach, but today it usually connotes the mathematical modeling components of the program (Van Dyne, 1979).

Classification of Ecosystem Models

Explanatory Models

An explanatory model is based on tested and conjectured hypotheses that control the interaction of elements within a system. These hypotheses can be translated into a set of mathematical equations which represent the rules and physical laws that govern a system (DeMichele, 1973). Most of these laws are laws of conservation; the processes can be expressed as a transfer of energy, mass or momentum (Schuepp, 1977). By combining sets of related equations into a continuum, the modeler hopes to simulate the behavior of a system, not through curve-fitting, but by expressing true causal relationships.

This type is well represented by SPUR (Simulation of Production and Utilization of Rangelands), a plant growth model which simulates above- and below-ground plant dynamics, developed by Hanson, Skiles and Parton (1984). Formulation of this model began in 1981, and the final version will be published in the fall of 1986. Using this model, plant production -- for selected species found on a variety of range sites -- is determined by simulating daily carbon and nitrogen flows through soil components, and living and dead plant parts. This is a complex model based on physiological laws, and will be used primarily as a research tool to develop insites into rangeland management (J.D. Hanson, personal communication, February, 1986).

Descriptive Models

Schuepp (1977) defines a descriptive model as one based on "a summary of observations, which are gained by listening to Nature rather than cross-examining her by experimentation." (p.99). It is based on observed responses and it provides a way of recalling what has happened within a system under similar conditions. Once a significant relationship is identified between several elements, a mathematical function is chosen that has a shape, either curved or linear, similar to the experimental data.

Comparison of Explanatory and Descriptive Models

Each type of model has advantages and limitations. Explanatory models can often be applied to broader physiographic areas because they are based on proven theories, rather than on data collected from certain regions (Smith, 1982). However, the scientific approach and knowledge required to construct these limits their application (Penning de Vries, 1982). Although the predictive results of descriptive models may be applicable to situations outside of their defined parameters, they are most suited to the physiographic areas where the data were gathered. They are most often used for developing management strategies (Smith, 1982). These models do not require a sophisticated mathematical or scientific background to construct, and are often considered too simple to arouse much scientific interest. F.E. Smith (1979) summarizes the differences between the types of models: a descriptive model "tells us where the action is", while an explanatory model "tells us how it happens." (p.197) Many models are a combination of submodels, some of which are explanatory and some of which are descriptive. Descriptive submodels are often superceded by explanatory ones when appropriate scientific theory can be justified. (deWit, 1982a)

Plant Growth Models

Plant growth models, the type of ecological models to be considered in this thesis, measure the "success" or "failure" of plant growth and development within the boundaries of a defined ecosystem. Here, the major focus is the response of plants and not the representation of the total dynamics of an ecosystem (Selirio & Brown, 1977). These responses are most often expressed as a measure of growth, such as plant height or spread (percentage of ground cover), or yield of biomass per given area.

Plant growth is affected directly and indirectly by many factors, and the modeler is looking for those factors which limit or promote growth, such as the level of available nutrients or competition between plant species for moisture. These are seldom simple cause-and-effect relationships. The effect of one factor may be altered by a shortage or surplus of another factor, or factors may combine to cause specific growth characteristics (Penning de Vries, 1982). Various factor combinations can cause the same results (Van Dyne, 1976). Other factors, such as climate, are difficult to evaluate. Climatic patterns occur over time and cannot be measured at a static point, as opposed to such measurements as the level of soil components or slope orientation. The process of plant growth can be complicated by "breaks" in the functioning of the ecosystem: points at which the system no longer exhibits the same behavior, when many of the interacting elements relate to each other in different ways (Shugart & O'Neill, 1979).

Most of the plant growth models developed to date were formulated to study agricultural crops. Elements within agricultural systems are more homogeneous and interactions among system components are not as complex as those among elements of a natural plant community (Holt, 1977). In natural systems, the interruption of successional growth causes the system to become unstable and highly sensitive to change. This may result in unpredictable or unusual system responses. For example, a sudden increase of weeds, insects and rodents was noted following the major midwestern drought in the 1930's (South Dakota Agricultural Experiment Station, 1973).

Plant growth depends on the genetic potential of the individual species, management strategies and environmental factors (Smith, 1982) -- such as soil composition, precipitation rates, temperature ranges, and topographic location. The modeler must develop a method for understanding these interrelated factors to simulate the processes of plant growth, as well as a method for translating these processes into a workable model.

Modeling Processes

> The process of model building is necessarily one of spasmotic and erratic evolution and improvisation; when a point of relative stability is reached, it may well indicate that the next step will result in a major upheaval. (Christian et al., 1978, p.4)

There is no "correct" method to follow when building a model; intended use and the capabilities and limitations of the modeler dictate the sensitivity, complexity and form of the model. If it is a model that will be used by those not involved in or knowledgeable of its development, it should be structurally and mathematically simple -- using precise, clearly written descriptions without "pretentious language, systems jargon and unnecessarily complex mathematical notation". (Holt, 1977, p.105) If possible, it should be designed so that future modifications or additions can be incorporated (Hommertzheim, 1979). Because model building is now considered to be one of the important research tools, the modeler should always be aware that it may be used for instruction or for application to the construction of related models, often in other fields that may not use the same professional vocabulary (Penning de Vries, 1982b).

Regardless of the purpose of model development, all modeling must be preceded by an identification of objectives, goals and constraints. For descriptive models, data must be acquired and interpreted as variables which represent aspects of the system being studied, and values must be stored in a form that can be easily manipulated. Often the terms variable, factor and element are used interchangeably. To avoid semantic confusion in this thesis, factor and element will be used to refer to the qualitative properties and components of an ecosystem to be modeled. Variable will denote the translation and quantification (represented by numbers) of these properties and components to be used within the model.

Once variables and parameters (measurements which represent the limits of the given system) are established, the modeler begins to analyze the data to determine what form the model will take. Dependent (controlled or response) variables and independent (controlling or predictor) variables are identified. Intermediate variables (single values that express relationships among existing variables) are created to simplify the process of understanding the system.

There are usually many complex relationships among the elements; controlled and controlling factors are often intertwined. One of the first tasks in model building is to attempt to understand these relationships and determine which ones, if any, are significant for predicting the desired outcome. Visual analysis, simple groupings of data by similar characteristics, and the study of existing hypotheses, theories, and facts, provide the modeler with clues. When combined with the judicious use of statistical analysis, such as correlation or regression tests, these initial studies will often provide enough information to construct preliminary models.

Testing the Model

The modeler must have some assurance that the model, once it is constructed, is accurate and serves as a useful predictor within the given range of conditions. Descriptive models cannot be proven true or false, but they can be evaluated by comparing the results of the model with the behavior of the real system (deWit, 1982b). If enough data are available, a set should be reserved for testing the model: data that will not used for model development. Then, statistical tests and other types of analysis can be used to decide how accurate a model must be to serve as a useful predictor. The final test of a model occurs when it is used in a decision-making situation.

Modeling and the Computer

A computer is an indispensable tool for developing a model. It is used for storing, sorting and transporting data; for running complex, repetitive statistical tests; for graphing relationships and trends; and for comparing alternatives. A computer, micro- or mainframe, simplifies labor-intensive tasks and allows modelers with a minimum of mathematical and scientific skills to create usable models. The computer programs used in this thesis are listed in Appendix F.

Once a model is created, writing a computerized version of it allows those that will ultimately use it to do so with little knowledge of how it was put together or of the mathematics necessary to manipulate it (deWit & Goudriaan, 1978).

There are some noteworthy limitations associated with computer use. One is the capacity of the computer and the sophistication of the programs used. Another is the failure of the user to detect formative and logical errors (Christian et al., 1978).

People tend to put unreasonable faith in results that flash across a computer screen. Keeping in mind that the model was not created by the computer, and judging the output accordingly, should be standard practice for anyone using a model.

Uses of Ecosystem Models

The benefits gained from the development of ecosystem models have surpassed the original intent of replicating the behavior of a system and developing management strategies (Smith, 1982). These models can indicate areas where knowledge is lacking. They can provide a basis for designing relevant experiments, by identifying conditions that can be observed in the field or laboratory (DeMichele, 1973). Alternative management strategies can be tested through model simulation, reducing the risk involved in costly experimental trial and error. They can be used to assess trade-offs by indicating several alternatives that will give the desired results in a real world system (Shugart & O'Neill, 1979). Clues for untried management factors often surface through development and manipulation of a model (deWit, 1982b). Unlike field experiments, a model can provide a means to "control" all of the factors that might contribute to a change within a system, and can be set up to change one variable or parameter at a time in any desired sequence (DeMichele, 1973).

Chapter 3

A CASE STUDY: REVEGETATION MODELS FOR MINED LANDS

The following case study of a series of descriptive prediction models illustrates some of the principles of modeling presented in Chapter 2, and the application of modeling to mined-land revegetation.

An Overview of the SEAM Report

In 1976, joint investigative research was begun by the Forest Service, the Environmental Protection Agency, and the Fish and Wildlife Service in response to the need for practical criteria for determining revegetation potential of lands surface-mined for coal, and to the need for effective revegetation treatment guidelines. Under the direction of the Forest Service SEAM (Surface Environment and Mining) project, this research culminated in a report published in 1982, Models to Estimate Revegetation Potentials of Land Surface Mined for Coal in the West (Packer, Jensen, Noble & Marshall).

The models that were developed with this report are based on data from 28 major coal surface mine sites throughout the western United States. The researchers analyzed the influences of selected factors on vegetative cover and forage production on mined and unmined lands, and isolated those factors that appeared to significantly affect revegetation (Packer et al., 1982).

Pre-development of the SEAM models included screening climatological data, results of soil tests, biological data, physical measurements and treatment alternatives with multiple regression techniques to determine their importance in predicting cover and production. Those showing the strongest relationships were isolated for use in the final models. Highly correlated factors were incorporated in interactive functions in preliminary models. Factors which showed less strength and little interaction with other factors, but which still had a significant effect on percentage of cover, were treated as additive components. Through statistical analysis, the researchers determined that these factors accounted for a minimum of one-half to three-fourths of the variance encountered in the measurement of forage production and density of vegetative cover (Packer et al., 1982).

The resulting models were used to establish a framework for evaluating the success of proposed revegetation efforts on areas to be surface mined. According to the researchers involved in the development of the prediction models, these models represented a "reasonably strong hypothesis," but they recommended further evaluation and refinement through future studies (Packer et al., 1982).

Description of the SEAM Revegetation Models

Model Components

The models, for mined and unmined lands, were developed to predict successful vegetation based on (a) the amount of forage produced (measured in pounds per acre) and (b) the density of plant material, including vegetation, ground litter and rock, measured as a percentage of total cover. Percentage of cover, a measurement of the total percentage of groundcover density, includes the aerial coverage area of the plants, accumulated litter (standing and fallen organic materials from previous plant growth or applied mulch) and rock (Chambers & Brown, 1983). Litter and rock are included because they serve to protect the soil from erosion and to moderate soil temperatures. Litter also interacts with the soil through decomposition, altering soil composition and mineral content.

The predicted values are determined by interactive and additive factors. For predicting potential forage production and vegetative cover on unmined land, three interactive factors were identified as accounting for the majority of variations in vegetative growth:

1. average annual precipitation
2. average length of growing season (number of frost-free days per year)
3. level of soil potassium (ppm)

For mined lands, the model is partitioned into two submodels, depending on whether the vegetative stand is predominately composed of more than 60 percent native or 60 percent introduced species (P.E. Packer, personal communication, October, 1985). In each of these models, revegetated mined-land plant growth was accounted for by three interactive factors;

1. average length of growing season
2. average annual precipitation
3. age of vegetative growth (from planting date to testing date)

three additive soil factors:

1. soil pH
2. level of soil sodium (ppm)
3. level of soil potassium (ppm)

and seven additive management factors determined by their absence or presence;

1. tillage -- ripping, discing or harrowing prior to seeding / no tillage
2. drill seeding / broadcast seeding
3. topsoil added prior to seeding / no topsoil
4. fertilizer used with initial seeding / no fertilizer
5. supplementary irrigation used / no irrigation
6. mulch applied with initial seeding / no mulch
7. spring seeding time / fall seeding time

Factors analyzed but not included in the final model were growing season precipitation, aspect, slope steepness, elevation, and soil properties -- texture, conductivity, nitrogen, phosphorus, calcium, magnesium, sodium absorption ratio, and saturation percentage (Packer et al., 1982).

Interpretive Maps

Two maps were produced to accompany the SEAM models which together cover most of the major coal mining areas in the western United States and all of the mining sites that provided data for the study. They were prepared to provide input data required by the model. Figure 3.1 shows the areas covered by these maps.

Precipitation rates and growing season length are shown as isobars that can be read directly from the map.

Natural vegetation classifications can be read by color-key and reference number. The numbers refer to Kuchler's (1964) reference system presented in The Potential Natural Vegetation of the Coterminous United States. This publication is now out of print, but it is an invaluable resource for information on dominant and associated species of natural vegetative communities.

Soil association information, recorded on the maps, is referenced by code number to several mapped sources. These reference numbers can only be interpreted by obtaining the original sources: Young and Singleton's Wyoming General Soil

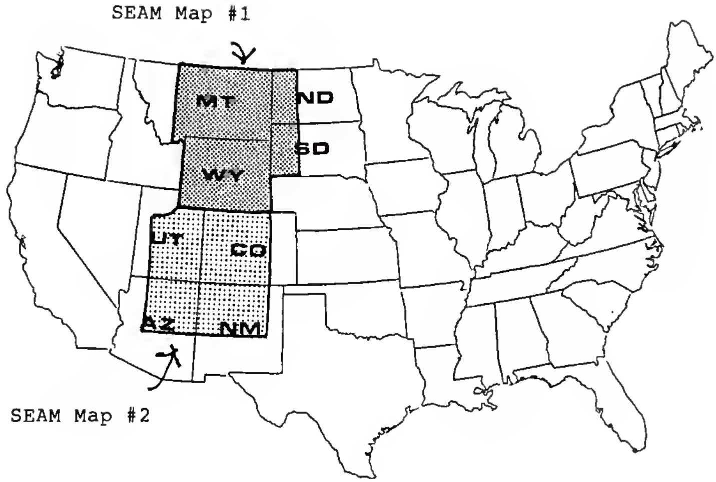

Figure 3.1. Areas Represented by the SEAM Report Interpretive Maps.

Source: Companion maps included with Models to Estimate Revegetation Potentials of Land Surface Mined for Coal in the West (Packer et al., 1982)p

Map (1977), Aandahl's Soils of the Great Plains (1972), Cipra's Soils of Colorado (1977), Jay's Arizona General Soil Map (1975), Maker's Soils of New Mexico (1974), Southard's Soils of Montana (1973), Wilson's Soils of Utah (1975). Figure 3.2 shows the areas mapped for soil information, and the coverage area for two of these maps. Although identifying these soil types provides useful background information, referenced maps and reports provide almost no information for determining pH, potassium and sodium content of the soil from a particular area. Short of testing soil samples from a specific site, there are few sources for this data. For hypothetical test data, however, The Soil Survey Laboratory Data series, published in conjunction with existing Soil Conservation Service soil surveys, provide a number of samples with the required test results.

Mathematical Representations of the Models

One of the most difficult tasks of model construction, especially for researchers without high levels of mathematical expertise, is evaluating the accuracy of the graphed forms, translating them into mathematical terms, and correctly combining a set of hypotheses into a workable model.

The process used in developing the components of the SEAM models was developed specifically for studies involving environmental and biological factors. These factors are often highly interactive, and when graphed, are most often

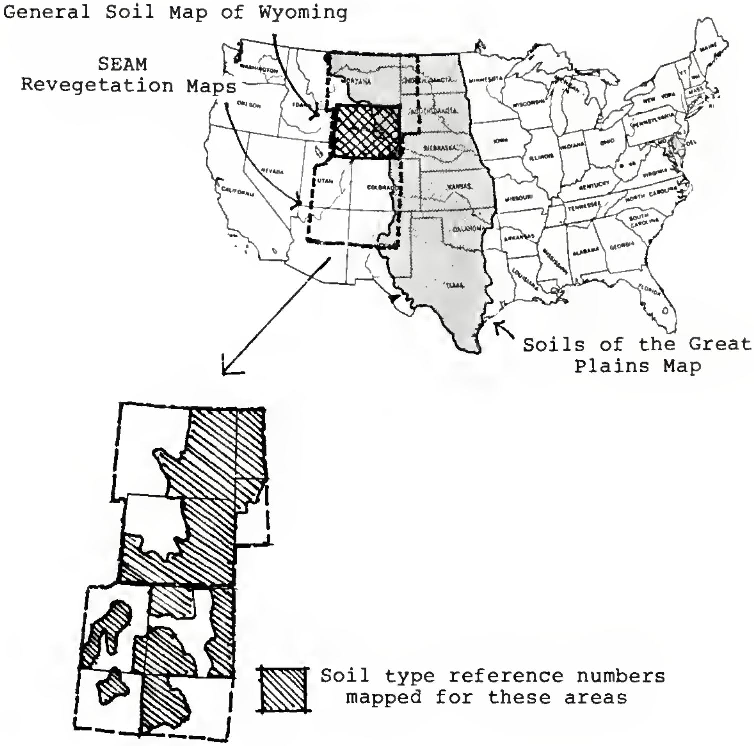

Figure 3.2. Areas Mapped for Soil Types on the SEAM Report Interpretive Maps.

Source: Aandahl's (1973) Soils of the Great Plains Map, Young & Singleton's (1977) General Soil Map of Wyoming, SEAM report interpretive maps.

represented by complex, curvilinear lines. The process was developed under the direction of C.E. Jensen, principal statistician for the Intermountain Forest and Range Experiment Station from 1967 to 1980. Jensen's (1984) "Match-a-curve" method provides a visual way to select the appropriate algebraic transforms that represent complex relationships, by matching a graphed representation of a hypothesis to a series of graphed standard curves that have predetermined algebraic equations. This method was initially presented in a series of publications (Jensen & Homeyer, 1971, 1972; Jensen, 1973, 1976) and is summarized clearly in <u>Development of Structured Regression Hypotheses / Interactive Descriptive Geometry Through Five Dimensions</u> (Jensen, 1984). One set of the standard graphs is shown in Figure 3.3.

This method has several advantages. Too often analysts resort to using simple linear regression models that do not always represent the true (complex, curvilinear) environmental response (Jensen, 1984). It is easy, especially with the aid of advanced statistical computer programs, to ignore pertinent information presented by a visual (graphic) representation of the data as well as previously tested theories and hypotheses. Using Jensen's method enables the analyst to remain in closer contact with the "reality" of the study, and helps to prevent reducing the study to a statistical exercise in data manipulation.

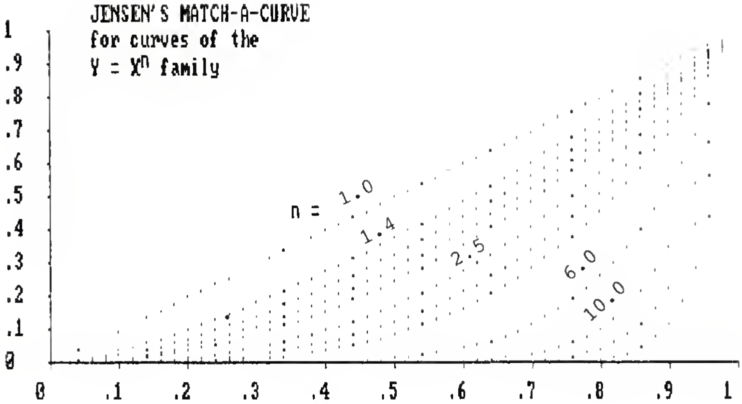

Figure 3.3. A Set of Computer-generated Curves for Describing Hypothetical Interactive Model Components.

Note. This graph is based on Jensen's (1984) algebraic expressions for producing standard sets of curves.

Computer Versions of the SEAM Models

The FORTRAN computer programs developed with this report were based on the algebraic equations used to construct the model. Although it is possible to manipulate these formulas using a calculator, the modelers incorporated them into several computer programs to enable the user to make comparisons among various combinations of conditions and treatments without repetitious and tedious calculations (Packer et al., 1982).

For this thesis, the FORTRAN computer programs were translated and modified in the BASICA programming language for use on IBM-compatible microcomputers. The programs were then used in the analysis and application of the SEAM models presented in Chapter 6.

Copies of the BASICA programs and examples of program printouts are included in Appendix A.

SEAM Report Results

Although both forage production and percentage of cover measurements are necessary for the determination of revegetation success, the remainder of this thesis focuses on percentage of cover models and their use in determining management strategies and in evaluating revegetation efforts. The methodology necessary for model development is the same for all of the models presented in the SEAM report, and an analysis of the percentage of cover models can be applied to the forage production models.

Unmined-Land Percentage of Cover Model

An analysis of the unmined-land model indicates that low annual precipitation rates (5 to 10 inches per year) combined with medium to long growing seasons (110 to 150 days) severely limit the percentage of cover. Where the growing season is in excess of 100 days, precipitation is the determining factor for cover. As precipitation increases to the medium to high range (15 to 25 inches per year) in areas with short to medium growing seasons (50 to 100 days), an increase in soil potassium increases the amount of cover (about a 10% increase in cover for each additional 60 ppm of potassium).

Mined-Land Percentage of Cover Models

An analysis of these models indicates that percentage of vegetative cover increases with increasing age and precipitation to a limit of 5 years. Although areas of predominantly introduced vegetation show a higher rate of forage production than areas of predominantly native vegetation, the areas of introduced species show an average of 8.8% lower percentage of cover under similar conditions. According to the SEAM report, introduced species appear to be superior for producing forage, but native species may provide better protective cover. As the length of the growing season increases, cover increases to a maximum of 85 days, peaks and then levels out in areas that have longer growing seasons. Precipitation shows a strong interaction with growing season, as it did in the unmined-land model. Soil factors and management factors on disturbed land show some influence on cover, but vary according to whether the vegetation is predominantly native or predominantly introduced.

Using the SEAM Models

These results are based only on the data gathered specifically for this study, and, at the time of publication, had not been tested in the field. The SEAM report concluded with strong recommendations that the models should be used as a base for further study to validate the results (Packer et al., 1982).

To use these models as management tools, cover predictions can be analyzed by comparing the results dictated by different combinations of environmental and management factors. By first establishing the potential cover with the unmined-land model, a baseline can be established to predict the levels of vegetative cover and forage production needed to indicate successful revegetation. The authors concluded that with the management techniques available, there are usually several alternatives to establishing cover that equal or exceed the ecological potential of most mined sites

(Packer et al., 1982). These results and conclusions will be analyzed in Chapter 5, when the models are tested using revegetation data from the Belle Ayr Mine.

Chapter 4

A STUDY SITE: THE BELLE AYR MINE

The Belle Ayr Mine, one of the original data collection sites for the SEAM report, was chosen to study the application of the SEAM models. Historical and environmental information and revegetation practices are presented to provide a context for this study.

Background

The Belle Ayr Mine, owned and operated by AMAX Coal Company, is located in Campbell County, Wyoming, approximately fifteen miles southeast of Gillette. Strip mining for coal in Campbell County began in 1967, with the opening of the Wyodak Mine. By 1982, the county had 16 mine sites either operating, under construction, or in the planning stages. Projections indicate that over 40,000 acres will have been disturbed through mining activities by the year 2000 (Steward 1984). Figure 4.1 shows the location of the mine and the extent of the coal deposits in Campbell County.

Belle Ayr is a shovel-truck operation begun in 1972 and is predicted to be mined out about 1993. The depth of the overburden ranges from 20-200 feet and the coal seam varies from 40 to 60 feet thick. Where possible, the overburden is

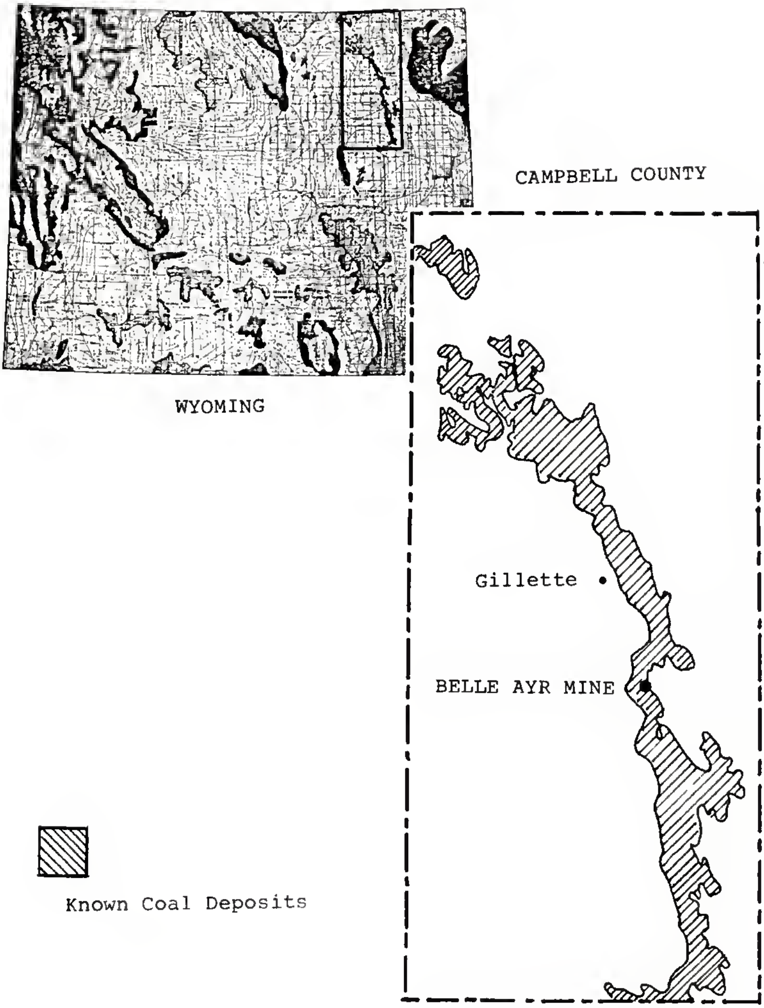

Figure 4.1. Belle Ayr Mine Location Map

Source: Companion map included with Models to Estimate Revegetation Potentials of Land Surface Mined for Coal in the West (Packer et al., 1982) removed in 40-foot benches, and the coal is removed in 35-foot benches. The overburden is hauled and used for backfill where the coal is removed, with deeper materials replaced first and weathered overburden placed near the surface. As the pit advances, the backfill and reclamation advance behind the current operations. Topsoil and higher quality spoil are stripped ahead of the pit and stockpiled or spread as needed. A second pit was opened in 1984, with the overburden hauled to the original pit backfill. After removal, the coal is loaded into 120-ton haul trucks for delivery to the preparation plant where it is crushed and then shipped to electric generating plants that are located principally in the Midwest. A smaller scoria pit is also mined within the permit boundaries (AMAX Coal Company, 1979, 1984).

Records kept by Belle Ayr (1972 through 1984) show that since the mine opened:

2,316	acres have been disturbed
136,000,000+	tons of coal have been removed
3,400,000+	cubic yards of topsoil have been stockpiled
8,200,000+	cubic yards of spoil have been stockpiled

Setting

Belle Ayr Mine is located in the Shortgrass Prairie province (Bailey, 1978), an area of rolling plains and moderate tablelands, with elevations ranging from 4450 to 4600 feet. It is characterized by short to medium-tall grasses and scattered trees and shrubs. Within the Belle Ayr boundaries, the two main naturally occurring vegetative types are upland sagebrush/grassland and bottomland types. The sagebrush/ grassland type is predominantly short to mid-grasses with a minor interspersion of shrubs and forbs. This land is characteristically dissected by small, deeply eroded, ephemeral and intermittent streams (NUS Corporation, 1979). The dominant species are western wheatgrass, blue grama, needleandthread, and green needlegrass (Kuchler, 1964). At Belle Ayr, this type occurs mainly in gently rolling upland areas. The bottomland type occurs along intermittent streams and along the lower reaches of large ephemeral drainageways. It is considered a minor type within the shortgrass prairie ecosystem. Dominant species in the bottomland type include western wheatgrass, silver sage, green needlegrass and bluegrass (NUS Corporation, 1979).

According to Andahl's (1972) classification system, the terrain is undulating (3-8% slopes) to rolling (8-16% slopes). The soils are primarily clayey (more than 35% clay) to loamy (less than 35% clay, variable amounts of silts and sands, and less than 70% sand). New soils are formed primarily through calcification. In poorly drained areas, salinization is common (NUS Corporation 1979).

The continental climate is semi-arid, with average annual precipitation of about 15 inches, most of which is rain. Precipitation patterns are erratic, with winter showing the lowest total moisture and the majority of rain falling in early summer. Temperature patterns are unstable in the fall and spring, but degree changes are relatively small. Winter and summer patterns are stable, with winter showing the widest range of temperatures. Combining temperature and precipitation patterns shows that late spring is the best time for plant growth, followed by favorable growth periods in early summer and early fall. Periods of limited rainfall can inhibit growth in June and September, and severe droughts most often occur in July and August (Steward, 1984). Wind speeds average 10 to 12 miles an hour, with frequent periods of much higher winds (Intermountain Laboratories, 1984).

Wildlife seen on the site is typical of the region; pronghorn antelope, mule deer, rabbits, grouse, hawks and rodents are common.

Land Use and Configuration

Prior to mining operations, most of the area was undeveloped rangeland used by cattle and wildlife, with minor acreage for agricultural production. The projected post-mining uses are the same (AMAX Coal Company, 1979).

Post-mining topography, although generally lower in elevation, has the same basic configuration present in the pre-mined sites. Because of the existing stream channels, entry and exit elevations must be maintained, resulting in slope alterations, but retaining pre-mining topographical orientations (AMAX Coal Company, 1982).

Revegetation History

By the end of 1984, 451 acres had been declared reclaimed, and had been planted with a permanent seed mix. Forty-one additional reclaimed acres were redisturbed to open the second pit. At that time, revegetation costs, including topsoil stripping and spreading, rough and finish grading, spoil and topsoil ripping, and the actual revegetation process, totaled more than $4500.00 per acre (AMAX Coal Company, 1984).

Management and Maintenance Practices

The management and maintenance practices at Belle Ayr have been established by law, policy, and as a response to field successes and failures. A description of anticipated revegetation practices was required for obtaining the permit to commence mining activities. New requirements were added in response to the 1977 federal Surface Mining Control and Reclamation Act and updated state policies.

Belle Ayr guidelines state that "self-containing communities with vegetation cover, production, composition and diversity equal or better than pre-mining communities will be established." (AMAX Coal Company, 1982). Before the required bonds are released (after a minimum of ten years has elapsed since the initial reclamation of the area), revegetated areas must be evaluated using tests for cover, production and density as defined by the Wyoming Department of Environmental Quality (WDEQ) (1979). To meet WDEQ standards, the revegetation team at Belle Ayr has outlined a basic revegetation program, supplemented by periodic testing and a series of special studies -- including the analysis of soil factors, species trials and alternative management techniques -- to increase the chances for successful revegetation. Of these, the tests for the effects of grazing, mulching and use of nurse crops are being updated and evaluated over time. Although the results of most of the studies indicated the need for further research, many have been discontinued with inconclusive results (AMAX Coal Company, 1983,1984).

Since revegetation efforts at Belle Ayr began in 1972, many areas have had to be partially or totally reworked. Some of these problems can be directly traced to mining activities; heavy accumulations of coal dust, siltation from road construction, spoil pile erosion, and isolated patches of unburied toxic materials have caused planting failures. Heavy thunderstorms have caused gullying, periods of drought have thinned new seedlings and prevented germination. Some areas have been invaded with persistant weeds, weakening stands through competition for water, nutrients and space. A serious grasshopper infestation during the summer of 1984 drastically affected legume production and cover (D.G. Steward, personal communication, March, 1985).

In response to unsuccessful seeding, a variety of ameliorating techniques have been tried, based on the suspected cause of seeding failure. These techniques include: soil stabilization (cover crops, surface manipulation or mulching) to combat erosion; readjusting seed mix rates and species for soil and microclimate compatibility; treating or replacing inadequate or toxic soils; spraying, burning, discing or fallowing areas heavily infested with weeds; interseeding and fertilizing to strengthen weak vegetation stands (Amax Coal Company, 1976-1984).

The use of a variety of tests, studies, and treatment alternatives at Belle Ayr prompted the revegetation specialists to find a way to coordinate all of this information to create guidelines for successful revegetation.

The Reclamation Monitoring Project

In 1984, the Reclamation Monitoring project (RECMON) was established by the revegetation specialists at Belle Ayr to "bring together under one file [database] diverse elements that might otherwise not be correlated." This database, when completed, will include 10 major categories: topography and microtopography, air quality, climate, soils, soil moisture, overburden, vegetation, wildlife, revegetation practices and water quality (Belle Ayr Mine, 1984).

As part of the RECMON program, the Belle Ayr revegetation specialists collected data from 445 individual test plots within the 58 designated Reclamation Units. The testing was done in the summer of 1984, from July 12 to September 6, after the period when the majority of plant growth was expected to have occurred. This data included historical information, environmental and ecological elements, species identification and percentage of cover measurements. Background information was taken from past studies, technical reports and annual progress reports for each of the Reclamation Units. Field maps were used to locate the test plots and soil sample locations for future reference (D.G. Steward, personal communication, March, 1985).

The data gathered for the RECMON program provided the information needed to establish a base for testing the SEAM models, and for investigating the use of more site-specific models for the Belle Ayr Mine.

Chapter 5

TESTING THE SEAM MODELS

According to the guidelines suggested in the SEAM report, a standard for potential total cover on mined lands could be established by looking at the total cover expected on unmined lands. In the following section, historical data from Belle Ayr is checked against the SEAM model for cover on unmined lands, and then the mined-land models are tested and discussed using the data from the 1984 Belle Ayr revegetative study.

Belle Ayr Baseline Vegetation Information

In August, 1979, an extensive vegetation reference study was conducted by the NUS Corporation of Denver, Colorado, covering approximately 2,463 acres of land scheduled to be disturbed by future mining operations. Two reference areas, representing sagebrush/grassland and bottomland plant communities, were established in areas that would not be affected by mining activities. These areas are shown on the map of the Belle Ayr Mine in Figure 5.1. Mean vegetative total cover, mean cover for each plant species, litter plus rock, bareground, and total cover (vegetation + litter + rock) were calculated. Cover sampling was conducted at 115 affected area sites and 115 control area sites (65 sagebrush/

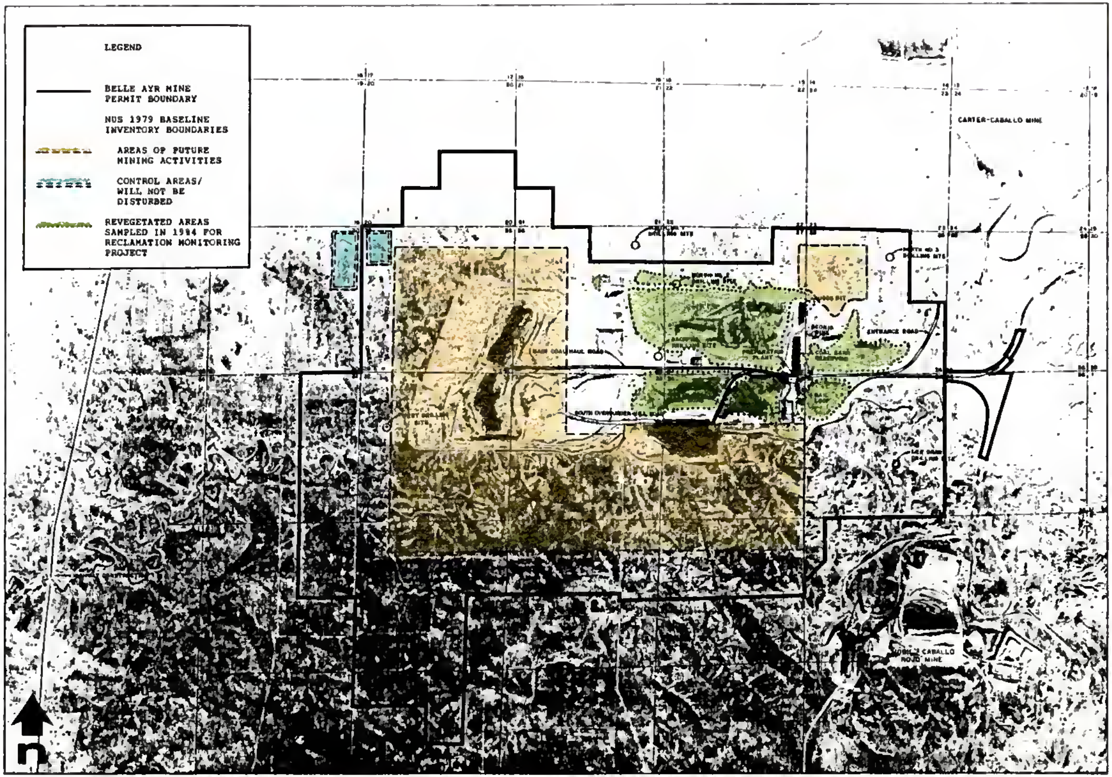

Figure 5.1. Belle Ayr Mine. Locations of 1979 Vegetation Inventory and Revegetated Area Boundaries

Source: Belle Ayr 1984 Annual Report Permit Area and Facilities Map, 1979 MUS Vegetation Inventory Map, 1984 Belle Ayr Reclamation Unit Field Map grassland sites and 50 bottomland sites in each area). Table 5.1 shows selected cover percentages recorded in this study.

The variations in the data may reflect the difficulty of comparing large (to be disturbed) areas and small (control) areas. No soil testing or gathering of auxiliary data was done for the NUS vegetation inventory.

Testing the SEAM Unmined-Land Percentage of Cover Models

It is possible to compare these baseline studies with the results of the SEAM model for predicting total cover on unmined lands. Soil potassium, a required input variable for the SEAM model, was not recorded for any of the Belle Ayr baseline studies. However, potassium content is usually low in the types of soils and climatic regime present in northeastern Wyoming, averaging between 1 to 200 parts per million (ppm) (Roger Pasch, Intermountain Laboratories, personal communication, April, 1985). Selecting an intermediate potassium level of 100 ppm, a growing season of 125 days and average annual precipitation of 15 inches (precipitation and growing season determined from SEAM report interpretive maps) for input into the SEAM model results in a predicted total percentage of cover value of 83 percent. The standard error-of-estimate for the SEAM model is 13.1 percent. This compares favorably with the results of the NUS inventory where total cover was estimated at between 73.3 percent and 84.5 percent for both sagebrush/grassland and

Table 5.1. Selected Percentage of Cover Measurements from the 1979 Vegetation Inventory

	Sagebrush/Grassland		Bottomland	
	Affected	Control	Affected	Control
Vegetative cover	48.3	59.7	65.6	74.4
Litter + Rock	25.0	24.8	14.6	9.6
Bare Ground	26.7	15.5	19.8	16.0
Total Cover	73.3	84.5	80.2	84.0
<u>Selected species</u>				
Western wheatgrass	5.8	6.2	25.8	27.4
Thickspike wheatgrass	0.2	--	--	1.2
Green needlegrass	9.2	12.0	4.0	2.0
Yellow sweetclover	0.3	--	3.0	3.6
Blue grama	11.4	3.2	2.8	0.6
Silver sage	0.8	0.5	5.2	6.6
Big sage	7.4	20.3	4.6	2.0
<u>Totals</u>				
Shrubs	10.8	25.1	11.0	10.2
Forbs	4.3	5.9	9.0	15.8
Grasses	33.4	28.8	45.6	48.4

Note. Affected areas will be disturbed by future mining activities. Control areas will not be disturbed in the future. The map in Figure 5.1 shows the location of these areas.

bottomland vegetation types, in control and affected (to be disturbed by mining activities) areas, as shown in Table 5.1.

Following the SEAM report guidelines, if mined-land percentage of total cover estimates equal or exceed this predicted amount of cover for unmined lands (83 percent) after five years of age (5 growing seasons), then this can be considered one indication of successful revegetation. The SEAM studies on mined lands indicated that after five years, under normal environmental and management conditions, the total percentage of cover stabilizes, with only minor variations in subsequent years (Packer et al., 1982).

Testing the SEAM Mined-Land Percentage of Cover Models

How useful are the SEAM models as predictors for total percentage of cover on the revegetated mined lands at Belle Ayr? To answer this question requires determining how the Belle Ayr RECMON study data could be translated to the form required for input into the SEAM models, deciding which sets and subsets of the data would be used for testing, and comparing the predicted total percentage of cover values with the actual values.

Belle Ayr Revegetation Data

Raw data are rarely useful as interpretive tools. Whether they are symbols of measurement, comparative values or categorical references, data take on meaning only in the context of how they can be analyzed or interpreted. The usefulness of a model is often determined by the availability of data, and how easily it can be collected (Sakamoto et al., 1977). It is important to be aware of the accuracy of the data and of the collection methods used.

For the purposes of this study, a computerized database, based on interpretation of the raw data collected at Belle Ayr, was established using the following variable categories:

1. identification
2. planting/testing dates
3. seed mix identification/seeding rates
4. slope/aspect/inclination
5. animal disturbance
6. management practices
7. soil factors
8. percentage of cover estimates
9. vegetation height
10. mean presence of species

The information required for testing the SEAM models is included in these categories. All of the variables established for the Belle Ayr data are detailed in Appendix B.

Daily weather records and monthly and annual summaries have been compiled for Belle Ayr mine since 1972. Since daily records did not show trends when compared on a year-to-year basis, and yearly and monthly summaries did not provide the level of sensitivity required for relating climatic factors to testing and planting dates, an alternative approach was developed for this study. Weather data, taken from Belle Ayr daily climatic records (1977-1984), was summarized for three divisions within each month -- mid, early and late. This method allows for identification of variable length pre- and post-planting and testing periods, growing seasons and other critical weather-related spans, while still allowing comparisons among different years.

Three separate computerized databases were established for climatic factors, since these could not be directly incorporated into the format of the main database. These contain the following information:

1. Yearly climatic data. Identification variables, precipitation rates, and temperature means for the years 1977-1984 divided into three periods for each month. When possible, this information was taken from weather data recorded at the Belle Ayr weather station. Missing information was filled in with data from the Gillette 2E weather station.

2. Long range climatic data. Identification variables, precipitation rates, and temperature means for the years 1951-1984 based on monthly summaries. The years 1951-1980 were taken from the Gillette 2E station data, and the years 1981-1984 from the Belle Ayr station data.

3. <u>Growing season data</u>. Growing season length, beginning and ending dates determined from the Gillette 2E station daily high-low temperature readings. As recommended by the statistical division of the Wyoming Agricultural Research Service, 28 degrees was used as the temperature to determine the start and end of the growing season (Personal communication, Wyoming Agricultural Research Service, February, 1986).

A description of the variables and recorded values for these climatic databases are presented in detail in Appendix C.

To relate climatic data to the Belle Ayr collected data, a series of graphs were developed for the years 1977-1984, that include:

1. mean temperature for the specific year
2. mean average temperature (summary of 1970-1984)
3. total precipitation for each of the 36 divisions
4. average total precipitation for each of the 36 divisions (summary of 1970-1984)
5. number of recorded precipitation daily totals exceeding one-tenth and one-half inch for each of the 36 divisions
6. beginning and end of the growing season
7. testing and planting dates
8. yearly precipitation and temperature summaries

Using these graphs allows initial identification of factors that can then be manipulated through the computerized climatic databases for further analysis. These graphs are reproduced in Appendix C.

Selecting a Data Set

The data for the 445 test sites (with the exceptions of the plots used for ongoing studies of the effects of mulch, nurse crops and legumes) were not collected with any specific testing program in mind. To evaluate the data for this thesis, it was decided to establish parameters, so that plots could be judged on the basis of similar characteristics.

First, values for all predictor variables (a complete listing is in Appendix B) were checked and plots with extreme values that appeared to be out of line with the rest of the values for the predictor variables were removed from the test set.

To accurately compare the revegetation percentages among plots, it was decided that there should be similar seed mixes used in the plantings. If the species used in the seed mixes were not among those species for which percentage of cover data were recorded, then there would be no way of evaluating their performance. Information was assembled on species included in the various seed mixes used, and the data were inspected to determine which species appeared in the seed mixes and had recorded cover values in the collected data. Ten species were identified, and translated as new variables in the database. The value of each variable corresponds to the seeding rate of the species in pounds per acre. These species, their variable designation and the range of seeding rates for each species are included in the description of variables and list of values in Appendix B. Of these, three species -- crested wheatgrass, smooth brome and indian ricegrass -- were either not included in enough of the seed mixes, or occurred in only a few of the test plots. The remaining seven species are: intermediate wheatgrass, thickspike wheatgrass, western wheatgrass, slender wheatgrass, yellow sweet clover, alfalfa, and green needlegrass. The test plots that had these seven species included in their original seed mix were isolated and divided into two sets using random numbers generated by a computer statistical package : a set of 100 plots was designated for evaluation and testing, and a set of 50 plots reserved to check the results of those tests.

A Computer Program for Evaluating the SEAM Models

A separate computer program was developed to test the post-mining SEAM models using the Belle Ayr data. This involved isolating the percentage of cover calculations from the original models, and determining how to transfer the required input factors from the Belle Ayr data base into the program. The computer program was set up to show plot identification, treatment alternatives, predicted percentage of total cover (vegetation + litter + rock) values for both predominantly native and introduced species types, actual total percentage of cover values, and the count and percentage of test plots that fell within the standard error-of-estimate (level of statistical significance = .05) as determined by the developers of the SEAM model. For native vegetation, the actual value should fall within +/- 17.5 percent of cover of the predicted value, and for introduced vegetation the actual value should fall within +/- 19.2 percent of cover of the predicted value, to be considered an acceptable prediction.

The computer program and an example of the formatted results for the 100 test plots are included in Appendix D.

The SEAM model requires determining whether the vegetation to be tested is made up of mostly native or introduced species. The seed mixes used at Belle Ayr contain a mix of native and introduced species, but introduced species tend to account for a higher percentage of cover in established stands. For comparative purposes, both alternatives were tested.

The growing season length given for the area on the maps included with the SEAM reports is between 120 and 130 days. This is based on continuous frost-free days, and was chosen because the test sites used for the model span a wide range of climatic conditions. In actuality, the growing season in northeastern Wyoming, an area where cool-season grasses predominate, begins earlier and ends later than in climatic regions farther south.

Precipitation rates for this area, based on the SEAM study maps, are between 14 and 15 inches per year. Precipitation amounts, recorded at Belle Ayr since the first permanent reclamation plantings, vary from 9 inches to over 18 inches per year with a long range (1950-1984) average of 15.4 inches per year. All of the pH, soil sodium and soil potassium values of the Belle Ayr test plots fell within the SEAM model limits.

For accuracy, standards established for input data required by a model should be maintained for data used to test the model. Soil samples for the SEAM models were taken to a depth of eight inches. Soil potassium and sodium content were determined by water extraction tests with the results given in milliequivalents per liter. To change meq/liter to parts/million, as required by the model, multiply sodium and potassium by their atomic weights (meq/l potassium X 39.19, meq/l sodium X 22.99). Soil pH was determined by saturated paste tests. The soil tests at Belle Ayr followed these standards.

Management variables

For this thesis, each of the treatments considered in the SEAM model was evaluated to determine how it would be handled in the test data sets:

Tillage -- all test plots received some form of tillage prior to planting, so this value was set at 1 for all plots.

Seeding method -- except for steep slopes, hard-to-reach areas and reseeding of small areas where initial seeding has failed, the areas at Belle Ayr have been seeded using brillion or Truax drills. Those areas where broadcasting was the major seeding method were given a value of 0, all other methods were given a value of 1.

Topsoiling -- all permanent reclamation areas were topsoiled prior to planting, so this value was set at 1 for all test plots.

Fertilizer -- plots not fertilized received a value of 0; all fertilized plots, regardless of the amount or ratio of fertilizer used, were given a value of 1.

Irrigation -- no supplemental irrigation is used at Belle Ayr, so all plots received a 0 in this category.

Mulch -- plots not mulched were given a value of 0, all other plots, regardless of the type or amount of mulch used were given a value of 1.

Seeding time -- Spring seeding time was determined to be any time immediately prior to or during the first two months of the growing season (value = 0). Fall seeding was defined as anytime after or immediately prior to the end of the growing season, a period when plant species experience an extended period of dormancy before spring growth begins (value = 1). The weather graphs (Appendix C) were used to decide which planting dates were to be included in the general categories of spring or fall planting.

Using the SEAM Models to Predict Vegetative Cover at Belle Ayr

First, all 445 test plots were evaluated. Of these 22% fell within the SEAM model error-of-estimate range (+/-17.5) for predominately native vegetation, and 43% were within the error-of-estimate range (+/- 19.5) for predominately introduced vegetation.

The summarized data for the 58 Reclamation Units were then tested. Twenty-seven percent fell within the acceptable range for predominately native vegetation, and 56% were within the acceptable range for predominately introduced vegetation.

Tests were also run on selected data subsets, including 150 plots that were being used for special studies (use of legumes, mulches and nurse crops) and that had a higher density of sample plots (all of these plots are the same age -- 1.3 to 1.4 years). Tests were also run on the 100 plots that had been systematically chosen for further evaluation of the Belle Ayr data, and for the 50 plots that had been set aside for testing any predictive results that might be derived from a study of those 100 plots. The results of all of these tests are summarized in Table 5.2.

Table 5.2. Summary of the Tests Comparing the SEAM Model Cover Predictions to the Belle Ayr Actual Cover Percentages

Identification of Test Plots	Number / Percentage of Plots That Fall Within the SEAM Model Standard Error-of-Estimate Range	
	Native Stands	Introduced Stands
All Plots (n = 445)	100 / 22%	192 / 43%
Selected Test Plots for Belle Ayr/SEAM Study (n = 100)	23 / 23%	50 / 50%
Reserved Test Plots for Future Testing (n = 50)	9 / 18%	27 / 54%
Summary Reclamation Units (n = 58)	16 / 27%	33 / 56%
Belle Ayr Special Studies Test Plots (n = 150)	49 / 32%	49 / 32%

Assuming that most of the revegetated areas at Belle Ayr are composed of predominantly introduced species, there is little more or less that a 50% chance that the SEAM models will accurately predict (within standard error-of-estimate ranges) the total percentage of cover for revegetated areas. The higher rates for the summary plots may indicate that these models are more suited to generating generalized predictions.

What factors could have influenced the outcome of these tests? Since Belle Ayr was one of the original test sites for the development of the SEAM models, the parameters developed for the SEAM models should be valid.

A number of people participated in the collection of data for both development of the SEAM models and for the Belle Ayr Reclamation Monitoring project; personal objectivity, interpretation and skills probably biased some of the data. Only 28 mine sites were available for testing at the time the SEAM study was initiated, and on many of these revegetation had only been underway for several years. This meant limited comparisons among ecological areas, and limited comparisons among revegetation results of different age plots (almost half of the sites were less than two years old). The number of samples for the SEAM study were small. Eighty-three samples were used to establish unmined site predictions. On mined sites, 44 samples were taken from predominately introduced stands and 33 samples were taken from predominately native stands. Only a few types of treatments were in general use at most of the mine sites. The definitions of treatments and combinations of treatments were not standardized and varied among mines. Necessary background information -- seed mix lists, history of fertilization, irrigation, mulching, and tilling methods -- had not been recorded at all of the sites, and the researchers had to rely on the memories of mine personnel or "best guess" estimates. Not all measurements were taken at the same time during the growing season (Packer et al., 1982).

The method of measuring percentage of cover -- point-intercept -- for the SEAM study was not the same as the method used at Belle Ayr -- quadrat sampling using a Daubenmire frame. The point-intercept method used required randomly locating 100-foot transects, dropping a pin at 50 random points along each of the transects, and recording the "hits" (vegetative species, litter, rock or bareground). A Daubenmire frame is a 100 cm by 50 cm frame, divided into five 20 cm by 50 cm areas. Visual estimations of percentage of cover for vegetative species, litter, rock and baregound are made, and the results of the five divisions are averaged. Based on the total percentage of cover measurements derived in the Belle Ayr study, the success of this method depends on the ability of field technician to accurately judge cover percentage. On some of the older, more densely vegetated plots, some of these totals exceeded 150 percent. According to standards developed for vegetative sampling, the same measurement methods should be used in all comparative studies (Chambers & Brown, 1983).

An Analysis of the SEAM Model Factors and Their Application to Belle Ayr Revegetation Studies

In the following section, each input variable required for the SEAM cover model will be discussed in relationship to the SEAM projections, to the standard revegetation practices at Belle Ayr, to conjectures and theories, to the methods used for data evaluation, and to the results as determined by an evaluation of the Belle Ayr data. Most of the information was derived from analyzing the 100 sample plots denoted for testing. References to the entire set of 445 plots will be made where inferences cannot be derived from the sample set.

Age of Planting

Belle Ayr has been involved in revegetation since the mine opened in 1972. Most of the earlier plantings have been reworked and the earliest plantings date to 1976. There were no first year plantings tested, and range of age in the sample set (n=100) is 1.3 to 4.9 years.

According to SEAM projections, for the average annual precipitation (15 inches) and growing season length (125 days) for this area, total cover should show a sharp rise for the first two years, a more moderate rise until the age of five, and then level off. The graph in Figure 5.2, derived

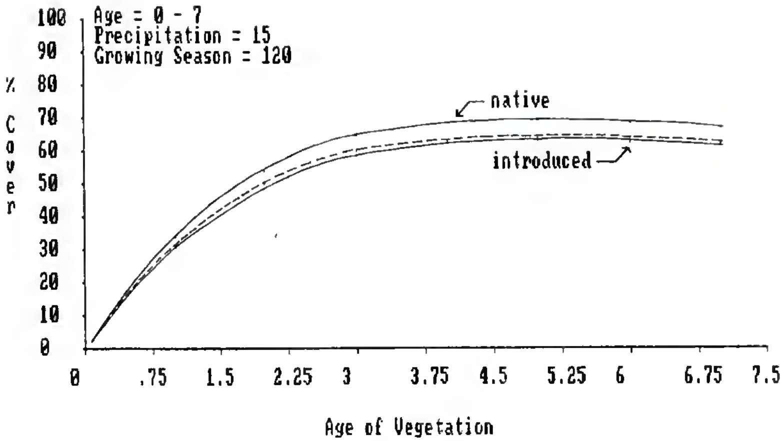

Figure 5.2. Expected Change in Percentage of Cover from 0 to 7 Years Based on SEAM Model Projections.

Note. Annual precipitation and growing season length were chosen to reflect average values for Belle Ayr.

from SEAM model algebraic equations illustrates this. Although there are no results from first year plantings, a previous 2-year study, done to analyze the effects of mulching at Belle Ayr (Davidson, Steward & Farrell, 1984), indicates that first year plantings have a much higher total cover than can be expected the second year. This is shown in Table 5.3. Calculations using the 100 test plots show an average of 60 percent total cover on plots less than two years old (n=36), and 88 percent cover on plots greater than two years old (n=64).

Climatic Factors

In any region, the general weather trends are more important to plants than year-to-year variations (Box, 1981). On disturbed lands, however, the sum of the environmental factors may be so out of balance that safeguards available during periods of unusual temperature and precipitation regimes are missing, and plant failure may result (Peperzak, 1956).

Based on the interactive components of the SEAM model, higher annual precipitation results in increasing amounts of cover (Figure 5.3). During the two years prior to the Reclamation Monitoring data collection, precipitation was well below average. However, substituting a lower precipitation value (12 inches) in the SEAM model reduces the accuracy of the predictions by 20 percent for predominantly introduced vegetation on plots that were planted just prior to these two

Table 5.3. Percentage of Cover Measurements Recorded for the 1983/1984 Belle Ayr Mulch Study

	Unmulched		Mulched	
	1983	1984	1983	1984
Total Vegetation	51.1	5.4	69.3	4.5
Litter	10.8	54.7	46.5	71.6
Total Cover*	62.3	65.1	113.8	74.6

* Total cover includes vegetation, litter and rock

Note. This study measured comparative cover percentages for test plots specifically designed to compare mulched and unmulched plantings. 1983 was the first growing season for these plantings (Source: Davidson et al., 1984)

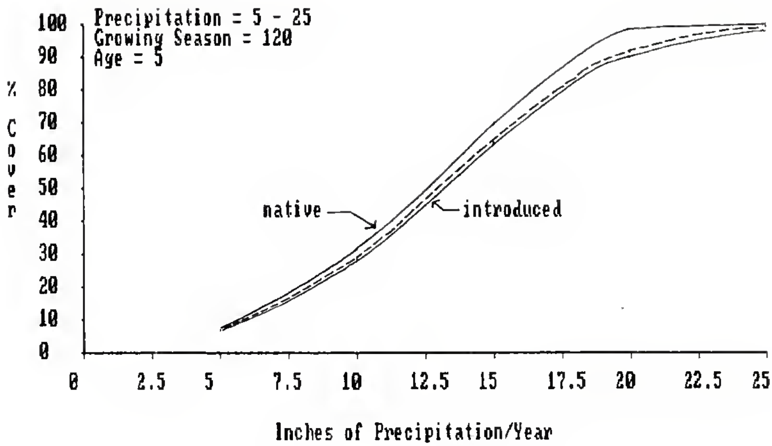

Figure 5.3. Expected Change in Percentage of Cover for Total Annual Precipitation Ranging from 5 to 25 Inches Based on SEAM Model Projections.

Note. An average age of 5 years was chosen to represent a stable plant community. The growing season length was chosen to reflect average conditions at Belle Ayr.

growing seasons. The SEAM models appear to be set up for regional differences, rather than seasonal variations.

Past a length of 100 days, according to the SEAM report, increased length of the growing season does not cause an increase in vegetative cover (Figure 5.4). When combined with precipitation rate, however, reduced rainfall and longer growing seasons reduce the percentage of cover. At Belle Ayr, the predominance of cool season grasses increases the length of the effective growing season. However, substituting longer growing season values again reduces the accuracy of the predictions.

Species Selection -- Native and Introduced

There are two main approaches to determining seed mixes to be used for revegetation. One approach is to use a general seed mix with a large variety of species to be seeded on all areas. Here, the rationale is that those species most suited to the ecological makeup of a specific site will become established through the processes of natural selection. The other approach uses a seed mix selected specifically for a site based on an analysis of ecological requirements. At Belle Ayr, an intermediate method was used. Several seed mixes were chosen on the basis of general categories (bottomland, grazingland, pasture), and these were supplemented with additional species according to the specific site requirements (clayey, sandy, loamy, rocky, moist, dry, saline, alkaline). Belle Ayr uses a mix of

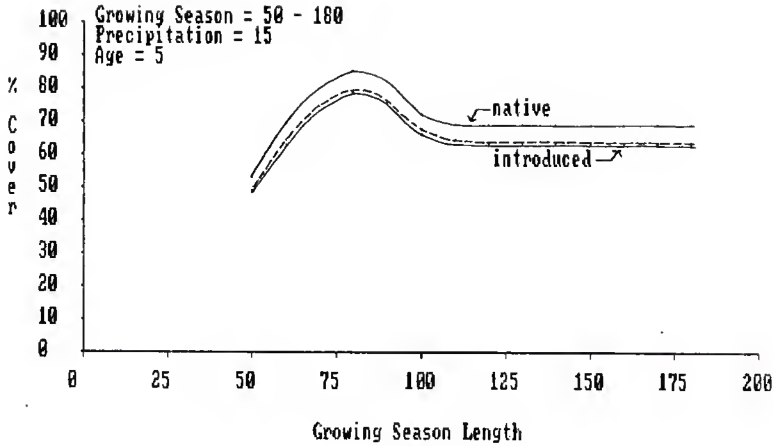

Figure 5.4. Expected Change in Percentage of Cover for Growing Season Length of 50 to 180 Days Based on SEAM Model Projections.

Note. An average age of 5 years was chosen to represent a stable plant community. The annual precipitation rate was chosen to reflect average conditions at Belle Ayr.

Table 5.4. Belle Ayr Permanent Grazingland Seed Mix

Species	Common Name	#/A. PLS
Achillea lanulosa	Western yarrow	0.1
Agropyron dasystachum	Thickspike wheatgrass	2.5
Agropyron smithii	Western Wheatgrass	4.0
Agropyron trachycaulum	Slender wheatgrass	2.5
Bouteloua gracilis	Blue grama	1.0 - 2.0
Ceratoides lanata	Winterfat	1.0 - 1.5
Helianthus annus	Sunflower	0.5
Medicago sativa	Alfalfa	1.0
Melilotus officinalis	Yellow sweetclover	1.0
Stipa viridula	Green needlegrass	2.0
(Other species commonly added to the base mix)		
Agropyron intermedium	intermediate wheatgrass	1.5
Bouteloua curtipendula	Sideoats grama	2.0
Koeleria cristata	Junegrass	1.0
Linum lewisii	Blue flax	0.5
Onobrychis viciaefolia	Sainfoin	2.0
Oryzopsis hymenoides	Indian ricegrass	1.5
(Nurse crop most often used)		
Avena fatua	Oats	12.0

Source: Amax Coal Company (1982)

introduced and native species. The species used most often are listed in Table 5.4. Because none of the mixes contained only native species, it was difficult to deduce how the native species would have fared without the competition from the introduced species. Studies have shown that using a mix of native and introduced species may inhibit the diversity and growth of native species (Law, 1984).

Cultivation and Topsoiling

Tillage practices at Belle Ayr include combinations of discing, cultipacking and ripping prior to seeding. All of the 58 Reclamation Units (445 test plots) were tilled and topsoiled. According to the SEAM results, tilling reduces the total percentage of cover by 3.9 percent for predominantly native stands and by 10.0 percent for predominantly introduced stands. The addition of topsoil should increase both native (6.0 percent) and introduced stands (0.4 percent). These effects are shown graphically in Figure 5.5. Since all of the revegetated plots were both tilled and fertilized, there was no way to evaluate the SEAM report findings.

Seeding Methods

Most seeding at Belle Ayr is done with a Truax drill because it adapts to a variety of soil textures and seed sizes. A brillion seeder is used for lighter soils and smaller seeds.

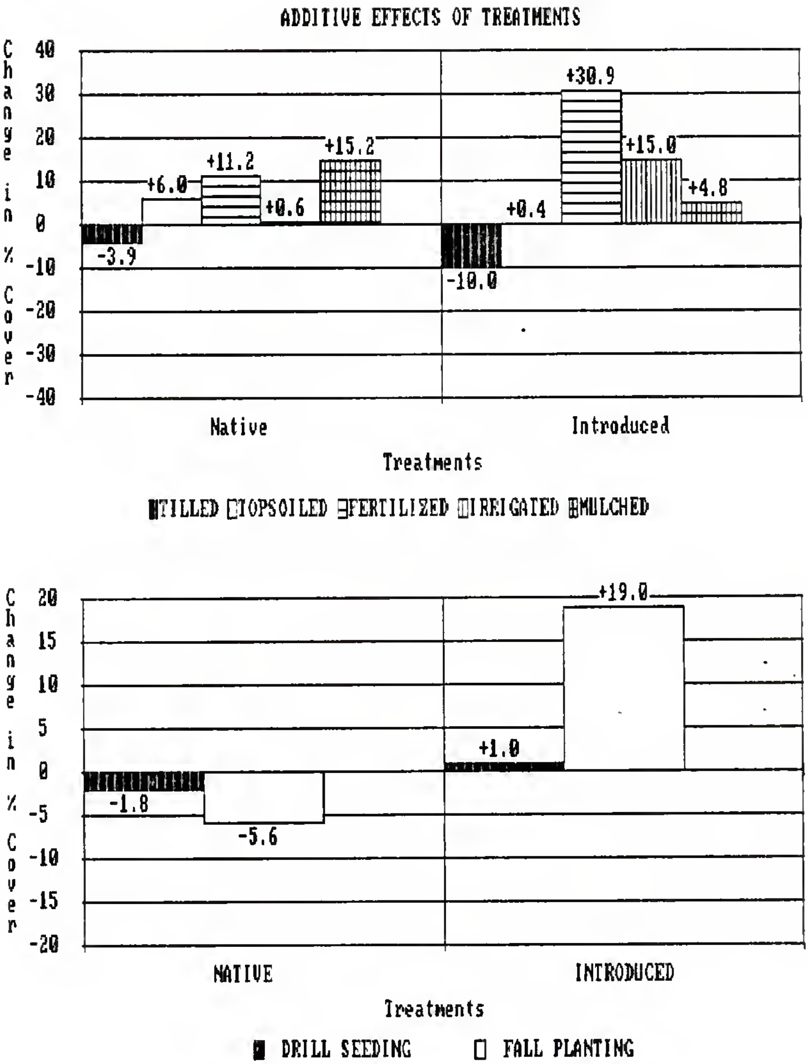

Figure 5.5. Expected Change in Percentage of Cover for Seven Revegetation Management Alternatives Based on SEAM Model Projections.

Broadcast seeding and hydroseeding are used for steeper slopes, hard-to-reach areas, and areas requiring temporary seeding.

The SEAM report indicates a drop of 1.8 percent in total cover for native stands, and an increase of 1.0 percent total cover for introduced stands, when seed mixes are drilled (this includes both brillion, Truax and other methods of drill seeding) rather than broadcast (Figure 5.5).

Only a few of the plots in the main data set (n=445) and none in the sample set (n=100) were seeded by broadcasting, so treatment response could not be measured using Belle Ayr data.

Fertilizer

When fertilizer is used at Belle Ayr, it is most often applied in a granular form at the time of planting. The amounts applied are either a combination of 20 pounds per acre of both nitrogen and phosphorus, 20 pounds per acre of nitrogen, phosphorus, and potassium, or 36 pounds per acre of nitrogen combined with 44 pounds per acre of phosphorus. Some areas that have shown poor response have been refertilized to attempt to promote better growth.

In the SEAM report, use of fertilizer causes an 11.2 percent increase in total percentage of cover in native stands, and a 30.9 percent increase in introduced stands (Figure 5.5). Only 18 of the 100 sample plots and 88 of the 445 total test plots were not fertilized. The differences in values for comparable plots were negligible, with no apparent increase in vegetative cover in the fertilized plots.

Irrigation

The SEAM models show an increase of 15 percent in total cover for introduced species, and only 0.6 percent increase in native species cover when irrigation is used (Figure 5.5).

Revegetation practices at Belle Ayr do not include supplementary irrigation; drought resistant species and ecotypes are selected, and moisture conserving techniques, such as the use of mulch and nurse crops, are used.

Mulching practices

Mulch is used to conserve moisture, control erosion and moderate soil temperatures. The types most often used at Belle Ayr are straw or hay applied by blower at a rate of two tons per acre and machine-crimped to adhere the mulch to the soil surface.

The results of the SEAM study indicate that mulching increases cover on native stands by 15.2 percent and on introduced stands by 4.8 percent (Figure 5.5). Data from Belle Ayr indicate that mulched plots show an average total cover of 88 percent (n=59) as compared to 64 percent for unmulched plots (n=41).

Soil Factors -- Sodium, Potassium and Soil pH

According to the SEAM report, increasing levels of soil sodium (to a limit of 1000 ppm) and soil potassium (to a level of 450 ppm) results in increased cover (Figures 5.6 and 5.7). Increasing soil pH (limits 4 to 9) increases introduced cover and decreases native cover (Figure 5.8). The range of soil pH (6.5 to 7.9) in the 100 test plots at Belle Ayr was too limited to note any appreciable difference in total cover percentages. There also appears to be no relationship between the levels of potassium and sodium and percent of total cover. Most of the soils at Belle Ayr have a high sand content and very low potassium levels (3 to 58 ppm). Sodium levels (10 to 330 ppm) fall within the normal range for this area of Wyoming.

Summary of the Test Results

A summary of the SEAM model application to mined-land revegetation at Belle Ayr is presented in Table 5.5.

Few of the input variables required for the SEAM models could be tested adequately based on the Belle Ayr data. However, the results of these tests should not be discarded; further data collection at Belle Ayr, and further evaluation of all applicable parts of the models evaluated in light of the Belle Ayr data, could be used for possible refinement of the SEAM models or development of a set of models more appropriate for percentage of cover studies at Belle Ayr.

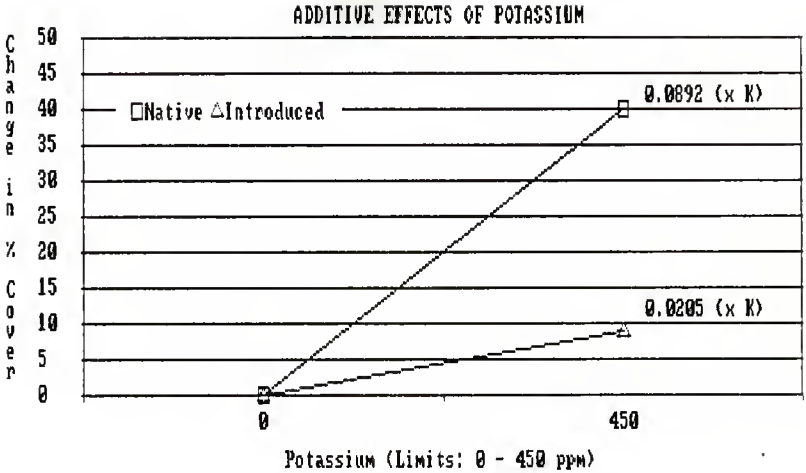

Figure 5.6 Expected Change in Percentage of Cover for Soil Potassium Levels Based on SEAM Model Projections.

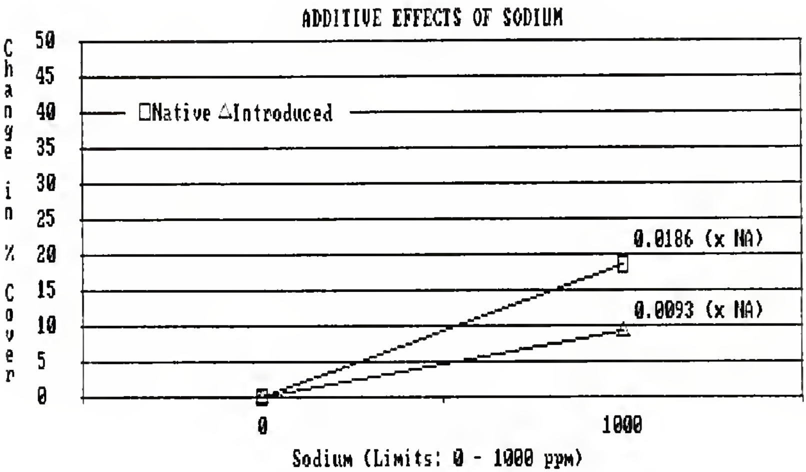

Figure 5.7 Expected Change in Percentage of Cover for Soil Sodium Levels Based on SEAM Model Projections.

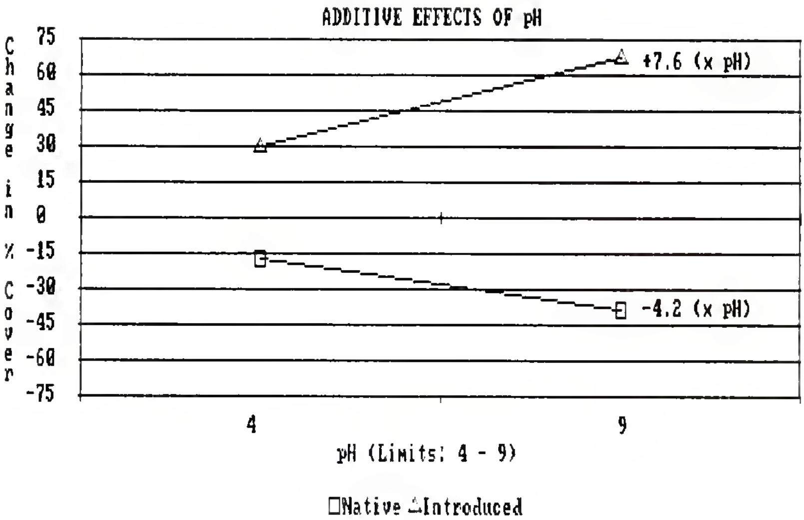

Figure 5.8 Expected Change in Percentage of Cover for Soil pH Ranges Based on SEAM Model Projections.

Table 5.5. Comparison of the SEAM Model Cover Predictions and the Belle Ayr Revegetation Cover Data

	Age of Planting
SEAM:	Rapid increase first two years, moderate to five years, stabilizes at maximum potential cover
BELLE AYR:	Higher cover first year, then marked decrease -- -- older plots (more than 5 years) show minor increase in total cover
	Climatic Factors
SEAM:	Longer growing season reduces cover in areas under 25 inches annual precipitation -- fall planting dramatically increase cover of introduced species
BELLE AYR:	Two years of below average precipitation preceded tests -- may account for low cover totals -- no appreciable difference in cover for spring or fall plantings
	Species Selection
SEAM:	Native species provide better cover, introduced species respond more to management treatments
BELLE AYR:	Introduced species account for higher percentage of total vegetative cover -- may out-compete natives in periods of low precipitation
	Cultivation and Topsoiling
SEAM:	Tilling reduces cover -- topsoiling increases native cover
BELLE AYR:	All plots tilled and topsoiled -- no way to compare
	Seeding Methods
SEAM:	Drill seeding causes a slight drop in native cover and slight rise in introduced cover
BELLE AYR:	Majority of plots drill seeded, no way to compare
	Fertilizer
SEAM:	Increases native stands and dramatically increases introduced stands
BELLE AYR:	The few plots not fertilized do not show a significant decrease in cover
	Irrigation
SEAM:	Causes major increase in introduced stands
BELLE AYR:	No irrigation used
	Mulching
SEAM:	Increases cover in native and introduced stands
BELLE AYR:	Cover averages more than 20% in mulched plots
	Sodium, Potassium and pH
SEAM:	Increasing sodium and potassium to given limits increases cover -- increasing pH decreases native cover and increases introduced cover
BELLE AYR:	No significant relationship to total cover

Chapter 6

FACTORS AFFECTING REVEGETATION AT BELLE AYR

Factors that were not tested by the SEAM models, but that were recorded as part of the Belle Ayr Reclamation Monitoring project, might account for variations in cover percentages. An understanding of the role that these factors have in vegetative growth is necessary for evaluating the collected data and establishing a base for model development.

Total cover (vegetation, litter and rock) is only one indication of revegetative success. The percentage of vegetative cover, and the relative percentages of specific plant species to total vegetation, may more accurately indicate the status of revegetation efforts. Although total cover measurements at Belle Ayr do not appear to be affected by many of the environmental and management factors tested by the SEAM model, percentages of individual plant species show significant correlation with some of these factors. The seven plant species that were used to determine the sample set of test plots in Chapter 5 are used here to illustrate these correlations. To better understand the role of these species and their response to environmental and management factors, background information for comparative analysis. Two of these factors, plant response to precipitation and soil texture, are represented by the graphs in Appendix E.

Analytical Tools for Model Development

To examine possible relationships among the variables created to represent the Belle Ayr data set, several common statistical tests were used.

Statistical tests are often meaningless unless they are used in light of practical knowledge and experience. This is particularly true when testing data sets that were not obtained from carefully controlled experiments.

Data can be structured, grouped, and identified in ways that allow for testing and measuring. Checks can be made for logically inconsistent values, values that conflict with prior informmation, extreme values, and missing values. The method of collecting data, including how the measurements and observations were taken and recorded, will also indicate something about the reliability of the data.

<u>Descriptive statistics</u> including mean, maximum and minimum values, and standard deviations, are helpful for becoming familiar with the variable ranges available for testing. They provide information that can be used to set parameters for further testing. Selected values for the set of test plots (n=100) from Belle Ayr are listed in Appendix E.

<u>Frequency distributions</u> are simple and visual tools that can quickly show whether the variables represent a normal population distribution, and how data might be grouped for further testing. These are applicable to both discrete

variables (those that are limited to assigned values, such as 1 = mulched, 0 = not mulched) and continuous variables (those that can be represented by any point within the given limits, such as percentage of sand or height of vegetation). Continuous variables are most often represented in frequency distributions by ranges rather than distinct values. How these ranges are determined can affect the distribution pattern; different distributions can indicate different information about the variables. Selected distributions for the variables in the 100 sample test plots for the Belle Ayr study are included in Appendix E.

Data may be separated into major categories on the basis of influential factors that cannot be categorized as either discrete or continuous variables. A climatic overview, based on the years sampled, might suggest differences among years that could not be explained in light of the other available variables. The climatic graphs prepared for the Belle Ayr study (Appendix C) can be used to help understand how weather might have affected the plantings.

In studies where data have been recorded for many test sites, graphic representations can show trends and relationships not readily apparent in written form. Scattergrams, graphs, and charts are useful to show relationships among variables. They can also show the magnitude of relationships, and indicate values that show extreme variation from the majority of the values. It is important to compare not only the relationships among the predictor and response variables, but also the relationships among different predictor variables. These may indicate interactions whose cumulative effects could change the predicted or controlled value, or they might indicate that only one of the factors is necessary for use as a predictor.

Correlation tests can indicate possible relationships (and their relative strengths) between variables. These are also useful for comparing relationships between different sets of variables. These will indicate whether the relationship is positive or negative (or both). A high correlation does not always represent a cause-effect relationship. The factors may have some other common denominator, such as higher concentrations of soil nutrients associated with clayey soils.

Rank correlation tests are useful when the values of the variables being compared do not have normal distributions. The values of each variable are ranked, and then the rankings are correlated. This method can show relationships that might not be apparent in correlations run on the original data set. A comparison of the results of ranked and unranked correlations on the set of test plots (n=100), indicating relationships between predicted values and selected soil elements, is presented in Appendix E.

By using regression analysis, a simple "model" of the data set being tested can be constructed. Regression models are often precursors of more accurate modeling methods. Full regression models incorporate all of the variables chosen to predict the desired response. Stepwise regression allows variables to be accepted or rejected according to the degree of correlation that they show with the response variable, and the probability that they contributed to the predicted response. Both types result in algebraic equations with coefficients for each included variable, and an estimate-of-error range that could be expected if the equation were used to predict the desired response. Residuals (the difference between the real and the predicted response) can be calculated and plotted to further analyze how well the model fits the data. The results of several regression tests, to determine which factors affected total cover percentages at Belle Ayr, are shown in Appendix E.

Regression models are only as valid as the data analysis and research that preceded them. One method of testing the reliability of these models is to reserve a set of data that was not used in model development, to test the results and evaluate the residuals and agreement within the given estimate-of-error range.

Interpreting the Belle Ayr Data

Preparation for developing accurate prediction models can start with background information, graphic analysis, and simple statistical tests. Examples of these methods are shown by looking at some of the Belle Ayr data categories.

Soils and Soil Components

Soil Texture (percent of sand, silt and clay) may be one of the main indicators of suitability for the establishment of vegetation. The textural classification is closely associated with moisture availability, fertility, and organic matter. (Peperzak, 1956). Nutrients and salts are more easily leached from sandy soils. Silty and clayey soils retain water within the root zones of most plants, an important factor in climates with extended periods of little or no precipitation. Normally favorable factors may have negative effects if the soil texture is not suited to the chosen plant materials. Over a period of time, clays and silts show a faster buildup of organic material and better aggregation than sandy soils (Peperzak, 1956). This is particularly important on disturbed lands; it may take many years to re-establish the complex interactions present in undisturbed soils that help to prevent unfavorable changes during times of stress. In semi-arid and arid regions, the reduced permiability of clay is not as much of a liability as it is in wetter climates. It can, however, lead to excessive buildups of undesirable salts and carbonates. Soils with a high clay content can crust, leading to poor seedling emergence (Sopher & Baird, 1978).

Many of the physical and chemical properties of soil are closely associated with textural classifications, making evaluations of the interaction of soil elements difficult.

The average soils at Belle Ayr are high in sand content. This is reflected by low levels of elements, such as potassium, which have been leached out of the soil.

One method of negating these inter-related effects is to analyze the data by separating them into groups based on intervals of sand, silt or clay percentages (Peperzak, 1956). A circle graph and one of the sets of regression models developed for Belle Ayr (Appendix E) are based on dividing the data into two sets, depending on whether clay content is greater or less than 20 percent.

Nitrogen is required for plant growth and reproduction. In undisturbed natural ecosystems, most plants have relatively slow growth rates and require small amounts of soil nitrogen. The amount of available nitrogen fluctuates according to the interaction of temperature, pH, moisture, aeration and plant nitrification processes. Normally, sufficent nitrogen is returned to the soil by accumulated plant litter and organic matter. Cultivation practices in revegetation result in rapid initial growth, and soil nitrogen is often insufficient for normal growth. It is often necessary to use chemical fertilizers or nitrogen-fixing legumes.

At Belle Ayr, nitrogen is included in the basic fertilizer, and legumes (alfalfa and yellow sweetcover) are included in most of the seed mixes. The level of nitrogen in the test set (n=100) indicates levels of 1.7 to 10.4 ppm. These values are low for this area, but the results of this soil test are questionable. The soil samples were not sent to be tested until several months after they were gathered. Although most soil elements will remain relatively stable over this period of time, nitrate-nitrogen levels may change by 50 to 100 percent (Roger Pasch, Intermountain Laboratories, personal communication, April, 1986).

Phosphorus is important for vigorous initial plant growth and root development. Adequate nitrogen has been shown to improve seedling germination and increase the winter hardiness of species seeded in the fall. Even in native soils, only small supplies may be available during any one growing season, and soils that test high in phosphorus may need supplementation for best growth (Sopher & Baird, 1978). The phosphorus levels recorded in the test set (n=100) range from 1 to 12 ppm, with many levels below 4. In this area, phosphorus levels are normally rather low; averaging between 1 and 5 ppm.

Potassium is the least understood of the three main soil nutrients. It is associated with plant metabolism and photosysthesis. Potassium is depleted easily through leaching, particularly in sandy soils like those at Belle Ayr. Grazing also reduces the amount of potassium (Sopher & Baird, 1978).

The potassium levels recorded for the test set (n=100) are extremely low, ranging from 7 to 31 ppm. Normals for this area range from 1 to 200.

Carbonates, such as calcite and dolomite, are formed from easily weathered materials. These are usually leached from the soil over a period of time. In arid and semi-arid regions, however, they may accumulate in the upper soil horizons, resulting in a more basic soil typically higher in pH (Bohn, McNeal & O'Conner, 1979). Carbonate levels for the test set (n=100) range from 0.4 to 3.4. The normal range for this area is from 1 to 3 percent.

Sodium. High sodium levels (most often the main contributor to high salt levels in the soil) impede the ability of plants to obtain necessary water and nutrients, even if these are present in the soil. In areas with a high sodium content, salt-tolerant plants should be chosen (Bohn et al., 1979). The sodium values at Belle Ayr range from 0.5 to 13 meq/l. Normal ranges in this region are from 1 to 5 meq/l.

Soil Moisture content may be a better indicator than precipitation for evaluating the moisture requirements of plants. Soil moisture supplies vary less than precipitation patterns (Box, 1981). These supplies depend on a number of factors -- available moisture, soil porosity, presence of organic matter, aspect, slope position and protective cover.

Soil moisture evaluations for the test plots at Belle Ayr were recorded as judgemental ratings of 1 to 10, for visual and actual soil moisture. Many of the tests were taken in early morning, and those performing the tests said that they were biased by dew on the ground. Most of these ratings were done during periods of little or no rain, and do not serve as reliable indicators.

<u>Topographical Factors</u>

Aspect refers to the angle of the slope in relation to the position of the sun. In general, north aspects are expected to show more vegetative growth than south aspects (Peperzak, 1956). On north-facing slopes, particularly in arid and semi-arid regions, there is less evaporation of available moisture, and more is retained for use by plants -- especially when conditions are droughty (Law, 1984).

The data from the test plots (n=100) do not indicate major differences in total vegetative cover for varying aspects. However, further analysis indicates that the percentages of individual species varies from one aspect to another. The circle graph in Appendix E comparing cover for east and west aspects illustrates these variations.

Inclination and slope position were also noted for the test plots. These were visual ratings, and do not appear to account for major differences in cover percentages at Belle Ayr.

Further Testing at Belle Ayr

There are many other studies that could be generated based on the information gathered for the Belle Ayr Reclamation

Monitoring program. Information on the effects of grazing, interseeding, presence and effect of weedy species and species that were not seeded, differentiations between types and amounts of mulch and nurse crops, are all recorded to some degree. Future collected data, if in the same format as that used in the Reclamation Monitoring program, could then be compared with present data.

Chapter 7

CONCLUSIONS AND RECOMMENDATIONS

The SEAM models serve as examples of model development. The methodology used seems appropiate for revegetation studies on disturbed lands, but the hypotheses generated need further analysis through field testing designed specifically to measure the accuracy of the predictions. Some of the methods used, particularly those for expressing the relationships among elements through mathematical model development, could be appropriate for assembling more site-specific models.

When this study began, it was assumed that the amount of data collected from the Belle Ayr project would be sufficient to generate acceptable revegetation prediction models. It is now apparent that the complexity of ecosystem dynamics requires a more rigorous approach to data collection and analysis, with specific objectives determined before the data is gathered. The revegetation specialists at Belle Ayr have plans to gather more data on the reclamation units in the summer of 1986. If the parameters from the 1984 tests can be replicated, combining new data and existing data could provide a base for successful modeling.

Guidelines could be established before the data collection begins. There should be consistant methods for measurement from year to year, with careful attention to those factors that require discrete ratings, making sure that all of those responsible for collecting data judge by the same standards. The accurate recording of data is probably as important as accurate measuring. Missing references locations or missing data can negate all of the time and effort required for data collection. The same tests should be run in the same manner from year to year so that the results from one study can be used in another. Control (unmined, undisturbed) areas should be tested to provide some means of comparison. Soil samples should be tested as soon possible after they have been collected. Because of the importance of climatic influences, weather data could be incorporated as a component of the database.

Those who attempt to create models are often limited to routinely collected data, and must evaluate and manipulate this data within the restrictions imposed by the situation. It is the goal of the modeler to build a model requiring the fewest possible number of input variables without sacrificing the validity of the model. In the model building stage, however, it is likely that as many factors as possible will be analyzed for acceptance or rejection as model components.

Model development is characterized by trial and error, diversionary discoveries, unexpected results, and often unplanned routes to unanticipated destinations. Though a modeler must be flexible as the project progresses, the initial checklist of goals and required tasks should be repeatedly reviewed and updated. These might best be listed as a series of questions, whose answers can be modified or strengthened at each juncture in the modeling process:

1. What purpose will the model serve?
2. Who will use the model?
3. What factors will be tested?
4. Are the data available, reliable, testable?
5. What are the parameters?
6. What forms of analysis will be used?
12. What form will the model take?
13. How well does the model predict the anticipated results?
14. Have the objectives of the study been met?
15. Does the model suggest further study?
16. Is the model usable?

The proliferation of computerized databases and geographical information systems places massive amounts of data into the hands of anyone who can use a computer. Modeling and related analytical activities are no longer restricted to those few who have advanced scientific and mathematical backgrounds.

Understanding the differences in types of models, how models are constructed, and how they apply to ecological studies of disturbed lands, will benefit the landscape architect or other associated professionals. These studies give new meaning to the familiar processes of site inventory and analysis, and provide a medium for closer communication among professionals involved in all areas of ecological studies.

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Appendix A

SEAM MODEL COMPUTER PROGRAMS

Description of the SEAM Model Computer Programs

The BASICA translation of the SEAM revegetation prediction models consists of two programs--REVEG and REVEG2. Both programs can be accessed by running REVEG and making selections from the main menu, or they can be run as independent programs. The REVEG program (for potential vegetation on unmined sites) will produce pre-programmed tables, or allow user input to determine values for a specific site.

The REVEG2 program (for revegetated mined sites) will produce tables dependent upon user input of required data. The BASICA version includes indexing (reference numbers) and page numbering for clarification. An additional option, directing the output to the screen, has also been added.

The original program for predicting revegetation potential on unmined sites was designed to produce tables for high, medium and low precipitation rates. The BASICA program has additional intermediate rates, as changes in precipitation rate show the most significant effect on the predicted amount of forage production and vegetative cover. The BASICA program includes the option of entering data for a specific site.

If the user wishes to produce the tables for unmined sites using values for precipitation rate, growing season and soil potassium content that are not in the original program, the

BASICA program must be altered. To do this, a copy of the program is loaded and the DATA statements (lines 1790-1830) must be changed to correspond to the new values. Unless the user is familiar with programming logic, the same number of values that exist in the original program should be entered in order to maintain the correct formatted output. Alterations should be made on a copy of the program, leaving the original program intact.

The four FORTRAN programs for unmined sites have incorporated a range of required data. Running the program, as originally designed, automatically produces 243 continuous tables: over 700 pages of printed tables! To compare percentage of cover and forage production for both introduced and native species at one, three and five years (age of vegetative growth) using a low, medium and high value for precipitation rate, growing season length, soil pH, soil sodium and soil potassium content, 2916 tables would be automatically generated. Each table contains 128 possible combinations of revegetation methods, yielding 373,248 estimations of forage production and percentage of cover. In the BASICA version, these three programs for mined areas have been combined into one program, including revisions which enable the user to enter the required data and print or view one table at a time. Because of the length of the formatted output, the user can elect to interrupt the program (on the screen option only) after viewing the desired results. This is done by pressing the [Control] and [Break] keys together, and then running the program again if another set of variables is to be entered.

The BASICA programs are not set up to guard against "illegal" or out-of-range values. The predicted forage production and percentage of cover will only be valid if input statements fall within the range of pre-set limits:

5 inches < = Yearly precipitation < = 25 inches

50 days < = Growing season length < = 180 days

0 ppm < = Potassium < = 450 ppm

0 ppm < = Sodium < = 1000 ppm

4 < = pH < = 9

0 years < = Age of vegetation < = 7 years

REVEG

A BASICA Computer Program (used in conjunction with the REVEG2 program) that generates predictions for forage production and cover on unmined lands, based on the mathematical models developed with the SEAM Report (Packer et al., 1982).

REVEG Computer Program

```
10 REM ** Reveg
20 CLEAR
30 DIM AMT(6,6,5)
40 CLS
50 PRINT "      ************************************************************"
60 PRINT "            A Computer Program to be used in conjunction with:"
70 PRINT
80 PRINT "                MODELS TO ESTIMATE REVEGETATION POTENTIAL"
90 PRINT "                   OF LANDS SURFACE MINED IN THE WEST"
100 PRINT
110 PRINT "             USDA/FS Technical Report INT-123 (August 1982)"
120 PRINT "               (P.Packer, C.Jensen, E.Nobel, J.Marshall)"
130 PRINT
140 PRINT "     Translated and revised from Fortran IV to MS-DOS/PC-DOS BASICA"
150 PRINT "                                 by"
160 PRINT "                         Barbara A. Meidinger"
170 PRINT "                        Kansas State University"
180 PRINT "                              April 1984"
190 PRINT "                         Revised February 1986"
200 PRINT "      ************************************************************"
210 PRINT:PRINT
220 PRINT "          [1] Estimated revegetation potential for unmined lands"
230 PRINT "          [2] Estimated revegetation potential for mined lands"
240 PRINT "          [3] Exit program"
250 PRINT
260 INPUT "                                            Press [1-3] ",II
270 ON II GOTO 280,1500,1490
280 CLS
290 PRINT "    UNMINED AREAS -- REVEGETATION POTENTIAL PREDICTION MODELS"
300 PRINT:PRINT
310 PRINT "     [1] Input data for a specific site"
320 PRINT "     [2] Generate comparative tables"
330 PRINT "     [3] Return to main menu"
340 PRINT "     [4] Exit program"
350 PRINT:PRINT
360 INPUT "                          Press [1-4] ",KK
370 ON KK GOTO 380,560,20,1490
380 CLS
390 PRINT "     UNMINED AREAS -- DATA INPUT FOR A SPECIFIC SITE"
400 PRINT:PRINT:PRINT "Unmined Site ID:____________________________________
    _________________________"
410 LOCATE 4,18: LINE INPUT SITE$
420 PRINT:PRINT
430 PRINT "    Input Limits:":PRINT
440 PRINT "      50 <= GS <= 180"
450 PRINT "       5 <= PR <= 25"
460 PRINT "       0 <=  K <= 450"
470 PRINT:PRINT
480 INPUT "          Growing season (days/year) = ", GS
490 INPUT "          Precipitation rate (inches/year) = ", PR
500 INPUT "          Soil Potassium (parts/million) = ", PO
510 K=1:L=1:M=1
520 GOSUB 1520
```

```
530 K=2:L=2:M=2
540 GOSUB 1620
550 GOTO 870
560 CLS
570 PRINT "     UNMINEO AREAS -- REVEGETATION POTENTIAL PREOICTION MOOELS"
580 PRINT:PRINT
590 PRINT "     [I] Estimation of percentage of vegetative cover"
600 PRINT "     [2] Estimation of forage production (lbs/acre)"
610 PRINT "     [3] Return to main menu"
620 PRINT "     [4] Exit program"
630 PRINT:PRINT
640 INPUT "                      Press [I-4] ",JJ
650 ON JJ GOTO 660,660,20,I490
660 CLS
670 LOCATE I0,27
680 PRINT "Calculating......please wait!"
690 FOR M=I TO 5
700 REAO PR(M)
710 NEXT M
720 FOR K=I TO 6
730 REAO GS(K)
740 NEXT K
750 FOR L=1 TO 3
760 REAO PO(L)
770 PO=PO(L)
780 FOR K=1 TO 6
790 GS=GS(K)
800 FOR M=1 TO 5
810 PR=PR(M)
820 ON JJ GOSUB 1520,I620
830 NEXT M
840 NEXT K
850 NEXT L
860 CLS
870 CLOSE #1:CLOSE #2
880 OPEN "LPT1:" FOR OUTPUT AS #I
890 OPEN "SCRN:" FOR OUTPUT AS #2
900 CLS:LOCATE 10,27
910 INPUT "Printer or display screen? (P/S) ",O$
920 IF (O$<>"S" AND O$<>"s") AND (O$<>"P" AND O$<>"p") THEN 910
930 IF O$="P" OR O$="p" THEN O=I ELSE O=2
940 CLS
950 IF KK=I GOTO I310
960 PRINT#O, "          UNMINEO AREAS"
970 IF JJ=2 GOTO 990
980 PRINT#O, "          PERCENT OF VEGETATIVE COVER":GOTO 1000
990 PRINT#O, "          FORAGE PROOUCTION (LBS/ACRE)"
1000 FOR L=I TO 3
1010 PRINT#O,:PRINT#O,
1020 GOSUB 1730
I030 PRINT#O, "          | Potassium = ";PO(L);" parts/million";TAB(62);"|"
1040 GOSUB 1730
1050 PRINT#O, "          | Oays of |                  Inches             |"
```

```
1060 PRINT#0, "            | Growing |            Precipitation            |"
1070 PRINT#0, "            |  Season |";
1080 FOR N=1 TO 5
1090 PRINT#0, USING "   ##   ";PR(N);
1100 NEXT N
1110 PRINT#0, "|"
1120 GOSUB 1700
1130 GOSUB 1760
1140 FOR K= 1 TO 6
1150 PRINT#0, USING "          |   ###   |";GS(K);
1160 FOR M=1 TO 5
1170 PRINT#0, USING "  ####  ";CINT(AMT(L,K,M));
1180 NEXT M
1190 PRINT#0, "|"
1200 NEXT K
1210 GOSUB 1760
1220 GOSUB 1700
1230 IF O=1 GOTO 1270
1240 LOCATE 22,35
1250 PRINT#0, "Press any key to continue":A$=INPUT$(1)
1260 CLS
1270 NEXT L
1280 LOCATE 5,27:PRINT "[1] Return to main menu":PRINT TAB(27);
     "[2] Exit program"
1290 LOCATE 11,35:INPUT "Press [1-2] ",PP
1300 ON PP GOTO 20,1490
1310 PRINT#0,:PRINT#0,
1320 PRINT#0, "          Unmined Site ID: ";SITE$
1330 PRINT#0, "            GS = ";GS
1340 PRINT#0, "            PR = ";PR
1350 PRINT#0, "             K = ";PO
1360 PRINT#0,
1370 PRINT#0, "          Estimated percentage of vegetative cover: ";
     CINT(AMT(1,1,1))
1380 PRINT#0, "          Estimated forage production (lbs/acre): ";
     CINT(AMT(2,2,2))
1390 IF O=1 GOTO 1410
1400 LOCATE 20,50:PRINT "Press any key to cont.":A$=INPUT$(1)
1410 CLS
1420 LOCATE 5,27
1430 PRINT TAB(27);"[1] Enter data for another site"
1440 PRINT TAB(27);"[2] Return to main menu"
1450 PRINT TAB(27);"[3] Exit program"
1460 LOCATE 12,35
1470 INPUT "                   Press [1-3] ",MM
1480 ON MM GOTO 380,20,1490
1490 CLS:END
1500 RUN "reveg2"
1510 REM ** SUBROUTINE/COVER CALCULATIONS
1520 I=.14+.285*(EXP(-(ABS((GS/180-1)/.46)^15)))
1530 YPFL=80+20*(EXP(-(ABS((GS/180-1)/.46)^15)))
1540 YPA=1-(EXP(-(ABS((GS/180-1)/.46)^15)))
1550 YPO=9*(EXP(-(ABS((PO/400-1)/.43)^15)))
```

```
1560 YP=YPFL+YPA*YPD
1570 LN=EXP(-(ABS((PR/25-1)/(1-I))^5))
1580 RN=EXP(-((1/(1-I))^5))
1590 AMT(L,K,M)=((LN-RN)/(1-RN))*YP*.97917
1600 RETURN
1610 REM ** SUBROUTINE/PRODUCTION CALCULATIONS
1620 YN=1.8-.56*(EXP(-(ABS(((180-GS)/106-1)/.3)^3.8)))
1630 YPFL=1570+1060*(EXP(-(ABS((GS/86.6-1)/.12)^4)))
1640 YP1=YPFL+560*(EXP(-(ABS((PO/450-1)/.6)^18)))
1650 IF GS>86.6 THEN 1660 ELSE 1670
1660 YP1=1700+(YP1-1700)*(EXP(-(ABS(((180-GS)/93.4-1)/9.000001E-02)^3)))
1670 AMT(L,K,M)=((YP1/25^YN)*PR^YN)*.94584
1680 RETURN
1690 REM ** SUBROUTINE/FORMAT
1700 PRINT#0, "             +---------+-------+-------+-------+-------+-------+--------+"
1710 RETURN
1720 REM ** SUBROUTINE/FORMAT
1730 PRINT#0, "             +---------+----------------------------------------------+"
1740 RETURN
1750 REM ** SUBROUTINE/FORMAT
1760 PRINT#0, "             !         !";TAB(62);"!"
1770 RETURN
1780 REM ** PR rates
1790 DATA 5,10,15,20,25
1800 REM ** GROWING SEASON
1810 DATA 50,70,85,100,120,150
1820 REM ** SOIL POTASSIUM
1830 DATA 0,200,400
```

REVEG2

A BASICA Computer Program (used in conjunction with the REVEG program) that generates predictions for forage production and cover on mined lands, based on the mathematical models developed with the SEAM Report (Packer et al., 1982).

REVEG2 Computer Program

```
10 REM ** Reveg2
20 REM ** To be used with "Reveg" program
30 REM ** B.A. Meidinger/KSU/April 1984/rev. Jan 1986
40 CLEAR
50 DIM PN(128,7)
60 DEFINT C,D,I-O,R
70 CLS
80 PRINT "MINED AREAS -- REVEGETATION POTENTIAL PREDICTION MODELS"
90 LOCATE 4,1
100 PRINT "   Input Limits":PRINT
110 PRINT "       5 <= PR <= 25"
120 PRINT "      50 <= GS <= 180"
130 PRINT "       0 <=  K <= 450"
140 PRINT "       0 <= NA <= 1000"
150 PRINT "       4 <= pH <= 9"
160 PRINT "       0 <=Age <= 7":PRINT:PRINT
170 INPUT "Site Identification Number (limit: 3 digits) = ",ID:PRINT
180 INPUT "Precipitation Rate (inches/year) = ",PR
190 INPUT "Growing Season (days/year) = ",GS
200 INPUT "Soil Potassium (parts/million) = ",PO
210 INPUT "Soil Sodium (parts/million) = ",SO
220 INPUT "Soil pH = ",PH
230 INPUT "Age of Vegetation (years) = ",AGE
240 CLS
250 LOCATE 5,27
260 PRINT TAB(27); "[1] Native Species Production"
270 PRINT TAB(27); "[2] Introduced Species Production"
280 PRINT TAB(27); "[3] Native Species Cover"
290 PRINT TAB(27); "[4] Introduced Species Cover"
300 LOCATE 13,35
310 INPUT "Choose [1-4] ",CHS
320 CLOSE #1:CLOSE #2
330 OPEN "LPT1:" FOR OUTPUT AS #1
340 OPEN "SCRN:" FOR OUTPUT AS #2
350 CLS:LOCATE 10,27:INPUT "Printer or display screen [P/S] ? ",D$
360 IF D$<>"S" AND D$<>"s" AND D$<>"P" AND D$<>"p" THEN 350
370 IF D$="P" OR D$="p" THEN D=1 ELSE D=2
380 CLS
390 GOSUB 1900
400 ON CHS GOSUB 1400,1470,1540,1610
410 ON CHS GOSUB 1680,1680,1750,1750
420 GOSUB 530
430 GOSUB 2070
440 IF D=1 THEN PRINT#D, TAB(30);"( 3 )" ELSE GOSUB 2100
450 CLS:LOCATE 5,27:PRINT "[1] Generate another chart"
460 PRINT TAB(27); "[2] Return to main menu"
470 PRINT TAB(27); "[3] Exit program"
480 LOCATE 12,35:INPUT "Press [1-3] ",D
490 ON D GOTO 40,500,510
500 RUN "reveg"
510 CLS:END
520 REM ** SUBROUTINE/ESTABLISH TREATMENT FACTOR ARRAY
530 RW=1
```

```
540 FOR I=1 TO 7
550 PN(RW,I)=0
560 NEXT I
570 GOSUB 1180
580 FOR I=1 TO 7
590 PN(RW,I)=1
600 GOSUB 1180
610 NEXT I
620 FOR I=1 TO 6
630 FOR J=(I+1) TO 7
640 PN(RW,I)=1:PN(RW,J)=1
650 GOSUB 1180
660 NEXT J
670 NEXT I
680 FOR I=1 TO 5
690 FOR J=(I+1) TO 6
700 FOR K=(J+1) TO 7
710 PN(RW,I)=1:PN(RW,J)=1:PN(RW,K)=1
720 GOSUB 1180
730 NEXT K
740 NEXT J
750 NEXT I
760 FOR I=1 TO 4
770 FOR J=(I+1) TO 5
780 FOR K=(J+1) TO 6
790 FOR L=(K+1) TO 7
800 PN(RW,I)=1:PN(RW,J)=1:PN(RW,K)=1:PN(RW,L)=1
810 GOSUB 1180
820 NEXT L
830 NEXT K
840 NEXT J
850 NEXT I
860 FOR I=1 TO 3
870 FOR J=(I+1) TO 4
880 FOR K=(J+1) TO 5
890 FOR L=(K+1) TO 6
900 FOR M=(L+1) TO 7
910 PN(RW,I)=1:PN(RW,J)=1:PN(RW,K)=1:PN(RW,L)=1:PN(RW,M)=1
920 GOSUB 1180
930 NEXT M
940 NEXT L
950 NEXT K
960 NEXT J
970 NEXT I
980 FOR I=1 TO 2
990 FOR J=(I+1) TO 3
1000 FOR K=(J+1) TO 4
1010 FOR L=(K+1) TO 5
1020 FOR M=(L+1) TO 6
1030 FOR MM=(M+1) TO 7
1040 PN(RW,I)=1:PN(RW,J)=1:PN(RW,K)=1:PN(RW,L)=1:PN(RW,M)=1:PN(RW,MM)=1
1050 GOSUB 1180
1060 NEXT MM
```

```
1070 NEXT M
1080 NEXT L
1090 NEXT K
1100 NEXT J
1110 NEXT I
1120 FOR I=1 TO 7
1130 PN(RW,I)=1
1140 NEXT I
1150 GOSUB 1180
1160 RETURN
1170 REM ** SUBROUTINE/CALCULATE VALUES/PRINT TABLES
1180 ON O GOTO 1190,1210
1190 IF RW>1 AND RW/43=INT(RW/43) THEN GOSUB 2070 ELSE GOTO 1250
1200 NO=CINT(RW/43):PRINT#O, TAB(30);"(";NO;")":GOTO 1240
1210 IF RW>1 AND RW/15=INT(RW/15) THEN GOTO 1220 ELSE GOTO 1250
1220 PRINT#O, TAB(10); "+-----+----+---+---+---+---+---+----+------+
     Press any key to cont."
1230 A$=INPUT$(1)
1240 PRINT#O, CHR$(12):GOSUB 1900
1250 PRINT#O, TAB(10); USING "| ### | ";RW;
1260 FOR N=1 TO 7
1270 IF PN(RW,N)=1 THEN M(N)=1 ELSE M(N)=0
1280 NEXT N
1290 Z=XT+T+M(1)*AD(1)+M(2)*AD(2)+M(3)*AD(3)+M(4)*AD(4)+M(5)*AD(5)
     +M(6)*AD(6)+M(7)*AD(7)+PD*AD(8)+SD*AD(9)+PH*AD(10)
1300 IF Z<0 THEN Z=0
1310 IF (CHS=3 OR CHS=4) AND (Z>100) THEN Z=100
1320 FOR N=1 TO 7
1330 IF M(N)=1 THEN M$=" X  " ELSE M$=" -  "
1340 PRINT#O, M$;
1350 NEXT N
1360 PRINT#O, USING "| #### |";CINT(Z)
1370 RW=RW+1
1380 RETURN
1390 REM ** SUBROUTINE/ADDITIVE COMPONENTS/NATIVE PRODUCTION
1400 T=-2215.925
1410 AD(1)=13.30125:AD(2)=340.7638:AD(3)=-83.07744:AD(4)=368.7023
1420 AD(5)=34.89601:AD(6)=-177.5357:AD(7)=334.5373
1430 AD(8)=5.39904:AD(9)=-8.788242E-02:AD(10)=117.9473
1440 X=1.04368
1450 REM ** SUBROUTINE/ADDITIVE COMPONENTS/INTRODUCED PRODUCTION
1460 RETURN
1470 T=-1180.82
1480 AD(1)=-307.9574:AD(2)=-782.8676:AD(3)=99.46091:AD(4)=429.5873
1490 AD(5)=418.1331:AD(6)=159.9511:AD(7)=-78.4929
1500 AD(8)=4.08251:AD(9)=-1.361515:AD(10)=143.3554
1510 X=1.17448
1520 RETURN
1530 REM ** SUBROUTINE/ADDITIVE COMPONENTS/NATIVE COVER
1540 T=12.86572
1550 AD(1)=-3.929149:AD(2)=-1.836147:AD(3)=6.056078:AD(4)=11.19705
1560 AD(5)=.5945488:AD(6)=15.16765:AD(7)=-5.601713
1570 AD(8)=8.918672E-02:AD(9)=-1.861335E-02:AD(10)=-4.176856
```

```
1580 X=1.07686
1590 RETURN
1600 REM ** SUBROUTINE/ADDITIVE COMPONENTS/INTRODUCED COVER
1610 T=-74.25283
1620 AD(1)=-10.02594:AD(2)=1.02198:AD(3)=.3622047:AD(4)=30.88224
1630 AD(5)=15.06255:AD(6)=4.778853:AD(7)=18.96781
1640 AD(8)=2.049003E-02:AD(9)=9.275586E-03:AD(10)=7.643977
1650 X=.98256
1660 RETURN
1670 REM ** SUBROUTINE/INTRODUCED CALCULATIONS
1680 YPPR=(EXP(-(ABS((AGE/7-1)/.9)^4.6)))
1690 IF GS>85 THEN GOTO 1710
1700 YPG1=2510*(EXP(-(ABS((GS/85-1)/.16)^4)))+940:YPG3=YPG1:GOTO 1720
1710 YPG2=1200*(EXP(-(ABS((GS/85-1)/.12)^4)))+2250:YPG3=YPG2
1720 XT=YPPR*YPG3*6.18959E-03*PR^1.6:XT=XT*X
1730 RETURN
1740 REM ** SUBROUTINE/NATIVE CALCULATIONS
1750 AYP=1.8+EXP(-(ABS(((180-GS)/180-1)/.52)^15))
1760 BYP=.29*(EXP(-(ABS((GS/180-1)/.5015)^12)))-.2
1770 YPGS=100*(EXP(-(ABS((GS/180-1)/.78)^8)))
1780 BGS=.23*(EXP(-(ABS(((180-GS)/180-1)/.36)^6.5)))+.1
1790 AX=AYP*(1.1397*(EXP(-(ABS((AGE/10-1)/.88)^5.8)))-.1397)+1
1800 BX=(BYP/10)*AGE+.38
1810 AY=EXP(-(ABS(((AGE+1)/11-1)/(1-BGS))^10))
1820 BY=EXP(-((1/(1-BGS))^10))
1830 YP=((AY-BY)/(1-BY))*YPGS
1840 TN=EXP(-(ABS((PR/26-1)/(1-BX))^AX))
1850 UN=EXP(-((1/(1-BX))^AX))
1860 PC=((TN-UN)/(1-UN))*YP
1870 XT=PC*X
1880 RETURN
1890 REM ** SUBROUTINE/USER CHOICES
1900 PRINT#0, TAB(10); "MINED AREAS -- ";
1910 IF CHS=1 THEN PRINT#0, "NATIVE SPECIES PRODUCTION"
1920 IF CHS=2 THEN PRINT#0, "INTRODUCED SPECIES PRODUCTION"
1930 IF CHS=3 THEN PRINT#0, "NATIVE SPECIES COVER"
1940 IF CHS=4 THEN PRINT#0, "INTRODUCED SPECIES COVER"
1950 PRINT#0, TAB(10); USING "Site No. ###   ";ID;
1960 PRINT#0, " PR   GS   K    NA   pH   AGE "
1970 PRINT#0, TAB(10); "                    ";
1980 PRINT#0, USING " ### ";PR,GS,PO,SO,PH,AGE
1990 GOSUB 2070
2000 IF CHS=1 OR CHS=2 THEN LBL1$="PROD/ |" ELSE LBL1$="  %   |"
2010 IF CHS=1 OR CHS=2 THEN LBL2$=" ACRE |" ELSE LBL2$="COVER |"
2020 PRINT#0, TAB(10); "| REF |                                 |";LBL1$
2030 PRINT#0, TAB(10); "|  #  | TIL  SM TPS FER IRR MUL  ST |";LBL2$
2040 GOSUB 2070
2050 RETURN
2060 REM ** SUBROUTINE
2070 PRINT#0, TAB(10); "+-----+----+---+---+---+---+----+------+"
2080 RETURN
2090 REM ** SUBROUTINE
2100 LOCATE 20,50:PRINT "Press any key to cont."
2110 A$=INPUT$(1)
2120 RETURN
```

Examples of Printed Output for the Computer Programs REVEG and REVEG2

The tables generated for unmined sites are self-explanatory. The tables for revegetated mined land forage production and cover can be interpreted using the following chart:

TREATMENT	CODE	X	-
Tillage	TIL	YES	NO
Seeding method	SM	DRILLING	BROADCASTING
Topsoil added	TPS	YES	NO
Fertilizer added	FER	YES	NO
Irrigation	IRR	YES	NO
Mulch	MUL	YES	NO
Seeding time	ST	FALL	SPRING

Example of REVEG Computer Program Print-out

UNMINED AREAS / PERCENT OF VEGETATIVE COVER

Potassium = 0 parts/million

Days of Growing Season	Inches Precipitation 5	10	15	20	25
50	34	65	76	78	78
70	34	65	76	78	78
85	34	65	76	78	78
100	13	57	84	89	89
120	1	29	83	97	98
150	1	28	83	97	98

Potassium = 200 parts/million

Days of Growing Season	Inches Precipitation 5	10	15	20	25
50	34	65	76	78	78
70	34	65	76	78	78
85	34	65	76	78	78
100	13	57	84	89	89
120	1	29	83	97	98
150	1	28	83	97	98

Potassium = 400 parts/million

Days of Growing Season	Inches Precipitation 5	10	15	20	25
50	37	72	85	87	87
70	37	72	85	87	87
85	37	72	85	87	87
100	14	59	88	93	93
120	1	29	83	97	98
150	1	28	83	97	98

Example of REVEG Print-out (continued)

UNMINED AREAS / FORAGE PRODUCTION (LBS/ACRE)

Potassium = 0 parts/million					
Days of Growing Season	Inches Precipitation 5	10	15	20	25
50	155	411	725	1086	1485
70	202	477	789	1127	1486
85	333	791	1313	1882	2487
100	156	426	767	1163	1607
120	90	312	644	1078	1608
150	89	309	641	1076	1608

Potassium = 200 parts/million					
Days of Growing Season	Inches Precipitation 5	10	15	20	25
50	198	525	927	1387	1897
70	258	609	1008	1440	1899
85	388	922	1531	2194	2899
100	157	428	770	1168	1614
120	90	312	644	1078	1608
150	89	309	641	1076	1608

Potassium = 400 parts/million					
Days of Growing Season	Inches Precipitation 5	10	15	20	25
50	211	557	984	1473	2015
70	274	647	1070	1529	2016
85	404	960	1593	2282	3017
100	157	429	771	1170	1616
120	90	312	644	1078	1608
150	89	309	641	1076	1608

Example of REVEG2 Computer Program Print-out

MINED AREAS -- NATIVE SPECIES COVER

Site No.	PR	GS	K	NA	pH	AGE
1	15	125	15	50	7	5

REF #	TIL	SM	TPS	FER	IRR	MUL	ST	% COVER
1	-	-	-	-	-	-	-	52
2	X	-	-	-	-	-	-	48
3	-	X	-	-	-	-	-	50
4	-	-	X	-	-	-	-	58
5	-	-	-	X	-	-	-	63
6	-	-	-	-	X	-	-	53
7	-	-	-	-	-	X	-	67
8	-	-	-	-	-	-	X	46
9	X	X	-	-	-	-	-	46
10	X	-	X	-	-	-	-	54
11	X	-	-	X	-	-	-	59
12	X	-	-	-	X	-	-	49
13	X	-	-	-	-	X	-	63
14	X	-	-	-	-	-	X	43
15	-	X	X	-	-	-	-	56
16	-	X	-	X	-	-	-	61
17	-	X	-	-	X	-	-	51
18	-	X	-	-	-	X	-	65
19	-	X	-	-	-	-	X	45
20	-	-	X	X	-	-	-	69
21	-	-	X	-	X	-	-	59
22	-	-	X	-	-	X	-	73
23	-	-	X	-	-	-	X	53
24	-	-	-	X	X	-	-	64
25	-	-	-	X	-	X	-	78
26	-	-	-	X	-	-	X	58
27	-	-	-	-	X	X	-	68
28	-	-	-	-	X	-	X	47
29	-	-	-	-	-	X	X	62
30	X	X	X	-	-	-	-	52
31	X	X	-	X	-	-	-	58
32	X	X	-	-	X	-	-	47
33	X	X	-	-	-	X	-	62
34	X	X	-	-	-	-	X	41
35	X	-	X	X	-	-	-	65
36	X	-	X	-	X	-	-	55
37	X	-	X	-	-	X	-	69
38	X	-	X	-	-	-	X	49
39	X	-	-	X	X	-	-	60
40	X	-	-	X	-	X	-	75
41	X	-	-	X	-	-	X	54
42	X	-	-	-	X	X	-	64

(1)

REVEG2 Program Printout (continued)

MINED AREAS -- NATIVE SPECIES COVER

Site No.	1	PR	GS	K	NA	pH	AGE
	15	125	15	50	7	5	

REF #	TIL	SM	TPS	FER	IRR	MUL	ST	% COVER
43	X	-	-	-	X	-	X	43
44	X	-	-	-	-	X	X	58
45	-	X	X	X	-	-	-	68
46	-	X	X	-	X	-	-	57
47	-	X	X	-	-	X	-	71
48	-	X	X	-	-	-	X	51
49	-	X	-	X	X	-	-	62
50	-	X	-	X	-	X	-	77
51	-	X	-	X	-	-	X	56
52	-	X	-	-	X	X	-	66
53	-	X	-	-	X	-	X	45
54	-	X	-	-	-	X	X	60
55	-	-	X	X	X	-	-	70
56	-	-	X	X	-	X	-	85
57	-	-	X	X	-	-	X	64
58	-	-	X	-	X	X	-	74
59	-	-	X	-	X	-	X	53
60	-	-	X	-	-	X	X	68
61	-	-	-	X	X	X	-	79
62	-	-	-	X	X	-	X	58
63	-	-	-	X	-	X	X	73
64	-	-	-	-	X	X	X	62
65	X	X	X	X	-	-	-	64
66	X	X	X	-	X	-	-	53
67	X	X	X	-	-	X	-	68
68	X	X	X	-	-	-	X	47
69	X	X	-	X	X	-	-	58
70	X	X	-	X	-	X	-	73
71	X	X	-	X	-	-	X	52
72	X	X	-	-	X	X	-	62
73	X	X	-	-	X	-	X	41
74	X	X	-	-	-	X	X	56
75	X	-	X	X	X	-	-	66
76	X	-	X	X	-	X	-	81
77	X	-	X	X	-	-	X	60
78	X	-	X	-	X	X	-	70
79	X	-	X	-	X	-	X	49
80	X	-	X	-	-	X	X	64
81	X	-	-	X	X	X	-	75
82	X	-	-	X	X	-	X	54
83	X	-	-	X	-	X	X	69
84	X	-	-	-	X	X	X	58
85	-	X	X	X	X	-	-	68

(2)

REVEG2 Program Printout (continued)

MINED AREAS -- NATIVE SPECIES COVER

Site No.	1	PR	GS	K	NA	pH	AGE
		15	125	15	50	7	5

REF #	TIL	SM	TPS	FER	IRR	MUL	ST	% COVER
86	-	X	X	X	-	X	-	83
87	-	X	X	X	-	-	X	62
88	-	X	X	-	X	X	-	72
89	-	X	X	-	X	-	X	51
90	-	X	X	-	-	X	X	66
91	-	X	-	X	X	X	-	77
92	-	X	-	X	X	-	X	56
93	-	X	-	X	-	X	X	71
94	-	X	-	-	X	X	X	60
95	-	-	X	X	X	X	-	85
96	-	-	X	X	X	-	X	64
97	-	-	X	X	-	X	X	79
98	-	-	X	-	X	X	X	68
99	-	-	-	X	X	X	X	73
100	X	X	X	X	X	-	-	64
101	X	X	X	X	-	X	-	79
102	X	X	X	X	-	-	X	58
103	X	X	X	-	X	X	-	68
104	X	X	X	-	X	-	X	47
105	X	X	X	-	-	X	X	62
106	X	X	-	X	X	X	-	73
107	X	X	-	X	X	-	X	53
108	X	X	-	X	-	X	X	67
109	X	X	-	-	X	X	X	56
110	X	-	X	X	X	X	-	81
111	X	-	X	X	X	-	X	60
112	X	-	X	X	-	X	X	75
113	X	-	X	-	X	X	X	64
114	X	-	-	X	X	X	X	70
115	-	X	X	X	X	X	-	83
116	-	X	X	X	X	-	X	63
117	-	X	X	X	-	X	X	77
118	-	X	X	-	X	X	X	66
119	-	X	-	X	X	X	X	72
120	-	-	X	X	X	X	X	80
121	X	X	X	X	X	X	-	79
122	X	X	X	X	X	-	X	59
123	X	X	X	X	-	X	X	73
124	X	X	X	-	X	X	X	63
125	X	X	-	X	X	X	X	68
126	X	-	X	X	X	X	X	76
127	-	X	X	X	X	X	X	78
128	X	X	X	X	X	X	X	74

(3)

MINED AREAS -- INTRODUCED SPECIES COVER

Site No.	1	PR	GS	K	NA	pH	AGE
		15	125	15	50	7	5

REF #	TIL	SM	TPS	FER	IRR	MUL	ST	% COVER
1	-	-	-	-	-	-	-	46
2	X	-	-	-	-	-	-	36
3	-	X	-	-	-	-	-	47
4	-	-	X	-	-	-	-	46
5	-	-	-	X	-	-	-	76
6	-	-	-	-	X	-	-	61
7	-	-	-	-	-	X	-	50
8	-	-	-	-	-	-	X	65
9	X	X	-	-	-	-	-	37
10	X	-	X	-	-	-	-	36
11	X	-	-	X	-	-	-	66
12	X	-	-	-	X	-	-	51
13	X	-	-	-	-	X	-	40
14	X	-	-	-	-	-	X	55
15	-	X	X	-	-	-	-	47
16	-	X	-	X	-	-	-	77
17	-	X	-	-	X	-	-	62
18	-	X	-	-	-	X	-	51
19	-	X	-	-	-	-	X	66
20	-	-	X	X	-	-	-	77
21	-	-	X	-	X	-	-	61
22	-	-	X	-	-	X	-	51
23	-	-	X	-	-	-	X	65
24	-	-	-	X	X	-	-	92
25	-	-	-	X	-	X	-	81
26	-	-	-	X	-	-	X	95
27	-	-	-	-	X	X	-	65
28	-	-	-	-	X	-	X	80
29	-	-	-	-	-	X	X	69
30	X	X	X	-	-	-	-	37
31	X	X	-	X	-	-	-	67
32	X	X	-	-	X	-	-	52
33	X	X	-	-	-	X	-	41
34	X	X	-	-	-	-	X	56
35	X	-	X	X	-	-	-	67
36	X	-	X	-	X	-	-	51
37	X	-	X	-	-	X	-	41
38	X	-	X	-	-	-	X	55
39	X	-	-	X	X	-	-	81
40	X	-	-	X	-	X	-	71
41	X	-	-	X	-	-	X	85
42	X	-	-	-	X	X	-	55

(1)

MINED AREAS -- INTRODUCED SPECIES COVER

Site No.	1	PR	GS	K	NA	pH	AGE
		15	125	15	50	7	5

REF #	TIL	SM	TPS	FER	IRR	MUL	ST	% COVER
43	X	-	-	-	X	-	X	70
44	X	-	-	-	-	X	X	59
45	-	X	X	X	-	-	-	78
46	-	X	X	-	X	-	-	62
47	-	X	X	-	-	X	-	52
48	-	X	X	-	-	-	X	66
49	-	X	-	X	X	-	-	93
50	-	X	-	X	-	X	-	82
51	-	X	-	X	-	-	X	96
52	-	X	-	-	X	X	-	66
53	-	X	-	-	X	-	X	81
54	-	X	-	-	-	X	X	70
55	-	-	X	X	X	-	-	92
56	-	-	X	X	-	X	-	82
57	-	-	X	X	-	-	X	96
58	-	-	X	-	X	X	-	66
59	-	-	X	-	X	-	X	80
60	-	-	X	-	-	X	X	70
61	-	-	-	X	X	X	-	96
62	-	-	-	X	X	-	X	100
63	-	-	-	X	-	X	X	100
64	-	-	-	-	X	X	X	84
65	X	X	X	X	-	-	-	68
66	X	X	X	-	X	-	-	52
67	X	X	X	-	-	X	-	42
68	X	X	X	-	-	-	X	56
69	X	X	-	X	X	-	-	83
70	X	X	-	X	-	X	-	72
71	X	X	-	X	-	-	X	86
72	X	X	-	-	X	X	-	56
73	X	X	-	-	X	-	X	71
74	X	X	-	-	-	X	X	60
75	X	-	X	X	X	-	-	82
76	X	-	X	X	-	X	-	72
77	X	-	X	X	-	-	X	86
78	X	-	X	-	X	X	-	56
79	X	-	X	-	X	-	X	70
80	X	-	X	-	-	X	X	60
81	X	-	-	X	X	X	-	86
82	X	-	-	X	X	-	X	100
83	X	-	-	X	-	X	X	90
84	X	-	-	-	X	X	X	74
85	-	X	X	X	X	-	-	93

(2)

REVEG2 Program Printout (continued)

MINED AREAS -- INTRODUCED SPECIES COVER

Site No.	1	PR	GS	K	NA	pH	AGE
		15	125	15	50	7	5

REF #	TIL	SM	TPS	FER	IRR	MUL	ST	% COVER
86	-	X	X	X	-	X	-	83
87	-	X	X	X	-	-	X	97
88	-	X	X	-	X	X	-	67
89	-	X	X	-	X	-	X	81
90	-	X	X	-	-	X	X	71
91	-	X	-	X	X	X	-	97
92	-	X	-	X	X	-	X	100
93	-	X	-	X	-	X	X	100
94	-	X	-	-	X	X	X	85
95	-	-	X	X	X	X	-	97
96	-	-	X	X	X	-	X	100
97	-	-	X	X	-	X	X	100
98	-	-	X	-	X	X	X	85
99	-	-	-	X	X	X	X	100
100	X	X	X	X	X	-	-	83
101	X	X	X	X	-	X	-	73
102	X	X	X	X	-	-	X	87
103	X	X	X	-	X	X	-	57
104	X	X	X	-	X	-	X	71
105	X	X	X	-	-	X	X	61
106	X	X	-	X	X	X	-	87
107	X	X	-	X	X	-	X	100
108	X	X	-	X	-	X	X	91
109	X	X	-	-	X	X	X	75
110	X	-	X	X	X	X	-	87
111	X	-	X	X	X	-	X	100
112	X	-	X	X	-	X	X	91
113	X	-	X	-	X	X	X	75
114	X	-	-	X	X	X	X	100
115	-	X	X	X	X	X	-	98
116	-	X	X	X	X	-	X	100
117	-	X	X	X	-	X	X	100
118	-	X	X	-	X	X	X	86
119	-	X	-	X	X	X	X	100
120	-	-	X	X	X	X	X	100
121	X	X	X	X	X	X	-	88
122	X	X	X	X	X	-	X	100
123	X	X	X	X	-	X	X	92
124	X	X	X	-	X	X	X	76
125	X	X	-	X	X	X	X	100
126	X	-	X	X	X	X	X	100
127	-	X	X	X	X	X	X	100
128	X	X	X	X	X	X	X	100

(3)

Appendix B

BELLE AYR REVEGETATION DATABASE

Description of Belle Ayr Revegetation Variables

The database abbreviation and description of each variable (for the 100 selected test plots) established for the Revegetation database are listed. This database is described in Chapter 5.

Identification Variables

ID	Entry identification number (1-445, 501-558, 601-608)
	ID# 1-445 Individual test plots ID# 501-558 Summaries for each of the Reclamation Units ID# 601-608 Split summaries for RecUnits 55-58 (8)
R	Reclamation Unit reference number (1-58)
TPR	Test Plot reference number (1-30)
PY	Year of most recent planting (76-83)
PDY	Julian date of most recent planting (15-347)
TDY	Julian date of testing in 1984 (194-250)
SEEDM	Seed mix reference number (1-59, 601, 602)
AGE	Age of Reclamation Unit (1.2-7.7)
	Age is figured from the most recent planting date to the testing date

Orientation Variables

TOP	Topographic location
	0 No data recorded 1 summit 2 shoulder 3 backslope 4 footslope 5 toeslope 6 playa 7 drainage

ASP	Aspect in compass degrees	
	0	level ground
	45	northeast
	90	east
	135	southeast
	180	south
	225	southwest
	270	west
	315	northwest
	360	north
INC	Inclination	
	1	level
	2	gradual slope
	3	moderately steep
	4	steep
	5	very steep

Management Variables

MAINT	Maintenance practices	
	0	No additional work needed
	1	Grazed
	2	Grazed repeatedly
	3	Hay
	4	Hay and replanted
	5	Interseeded
	6	Interseeded repeatedly
	7	Replanted
	8	Replanted and interseeded
	9	Replanted and interseeded and grazed
PLNT	Planting methods used in most recent planting	
	0	no methods recorded
	1	drill seeded
	2	drill seeded and interseeded (drill)
	3	interseeded (drill)
	4	drill seeded and brillion seeded
	5	drill seeded and broadcast
	6	other (brillion or broadcast alone)
CULT	Cultivation methods used in most recent planting	
	0	no methods recorded
	1	discing and cultipacking
	2	discing, cultipacking, and ripping

FERT Fertilizer treatments for most recent planting

0 no treatment
1 20 lbs nitrogen, 20 lbs phosphorus per acre
2 36 lbs nitrogen, 44 lbs phosphorus per acre
3 20 lbs nitrogen, 20 lbs phosphorus, 20 lbs potassium per acre

MULCH Mulch applied to most recent planting

0 no mulch applied
1 2 tons/acre grass hay, crimped
2 2 tons/acre wheat hay, crimped

CC Cover crop used in most recent planting

0 no nurse crop used
1 oats at 10 pounds/acre
2 oats at 12 pounds/acre
3 oats at 20 pounds/acre
4 winter wheat at 10 pounds per acre
5 winter wheat at 12 pounds per acre
6 winter wheat at 20 pounds per acre
7 other

ADT Relative degree of animal disturbance (excluding grass-hopper devastation)

1 - 10, 1 = undisturbed 10 = extremely disturbed

Soil Related Variables

SOIL Reclamation Unit soil sample indentification number

0 - 6
0 = pooled data: no individual test plot data identified

MATCH Match between soil sample and vegetation sample

1 very close match
2 soil sample not very close to nearest vegetation
3 insufficient information to match with vegetation
4 pooled data for entire Reclamation Unit

SAND Sand percent in soil sample

SILT Silt percent in soil sample

CLAY Clay percent in soil sample

TEX	Texture classification of soil sample
	1 loam 2 sandy loam 3 loamy sand 4 sandy clay loam 5 silty loam 6 silty clay loam 7 silty clay 8 clay loam 9 clay
PH	pH of soil sample
CARB	Carbonate percent of soil sample
N	Nitrate-nitrogen content of soil sample (ppm)
P	Phosphorus content of soil sample (ppm)
K	Potassium content of soil sample (meq/l)
NA	Sodium content of soil sample (meq/l)
RMST	Relative degree of moisture (visual)
	1 - 10, 1 = dry 10 = marshy
CMST	Relative degree of moisture (actual)
	1 - 10, 1 = dry 10 = marshy

Dependent Variables

Percent cover of selected individual species

AGIN	*Agropyron intermedium* / Intermediate Wheatgrass
AGCR	*Agropyron cristatum* / Crested Wheatgrass
AGDA	*Agropyron dasytachum* / Thickspike Wheatgrass
AGSM	*Agropyron smithii* / Western Wheatgrass
AGTR	*Agroopyron trachycaulum* / Slender Wheatgrass
ALDE	*Alyssum desertorum* / Alyssum
BRIN	*Bromus inermis* / Smooth Brome
BRTE	*Bromus tectorum* / Cheatgrass

CAMI Camelina microcarpa / False Flax

DAGL Dactylis glomerata / Orchardgrass

DESI Descurainia richardsonii / Tansy Mustard

KOSC Kochia scoparia / Summer Cypress

MESA Medicago sativa / Alfalfa

MEOF Melilotus officinalis / Yellow Sweetclover

ORHY Oryzopsis hymenoides / Indian Ricegrass

PHPR Phleum pratensis / Timothy

POAS Poa species

SAIB Salsoa iberica / Russian Thistle

SAIL Sisymbrium altissimum / Tumble Mustard

STCO Stipa comata / Needle and Thread

STVI Stipa viridula / Green Needlegrass

THAR Thlaspi arvense / Penny-cress

VUOC Vulpia octoflora / Six-weeks grass

Totals and summary percent cover values

LITTR Percent litter cover

ROCK Percent rock cover

BRGD Percent bareground

TVEG Percent of total vegetative cover

TGCR Percent of total non-vegetative cover

ADTGC Adjusted TGCR -- Maximum value = 100%

Due to visual estimations used in gathering data, TGCR sometimes exceeds 100. For calculating and testing, an adjusted value is needed.

TOTAL Total percent cover of litter, rock and vegetation

ADTOT Adjusted TOTAL -- Maximum value = 100%

See ADTGC for explanation

Height of vegetation

VMAX	Maximum height of vegetation
VMIN	Minimum height of vegetation
VMEAN	Mean height of vegetation

Mean Presence of selected species (MP--)

Recorded as summary information for the 58 Reclamation Units, not individual test plots. The last two letters indicate plant species. There is a Mean Presence variable for each of the species measured in the study. Thes are determined by the distribution of the species throughout the test plots.

MPAI	Agropyron intermedium
MPAC	Agropyron cristatum
MPAD	Agropyron dasytachum
MPAS	Agropyron smithii
MPAT	Agropyron trachycaulum
MPAL	Alyssum desertorum
MPBI	Bromus inermis
MPBJ	Bromus japonicus
MPBT	Bromus tectorum
MPCM	Camelina microcarpa
MPDG	Dactylis glomerata
MPDS	Descurainia richardsonii
MPKS	Kochia scoparia
MPMS	Medicago sativa
MPMO	Melilotus officinalis
MPOH	Oryzopsis hymenoides
MPPP	Phleum pratensis
MPPO	Poa species
MPSB	Salsoa iberica
MPSL	Sisymbrium altissimum
MPSC	Stipa comata
MPSV	Stipa viridula
MPTA	Thlaspi arvense
MPVO	Vulpia octoflora

Seed Mix Species and Rates

The following variables are for the ten species that were included in the percentage of cover measurements and in the seed mixes used for the reclamation units. Data are recorded as pounds per acre of seed included in each mix.

AIV	*Agropyron intermedium*	BIV	*Bromus inermis*
ACV	*Agropyron cristatum*	MOV	*Melilotus officinalis*
ADV	*Agropyron dasytachum*	MSV	*Medicago sativa*
ASV	*Agropyron smithii*	SVV	*Stipa viridula*
ATV	*Agropyron trachycaulum*	OHV	*Oryzopsis hymenoides*

Intermediate Independent Variables

The following variables were extrapolated from the data to provide alternative predictor variables.

PCAI	Percent *Agropyron inermis*/total vegetation
PCAD	Percent *Agropyron dasytachum*/total vegetation
PCAS	Percent *Agropyron smithii*/total vegetation
PCAT	Percent *Agropyron trachycaulum*/total vegetation
PCMO	Percent *Melilotus officinalis*/total vegetation
PCMS	Percent *Medicago sativa*/total vegetation
PCSV	Percent *Stipa Viridula*/total vegetation
PCVEG7	Percent 7 major species/total vegetation
PCVEGW	Percent 4 wheatgrasses/total vegetation
PCVEGL	Percent 2 legumes/total vegetation
PCTVTOT	Percent total vegetation/total cover
PCLITOT	Percent litter/total cover

Table B.1. Belle Ayr Data -- Values for 100 Selected Variables

ID	R	TPR	PY	POY	TOY	AGE	TOP	ASP	INC	SEEDM	MAINT	AOT	PLNT	CULT	FERT	MULCH	CC	RMST	CMST
47	8	2	79.0	289.0	208.0	4.8	3.0	90.00	4.0	28.0	6.00	2.	3.0	0.0	0.0	0.00	0.0	3.0	2.0
48	8	3	79.0	289.0	208.0	4.8	3.0	90.00	4.0	28.0	6.00	2.	3.0	0.0	0.0	0.00	0.0	2.0	2.0
49	8	4	79.0	289.0	208.0	4.8	4.0	90.00	4.0	28.0	6.00	2.	3.0	0.0	0.0	0.00	0.0	4.0	3.0
50	8	5	79.0	289.0	208.0	4.8	3.0	90.00	4.0	28.0	6.00	2.	3.0	0.0	0.0	0.00	0.0	3.0	2.0
91	14	1	79.0	320.0	209.0	4.7	7.0	0.000	2.0	29.0	9.00	7.	1.0	2.0	0.0	1.00	4.0	4.0	2.0
92	14	2	79.0	320.0	209.0	4.7	7.0	0.000	2.0	29.0	9.00	8.	1.0	2.0	0.0	1.00	4.0	3.0	2.0
93	14	3	79.0	320.0	209.0	4.7	7.0	0.000	2.0	29.0	9.00	6.	1.0	2.0	0.0	1.00	4.0	5.0	2.0
94	14	4	79.0	320.0	209.0	4.7	7.0	0.000	2.0	29.0	9.00	7.	1.0	2.0	0.0	1.00	4.0	5.0	2.0
95	14	5	79.0	320.0	209.0	4.7	7.0	0.000	1.0	29.0	9.00	7.	1.0	2.0	0.0	1.00	4.0	3.0	2.0
110	17	5	79.0	347.0	223.0	4.7	3.0	360.0	2.0	23.0	0.00	3.	0.0	0.0	1.0	1.00	5.0	2.0	2.0
124	20	4	81.0	289.0	208.0	2.8	1.0	0.000	1.0	13.0	8.00	2.	3.0	1.0	0.0	1.00	6.0	4.0	3.0
125	20	5	81.0	289.0	208.0	2.8	1.0	360.0	1.0	13.0	8.00	1.	3.0	1.0	0.0	1.00	6.0	4.0	3.0
141	23	1	81.0	289.0	222.0	2.8	3.0	360.0	3.0	14.0	9.00	2.	1.0	1.0	0.0	1.00	6.0	1.0	2.0
142	23	2	81.0	289.0	222.0	2.8	3.0	360.0	3.0	14.0	9.00	2.	1.0	1.0	0.0	1.00	6.0	2.0	2.0
143	23	3	81.0	289.0	222.0	2.8	2.0	360.0	3.0	14.0	9.00	2.	1.0	1.0	0.0	1.00	6.0	2.0	2.0
145	23	5	81.0	289.0	222.0	2.8	4.0	360.0	3.0	14.0	9.00	3.	1.0	1.0	0.0	1.00	6.0	3.0	2.0
150	24	5	79.0	289.0	222.0	4.8	3.0	180.0	2.0	10.0	1.00	1.	4.0	2.0	1.0	1.00	4.0	2.0	2.0
161	27	1	79.0	289.0	223.0	4.8	3.0	315.0	3.0	10.0	1.00	2.	3.0	0.0	1.0	0.00	4.0	3.0	2.0
162	27	2	79.0	289.0	223.0	4.8	3.0	270.0	3.0	10.0	1.00	3.	3.0	0.0	1.0	0.00	4.0	3.0	2.0
163	27	3	79.0	289.0	223.0	4.8	3.0	225.0	3.0	10.0	1.00	2.	3.0	0.0	1.0	0.00	4.0	3.0	3.0
164	27	4	79.0	289.0	223.0	4.8	2.0	225.0	2.0	10.0	1.00	4.	3.0	0.0	1.0	0.00	4.0	3.0	3.0
165	27	5	79.0	289.0	223.0	4.8	3.0	225.0	2.0	10.0	1.00	3.	3.0	0.0	1.0	0.00	4.0	3.0	3.0
166	28	1	79.0	289.0	250.0	4.9	3.0	135.0	2.0	10.0	0.00	2.	3.0	0.0	1.0	0.00	4.0	2.0	2.0
168	28	3	79.0	289.0	250.0	4.9	3.0	270.0	2.0	10.0	0.00	2.	3.0	0.0	1.0	0.00	4.0	3.0	2.0
169	28	4	79.0	289.0	250.0	4.9	2.0	270.0	2.0	10.0	0.00	2.	3.0	0.0	1.0	0.00	4.0	2.0	2.0
171	29	1	79.0	289.0	223.0	4.8	3.0	360.0	2.0	10.0	0.00	2.	4.0	2.0	1.0	1.00	4.0	3.0	2.0
172	29	2	79.0	289.0	223.0	4.8	2.0	360.0	2.0	10.0	0.00	2.	4.0	2.0	1.0	1.00	4.0	2.0	2.0
173	29	3	79.0	289.0	223.0	4.8	4.0	360.0	3.0	10.0	0.00	2.	4.0	2.0	1.0	1.00	4.0	3.0	2.0
174	29	4	79.0	289.0	223.0	4.8	3.0	360.0	3.0	10.0	0.00	3.	4.0	2.0	1.0	1.00	4.0	3.0	2.0
181	31	1	80.0	289.0	202.0	3.8	2.0	180.0	3.0	20.0	0.00	2.	1.0	1.0	1.0	1.00	4.0	2.0	3.0
184	31	4	80.0	289.0	202.0	3.8	4.0	180.0	2.0	20.0	0.00	2.	1.0	1.0	1.0	1.00	4.0	2.0	3.0
185	31	5	80.0	289.0	202.0	3.8	2.0	180.0	3.0	20.0	0.00	3.	1.0	1.0	1.0	1.00	4.0	2.0	3.0
206	36	1	80.0	289.0	214.0	3.8	3.0	90.00	2.0	20.0	0.00	4.	1.0	1.0	1.0	1.00	4.0	2.0	2.0
207	36	2	80.0	289.0	214.0	3.8	4.0	90.00	1.0	20.0	0.00	4.	1.0	1.0	1.0	1.00	4.0	3.0	8.0
209	36	4	80.0	289.0	214.0	3.8	3.0	90.00	2.0	20.0	0.00	3.	1.0	1.0	1.0	1.00	4.0	3.0	8.0
210	36	5	80.0	289.0	214.0	3.8	1.0	0.000	1.0	20.0	0.00	4.	1.0	1.0	1.0	1.00	4.0	3.0	7.0
211	37	1	80.0	289.0	215.0	3.8	4.0	270.0	2.0	20.0	0.00	2.	1.0	1.0	1.0	1.00	4.0	3.0	5.0
214	37	4	80.0	289.0	215.0	3.8	4.0	315.0	2.0	20.0	0.00	2.	1.0	1.0	1.0	1.00	4.0	4.0	3.0
216	38	1	80.0	136.0	223.0	4.2	4.0	360.0	2.0	18.0	0.00	3.	1.0	1.0	1.0	1.00	2.0	1.0	3.0
217	38	2	80.0	136.0	223.0	4.2	3.0	315.0	3.0	18.0	0.00	2.	1.0	1.0	1.0	1.00	2.0	2.0	2.0
218	38	3	80.0	136.0	223.0	4.2	3.0	360.0	2.0	18.0	0.00	4.	1.0	1.0	1.0	1.00	2.0	2.0	2.0
220	38	5	80.0	136.0	223.0	4.2	3.0	360.0	2.0	18.0	0.00	3.	1.0	1.0	1.0	1.00	2.0	3.0	2.0
226	40	1	81.0	289.0	205.0	2.8	3.0	180.0	3.0	6.00	0.00	2.	1.0	1.0	0.0	1.00	5.0	2.0	2.0
227	40	2	81.0	289.0	205.0	2.8	2.0	180.0	2.0	6.00	0.00	2.	1.0	1.0	0.0	1.00	5.0	2.0	2.0
228	40	3	81.0	289.0	205.0	2.8	2.0	180.0	2.0	6.00	0.00	3.	1.0	1.0	0.0	1.00	5.0	2.0	2.0
230	40	5	81.0	289.0	205.0	2.8	3.0	180.0	2.0	6.00	0.00	2.	1.0	1.0	0.0	1.00	5.0	2.0	2.0
233	41	3	81.0	289.0	194.0	2.7	0.0	360.0	2.0	16.0	0.00	2.	1.0	1.0	1.0	1.00	5.0	2.0	2.0
235	41	5	81.0	289.0	194.0	2.7	0.0	360.0	2.0	16.0	0.00	2.	1.0	1.0	1.0	1.00	5.0	2.0	2.0
236	42	1	81.0	289.0	199.0	2.7	3.0	180.0	3.0	16.0	0.00	2.	1.0	1.0	1.0	1.00	5.0	2.0	2.0
237	42	2	81.0	289.0	199.0	2.7	2.0	180.0	4.0	16.0	0.00	3.	1.0	1.0	1.0	1.00	5.0	2.0	2.0

Table B.1 (continued)

ID	R	TPR	PY	POY	TOY	AGE	TOP	ASP	INC	SEEOM	MAINT	AOT	PLNT	CULT	FERT	MULCH	CC	RMST	CMST
238	42	3	81.0	289.0	199.0	2.7	2.0	180.0	4.0	16.0	0.00	3.	1.0	1.0	1.0	1.00	5.0	2.0	2.0
239	42	4	81.0	289.0	199.0	2.7	1.0	180.0	1.0	16.0	0.00	3.	1.0	1.0	1.0	1.00	5.0	2.0	2.0
258	46	3	81.0	289.0	205.0	2.8	3.0	180.0	4.0	6.00	7.00	2.	1.0	1.0	1.0	1.00	5.0	4.0	3.0
259	46	4	81.0	289.0	205.0	2.8	3.0	180.0	4.0	6.00	7.00	3.	1.0	1.0	1.0	1.00	5.0	5.0	3.0
260	46	5	81.0	289.0	205.0	2.8	4.0	180.0	4.0	6.00	7.00	2.	1.0	1.0	1.0	1.00	5.0	6.0	3.0
266	48	1	81.0	75.00	215.0	3.4	3.0	90.00	2.0	7.00	0.00	3.	1.0	1.0	1.0	1.00	2.0	4.0	6.0
267	48	2	81.0	75.00	215.0	3.4	3.0	270.0	2.0	7.00	0.00	2.	1.0	1.0	1.0	1.00	2.0	5.0	6.0
269	48	4	81.0	75.00	215.0	3.4	3.0	45.00	2.0	7.00	0.00	3.	1.0	1.0	1.0	1.00	2.0	3.0	5.0
270	48	5	81.0	75.00	215.0	3.4	2.0	360.0	2.0	7.00	0.00	2.	1.0	1.0	1.0	1.00	2.0	3.0	5.0
271	49	1	81.0	105.0	250.0	3.4	3.0	360.0	4.0	7.00	0.00	3.	1.0	1.0	1.0	1.00	2.0	3.0	2.0
272	49	2	81.0	105.0	250.0	3.4	3.0	90.00	3.0	7.00	0.00	2.	1.0	1.0	1.0	1.00	2.0	2.0	2.0
273	49	3	81.0	105.0	250.0	3.4	3.0	360.0	3.0	7.00	0.00	6.	1.0	1.0	1.0	1.00	2.0	2.0	2.0
274	49	4	81.0	105.0	250.0	3.4	3.0	270.0	3.0	7.00	0.00	6.	1.0	1.0	1.0	1.00	2.0	3.0	2.0
275	49	5	81.0	105.0	250.0	3.4	2.0	90.00	3.0	7.00	0.00	3.	1.0	1.0	1.0	1.00	2.0	2.0	2.0
277	50	2	82.0	289.0	250.0	1.9	5.0	180.0	2.0	3.00	0.00	3.	1.0	1.0	1.0	0.00	5.0	3.0	2.0
278	50	3	82.0	289.0	250.0	1.9	3.0	180.0	2.0	3.00	0.00	4.	1.0	1.0	1.0	0.00	5.0	2.0	2.0
280	50	5	82.0	289.0	250.0	1.9	3.0	180.0	2.0	3.00	0.00	3.	1.0	1.0	1.0	0.00	5.0	1.0	2.0
301	54	6	83.0	118.0	243.0	1.3	4.0	270.0	3.0	601.	0.00	2.	1.0	1.0	2.0	1.00	2.0	4.0	2.0
304	54	9	83.0	118.0	243.0	1.3	3.0	90.00	3.0	601.	0.00	2.	1.0	1.0	2.0	1.00	2.0	3.0	2.0
308	54	13	83.0	118.0	243.0	1.3	2.0	270.0	2.0	601.	0.00	2.	1.0	1.0	2.0	1.00	2.0	3.0	2.0
311	54	16	83.0	118.0	243.0	1.3	3.0	270.0	2.0	601.	0.00	4.	1.0	1.0	2.0	1.00	2.0	3.0	2.0
313	54	18	83.0	118.0	243.0	1.3	3.0	270.0	2.0	601.	0.00	3.	1.0	1.0	2.0	1.00	2.0	2.0	2.0
314	54	19	83.0	118.0	243.0	1.3	3.0	270.0	2.0	601.	0.00	2.	1.0	1.0	2.0	1.00	2.0	2.0	2.0
324	54	29	83.0	118.0	243.0	1.3	2.0	90.00	2.0	601.	0.00	2.	1.0	1.0	2.0	1.00	2.0	3.0	2.0
329	55	4	83.0	111.0	240.0	1.4	3.0	270.0	3.0	602.	0.00	2.	1.0	1.0	2.0	0.00	2.0	3.0	3.0
331	55	6	83.0	111.0	240.0	1.4	1.0	270.0	1.0	602.	0.00	2.	1.0	1.0	2.0	0.00	2.0	3.0	3.0
336	55	11	83.0	111.0	240.0	1.4	4.0	135.0	2.0	602.	0.00	2.	1.0	1.0	2.0	0.00	2.0	4.0	2.0
338	55	13	83.0	111.0	240.0	1.4	5.0	135.0	2.0	602.	0.00	2.	1.0	1.0	2.0	0.00	2.0	2.0	2.0
353	55	28	83.0	111.0	240.0	1.4	5.0	225.0	2.0	602.	0.00	2.	1.0	1.0	2.0	0.00	2.0	2.0	2.0
355	55	30	83.0	111.0	240.0	1.4	6.0	0.000	1.0	602.	0.00	2.	1.0	1.0	2.0	0.00	2.0	2.0	2.0
362	56	7	83.0	111.0	240.0	1.4	3.0	135.0	2.0	602.	0.00	3.	1.0	1.0	2.0	0.00	0.0	2.0	2.0
366	56	11	83.0	111.0	240.0	1.4	3.0	270.0	3.0	602.	0.00	2.	1.0	1.0	2.0	0.00	0.0	3.0	3.0
368	56	13	83.0	111.0	240.0	1.4	3.0	225.0	3.0	602.	0.00	2.	1.0	1.0	2.0	0.00	0.0	3.0	3.0
372	56	17	83.0	111.0	240.0	1.4	2.0	90.00	2.0	602.	0.00	2.	1.0	1.0	2.0	0.00	0.0	3.0	2.0
381	56	26	83.0	111.0	240.0	1.4	3.0	90.00	3.0	602.	0.00	2.	1.0	1.0	2.0	0.00	0.0	3.0	2.0
384	56	29	83.0	111.0	240.0	1.4	2.0	90.00	3.0	602.	0.00	2.	1.0	1.0	2.0	0.00	0.0	2.0	2.0
389	57	4	83.0	111.0	240.0	1.4	3.0	270.0	3.0	601.	0.00	2.	1.0	1.0	2.0	0.00	2.0	2.0	2.0
397	57	12	83.0	111.0	240.0	1.4	3.0	270.0	3.0	601.	0.00	2.	1.0	1.0	2.0	0.00	2.0	2.0	2.0
398	57	13	83.0	111.0	240.0	1.4	3.0	270.0	4.0	601.	0.00	2.	1.0	1.0	2.0	0.00	2.0	2.0	2.0
400	57	15	83.0	111.0	240.0	1.4	3.0	270.0	2.0	601.	0.00	2.	1.0	1.0	2.0	0.00	2.0	2.0	2.0
401	57	16	83.0	111.0	240.0	1.4	3.0	90.00	3.0	601.	0.00	2.	1.0	1.0	2.0	0.00	2.0	4.0	2.0
412	57	27	83.0	111.0	240.0	1.4	4.0	90.00	2.0	601.	0.00	2.	1.0	1.0	2.0	0.00	2.0	2.0	2.0
417	58	2	83.0	111.0	241.0	1.4	5.0	90.00	3.0	601.	0.00	3.	1.0	1.0	2.0	0.00	0.0	3.0	2.0
421	58	6	83.0	111.0	241.0	1.4	5.0	135.0	2.0	601.	0.00	3.	1.0	1.0	2.0	0.00	0.0	3.0	2.0
422	58	7	83.0	111.0	241.0	1.4	5.0	135.0	2.0	601.	0.00	3.	1.0	1.0	2.0	0.00	0.0	3.0	2.0
424	58	9	83.0	111.0	241.0	1.4	4.0	90.00	2.0	601.	0.00	4.	1.0	1.0	2.0	0.00	0.0	2.0	2.0
433	58	18	83.0	111.0	241.0	1.4	4.0	270.0	3.0	601.	0.00	2.	1.0	1.0	2.0	0.00	0.0	3.0	3.0
437	58	22	83.0	111.0	241.0	1.4	3.0	270.0	3.0	601.	0.00	2.	1.0	1.0	2.0	0.00	0.0	3.0	3.0
442	58	27	83.0	111.0	241.0	1.4	3.0	270.0	3.0	601.	0.00	2.	1.0	1.0	2.0	0.00	0.0	2.0	2.0
443	58	28	83.0	111.0	241.0	1.4	3.0	270.0	3.0	601.	0.00	2.	1.0	1.0	2.0	0.00	0.0	2.0	2.0

Table B.1 (continued)

ID	SOIL	MATCH	SAND	SILT	CLAY	TEX	PH	CARB	N	P	K	NA
47	1.0	1.00	59.5	20.5	20.0	4.0	6.60	1.30	3.15	1.56	0.38	2.63
48	1.0	2.00	59.5	20.5	20.0	4.0	6.60	1.30	3.15	1.56	0.38	2.63
49	2.0	2.00	59.5	20.5	20.0	4.0	6.90	1.40	2.74	4.68	0.79	1.64
50	2.0	2.00	59.5	20.5	20.0	4.0	6.90	1.40	2.74	4.68	0.79	1.64
91	0.0	3.00	48.5	29.2	22.2	1.0	6.50	0.35	10.4	4.84	0.56	1.59
92	0.0	3.00	48.5	29.2	22.2	1.0	6.50	0.35	10.4	4.84	0.56	1.59
93	0.0	3.00	48.5	29.2	22.2	1.0	6.50	0.35	10.4	4.84	0.56	1.59
94	0.0	3.00	48.5	29.2	22.2	1.0	6.50	0.35	10.4	4.84	0.56	1.59
95	0.0	3.00	48.5	29.2	22.2	1.0	6.50	0.35	10.4	4.84	0.56	1.59
110	0.0	3.00	41.2	39.5	19.3	1.0	7.10	0.95	6.79	3.87	0.36	1.03
124	5.0	3.00	39.0	21.0	40.0	8.0	7.90	0.76	1.67	3.67	0.28	4.03
125	0.0	3.00	54.3	25.0	20.6	4.0	7.30	0.90	1.96	2.61	0.28	0.98
141	0.0	3.00	68.4	21.4	10.1	2.0	7.40	1.00	4.92	4.91	0.35	1.26
142	0.0	3.00	68.4	21.4	10.1	2.0	7.40	1.00	4.92	4.91	0.35	1.26
143	0.0	3.00	68.4	21.4	10.1	2.0	7.40	1.00	4.92	4.91	0.35	1.26
145	0.0	3.00	68.4	21.4	10.1	2.0	7.40	1.00	4.92	4.91	0.35	1.26
150	2.0	2.00	38.9	41.1	20.0	1.0	7.10	0.90	3.05	6.54	0.32	1.48
161	0.0	3.00	48.9	33.8	17.3	1.0	7.40	2.70	2.86	3.66	0.48	2.41
162	0.0	3.00	48.9	33.8	17.3	1.0	7.40	2.70	2.86	3.66	0.48	2.41
163	2.0	1.00	51.6	31.1	17.3	1.0	7.40	3.10	2.69	3.01	0.49	2.48
164	2.0	1.00	51.6	31.1	17.3	1.0	7.40	3.10	2.69	3.01	0.49	2.48
165	1.0	1.00	46.2	36.5	17.3	1.0	7.40	2.30	3.04	4.31	0.47	2.34
166	1.0	1.00	46.2	32.9	20.9	1.0	7.10	0.70	3.07	4.02	0.46	2.82
168	1.0	2.00	46.2	32.9	20.9	1.0	7.10	0.70	3.07	4.02	0.46	2.82
169	2.0	2.00	28.9	41.1	30.0	8.0	7.30	2.90	10.4	1.34	0.46	5.79
171	1.0	2.00	31.3	46.2	22.5	1.0	7.50	1.30	10.0	12.9	0.62	12.1
172	2.0	2.00	22.2	59.1	18.7	5.0	7.50	2.20	2.83	8.85	0.49	13.2
173	2.0	2.00	22.2	59.1	18.7	5.0	7.50	2.20	2.83	8.85	0.49	13.2
174	2.0	2.00	22.2	59.1	18.7	5.0	7.50	2.20	2.83	8.85	0.49	13.2
181	0.0	3.00	40.4	33.3	26.2	1.0	7.30	1.10	2.82	1.88	0.18	1.78
184	0.0	3.00	40.4	33.3	26.2	1.0	7.30	1.10	2.82	1.88	0.18	1.78
185	0.0	3.00	40.4	33.3	26.2	1.0	7.30	1.10	2.82	1.88	0.18	1.78
206	0.0	3.00	51.7	23.0	25.2	4.0	7.30	0.95	2.98	4.14	0.17	2.12
207	0.0	3.00	51.7	23.0	25.2	4.0	7.30	0.95	2.98	4.14	0.17	2.12
209	0.0	3.00	51.7	23.0	25.2	4.0	7.30	0.95	2.98	4.14	0.17	2.12
210	0.0	3.00	51.7	23.0	25.2	4.0	7.30	0.95	2.98	4.14	0.17	2.12
211	0.0	3.00	52.1	32.2	15.6	2.0	7.00	0.45	2.39	1.89	0.16	0.73
214	0.0	3.00	52.1	32.2	15.6	2.0	7.00	0.45	2.39	1.89	0.16	0.73
216	0.0	3.00	31.7	49.2	19.1	1.0	7.50	0.90	3.94	8.71	0.21	3.10
217	2.0	1.00	15.8	65.1	19.1	5.0	7.50	0.40	2.56	6.82	0.20	2.78
218	2.0	2.00	15.8	65.1	19.1	5.0	7.50	0.40	2.56	6.82	0.20	2.78
220	2.0	2.00	15.8	65.1	19.1	5.0	7.50	0.40	2.56	6.82	0.20	2.78
226	0.0	3.00	41.2	22.4	36.3	8.0	7.50	1.80	2.65	1.06	0.16	1.84
227	0.0	3.00	41.2	22.4	36.3	8.0	7.50	1.80	2.65	1.06	0.16	1.84
228	0.0	3.00	41.2	22.4	36.3	8.0	7.50	1.80	2.65	1.06	0.16	1.84
230	0.0	3.00	41.2	22.4	36.3	8.0	7.50	1.80	2.65	1.06	0.16	1.84
233	0.0	3.00	38.5	35.5	25.9	1.0	7.00	0.70	3.53	3.44	0.21	1.53
235	0.0	3.00	38.5	35.5	25.9	1.0	7.00	0.70	3.53	3.44	0.21	1.53
236	0.0	3.00	37.1	37.1	25.7	1.0	7.30	2.10	3.03	6.96	0.28	1.46
237	0.0	3.00	37.1	37.1	25.7	1.0	7.30	2.10	3.03	6.96	0.28	1.46

Table B.1 (continued)

ID	SOIL	MATCH	SAND	SILT	CLAY	TEX	PH	CARB	N	P	K	NA
238	0.0	3.00	37.1	37.1	25.7	1.0	7.30	2.10	3.03	6.96	0.28	1.46
239	0.0	3.00	37.1	37.1	25.7	1.0	7.30	2.10	3.03	6.96	0.28	1.46
258	0.0	3.00	43.1	29.4	27.4	1.0	7.30	0.70	3.15	2.82	0.43	1.07
259	0.0	3.00	43.1	29.4	27.4	1.0	7.30	0.70	3.15	2.82	0.43	1.07
260	0.0	3.00	43.1	29.4	27.4	1.0	7.30	0.70	3.15	2.82	0.43	1.07
266	1.0	2.00	41.3	33.6	25.1	1.0	7.30	0.30	3.57	4.90	0.28	1.04
267	1.0	1.00	41.3	33.6	25.1	1.0	7.30	0.30	3.57	4.90	0.28	1.04
269	2.0	1.00	34.2	36.2	29.6	8.0	7.80	1.80	2.24	2.15	0.31	3.65
270	2.0	2.00	34.2	36.2	29.6	8.0	7.80	1.80	2.24	2.15	0.31	3.65
271	0.0	3.00	28.1	39.5	32.3	8.0	7.40	1.70	4.22	3.83	0.12	1.71
272	0.0	3.00	28.1	39.5	32.3	8.0	7.40	1.70	4.22	3.83	0.12	1.71
273	0.0	3.00	28.1	39.5	32.3	8.0	7.40	1.70	4.22	3.83	0.12	1.71
274	0.0	3.00	28.1	39.5	32.3	8.0	7.40	1.70	4.22	3.83	0.12	1.71
275	0.0	3.00	28.1	39.5	32.3	8.0	7.40	1.70	4.22	3.83	0.12	1.71
277	0.0	3.00	49.2	26.7	24.0	4.0	7.20	0.90	3.11	4.05	0.21	1.18
278	0.0	3.00	49.2	26.7	24.0	4.0	7.20	0.90	3.11	4.05	0.21	1.18
280	0.0	3.00	49.2	26.7	24.0	4.0	7.20	0.90	3.11	4.05	0.21	1.18
301	4.0	2.00	71.1	15.6	13.3	2.0	7.60	0.80	2.46	4.61	0.25	0.78
304	2.0	2.00	71.1	18.4	10.5	2.0	7.40	1.20	3.35	3.33	0.22	0.58
308	4.0	2.00	71.1	15.6	13.3	2.0	7.60	0.80	2.46	4.61	0.25	0.78
311	4.0	1.00	71.1	15.6	13.3	2.0	7.60	0.80	2.46	4.61	0.25	0.78
313	4.0	2.00	71.1	15.6	13.3	2.0	7.60	0.80	2.46	4.61	0.25	0.78
314	4.0	2.00	71.1	15.6	13.3	2.0	7.60	0.80	2.46	4.61	0.25	0.78
324	2.0	2.00	71.1	18.4	10.5	2.0	7.40	1.20	3.35	3.33	0.22	0.58
329	2.0	2.00	52.7	36.4	10.9	2.0	7.50	0.50	3.95	5.37	0.40	0.71
331	1.0	2.00	59.3	25.6	15.1	2.0	7.40	2.10	2.84	4.17	0.27	0.70
336	3.0	2.00	70.9	15.5	13.6	2.0	6.80	0.50	1.68	2.92	0.14	0.93
338	1.0	2.00	59.3	25.6	15.1	2.0	7.40	2.10	2.84	4.17	0.27	0.70
353	4.0	1.00	68.4	17.4	14.2	2.0	7.40	0.70	2.77	2.43	0.21	0.99
355	4.0	2.00	68.4	17.4	14.2	2.0	7.40	0.70	2.77	2.43	0.21	0.99
362	2.0	1.00	61.8	26.4	11.8	2.0	7.70	2.60	4.87	2.98	0.22	0.66
366	1.0	2.00	59.3	26.5	14.2	2.0	7.30	1.10	3.25	4.85	0.25	0.56
368	3.0	2.00	71.1	14.7	14.2	2.0	7.50	0.70	3.30	2.13	0.27	1.04
372	4.0	1.00	71.1	18.4	10.5	2.0	7.20	0.40	2.02	5.34	0.16	0.99
381	6.0	2.00	70.2	20.2	9.60	2.0	7.10	2.70	2.74	5.02	0.29	0.71
384	5.0	1.00	70.2	17.4	12.4	2.0	6.70	0.50	3.13	3.80	0.20	0.66
389	3.0	1.00	77.5	12.9	9.60	2.0	7.50	1.20	3.41	2.80	0.30	0.47
397	3.0	2.00	77.5	12.9	9.60	2.0	7.50	1.20	3.41	2.80	0.30	0.47
398	1.0	1.00	48.4	32.9	18.7	1.0	7.20	3.40	2.84	2.34	0.15	1.72
400	1.0	2.00	48.4	32.9	18.7	1.0	7.20	3.40	2.84	2.34	0.15	1.72
401	4.0	2.00	63.8	24.7	11.5	2.0	7.30	0.60	3.60	5.46	0.22	0.96
412	5.0	2.00	67.5	18.3	14.2	2.0	7.30	0.50	3.44	3.68	0.18	0.70
417	1.0	2.00	41.1	33.8	25.1	1.0	7.40	1.70	3.85	3.24	0.29	0.49
421	3.0	1.00	80.2	12.9	6.90	3.0	7.30	0.40	2.98	3.74	0.20	0.69
422	2.0	2.00	78.2	9.10	12.7	2.0	7.60	2.60	4.48	2.88	0.28	0.48
424	1.0	2.00	41.1	33.8	25.1	1.0	7.40	1.70	3.85	3.24	0.29	0.49
433	4.0	1.00	64.7	20.2	15.1	2.0	6.60	0.40	2.18	3.36	0.14	0.94
437	6.0	2.00	65.6	22.9	11.5	2.0	7.60	2.20	3.28	4.29	0.26	0.78
442	6.0	2.00	65.6	22.9	11.5	2.0	7.60	2.20	3.28	4.29	0.26	0.78
443	6.0	1.00	65.6	22.9	11.5	2.0	7.60	2.20	3.28	4.29	0.26	0.78

Table B.1 (continued)

ID	AGIN	AGCR	AGOA	AGTR	AGSM	ALOE	BRIN	BRJA	BRTE	CAMI	DAGL	DESI	KOSC	MESA	MEOF	ORHY	PHPR
47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.00	0.20	0.00	0.00	0.00	0.00	0.00	0.20	0.00
48	0.00	0.00	0.00	0.20	0.00	0.40	0.00	1.80	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
49	0.20	3.40	0.00	0.00	0.40	0.00	0.00	2.20	0.80	0.00	0.00	0.00	0.00	2.80	0.00	0.00	0.00
50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.20	0.00	0.20	0.00	0.00	0.00	4.00	0.20	0.00	0.00
91	13.6	0.00	0.00	1.40	0.00	0.00	0.00	0.60	0.60	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00
92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.00	0.00	0.00	0.00
93	4.20	0.00	0.00	1.00	0.00	0.00	0.00	2.00	2.20	0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.00
94	5.20	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
95	1.80	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.00	4.00	0.00	0.00	0.00
110	0.80	0.00	0.00	0.00	0.20	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	1.40	0.00	0.00	0.00
124	1.60	0.00	0.00	1.20	0.00	0.00	0.00	0.00	0.00	0.00	2.80	0.00	0.00	0.80	0.00	0.00	2.80
125	6.00	0.00	0.00	3.80	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.80
141	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	2.20	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00
142	0.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	12.2	0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.00
143	0.00	3.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00
145	0.00	0.20	0.00	0.00	0.00	0.60	0.00	0.00	4.80	0.00	0.00	0.00	0.00	1.60	0.00	0.00	0.00
150	0.00	9.80	0.00	0.00	0.00	0.00	0.00	0.00	2.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
161	0.00	4.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00
162	0.00	4.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
163	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
164	0.00	2.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60	0.00	0.00	0.00
165	0.00	7.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00
166	0.00	3.80	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00
168	0.00	4.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
169	0.00	9.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
171	0.00	12.6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00
172	0.60	1.20	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.40	0.00	0.00	0.00	0.20	0.00	0.00	0.00
173	0.00	2.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.20	0.00	0.00	0.00
174	0.40	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.40	0.00	0.00	0.00
181	0.40	0.00	0.00	3.80	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00
184	7.00	0.00	0.00	2.80	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00
185	6.20	0.00	0.00	0.40	5.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
206	0.60	0.00	0.00	0.20	0.00	0.80	0.00	0.00	2.80	0.00	0.00	0.00	0.00	3.20	0.00	0.00	0.00
207	1.40	0.00	1.40	0.00	0.00	0.00	0.00	4.20	0.00	0.00	0.00	0.00	0.00	1.60	0.00	0.00	0.00
209	0.00	0.00	0.00	2.40	0.00	0.00	0.00	9.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
210	0.00	0.00	0.00	0.20	0.00	0.00	0.00	26.8	0.00	0.00	0.00	0.00	0.00	1.60	0.00	0.00	0.00
211	0.00	0.00	0.40	0.20	0.60	0.00	0.00	20.2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00
214	0.00	0.00	0.00	2.20	0.60	0.00	0.00	3.20	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00
216	0.00	0.00	0.00	0.20	0.20	0.00	0.00	0.00	5.80	0.00	0.00	0.00	0.00	1.60	0.00	0.00	0.00
217	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.40	0.00	0.00	0.00	0.00
218	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.00	0.20	0.00	1.40	0.00	0.00	0.00
220	0.00	5.80	0.00	0.00	0.00	0.00	0.00	0.00	1.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
226	0.80	0.00	0.20	0.00	0.20	0.00	1.20	0.00	0.00	0.00	5.20	0.00	0.00	0.00	0.00	0.00	1.40
227	2.40	0.00	0.00	0.00	3.60	0.00	0.20	0.00	0.00	0.00	1.40	0.00	0.00	0.40	0.00	0.00	2.00
228	0.40	0.00	0.00	1.20	1.40	0.00	0.00	0.00	0.00	0.00	1.20	0.00	0.00	0.00	0.00	0.00	2.00
230	0.00	0.00	0.00	2.60	0.00	0.00	0.00	0.00	0.00	0.20	1.80	0.00	0.00	0.00	0.00	0.00	0.40
233	6.80	0.00	0.60	2.20	0.40	0.00	0.00	2.40	0.00	0.00	1.20	0.00	0.00	0.00	0.00	0.00	0.40
235	1.20	0.00	0.00	2.80	2.60	0.00	1.20	1.00	0.00	0.00	1.20	0.40	0.00	0.00	0.00	0.00	6.40
236	0.00	0.00	0.00	3.60	0.00	0.00	0.00	0.40	0.00	0.00	5.00	0.00	0.00	0.80	0.00	0.00	0.80
237	0.00	0.00	0.00	5.00	0.00	0.00	0.00	0.00	0.00	0.00	1.60	0.00	0.00	0.00	0.00	0.00	1.00

Table B.1 (continued)

ID	AGIN	AGCR	AGOA	AGTR	AGSM	ALOE	BRIN	BRJA	BRTE	CAMI	DAGL	DESI	KOSC	MESA	MEOF	ORHY	PHPR
238	0.00	0.00	0.40	1.60	0.00	0.00	0.00	0.00	0.00	0.00	2.80	0.00	0.00	1.00	0.00	0.00	9.60
239	0.20	0.00	0.00	2.60	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.20	0.60	0.00	0.00	1.60
258	1.20	0.00	0.00	1.40	1.80	0.00	0.00	0.00	0.00	0.00	6.00	0.00	0.00	0.00	0.00	0.00	0.80
259	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.80	0.40	0.00	0.00	0.00	0.00	0.20
260	2.00	0.00	1.20	2.80	0.20	0.00	0.00	0.80	0.00	0.60	0.80	0.00	0.00	0.00	0.00	0.00	0.60
266	0.60	0.00	0.00	4.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.40	0.00	0.00	0.00
267	1.80	0.00	0.00	2.20	0.00	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.00	1.40	0.00	0.00	0.00
269	0.00	0.00	0.00	2.40	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	1.20	0.00	0.00	0.00
270	1.40	0.00	0.00	0.20	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.00	3.00	0.00	0.00	0.00
271	0.00	0.00	0.00	0.00	0.00	0.00	0.40	1.00	0.00	0.00	0.00	0.20	0.00	1.40	0.00	0.00	0.00
272	1.00	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00	0.00	0.00	0.00
273	2.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00
274	1.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00
275	0.00	0.20	0.00	0.40	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.00
277	0.40	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	1.20	0.00	0.00	0.00	0.00	0.00
278	0.40	0.00	0.00	2.40	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00
280	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00	2.80	0.00	0.00	0.00	0.00
301	4.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00
304	2.40	0.00	3.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
308	2.40	0.00	0.80	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00
311	1.40	0.00	0.40	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.20	0.00	0.00
313	1.20	0.00	1.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.20
314	0.40	0.00	0.60	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.20	0.00	0.00
324	1.20	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00
329	0.40	0.00	0.80	2.20	1.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.40	0.00	0.00	0.00
331	2.40	0.00	2.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.6	0.00	0.00	0.00	0.00
336	0.80	0.00	0.20	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
338	0.00	0.00	1.00	1.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	0.00	0.00	0.00
353	0.00	0.00	4.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.2	0.20	0.00	0.00	0.00
355	0.40	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
362	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
366	3.00	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00
368	3.00	0.00	0.40	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
372	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.40	0.00	0.00	0.00	0.00
381	1.60	0.00	0.60	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
384	0.00	0.00	1.40	1.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.80	0.00	0.00	0.20	0.00
389	1.20	0.00	2.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	2.40	0.00	0.00
397	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.00	0.20	0.00
398	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.80	0.00	0.60	0.00	0.00
400	0.00	0.00	0.40	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.40	0.00	0.00	0.00	0.00
401	2.60	0.00	1.40	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.00	1.20	0.00	0.00
412	0.60	0.00	1.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
417	1.60	0.00	1.20	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.40	0.00
421	1.00	0.00	1.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.40	2.20	0.20	0.00
422	0.40	0.00	1.40	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.20	0.60	0.00	0.00
424	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	1.00	0.00	0.00
433	1.20	0.00	2.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.40	0.40	0.00	0.00	0.00
437	1.60	0.00	0.40	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	1.20	2.20	0.00	0.00
442	0.60	0.00	0.20	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.40	0.00	0.00	0.00
443	0.20	0.00	0.00	1.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.40	0.20	0.00

Table B.1 (continued)

ID	POAS	SAIB	SAIL	STCO	STVI	THAR	VUOC	LITTR	ROCK	BRGO	TVEG	TGCR	AOTGC	TOTAL	ADTOT
47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	83.80	0.00	12.60	4.400	83.80	83.80	88.20	88.20
48	0.00	0.00	0.00	0.00	0.20	0.00	0.00	71.60	0.00	26.20	3.600	71.60	71.60	75.20	75.20
49	0.00	0.00	0.00	0.00	0.20	0.00	0.00	63.20	0.00	35.20	10.00	63.20	63.20	73.20	73.20
50	0.00	0.00	1.80	0.00	0.40	0.00	0.00	41.00	0.00	55.40	8.800	41.00	41.00	49.80	49.80
91	0.00	0.00	0.00	0.00	0.20	0.00	0.00	94.60	0.00	1.800	17.00	94.60	94.60	111.6	100.0
92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	91.40	0.00	6.000	8.000	91.40	91.40	99.40	99.40
93	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.60	0.00	47.00	10.00	50.60	50.60	60.60	60.60
94	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.000	0.00	92.20	5.600	7.000	7.000	12.60	12.60
95	0.00	0.00	0.00	0.00	0.00	0.00	0.00	78.80	0.00	16.60	6.400	78.80	78.80	85.20	85.20
110	0.00	0.00	0.00	0.00	0.00	0.00	0.00	98.80	0.00	0.000	2.600	98.80	98.80	101.4	100.0
124	0.80	0.00	0.00	0.00	0.00	0.00	0.00	87.40	0.00	6.400	10.00	87.40	87.40	97.40	97.40
125	0.60	0.00	0.00	0.00	0.00	0.00	0.00	60.60	1.40	31.80	12.20	62.00	62.00	74.20	74.20
141	0.00	0.00	0.20	0.00	0.00	0.00	0.00	92.20	0.40	5.600	4.200	92.60	92.60	96.80	96.80
142	0.00	0.00	0.00	0.00	0.00	0.00	0.00	93.60	0.00	2.200	16.80	93.60	93.60	110.4	100.0
143	0.00	0.00	0.00	0.00	0.00	0.00	0.00	96.80	0.00	0.800	3.600	96.80	96.80	100.4	100.0
145	0.00	0.00	0.00	0.00	0.00	0.00	0.00	97.20	0.00	0.400	7.200	97.20	97.20	104.4	100.0
150	0.00	0.00	0.00	0.00	0.00	0.00	0.00	94.40	0.00	3.000	12.60	94.40	94.40	107.0	100.0
161	0.00	0.00	0.00	0.00	0.00	0.00	0.00	63.20	0.00	34.80	4.600	63.20	63.20	67.80	67.80
162	0.00	0.00	0.00	0.00	0.00	0.00	0.00	69.40	0.00	28.60	4.400	69.40	69.40	73.80	73.80
163	0.00	0.00	0.00	0.00	0.00	0.00	0.00	96.40	0.00	2.200	5.000	96.40	96.40	101.4	100.0
164	0.00	0.00	0.00	0.00	0.00	0.00	0.00	77.80	0.00	21.00	4.400	77.80	77.80	82.20	82.20
165	0.00	0.00	0.00	0.00	0.00	0.00	0.00	95.60	0.00	2.800	7.400	95.60	95.60	103.0	100.0
166	0.00	0.00	0.00	0.00	0.00	0.00	0.00	68.60	0.20	29.20	4.400	68.80	68.80	73.20	73.20
168	0.00	0.00	0.00	0.00	0.00	0.00	0.00	98.60	0.00	0.400	4.800	98.60	98.60	103.4	100.0
169	0.00	0.00	0.00	0.00	0.00	0.00	0.00	97.40	0.00	1.200	9.200	97.40	97.40	106.6	100.0
171	0.00	0.00	0.00	0.00	0.00	0.00	0.00	91.60	0.00	4.600	13.40	91.60	91.60	105.0	100.0
172	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35.60	0.00	62.60	2.600	35.60	35.60	38.20	38.20
173	0.00	0.00	0.00	0.00	0.00	0.00	0.00	91.00	0.00	7.400	3.800	91.00	91.00	94.80	94.80
174	0.00	0.00	0.00	0.00	0.80	0.00	0.00	96.60	0.00	1.200	3.200	96.60	96.60	99.80	99.80
181	0.00	0.00	2.40	0.00	0.00	0.00	0.00	95.40	0.00	0.800	7.600	95.40	95.40	103.0	100.0
184	0.40	0.00	0.20	0.00	0.20	0.00	0.00	91.40	0.00	2.400	11.60	91.40	91.40	103.0	100.0
185	0.00	0.00	0.20	0.00	0.40	0.00	0.00	91.00	0.00	1.000	12.20	91.00	91.00	103.2	100.0
206	0.00	0.00	0.00	0.00	0.00	0.00	0.00	82.60	0.00	15.20	7.800	82.60	82.60	90.40	90.40
207	0.00	0.00	0.00	0.00	0.80	0.00	0.00	94.40	0.00	1.400	9.400	94.40	94.40	103.8	100.0
209	0.00	0.00	0.00	0.00	0.40	0.00	0.00	96.80	0.00	0.400	12.20	96.80	96.80	109.0	100.0
210	0.00	0.00	0.00	0.00	0.00	0.00	0.00	95.20	0.00	0.000	28.60	95.20	95.20	123.8	100.0
211	0.80	0.00	0.00	0.00	0.20	0.00	0.00	94.60	0.00	1.800	22.80	94.60	94.60	117.4	100.0
214	1.60	0.00	0.40	0.00	0.80	0.00	0.00	48.20	0.00	48.00	9.000	48.20	48.20	57.20	57.20
216	0.00	0.00	0.00	0.00	0.00	0.00	0.00	97.20	0.20	0.200	7.800	97.40	97.40	105.2	100.0
217	0.00	0.00	0.00	0.00	0.60	0.00	0.00	87.20	0.00	11.80	2.200	87.20	87.20	89.40	89.40
218	0.00	0.00	0.00	0.00	0.00	0.00	0.00	98.20	0.00	0.200	2.800	98.20	98.20	101.0	100.0
220	0.00	0.00	0.00	0.00	0.00	0.00	0.00	96.80	0.00	0.000	7.400	96.80	96.80	104.2	100.0
226	0.00	0.00	0.00	0.00	0.00	0.00	0.00	79.40	0.00	15.00	9.000	79.40	79.40	88.40	88.40
227	0.00	0.00	0.00	0.00	0.00	0.00	0.00	61.80	0.00	30.60	10.20	61.80	61.80	72.00	72.00
228	0.00	0.00	0.00	0.00	0.00	0.00	0.00	47.00	0.00	49.60	6.200	47.00	47.00	53.20	53.20
230	0.00	0.00	0.00	0.00	0.40	0.00	0.00	88.20	0.00	8.000	5.400	88.20	88.20	93.60	93.60
233	1.40	0.00	0.00	0.00	0.00	0.00	0.00	79.00	0.00	7.400	16.00	79.00	79.00	95.00	95.00
235	0.20	0.00	0.00	0.00	0.40	0.00	0.00	83.40	0.00	3.400	17.40	83.40	83.40	100.8	100.0
236	0.00	0.00	0.00	0.00	0.00	0.00	0.00	79.20	0.00	6.200	10.80	79.20	79.20	90.00	90.00
237	0.60	0.00	0.00	0.00	0.00	1.00	0.00	89.00	0.00	1.400	9.400	89.00	89.00	98.40	98.40

Table B.1 (continued)

ID	POAS	SAIB	SAIL	STCO	STVI	THAR	VUOC	LITTR	ROCK	BRGO	TVEG	TGCR	AOTGC	TOTAL	AOTOT
238	1.60	0.00	0.00	0.00	0.00	1.00	0.00	89.40	0.00	1.600	18.40	89.40	89.40	107.8	100.0
239	1.60	0.00	0.00	0.00	0.00	2.20	0.00	84.80	0.00	6.800	9.600	84.80	84.80	94.40	94.40
258	0.00	0.00	0.00	0.00	0.00	0.00	0.00	91.20	0.00	3.200	11.20	91.20	91.20	102.4	100.0
259	2.80	0.00	3.00	0.00	0.00	0.00	0.00	91.60	0.00	4.400	10.20	91.60	91.60	101.8	100.0
260	0.40	0.00	0.60	0.00	0.00	0.80	0.00	91.20	0.00	2.600	10.80	91.20	91.20	102.0	100.0
266	0.00	0.00	0.00	0.00	0.00	0.00	0.00	75.40	0.00	21.00	8.200	75.40	75.40	83.60	83.60
267	0.00	0.00	0.00	0.00	0.20	0.00	0.00	92.80	0.00	3.600	6.200	92.80	92.80	99.00	99.00
269	0.00	0.00	0.00	0.00	1.20	0.00	0.00	74.40	0.00	23.00	7.200	74.40	74.40	81.60	81.60
270	0.00	0.00	0.00	0.00	0.00	0.00	0.00	68.40	0.00	28.40	7.000	68.40	68.40	75.40	75.40
271	0.00	0.00	0.00	0.00	0.60	0.00	0.00	94.00	0.20	3.200	3.600	94.20	94.20	97.80	97.80
272	0.00	0.00	0.00	0.00	0.00	0.00	0.00	95.40	0.00	1.800	3.800	95.40	95.40	99.20	99.20
273	0.00	0.00	0.00	0.00	0.00	0.00	0.00	93.80	0.00	5.200	2.800	93.80	93.80	96.60	96.60
274	0.00	0.00	0.00	0.00	0.00	0.00	0.00	97.20	0.00	1.400	1.600	97.20	97.20	98.80	98.80
275	0.00	0.00	0.00	0.00	0.20	0.00	0.00	37.60	0.00	60.40	2.400	37.60	37.60	40.00	40.00
277	0.00	0.00	0.60	0.00	0.00	0.00	0.00	95.60	0.00	3.200	3.600	95.60	95.60	99.20	99.20
278	0.00	0.00	0.00	0.00	0.00	0.00	0.00	77.20	0.00	20.00	4.000	77.20	77.20	81.20	81.20
280	0.00	0.00	0.00	0.00	0.00	0.00	0.00	96.20	0.00	1.400	3.400	96.20	96.20	99.60	99.60
301	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.600	0.00	91.00	5.200	5.600	5.600	10.80	10.80
304	0.00	0.00	0.00	0.00	0.40	0.00	0.00	78.00	0.00	17.40	7.200	78.00	78.00	85.20	85.20
308	0.00	0.00	0.00	0.00	0.00	0.00	0.00	89.60	0.00	7.200	3.800	89.60	89.60	93.40	93.40
311	0.00	0.00	0.00	0.00	0.40	0.00	0.00	78.20	0.00	20.60	3.200	78.20	78.20	81.40	81.40
313	0.00	0.20	0.00	0.00	0.20	0.00	0.00	88.00	0.00	11.00	3.800	88.00	88.00	91.80	91.80
314	0.00	0.00	0.00	0.00	0.00	0.00	0.00	74.80	0.00	24.20	2.200	74.80	74.80	77.00	77.00
324	0.00	0.00	0.00	0.00	0.20	0.00	0.00	91.60	0.00	7.400	2.000	91.60	91.60	93.60	93.60
329	0.00	1.20	0.00	0.00	0.00	0.00	0.00	16.40	0.20	79.80	7.800	16.60	16.60	24.40	24.40
331	0.00	1.00	0.00	0.00	0.20	0.00	0.00	39.80	0.00	40.60	18.20	39.80	39.80	58.00	58.00
336	0.00	1.00	0.00	0.00	0.00	0.00	0.00	55.40	1.80	42.00	2.600	57.20	57.20	59.80	59.80
338	0.00	0.40	0.00	0.00	0.00	0.00	0.00	51.00	0.00	47.80	3.400	51.00	51.00	54.40	54.40
353	0.00	1.40	0.00	0.00	0.00	0.00	0.00	60.60	0.00	34.00	15.80	60.60	60.60	76.40	76.40
355	0.00	0.60	0.00	0.00	0.00	0.00	0.00	56.00	0.00	43.00	2.400	56.00	56.00	58.40	58.40
362	0.00	0.00	0.40	0.00	0.00	0.00	0.00	93.00	0.00	5.000	2.800	93.00	93.00	95.80	95.80
366	0.00	3.00	0.00	0.00	0.20	0.00	0.00	16.00	0.00	79.80	7.200	16.00	16.00	23.20	23.20
368	0.00	1.20	0.00	0.00	0.00	0.00	0.00	5.400	0.00	92.00	4.800	5.400	5.400	10.20	10.20
372	0.00	0.00	0.00	0.20	0.20	0.00	0.00	92.40	0.00	6.600	5.200	92.40	92.40	97.60	97.60
381	0.00	1.20	0.00	0.00	0.40	0.00	0.00	28.80	0.00	68.00	4.800	28.80	28.80	33.60	33.60
384	0.00	2.80	0.00	0.00	0.20	0.00	0.00	61.20	0.00	35.20	10.00	61.20	61.20	71.20	71.20
389	0.00	0.60	0.00	0.00	0.00	0.00	0.00	23.80	0.00	72.40	7.000	23.80	23.80	30.80	30.80
397	0.00	2.40	0.00	0.00	0.00	0.00	0.00	56.00	0.00	43.00	3.200	56.00	56.00	59.20	59.20
398	0.00	0.00	0.00	0.00	0.00	0.00	0.00	86.80	0.00	12.20	2.800	86.80	86.80	89.60	89.60
400	0.00	0.20	0.00	0.00	0.00	0.00	0.00	96.40	0.00	2.600	2.200	96.40	96.40	98.60	98.60
401	0.00	0.20	0.00	0.00	0.00	0.00	0.00	8.400	0.00	88.40	5.800	8.400	8.400	14.20	14.20
412	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.00	0.00	69.00	1.800	30.00	30.00	31.80	31.80
417	0.00	0.00	0.00	0.00	0.20	0.00	0.00	17.00	0.00	80.20	4.200	17.00	17.00	21.20	21.20
421	0.00	0.00	0.00	0.20	0.00	0.00	0.00	22.80	0.00	72.00	6.400	22.80	22.80	29.20	29.20
422	0.00	0.20	0.00	0.00	0.20	0.00	0.00	30.40	0.00	66.00	4.200	30.40	30.40	34.60	34.60
424	0.00	0.00	0.00	0.00	0.00	0.00	0.00	64.00	0.00	35.00	2.000	64.00	64.00	66.00	66.00
433	0.00	6.60	0.00	0.00	0.00	0.00	0.00	34.80	0.00	61.00	12.00	34.80	34.80	46.80	46.80
437	0.00	2.00	0.00	0.00	0.00	0.00	0.00	22.00	0.00	74.80	8.600	22.00	22.00	30.60	30.60
442	0.00	1.20	0.00	0.20	0.00	0.00	0.00	85.60	0.00	13.00	3.200	85.60	85.60	88.80	88.80
443	0.00	0.20	0.00	0.00	0.00	0.00	0.00	48.00	0.00	50.60	2.400	48.00	48.00	50.40	50.40

Table B.1 (continued)

ID	VMAX	VMIN	VMEAN	AIV	ACV	AOV	ASV	ATV	BIV	MOV	MSV	SVV	OHV
47	23.0	5.0	12.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
48	16.0	8.0	3.00	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
49	23.0	3.0	12.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
50	36.0	3.0	15.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
91	48.0	5.0	27.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
92	19.0	4.0	16.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
93	28.0	3.0	18.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
94	34.0	4.0	16.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
95	36.0	4.0	12.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
110	26.0	3.5	18.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
124	24.0	3.0	12.0	1.0	0.0	2.5	7.0	2.5	0.0	1.0	1.0	2.0	0.0
125	28.0	2.0	16.0	1.0	0.0	2.5	7.0	2.5	0.0	1.0	1.0	2.0	0.0
141	15.0	4.0	11.0	1.0	0.0	4.5	4.0	4.5	0.0	1.0	1.0	2.0	0.0
142	22.0	3.0	10.0	1.0	0.0	4.5	4.0	4.5	0.0	1.0	1.0	2.0	0.0
143	23.0	5.0	16.0	1.0	0.0	4.5	4.0	4.5	0.0	1.0	1.0	2.0	0.0
145	18.0	3.0	13.0	1.0	0.0	4.5	4.0	4.5	0.0	1.0	1.0	2.0	0.0
150	25.0	3.0	16.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
161	18.0	1.5	11.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
162	14.0	4.0	10.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
163	20.0	9.0	12.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
164	20.0	5.0	15.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
165	15.0	4.0	7.00	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
166	20.0	4.0	11.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
168	15.0	5.0	13.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
169	13.0	6.0	11.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
171	25.0	2.0	12.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
172	18.0	2.5	11.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
173	21.0	6.0	15.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
174	26.0	6.0	17.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
181	26.0	2.0	12.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
184	26.0	2.0	12.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
185	26.0	2.0	12.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
206	30.0	3.0	17.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
207	38.0	5.0	15.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
209	31.0	3.0	10.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
210	15.0	2.5	7.00	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
211	32.0	4.0	13.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
214	32.0	8.0	18.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	1.0
216	11.0	1.0	7.00	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	0.0
217	31.0	2.0	15.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	0.0
218	26.0	4.0	18.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	0.0
220	35.0	5.0	16.0	1.0	0.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0	0.0
226	29.0	4.0	12.0	1.0	0.0	2.5	4.0	3.5	0.0	1.0	1.0	2.0	1.0
227	30.0	4.0	14.0	1.0	0.0	2.5	4.0	3.5	0.0	1.0	1.0	2.0	1.0
228	29.0	4.0	12.0	1.0	0.0	2.5	4.0	3.5	0.0	1.0	1.0	2.0	1.0
230	35.0	2.0	12.0	1.0	0.0	2.5	4.0	3.5	0.0	1.0	1.0	2.0	1.0
233	32.0	1.0	14.0	1.0	0.0	2.5	4.0	3.5	0.0	1.0	1.0	2.0	1.0
235	32.0	1.0	14.0	1.0	0.0	2.5	4.0	3.5	0.0	1.0	1.0	2.0	1.0
236	27.0	5.0	13.0	1.0	0.0	2.5	4.0	3.5	0.0	1.0	1.0	2.0	1.0
237	32.0	1.0	16.0	1.0	0.0	2.5	4.0	3.5	0.0	1.0	1.0	2.0	1.0

Table B.1 (continued)

ID	VMAX	VMIN	VMEAN	A1V	ACV	AOV	ASV	ATV	B1V	MOV	MSV	SVV	OHV
238	32.0	1.0	16.0	1.0	0.0	2.5	4.0	3.5	0.0	1.0	1.0	2.0	1.0
239	32.0	1.0	16.0	1.0	0.0	2.5	4.0	3.5	0.0	1.0	1.0	2.0	1.0
258	29.0	5.0	12.0	1.0	0.0	2.5	4.0	3.5	0.0	1.0	1.0	2.0	1.0
259	29.0	5.0	12.0	1.0	0.0	2.5	4.0	3.5	0.0	1.0	1.0	2.0	1.0
260	40.0	4.0	20.0	1.0	0.0	2.5	4.0	3.5	0.0	1.0	1.0	2.0	1.0
266	29.0	3.0	13.0	1.0	0.0	2.5	4.0	3.5	0.0	1.0	1.0	2.0	1.0
267	36.0	7.0	20.0	1.0	0.0	2.5	4.0	3.5	0.0	1.0	1.0	2.0	1.0
269	39.0	2.0	24.0	1.0	0.0	2.5	4.0	3.5	0.0	1.0	1.0	2.0	1.0
270	35.0	3.0	15.0	1.0	0.0	2.5	4.0	3.5	0.0	1.0	1.0	2.0	1.0
271	46.0	5.0	19.0	1.0	0.0	2.5	4.0	3.5	0.0	1.0	1.0	2.0	1.0
272	26.0	4.0	19.0	1.0	0.0	2.5	4.0	3.5	0.0	1.0	1.0	2.0	1.0
273	30.0	22.	9.00	1.0	0.0	2.5	4.0	3.5	0.0	1.0	1.0	2.0	1.0
274	38.0	9.0	29.0	1.0	0.0	2.5	4.0	3.5	0.0	1.0	1.0	2.0	1.0
275	27.5	6.0	13.0	1.0	0.0	2.5	4.0	3.5	0.0	1.0	1.0	2.0	1.0
277	24.0	9.0	20.0	1.0	0.0	2.0	2.0	2.0	0.0	1.0	1.0	2.0	1.0
278	33.0	4.0	20.0	1.0	0.0	2.0	2.0	2.0	0.0	1.0	1.0	2.0	1.0
280	29.0	3.0	11.0	1.0	0.0	2.0	2.0	2.0	0.0	1.0	1.0	2.0	1.0
301	43.0	1.0	17.0	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
304	37.0	1.0	20.0	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
308	43.0	1.0	23.0	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
311	30.0	1.0	12.0	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
313	27.0	5.0	7.00	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
314	26.0	0.5	4.00	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
324	30.0	1.0	13.0	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
329	35.0	1.0	22.0	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
331	34.0	0.5	16.0	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
336	37.0	0.5	6.00	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
338	27.0	2.0	7.00	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
353	28.0	1.0	12.0	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
355	30.0	1.0	12.0	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
362	21.0	1.0	10.0	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
366	33.0	1.0	17.0	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
368	34.0	1.0	18.0	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
372	22.0	0.5	5.00	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
381	36.0	1.0	21.0	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
384	28.0	1.0	14.0	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
389	26.0	1.0	13.0	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
397	22.0	1.0	11.0	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
398	30.0	1.0	15.0	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
400	31.0	1.0	6.00	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
401	31.0	1.0	12.0	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
412	32.0	1.0	8.00	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
417	36.0	1.0	16.0	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
421	35.0	1.0	15.0	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
422	29.0	1.0	14.0	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
424	33.0	3.0	9.00	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
433	39.0	1.0	13.0	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
437	38.0	1.0	18.0	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
442	39.0	1.0	19.0	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5
443	34.0	0.5	25.0	1.5	0.0	2.5	4.0	2.5	0.0	1.0	1.0	2.0	1.5

Table B.1 (continued)

ID	PCA1	PCAO	PCAS	PCAT	PCMS	PCMO	PCSV	PCTVTOT	PCL1TOT	PDVS	ASP2	ASPE	XFER	XMUL	XCC
47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.989	95.01	2.0	1.0	1.0	0.0	0.0	0.0
48	0.00	0.00	0.00	5.56	0.00	0.00	5.56	4.787	95.21	2.0	1.0	1.0	0.0	0.0	0.0
49	2.00	0.00	4.00	0.00	28.0	0.00	2.00	13.66	86.34	2.0	1.0	1.0	0.0	0.0	0.0
50	0.00	0.00	0.00	0.00	45.5	2.27	4.55	17.67	82.33	2.0	1.0	1.0	0.0	0.0	0.0
91	80.0	0.00	0.00	8.24	0.00	1.18	1.18	15.23	84.77	2.0	2.0	####	0.0	1.0	1.0
92	0.00	0.00	0.00	0.00	100.	0.00	0.00	8.048	91.95	2.0	2.0	####	0.0	1.0	1.0
93	42.0	0.00	0.00	10.0	6.00	0.00	0.00	16.50	83.50	2.0	2.0	####	0.0	1.0	1.0
94	92.9	0.00	3.57	0.00	0.00	0.00	0.00	44.44	55.56	2.0	2.0	####	0.0	1.0	1.0
95	28.1	0.00	0.00	0.00	62.5	0.00	0.00	7.512	92.49	2.0	2.0	####	0.0	1.0	1.0
110	30.8	0.00	7.69	0.00	53.8	0.00	0.00	2.564	97.44	2.0	1.0	####	1.0	1.0	1.0
124	16.0	0.00	0.00	12.0	8.00	0.00	0.00	10.27	89.73	2.0	2.0	####	0.0	1.0	1.0
125	49.2	0.00	0.00	31.1	0.00	0.00	0.00	16.44	81.67	2.0	1.0	####	0.0	1.0	1.0
141	0.00	0.00	0.00	0.00	19.0	0.00	0.00	4.339	95.25	2.0	1.0	####	0.0	1.0	1.0
142	0.00	0.00	0.00	0.00	3.57	0.00	0.00	15.22	84.78	2.0	1.0	####	0.0	1.0	1.0
143	0.00	0.00	0.00	0.00	5.56	0.00	0.00	3.586	96.41	2.0	1.0	####	0.0	1.0	1.0
145	0.00	0.00	0.00	0.00	22.2	0.00	0.00	6.897	93.10	2.0	1.0	####	0.0	1.0	1.0
150	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.78	88.22	2.0	2.0	####	1.0	1.0	1.0
161	0.00	0.00	0.00	0.00	8.70	0.00	0.00	6.785	93.22	2.0	1.0	2.0	1.0	0.0	1.0
162	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.962	94.04	2.0	2.0	2.0	1.0	0.0	1.0
163	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.931	95.07	2.0	2.0	2.0	1.0	0.0	1.0
164	0.00	0.00	0.00	0.00	36.4	0.00	0.00	5.353	94.65	2.0	2.0	2.0	1.0	0.0	1.0
165	0.00	0.00	0.00	0.00	2.70	0.00	0.00	7.184	92.82	2.0	2.0	2.0	1.0	0.0	1.0
166	0.00	0.00	0.00	0.00	9.09	0.00	0.00	6.011	93.72	2.0	1.0	1.0	1.0	0.0	1.0
168	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.642	95.36	2.0	2.0	2.0	1.0	0.0	1.0
169	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.630	91.37	2.0	2.0	2.0	1.0	0.0	1.0
171	0.00	0.00	0.00	0.00	5.97	0.00	0.00	12.76	87.24	2.0	1.0	####	1.0	1.0	1.0
172	23.1	0.00	0.00	0.00	7.69	0.00	0.00	6.806	93.19	2.0	1.0	####	1.0	1.0	1.0
173	0.00	0.00	0.00	0.00	31.6	0.00	0.00	4.008	95.99	2.0	1.0	####	1.0	1.0	1.0
174	12.5	0.00	0.00	0.00	43.7	0.00	25.0	3.206	96.79	2.0	1.0	####	1.0	1.0	1.0
181	5.26	0.00	0.00	50.0	0.00	0.00	0.00	7.379	92.62	2.0	2.0	####	1.0	1.0	1.0
184	60.3	0.00	0.00	24.1	0.00	0.00	1.72	11.26	88.74	2.0	2.0	####	1.0	1.0	1.0
185	50.8	0.00	41.0	3.28	0.00	0.00	3.28	11.82	88.18	2.0	2.0	####	1.0	1.0	1.0
206	7.69	0.00	0.00	2.56	41.0	0.00	0.00	8.628	91.37	2.0	1.0	1.0	1.0	1.0	1.0
207	14.9	14.9	0.00	0.00	17.0	0.00	8.51	9.056	90.94	2.0	1.0	1.0	1.0	1.0	1.0
209	0.00	0.00	0.00	19.7	0.00	0.00	3.28	11.19	88.81	2.0	1.0	1.0	1.0	1.0	1.0
210	0.00	0.00	0.00	0.70	5.59	0.00	0.00	23.10	76.90	2.0	2.0	0.0	1.0	1.0	1.0
211	0.00	1.75	2.63	0.88	0.00	0.00	0.88	19.42	80.58	2.0	2.0	2.0	1.0	1.0	1.0
214	0.00	0.00	6.67	24.4	2.22	0.00	8.89	15.73	84.27	2.0	1.0	2.0	1.0	1.0	1.0
216	0.00	0.00	2.56	2.56	20.5	0.00	0.00	7.414	92.40	1.0	1.0	####	1.0	1.0	1.0
217	0.00	0.00	36.4	0.00	0.00	0.00	27.3	2.461	97.54	1.0	1.0	2.0	1.0	1.0	1.0
218	0.00	0.00	0.00	0.00	50.0	0.00	0.00	2.772	97.23	1.0	1.0	####	1.0	1.0	1.0
220	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.102	92.90	1.0	1.0	####	1.0	1.0	1.0
226	8.89	2.22	2.22	0.00	0.00	0.00	0.00	10.18	89.82	2.0	2.0	####	0.0	1.0	1.0
227	23.5	0.00	35.3	0.00	3.92	0.00	0.00	14.17	85.83	2.0	2.0	####	0.0	1.0	1.0
228	6.45	0.00	22.6	19.4	0.00	0.00	0.00	11.65	88.35	2.0	2.0	####	0.0	1.0	1.0
230	0.00	0.00	0.00	48.1	0.00	0.00	7.41	5.769	94.23	2.0	2.0	####	0.0	1.0	1.0
233	42.5	3.75	2.50	13.8	0.00	0.00	0.00	16.84	83.16	2.0	1.0	####	1.0	1.0	1.0
235	6.90	0.00	14.9	16.1	0.00	0.00	2.30	17.26	82.74	2.0	1.0	####	1.0	1.0	1.0
236	0.00	0.00	0.00	33.3	7.41	0.00	0.00	12.00	88.00	2.0	2.0	####	1.0	1.0	1.0
237	0.00	0.00	0.00	53.2	0.00	0.00	0.00	9.553	90.45	2.0	2.0	####	1.0	1.0	1.0

Table B.1 (continued)

ID	PCAI	PCAD	PCAS	PCAT	PCMS	PCMO	PCSV	PCTVTOT	PCLITOT	PDYS	ASP2	ASPE	XFER	XMUL	XCC
238	0.00	2.17	0.00	8.70	5.43	0.00	0.00	17.07	82.93	2.0	2.0	****	1.0	1.0	1.0
239	2.08	0.00	0.00	27.1	6.25	0.00	0.00	10.17	89.83	2.0	2.0	****	1.0	1.0	1.0
258	10.7	0.00	16.1	12.5	0.00	0.00	0.00	10.94	89.06	2.0	2.0	****	1.0	1.0	1.0
259	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.02	89.98	2.0	2.0	****	1.0	1.0	1.0
260	18.5	11.1	1.85	25.9	0.00	0.00	0.00	10.59	89.41	2.0	2.0	****	1.0	1.0	1.0
266	7.32	0.00	0.00	51.2	41.5	0.00	0.00	9.809	90.19	1.0	1.0	1.0	1.0	1.0	1.0
267	29.0	0.00	0.00	35.5	22.6	0.00	3.23	6.263	93.74	1.0	2.0	2.0	1.0	1.0	1.0
269	0.00	0.00	0.00	33.3	16.7	0.00	16.7	8.824	91.18	1.0	1.0	1.0	1.0	1.0	1.0
270	20.0	0.00	0.00	2.86	42.9	0.00	0.00	9.284	90.72	1.0	1.0	****	1.0	1.0	1.0
271	0.00	0.00	0.00	0.00	38.9	0.00	16.7	3.681	96.11	1.0	1.0	****	1.0	1.0	1.0
272	26.3	0.00	0.00	21.1	52.6	0.00	0.00	3.831	96.17	1.0	1.0	1.0	1.0	1.0	1.0
273	85.7	0.00	0.00	0.00	14.3	0.00	0.00	2.899	97.10	1.0	1.0	****	1.0	1.0	1.0
274	62.5	0.00	0.00	12.5	25.0	0.00	0.00	1.619	98.38	1.0	2.0	2.0	1.0	1.0	1.0
275	0.00	0.00	0.00	16.7	25.0	0.00	8.33	6.000	94.00	1.0	1.0	1.0	1.0	1.0	1.0
277	11.1	0.00	0.00	0.00	0.00	0.00	0.00	3.629	96.37	2.0	2.0	****	1.0	0.0	1.0
278	10.0	0.00	0.00	60.0	0.00	0.00	0.00	4.926	95.07	2.0	2.0	****	1.0	0.0	1.0
280	0.00	11.8	0.00	0.00	0.00	0.00	0.00	3.414	96.59	2.0	2.0	****	1.0	0.0	1.0
301	76.9	0.00	0.00	0.00	0.00	19.2	0.00	48.15	51.85	1.0	2.0	2.0	1.0	1.0	1.0
304	33.3	41.7	0.00	13.9	0.00	0.00	5.56	8.451	91.55	1.0	1.0	1.0	1.0	1.0	1.0
308	63.2	21.1	0.00	10.5	5.26	0.00	0.00	4.069	95.93	1.0	2.0	2.0	1.0	1.0	1.0
311	43.7	12.5	0.00	12.5	12.5	6.25	12.5	3.931	96.07	1.0	2.0	2.0	1.0	1.0	1.0
313	31.6	26.3	0.00	5.26	0.00	0.00	5.26	4.139	95.86	1.0	2.0	2.0	1.0	1.0	1.0
314	18.2	27.3	0.00	9.09	0.00	9.09	0.00	2.857	97.14	1.0	2.0	2.0	1.0	1.0	1.0
324	60.0	20.0	0.00	0.00	0.00	10.0	10.0	2.137	97.86	1.0	1.0	1.0	1.0	1.0	1.0
329	5.13	10.3	15.4	28.2	5.13	0.00	0.00	31.97	67.21	1.0	2.0	2.0	1.0	0.0	1.0
331	13.2	11.0	0.00	5.49	0.00	0.00	1.10	31.38	68.62	1.0	2.0	2.0	1.0	0.0	1.0
336	30.8	7.69	0.00	23.1	0.00	0.00	0.00	4.348	92.64	1.0	1.0	1.0	1.0	0.0	1.0
338	0.00	29.4	0.00	52.9	0.00	0.00	0.00	6.250	93.75	1.0	1.0	1.0	1.0	0.0	1.0
353	0.00	25.3	0.00	0.00	1.27	0.00	0.00	20.68	79.32	1.0	2.0	2.0	1.0	0.0	1.0
355	16.7	0.00	0.00	16.7	0.00	0.00	0.00	4.110	95.89	1.0	2.0	****	1.0	0.0	1.0
362	0.00	0.00	0.00	35.7	0.00	0.00	0.00	2.923	97.08	1.0	1.0	1.0	1.0	0.0	0.0
366	41.7	8.33	0.00	0.00	0.00	0.00	2.78	31.03	68.97	1.0	2.0	2.0	1.0	0.0	0.0
368	62.5	8.33	0.00	4.17	0.00	0.00	0.00	47.06	52.94	1.0	2.0	2.0	1.0	0.0	0.0
372	0.00	7.69	0.00	0.00	0.00	0.00	3.85	5.328	94.67	1.0	1.0	1.0	1.0	0.0	0.0
381	33.3	12.5	0.00	20.8	0.00	0.00	8.33	14.29	85.71	1.0	1.0	1.0	1.0	0.0	0.0
384	0.00	14.0	0.00	14.0	0.00	0.00	2.00	14.04	85.96	1.0	1.0	1.0	1.0	0.0	0.0
389	17.1	34.3	0.00	0.00	5.71	34.3	0.00	22.73	77.27	1.0	2.0	2.0	1.0	0.0	1.0
397	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5.405	94.59	1.0	2.0	2.0	1.0	0.0	1.0
398	0.00	0.00	0.00	14.3	0.00	21.4	0.00	3.125	96.87	1.0	2.0	2.0	1.0	0.0	1.0
400	0.00	18.2	0.00	9.09	0.00	0.00	0.00	2.231	97.77	1.0	2.0	2.0	1.0	0.0	1.0
401	44.8	24.1	0.00	3.45	0.00	20.7	0.00	40.85	59.15	1.0	1.0	1.0	1.0	0.0	1.0
412	33.3	55.6	0.00	11.1	0.00	0.00	0.00	5.660	94.34	1.0	1.0	1.0	1.0	0.0	1.0
417	38.1	28.6	0.00	9.52	9.52	0.00	4.76	19.81	80.19	1.0	1.0	1.0	1.0	0.0	0.0
421	15.6	15.6	0.00	6.25	21.9	34.4	0.00	21.92	78.08	1.0	1.0	1.0	1.0	0.0	0.0
422	9.52	33.3	0.00	4.76	28.6	14.3	4.76	12.14	87.86	1.0	1.0	1.0	1.0	0.0	0.0
424	0.00	40.0	0.00	0.00	10.0	50.0	0.00	3.030	96.97	1.0	1.0	1.0	1.0	0.0	0.0
433	10.0	16.7	0.00	3.33	3.33	0.00	0.00	25.64	74.36	1.0	2.0	2.0	1.0	0.0	0.0
437	18.6	4.65	0.00	11.6	14.0	25.6	0.00	28.10	71.90	1.0	2.0	2.0	1.0	0.0	0.0
442	18.7	6.25	0.00	12.5	12.5	0.00	0.00	3.604	96.40	1.0	2.0	2.0	1.0	0.0	0.0
443	8.33	0.00	0.00	50.0	8.33	16.7	0.00	4.762	95.24	1.0	2.0	2.0	1.0	0.0	0.0

Appendix C

BELLE AYR CLIMATIC DATA

Description of Belle Ayr Database Climatic Variables

The database abbreviation and description of each variable in the four climatic databases are listed. The uses for these databases are detailed in Chapter 5.

Variables for Belle Ayr climatic data summaries 1977-1984 / 36 divisions per year (these are listed in Table C.1) and averaged climatic data for the 36 divisions /1977-1984 (Table C.2):

TID	Climate interval identification number
YR	Year identification (1977-1984)
MO	Month identification (1-12)
TH	First, middle or last interval of each month (1-3)
THD	Identification number of 36 summary data periods within each year (1-36)
BJDA	Beginning Julian date of each interval
EJDA	Ending Julian date of each interval
LAT	Lowest daily mean temperature for each interval
HAT	Highest daily mean temperature for each interval
ATEMP	Average mean temperature for each interval
TPREC	Total precipitation for each interval
PR1	Number of days with more than 1/10 inch precipitation for each interval
PR5	Number of days with more than 5/10 inch precipitation for each interval

Variables for Belle Ayr long-range monthly climatic data / 1950-1984 (Table C.3):

LID	Identification number
LMO	Month identification (1-12)
LRATEMP	Long-range average monthly temperature
LRTPREP	Long-range average total monthly precipitation
LRPREP1	Average number of days with more than 1/10 inch precipitation for each month
LRPREP5	Average number of days with more than 5/10 inch precipitation for each month
GRID	Month abbreviation

Variables for Belle Ayr growing season data / 1970-1984 (Table C.4):

GID	Growing season identification number
GSL	Length of growing season
GBJD	Beginning Julian date of growing season
GEJD	Ending Julian date of growing season

Table C.1. Values for Belle Ayr Climatic Data Variables
1977-1984 / 36 Divisions per Year

TIO	YR	MD	TH	THD	BJDA	EJDA	LAT	HAT	ATEMP	TPREC	PR1	PR5	MO3
1	77	1	1	1	1	10	-9.0	21.	4.80	0.33	1.	0.	JA1
2	77	1	2	2	11	20	-5.0	28.	15.8	0.45	1.	0.	JA2
3	77	1	3	3	21	31	1.0	25.	17.0	0.24	0.	0.	JA3
4	77	2	1	4	32	41	18.	27.	22.9	0.00	0.	0.	FB1
5	77	2	2	5	42	51	25.	36.	31.1	0.02	0.	0.	FB2
6	77	2	3	6	52	59	22.	39.	28.1	0.62	2.	0.	FB3
7	77	3	1	7	60	69	16.	39.	27.3	0.07	0.	0.	MR1
8	77	3	2	8	70	79	19.	41.	26.8	0.25	1.	0.	MR2
9	77	3	3	9	80	89	19.	48.	33.8	1.13	3.	0.	MR3
10	77	4	1	10	90	99	27.	52.	40.4	0.16	1.	0.	AP1
11	77	4	2	11	100	109	36.	50.	44.3	0.44	2.	0.	AP2
12	77	4	3	12	110	120	48.	61.	55.6	0.33	1.	0.	AP3
13	77	5	1	13	121	130	50.	66.	57.8	0.41	1.	0.	MY1
14	77	5	2	14	131	140	43.	64.	52.7	1.03	3.	1.	MY2
15	77	5	3	15	141	151	53.	69.	58.0	0.09	0.	0.	MY3
16	77	6	1	16	152	161	64.	74.	70.1	0.00	0.	0.	JN1
17	77	6	2	17	162	171	55.	68.	62.3	1.40	3.	1.	JN2
18	77	6	3	18	172	181	60.	74.	67.8	2.16	3.	2.	JN3
19	77	7	1	19	182	191	64.	81.	72.5	0.22	1.	0.	JL1
20	77	7	2	20	192	201	61.	88.	75.2	0.59	1.	1.	JL2
21	77	7	3	21	202	212	66.	81.	72.0	0.22	1.	0.	JL3
22	77	8	1	22	213	222	52.	73.	64.8	0.98	2.	1.	AG1
23	77	8	2	23	223	232	61.	70.	65.1	0.30	1.	0.	AG2
24	77	8	3	24	233	243	56.	74.	63.7	0.87	3.	1.	AG3
25	77	9	1	25	244	253	54.	74.	66.0	0.00	0.	0.	SP1
26	77	9	2	26	254	263	54.	66.	60.8	0.00	0.	0.	SP2
27	77	9	3	27	264	273	48.	59.	52.4	1.45	3.	1.	SP3
28	77	10	1	28	274	283	34.	59.	45.1	0.51	3.	0.	OC1
29	77	10	2	29	284	293	34.	57.	48.6	0.00	0.	0.	OC2
30	77	10	3	30	294	304	39.	61.	50.0	0.10	0.	0.	OC3
31	77	11	1	31	305	314	2.4	48.	36.3	0.14	1.	0.	NV1
32	77	11	2	32	315	324	-2.2	46.	28.6	0.72	2.	0.	NV2
33	77	11	3	33	325	334	-4.7	36.	23.5	0.06	0.	0.	NV3
34	77	12	1	34	335	344	-4.0	35.	18.3	0.46	3.	0.	DC1
35	77	12	2	35	345	354	25.	50.	38.7	0.10	0.	0.	DC2
36	77	12	3	36	355	365	12.	41.	24.0	0.20	1.	0.	DC3
37	78	1	1	1	1	10	-4.0	13.	33.8	0.13	1.	0.	JA1
38	78	1	2	2	11	20	-0.4	23.	9.50	0.31	1.	0.	JA2
39	78	1	3	3	21	31	0.5	21.	10.2	0.32	1.	0.	JA3
40	78	2	1	4	32	41	-5.8	28.	17.2	0.28	2.	0.	FB1
41	78	2	2	5	42	51	9.2	23.	7.70	0.58	2.	0.	FB2
42	78	2	3	6	52	59	6.8	28.	21.0	0.29	1.	0.	FB3
43	78	3	1	7	60	69	-7.6	34.	17.6	0.19	1.	0.	MR1
44	78	3	2	8	70	79	23.	41.	31.3	0.01	0.	0.	MR2
45	78	3	3	9	80	89	30.	57.	43.8	0.31	2.	0.	MR3
46	78	4	1	10	90	99	34.	50.	43.9	0.12	0.	0.	AP1
47	78	4	2	11	100	109	34.	46.	38.8	0.55	1.	0.	AP2
48	78	4	3	12	110	120	36.	55.	44.1	0.81	3.	0.	AP3
49	78	5	1	13	121	130	30.	52.	39.4	3.25	5.	2.	MY1
50	78	5	2	14	131	140	43.	70.	51.3	3.33	3.	3.	MY2

Table C.1 (continued)

TID	YR	MO	TH	THD	BJDA	EJOA	LAT	HAT	ATEMP	TPREC	PR1	PR5	MO3
51	78	5	3	15	141	151	64.	41.	54.4	0.93	4.	0.	MY3
52	78	6	1	16	152	161	43.	66.	55.9	0.19	1.	0.	JN1
53	78	6	2	17	162	171	52.	70.	59.4	0.48	1.	0.	JN2
54	78	6	3	18	172	181	57.	72.	67.1	0.72	2.	0.	JN3
55	78	7	1	19	182	191	59.	73.	66.2	0.75	3.	0.	JL1
56	78	7	2	20	192	201	60.	75.	69.1	0.00	0.	0.	JL2
57	78	7	3	21	202	212	59.	77.	69.3	0.94	1.	1.	JL3
58	78	8	1	22	213	222	50.	73.	65.4	0.62	1.	1.	AG1
59	78	8	2	23	223	232	52.	84.	65.3	0.20	1.	0.	AG2
60	78	8	3	24	233	243	61.	75.	67.7	0.05	0.	0.	AG3
61	78	9	1	25	244	253	69.	81.	74.4	0.00	0.	0.	SP1
62	78	9	2	26	254	263	39.	63.	50.4	0.41	2.	0.	SP2
63	78	9	3	27	264	273	46.	63.	56.6	0.00	0.	0.	SP3
64	78	10	1	28	274	283	41.	51.	47.6	0.00	0.	0.	OC1
65	78	10	2	29	284	293	36.	54.	45.6	0.20	1.	0.	OC2
66	78	10	3	30	294	304	32.	50.	44.6	0.07	0.	0.	OC3
67	78	11	1	31	305	314	12.	52.	38.4	0.69	2.	0.	NV1
68	78	11	2	32	315	324	-2.0	21.	8.50	0.24	1.	0.	NV2
69	78	11	3	33	325	334	12.	27.	21.5	0.35	2.	0.	NV3
70	78	12	1	34	335	344	-4.0	25.	10.8	0.62	3.	0.	DC1
71	78	12	2	35	345	354	14.	38.	23.8	0.26	1.	0.	DC2
72	78	12	3	36	355	365	-17.	26.	8.90	0.29	1.	0.	DC3
73	79	1	1	1	1	10	-11.	4.0	-3.00	0.09	0.	0.	JA1
74	79	1	2	2	11	20	-13.	21.	8.60	0.30	1.	0.	JA2
75	79	1	3	3	21	31	-6.0	25.	5.20	0.24	1.	0.	JA3
76	79	2	1	4	32	41	-4.0	35.	14.4	0.17	1.	0.	FB1
77	79	2	2	5	42	51	-2.0	39.	23.2	0.07	0.	0.	FB2
78	79	2	3	6	52	59	5.0	32.	21.3	0.48	1.	0.	FB3
79	79	3	1	7	60	69	16.	37.	27.9	0.11	0.	0.	MR1
80	79	3	2	8	70	79	27.	46.	36.3	0.02	0.	0.	MR2
81	79	3	3	9	80	89	21.	43.	37.9	0.09	0.	0.	MR3
82	79	4	1	10	90	99	25.	52.	35.9	0.15	1.	0.	AP1
83	79	4	2	11	100	109	27.	63.	43.8	0.97	2.	1.	AP2
84	79	4	3	12	110	120	37.	50.	42.7	0.05	0.	0.	AP3
85	79	5	1	13	121	130	30.	59.	41.0	0.52	2.	0.	MY1
86	79	5	2	14	131	140	39.	66.	51.3	0.28	2.	0.	MY2
87	79	5	3	15	141	151	41.	64.	53.5	0.24	1.	0.	MY3
88	79	6	1	16	152	161	41.	66.	55.7	0.40	3.	0.	JN1
89	79	6	2	17	162	171	54.	79.	62.6	1.03	2.	1.	JN2
90	79	6	3	18	172	181	61.	75.	66.8	0.70	2.	0.	JN3
91	79	7	1	19	182	191	63.	79.	71.0	0.86	2.	0.	JL1
92	79	7	2	20	192	201	63.	75.	68.6	0.02	0.	0.	JL2
93	79	7	3	21	202	212	63.	79.	69.6	1.48	3.	1.	JL3
94	79	8	1	22	213	222	64.	81.	72.6	0.88	1.	1.	AG1
95	79	8	2	23	223	232	54.	72.	61.4	0.81	3.	0.	AG2
96	79	8	3	24	233	243	57.	73.	63.0	0.41	1.	0.	AG3
97	79	9	1	25	244	253	54.	77.	67.7	0.00	0.	0.	SP1
98	79	9	2	26	254	263	45.	66.	56.6	0.11	0.	0.	SP2
99	79	9	3	27	264	273	55.	64.	60.8	0.00	0.	0.	SP3
100	79	10	1	28	274	283	37.	59.	50.8	0.00	0.	0.	OC1

Table C.1 (continued)

TID	YR	MD	TH	THD	BJDA	EJDA	LAT	HAT	ATEMP	TPREC	PR1	PR5	MO3
101	79	10	2	29	284	293	41.	55.	50.0	0.11	0.	0.	DC2
102	79	10	3	30	294	304	27.	55.	39.7	0.00	0.	0.	OC3
103	79	11	1	31	305	314	23.	34.	29.3	0.05	0.	0.	NV1
104	79	11	2	32	316	325	21.	46.	33.3	0.59	3.	0.	NV2
105	79	11	3	33	325	334	7.0	30.	17.0	0.00	1.	0.	NV3
106	79	12	1	34	335	344	19.	45.	33.2	0.26	1.	0.	DC1
107	79	12	2	35	345	354	1.0	45.	25.4	0.02	0.	0.	DC2
108	79	12	3	36	355	365	21.	39.	28.1	0.02	0.	0.	DC3
109	80	1	1	1	1	10	-8.0	43.	19.5	0.36	2.	0.	JA1
110	80	1	2	2	11	20	12.	43.	29.9	0.22	1.	0.	JA2
111	80	1	3	3	21	31	-11.	39.	13.5	0.19	1.	0.	JA3
112	80	2	1	4	32	41	18.	36.	27.0	0.04	0.	0.	FB1
113	80	2	2	5	42	51	-2.0	39.	19.2	0.41	2.	0.	FB2
114	80	2	1	6	52	60	12.	48.	32.0	0.13	0.	0.	FB3
115	80	3	1	7	61	70	5.0	34.	22.2	0.40	1.	0.	MR1
116	80	3	2	8	71	80	27.	41.	33.6	0.25	1.	0.	MR2
117	80	3	3	9	81	90	28.	41.	33.4	0.31	1.	0.	MR3
118	80	4	1	10	91	100	28.	45.	33.5	0.36	1.	0.	AP1
119	80	4	2	11	101	110	30.	64.	46.5	0.13	0.	0.	AP2
120	80	4	3	12	111	121	46.	66.	52.8	0.07	0.	0.	AP3
121	80	5	1	13	122	131	41.	55.	51.7	0.58	3.	0.	MY1
122	80	5	2	14	132	141	43.	63.	48.3	0.49	1.	0.	MY2
123	80	5	3	15	142	152	48.	73.	58.9	1.29	4.	0.	MY3
124	80	6	1	16	153	162	50.	70.	59.3	0.27	1.	0.	JN1
125	80	6	2	17	163	172	63.	72.	64.2	0.74	2.	0.	JN2
126	80	6	3	18	173	182	61.	82.	71.2	0.01	0.	0.	JN3
127	80	7	1	19	183	192	64.	84.	75.2	0.22	1.	0.	JL1
128	80	7	2	20	193	202	64.	79.	70.6	0.12	0.	0.	JL2
129	80	7	3	21	203	213	57.	86.	76.0	0.22	1.	0.	JL3
130	80	8	1	22	214	223	55.	75.	70.5	0.00	0.	0.	AG1
131	80	8	2	23	224	233	55.	79.	66.1	1.63	3.	1.	AG2
132	80	8	3	24	234	244	54.	75.	65.7	0.34	1.	0.	AG3
133	80	9	1	25	245	254	46.	82.	63.4	0.20	0.	0.	SP1
134	80	9	2	26	255	264	46.	70.	62.1	1.36	3.	1.	SP2
135	80	9	3	27	265	274	46.	84.	59.3	0.19	1.	0.	SP3
136	80	10	1	28	275	284	36.	58.	49.8	0.02	0.	0.	DC1
137	80	10	2	29	285	294	28.	54.	39.0	0.71	1.	1.	DC2
138	80	10	3	30	295	305	24.	40.	33.3	0.06	0.	0.	DC3
139	80	11	1	31	306	315	37.	55.	45.2	0.00	0.	0.	NV1
140	80	11	2	32	316	325	14.	34.	21.5	0.36	1.	0.	NV2
141	80	11	3	33	326	335	28.	48.	38.3	0.29	1.	0.	NV3
142	80	12	1	34	336	345	9.0	41.	21.7	0.00	3.	0.	DC1
143	80	12	2	35	346	355	14.	34.	21.5	0.07	0.	0.	DC2
144	80	12	3	36	356	366	5.0	48.	34.0	0.43	1.	0.	DC3
145	81	1	1	1	1	10	25.	34.	30.7	0.00	0.	0.	JA1
146	81	1	2	2	11	20	16.	36.	27.3	0.03	0.	0.	JA2
147	81	1	3	3	21	31	16.	43.	29.5	0.07	0.	0.	JA3
148	81	2	1	4	32	41	-6.0	21.	10.5	0.28	1.	0.	FB1
149	81	2	2	5	42	51	10.	46.	35.5	0.06	0.	0.	FB2
150	81	2	3	6	52	59	28.	43.	35.5	0.03	0.	0.	FB3

Table C.1 (continued)

TID	YR	MO	TM	TMO	BJOA	EJOA	LAT	HAT	ATEMP	TPREC	PR1	PR5	MO3
151	81	3	1	7	60	69	30.	39.	34.0	0.00	0.	0.	MR1
152	81	3	2	8	70	79	30.	45.	38.0	0.15	0.	0.	MR2
153	81	3	3	9	80	89	28.	46.	37.7	0.39	2.	0.	MR3
154	81	4	1	10	90	99	32.	48.	38.8	0.15	0.	0.	AP1
155	81	4	2	11	100	109	37.	57.	50.2	0.18	0.	0.	AP2
156	81	4	3	12	110	120	43.	61.	53.6	0.04	0.	0.	AP3
157	81	5	1	13	121	130	37.	64.	47.1	1.33	3.	1.	MY1
158	81	5	2	14	131	140	37.	57.	48.0	0.19	0.	0.	MY2
159	81	5	3	15	141	151	46.	61.	55.4	0.62	2.	0.	MY3
160	81	6	1	16	152	161	54.	70.	59.4	0.33	1.	0.	JN1
161	81	6	2	17	131	140	46.	64.	56.3	0.66	1.	0.	JN2
162	81	6	3	18	172	181	57.	79.	68.1	0.06	0.	0.	JN3
163	81	7	1	19	182	191	63.	81.	75.6	0.01	0.	0.	JL1
164	81	7	2	20	192	201	66.	79.	70.4	0.54	2.	0.	JL2
165	81	7	3	21	202	212	55.	75.	66.5	2.68	2.	1.	JL3
166	81	8	1	22	213	222	57.	75.	67.1	0.29	1.	0.	AG1
167	81	8	2	23	223	232	63.	75.	69.5	0.75	0.	1.	AG2
168	81	8	3	24	233	243	55.	72.	67.0	0.12	0.	0.	AG3
169	81	9	1	25	244	253	55.	72.	65.0	0.11	0.	0.	SP1
170	81	9	2	26	254	263	54.	73.	63.4	0.00	0.	0.	SP2
171	81	9	3	27	264	273	45.	64.	55.2	0.14	0.	0.	SP3
172	81	10	1	28	274	283	41.	63.	50.1	0.05	0.	0.	OC1
173	81	10	2	29	284	293	34.	52.	41.7	0.95	2.	1.	OC2
174	81	10	3	30	294	304	23.	52.	37.2	0.24	1.	0.	OC3
175	81	11	1	31	305	314	36.	46.	42.3	0.00	0.	0.	NV1
176	81	11	2	32	315	324	25.	50.	41.3	0.03	0.	0.	NV2
177	81	11	3	33	325	334	19.	46.	29.4	0.13	0.	0.	NV3
178	81	12	1	34	335	344	23.	50.	34.4	0.05	0.	0.	OC1
179	81	12	2	35	345	354	5.0	36.	20.3	0.57	1.	0.	OC2
180	81	12	3	36	355	365	9.0	27.	15.6	1.04	2.	1.	OC3
181	82	1	1	1	1	10	-11.	22.	7.10	0.26	1.	0.	JA1
182	82	1	2	2	11	20	-6.0	30.	12.2	0.28	1.	0.	JA2
183	82	1	3	3	21	31	-15.	41.	19.5	0.28	1.	0.	JA3
184	82	2	1	4	32	41	-15.	23.	3.30	0.10	0.	0.	FB1
185	82	2	2	5	42	51	12.	46.	35.5	0.00	0.	0.	FB2
186	82	2	3	6	52	59	19.	52.	35.5	0.12	1.	0.	FB3
187	82	3	1	7	60	69	12.	43.	27.1	0.42	2.	0.	MR1
188	82	3	2	8	70	79	16.	45.	33.1	0.54	1.	0.	MR2
189	82	3	3	9	80	89	18.	46.	31.8	0.24	2.	0.	MR3
190	82	4	1	10	90	99	19.	48.	27.5	0.59	1.	0.	AP1
191	82	4	2	11	100	109	28.	52.	39.6	0.11	0.	0.	AP2
192	82	4	3	12	110	120	36.	55.	44.9	0.61	3.	0.	AP3
193	82	5	1	13	121	130	43.	61.	48.3	0.32	1.	0.	MY1
194	82	5	2	14	131	140	37.	54.	46.6	2.35	6.	2.	MY2
195	82	5	3	15	141	151	43.	57.	48.8	1.58	3.	1.	MY3
196	82	6	1	16	152	161	45.	55.	49.4	1.60	5.	1.	JN1
197	82	6	2	17	162	171	52.	61.	56.9	0.39	1.	0.	JN2
198	82	6	3	18	172	181	54.	70.	62.1	0.17	1.	0.	JN3
199	82	7	1	19	182	191	50.	72.	63.0	0.12	0.	0.	JL1
200	82	7	2	20	192	201	59.	84.	69.3	0.14	1.	0.	JL2

Table C.1 (continued)

TIO	YR	MO	TH	THO	BJOA	EJOA	LAT	HAT	ATEMP	TPREC	PR1	PR5	MO3
201	82	7	3	21	202	212	64.	84.	72.5	2.54	3.	1.	JL3
202	82	8	1	22	213	222	63.	77.	71.4	0.11	1.	0.	AG1
203	82	8	2	23	223	232	70.	79.	73.1	0.31	2.	0.	AG2
204	82	8	3	24	233	243	57.	90.	67.3	0.63	2.	0.	AG3
205	82	9	1	25	244	253	56.	64.	60.8	0.10	1.	0.	SP1
206	82	9	2	26	254	263	32.	46.	39.7	1.71	2.	2.	SP2
207	82	9	3	27	264	273	29.	54.	45.0	0.52	2.	0.	SP3
208	82	10	1	28	274	283	27.	45.	37.4	0.60	2.	0.	OC1
209	82	10	2	29	284	293	22.	49.	37.4	0.04	0.	0.	OC2
210	82	10	3	30	294	304	31.	45.	36.7	0.09	0.	0.	OC3
211	82	11	1	31	305	314	17.	37.	27.5	0.06	0.	0.	NV1
212	82	11	2	32	315	324	13.	37.	23.8	0.25	1.	0.	NV2
213	82	11	3	33	325	334	9.0	36.	24.2	0.00	0.	0.	NV3
214	82	12	1	34	335	344	-2.0	34.	15.3	0.65	2.	0.	OC1
215	82	12	2	35	345	354	3.0	32.	19.4	0.01	0.	0.	DC2
216	82	12	3	36	355	365	18.	37.	24.9	0.54	3.	0.	DC3
217	83	1	1	1	1	10	10.	31.	22.4	0.11	0.	0.	JA1
218	83	1	2	2	11	20	21.	33.	25.2	0.00	0.	0.	JA2
219	83	1	3	3	21	31	18.	37.	24.9	0.10	0.	0.	JA3
220	83	2	1	4	32	41	9.0	29.	19.2	0.00	0.	0.	FB1
221	83	2	2	5	42	51	24.	52.	34.9	0.05	0.	0.	FB2
222	83	2	3	6	52	59	25.	38.	31.9	0.00	0.	0.	FB3
223	83	3	1	7	60	69	21.	47.	33.7	0.47	2.	0.	MR1
224	83	3	2	8	70	79	10.	52.	29.0	0.26	2.	0.	MR2
225	83	3	3	9	80	89	18.	46.	28.4	0.51	1.	0.	MR3
226	83	4	1	10	90	99	19.	42.	26.2	0.16	1.	0.	AP1
227	83	4	2	11	100	109	12.	47.	31.4	1.04	3.	1.	AP2
228	83	4	3	12	110	120	28.	54.	41.3	0.49	2.	0.	AP3
229	83	5	1	13	121	130	32.	53.	42.4	0.37	1.	0.	MY1
230	83	5	2	14	131	140	25.	43.	35.7	0.44	1.	0.	MY2
231	83	5	3	15	141	151	41.	62.	52.7	0.27	1.	0.	MY3
232	83	6	1	16	152	161	48.	64.	55.6	0.34	1.	0.	JN1
233	83	6	2	17	162	171	47.	65.	56.6	0.86	3.	0.	JN2
234	83	6	3	18	172	181	61.	72.	61.4	0.20	1.	0.	JN3
235	83	7	1	19	182	191	49.	79.	55.6	0.31	2.	0.	JL1
236	83	7	2	20	192	201	47.	75.	64.6	0.54	1.	1.	JL2
237	83	7	3	21	202	212	56.	73.	65.6	0.55	1.	1.	JL3
238	83	8	1	22	213	222	71.	79.	74.9	0.10	1.	0.	AG1
239	83	8	2	23	223	232	65.	82.	71.0	0.65	1.	1.	AG2
240	83	8	3	24	233	243	65.	79.	71.7	0.88	2.	1.	AG3
241	83	9	1	25	244	253	50.	82.	62.4	0.15	0.	0.	SP1
242	83	9	2	26	254	263	22.	59.	46.6	0.03	0.	0.	SP2
243	83	9	3	27	264	273	31.	59.	46.3	0.05	0.	0.	SP3
244	83	10	1	28	274	283	34.	54.	44.0	0.95	4.	0.	OC1
245	83	10	2	29	284	293	28.	42.	36.2	0.63	4.	0.	OC2
246	83	10	3	30	294	304	33.	52.	42.7	0.04	0.	0.	OC3
247	83	11	1	31	305	314	14.	51.	36.3	0.75	2.	0.	NV1
248	83	11	2	32	315	324	23.	37.	30.3	0.02	0.	0.	NV2
249	83	11	3	33	325	334	1.0	20.	8.70	0.15	1.	0.	NV3
250	83	12	1	34	335	344	7.0	34.	20.9	0.35	2.	0.	DC1

Table C.1 (continued)

TID	YR	MO	TM	TMD	BJDA	EJDA	LAT	HAT	ATEMP	TPREC	PR1	PR5	MO3
251	83	12	2	35	345	354	-24.	27.	0.70	0.20	1.	0.	DC2
252	83	12	3	36	355	365	-28.	30.	-6.30	0.31	1.	0.	DC3
253	84	1	1	1	1	10	21.	38.	31.1	0.00	0.	0.	JA1
254	84	1	2	2	11	20	-12.	29.	6.20	0.14	0.	0.	JA2
255	84	1	3	3	21	31	14.	37.	27.5	0.16	1.	0.	JA3
256	84	2	1	4	32	41	29.	34.	31.6	0.05	0.	0.	FB1
257	84	2	2	5	42	51	22.	38.	29.1	0.01	0.	0.	FB2
258	84	2	3	6	52	60	19.	37.	27.8	0.05	0.	0.	FB3
259	84	3	1	7	61	70	18.	35.	26.4	0.33	2.	0.	MR1
260	84	3	2	8	71	80	28.	42.	35.5	0.18	1.	0.	MR2
261	84	3	3	9	81	90	28.	43.	34.1	0.18	0.	0.	MR3
262	84	4	1	10	91	100	29.	48.	38.9	0.40	3.	0.	AP1
263	84	4	2	11	101	110	35.	54.	43.4	0.10	0.	0.	AP2
264	84	4	3	12	111	121	19.	44.	31.6	2.00	2.	1.	AP3
265	84	5	1	13	122	131	32.	53.	40.6	0.31	2.	0.	MY1
266	84	5	2	14	132	141	51.	65.	58.6	0.17	1.	0.	MY2
267	84	5	3	15	142	152	41.	69.	52.8	0.75	2.	0.	MY3
268	84	6	1	16	153	162	43.	58.	52.0	1.24	3.	1.	JN1
269	84	6	2	17	163	172	57.	66.	61.9	0.42	2.	0.	JN2
270	84	6	3	18	173	182	62.	77.	66.9	0.00	0.	0.	JN3
271	84	7	1	19	183	192	63.	73.	67.9	0.18	1.	0.	JL1
272	84	7	2	20	193	202	71.	77.	73.4	0.00	0.	0.	JL2
273	84	7	3	21	203	213	64.	77.	71.2	0.62	2.	0.	JL3
274	84	8	1	22	214	223	68.	77.	72.1	0.04	0.	0.	AG1
275	84	8	2	23	224	233	66.	79.	72.1	0.05	0.	0.	AG2
276	84	8	3	24	234	244	64.	75.	70.3	0.03	0.	0.	AG3
277	84	9	1	25	245	254	51.	71.	60.4	0.02	0.	0.	SP1
278	84	9	2	26	255	264	48.	70.	60.2	0.05	0.	0.	SP2
279	84	9	3	27	265	274	23.	52.	36.3	0.75	2.	1.	SP3
280	84	10	1	28	275	284	49.	65.	56.9	0.19	1.	0.	OC1
281	84	10	2	29	285	294	24.	67.	41.0	0.16	0.	0.	OC2
282	84	10	3	30	295	305	24.	53.	34.0	0.00	0.	0.	OC3
283	84	11	1	31	306	315	21.	48.	34.6	0.40	1.	0.	NV1
284	84	11	2	32	316	325	28.	47.	34.5	0.00	0.	0.	NV2
285	84	11	3	33	326	335	18.	46.	31.4	0.26	1.	0.	NV3
286	84	12	1	34	336	345	9.3	39.	26.0	0.04	0.	0.	DC1
287	84	12	2	35	346	355	1.4	29.	16.2	0.05	0.	0.	DC2
288	84	12	3	36	356	366	0.3	40.	17.8	0.18	0.	0.	DC3

Table C.2. Values for Belle Ayr Averaged Climatic Data Variables 1977-1984 / 36 Divisions per Year

TID	YR	MO	TH	THD	BJDA	EJDA	LAT	HAT	ATEMP	TPREC	PR1	PR5	MO3
501	-0-	1	1	1	-0-	-0-	1.6	26.	18.3	0.16	1.	0.	JA1
502	-0-	1	2	2	-0-	-0-	1.6	30.	16.8	0.22	1.	0.	JA2
503	-0-	1	3	3	-0-	-0-	2.2	34.	18.4	0.20	1.	0.	JA3
504	-0-	2	1	4	-0-	-0-	5.4	29.	18.3	0.12	1.	0.	FB1
505	-0-	2	2	5	-0-	-0-	12.	40.	27.0	0.15	1.	0.	FB2
506	-0-	2	3	6	-0-	-0-	17.	40.	29.1	0.22	1.	0.	FB3
507	-0-	3	1	7	-0-	-0-	14.	38.	27.0	0.25	1.	0.	MR1
508	-0-	3	2	8	-0-	-0-	23.	44.	33.0	0.21	1.	0.	MR2
509	-0-	3	3	9	-0-	-0-	24.	46.	35.1	0.40	1.	0.	MR3
510	-0-	4	1	10	-0-	-0-	27.	48.	35.6	0.26	1.	0.	AP1
511	-0-	4	2	11	-0-	-0-	30.	54.	42.2	0.44	1.	0.	AP2
512	-0-	4	3	12	-0-	-0-	37.	56.	45.8	0.55	1.	0.	AP3
513	-0-	5	1	13	-0-	-0-	37.	58.	46.0	0.89	2.	0.	MY1
514	-0-	5	2	14	-0-	-0-	40.	60.	49.1	1.04	2.	1.	MY2
515	-0-	5	3	15	-0-	-0-	47.	62.	54.3	0.72	2.	0.	MY3
516	-0-	6	1	16	-0-	-0-	48.	65.	57.2	0.55	2.	0.	JN1
517	-0-	6	2	17	-0-	-0-	53.	68.	60.0	0.75	2.	0.	JN2
518	-0-	6	3	18	-0-	-0-	59.	75.	66.4	0.50	1.	0.	JN3
519	-0-	7	1	19	-0-	-0-	59.	78.	68.4	0.33	1.	0.	JL1
520	-0-	7	2	20	-0-	-0-	61.	79.	70.2	0.24	1.	0.	JL2
521	-0-	7	3	21	-0-	-0-	61.	79.	70.3	1.16	2.	1.	JL3
522	-0-	8	1	22	-0-	-0-	60.	76.	69.9	0.38	1.	0.	AG1
523	-0-	8	2	23	-0-	-0-	61.	78.	68.0	0.59	1.	0.	AG2
524	-0-	8	3	24	-0-	-0-	59.	77.	67.1	0.42	1.	0.	AG3
525	-0-	9	1	25	-0-	-0-	54.	75.	65.0	0.07	0.	0.	SP1
526	-0-	9	2	26	-0-	-0-	43.	64.	55.0	0.46	1.	0.	SP2
527	-0-	9	3	27	-0-	-0-	40.	62.	51.5	0.39	1.	0.	SP3
528	-0-	10	1	28	-0-	-0-	37.	57.	47.7	0.29	1.	0.	OC1
529	-0-	10	2	29	-0-	-0-	31.	54.	42.4	0.36	1.	3.	OC2
530	-0-	10	3	30	-0-	-0-	29.	51.	39.8	0.08	0.	0.	OC3
531	-0-	11	1	31	-0-	-0-	20.	46.	36.2	0.26	1.	0.	NV1
532	-0-	11	2	32	-0-	-0-	15.	40.	27.7	0.28	1.	0.	NV2
533	-0-	11	3	33	-0-	-0-	11.	36.	24.2	0.20	1.	0.	NV3
534	-0-	12	1	34	-0-	-0-	7.2	38.	22.6	0.38	2.	0.	DC1
535	-0-	12	2	35	-0-	-0-	4.9	36.	20.7	0.16	0.	0.	DC2
536	-0-	12	3	36	-0-	-0-	2.5	36.	18.4	0.38	1.	0.	DC3

Table C.3. Values for Belle Ayr Average Monthly Climatic Data Variables 1950-1954

LIO	LMO	LRATEMP	LRTPREC	LRPREP1	LRPREP5	GR10
1	1	21.100	0.5500	2	0	JA
2	2	26.500	0.6200	2	0	FB
3	3	31.700	0.7800	3	0	MR
4	4	42.100	1.7800	5	1	AP
5	5	52.800	2.4200	6	1	MY
6	6	62.100	3.1800	6	2	JN
7	7	70.500	1.3600	3	1	JL
8	8	69.500	1.1500	3	1	AG
9	9	58.200	1.3100	3	1	SP
10	10	47.900	1.0300	3	0	OC
11	11	33.100	0.6700	2	0	NV
12	12	24.800	0.5700	2	0	OC

Table C.4 Values for Belle Ayr Growing Season Data Variables 1970-1984

GIO	GYR	GSL	GBJO	GEJO
1	70	133.0	121	255
2	71	143.0	117	261
3	72	155.0	114	270
4	73	156.0	120	277
5	74	150.0	136	287
6	75	163.0	110	274
7	76	155.0	123	279
8	77	170.0	112	283
9	78	167.0	111	279
10	79	163.0	130	294
11	80	177.0	107	285
12	81	175.0	103	279
13	82	165.0	126	292
14	83	126.0	135	262
15	84	139.0	128	278

Table C.5. Julian Date Conversion Equivalents

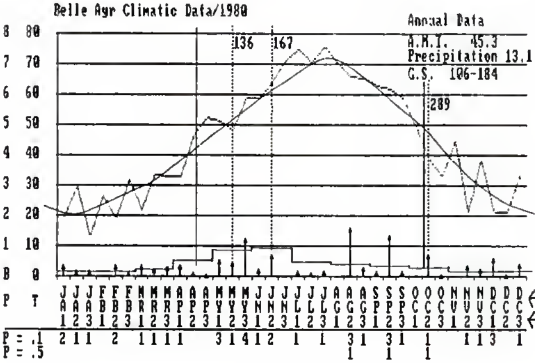
JANUARY	1-31	1-31 (Leap Year)
Early	1-10	1-10
Mid	11-20	11-20
Late	21-31	21-31
FEBRUARY	32-59	32-60
Early	32-41	32-41
Mid	42-51	42-51
Late	52-59	52-60
MARCH	60-89	61-90
Early	60-69	61-70
Mid	70-79	71-80
Late	80-89	81-90
APRIL	90-120	91-121
Early	90-99	91-100
Mid	100-109	101-110
Late	110-120	111-121
MAY	121-151	122-152
Early	121-130	122-131
Mid	131-140	132-141
Late	141-151	142-152
JUNE	152-181	153-182
Early	152-161	153-162
Mid	162-171	163-172
Late	172-181	173-182
JULY	182-212	183-213
Early	182-191	183-192
Mid	192-201	193-202
Late	202-212	203-213
AUGUST	213-243	214-244
Early	213-222	214-223
Mid	223-232	224-233
Late	233-243	234-244
SEPTEMBER	244-273	245-274
Early	244-253	245-254
Mid	254-263	255-264
Late	264-273	265-274
OCTOBER	274-304	275-305
Early	274-283	275-284
Mid	284-293	285-294
Late	294-304	295-305
NOVEMBER	305-334	306-335
Early	305-314	306-315
Mid	315-324	316-325
Late	325-334	326-335
DECEMBER	335-365	336-366
Early	335-344	336-345
Mid	345-354	346-355
Late	355-365	356-366

Figure C.1. Belle Ayr Climatic Summary Graphs 1977-1984

KEY

ANNUAL DATA

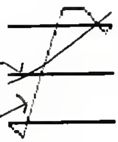
A.M.T. Annual Mean Temperature
Annual Precipitation Totals
G.S. Growing Season (beginning and ending Julian Dates)



Month
1 = Early
2 = Mid
3 = Late

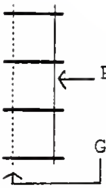
Average precipitation (1950-1984)

Precipitation



Average mean temperature (1950-1984)

Mean temperature



Planting dates

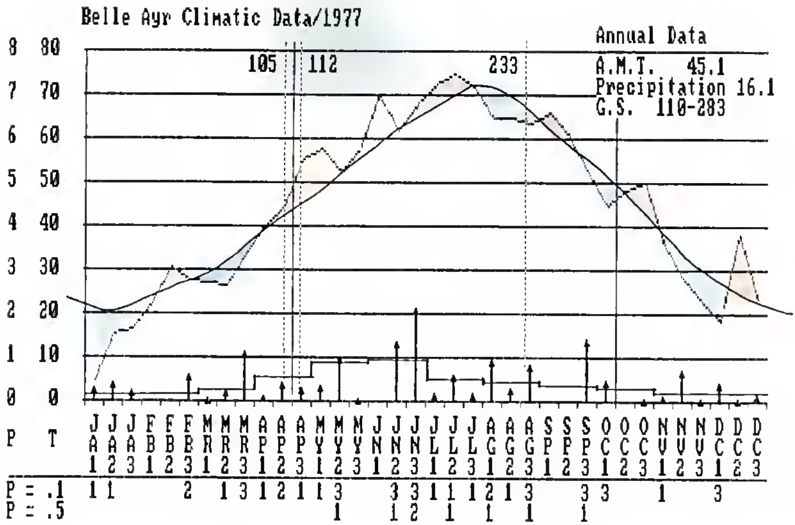
Growing season limits

Temperature in Degrees

Precipitation in Inches

P = .1
P = .5 Number of days during each period (1/3 month) that precipitation totals exceeded 0.1 or 0.5 inches

Figure C.1 (continued)



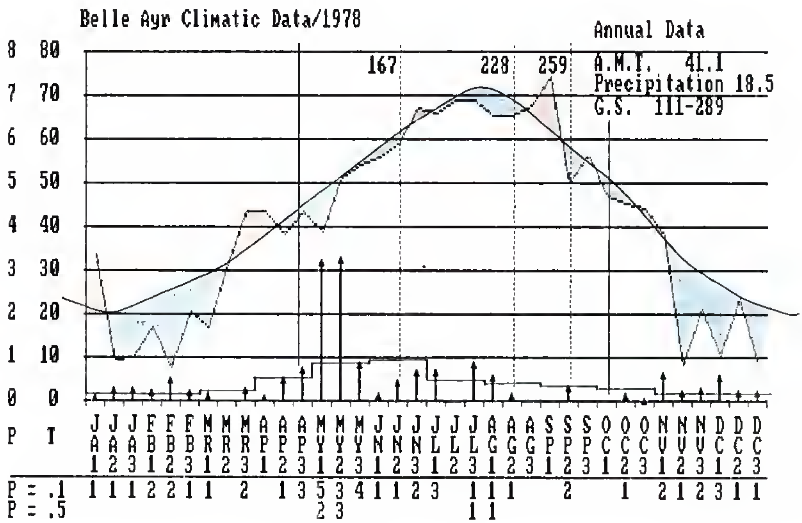
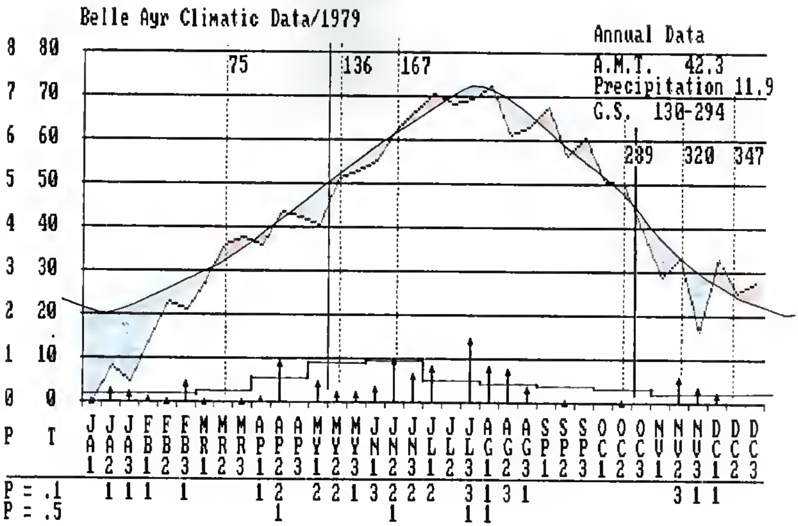


Figure C.1 (continued)



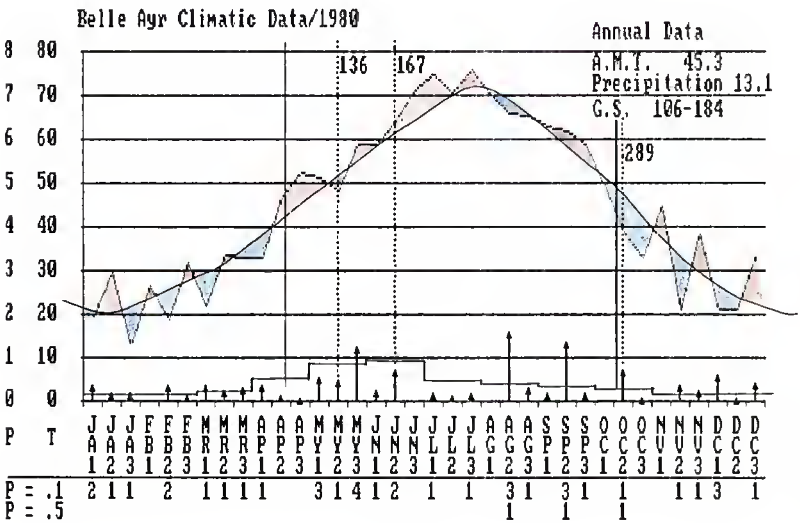
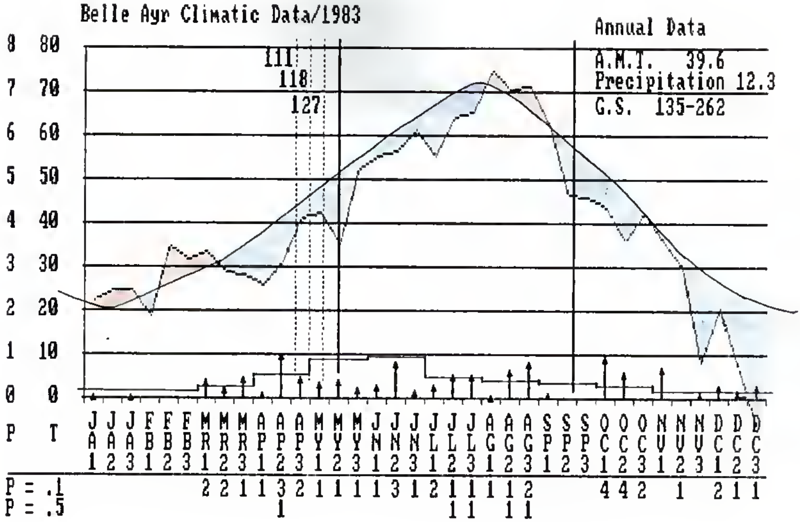


Figure C.1 (continued)



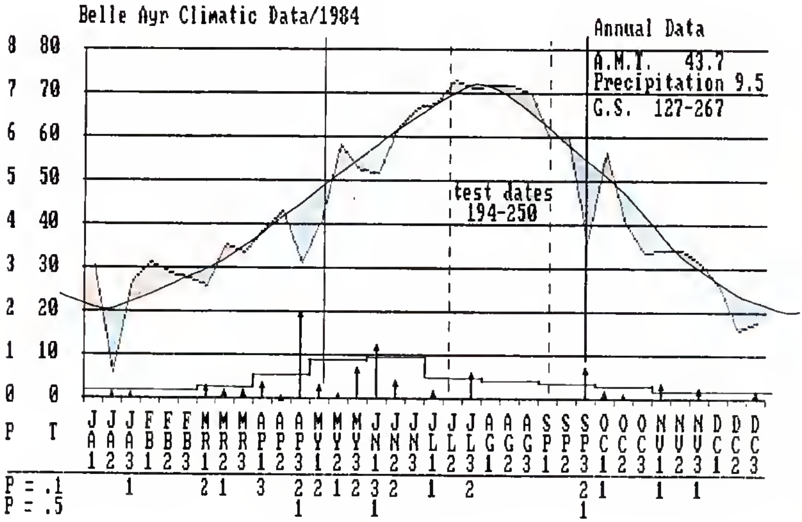
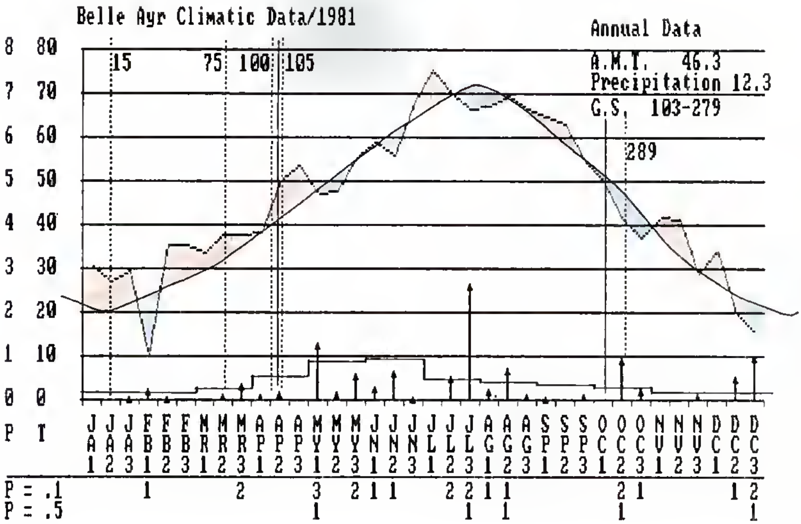
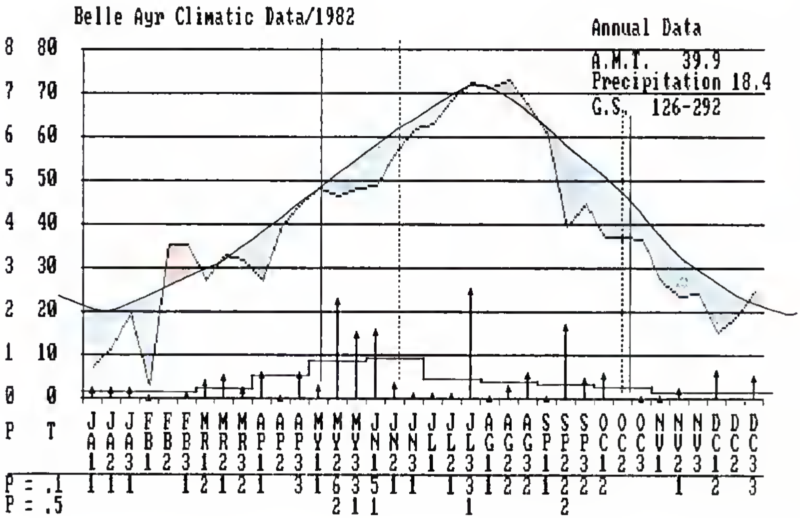


Figure C.1 (continued)





Appendix D

BELLE AYR/SEAM TEST RESULTS

BELLE AYR/SEAM Computer Program Description

The BELLE AYR/SEAM computer program was created to transfer selected variable values from the Belle Ayr database to a program that would compare the actual percentage of total cover with the SEAM model predicted percentage of total cover. Comparisons are made with predictions for both predominantly native and predominantly introduced vegetative stands, as it was difficult to determine which was appropriate for many of the Belle Ayr test plots. The program then calculates the number of Belle Ayr test plots that were within the SEAM model standard error-of-estimate range.

The print-out includes identification variables; potassium, sodium and pH values; treatment alternatives; total percentage of vegetative cover (TVEG); the adjusted total percentage (TOTAL) -- plots with recorded values of more than 100% were given a value of 100%; and the SEAM model predictions for native cover (N%C) and introduced cover (I%C). The results are given as number of cases and percentage of cases within the SEAM model standard error-of-estimate range for native cover (NCOUNT) and introduced cover (ICOUNT).

BELLE AYR/SEAM TEST Computer Program

```
10 REM **BELLE AYR DATA/BARV.BAS
20 REM **USDA/FS REVEGETATION PREDICTION MODEL PROGRAM
30 REM **B A MEIDINGER/KSU/JANUARY 1986
40 CLEAR
50 CLS
60 PRINT:PRINT:PRINT "      [1] PRINT OUT ENTIRE PROGRAM":
   PRINT "      [2] PRINT ONLY PARAMETERS/COUNT"
70 PRINT:INPUT "           CHOOSE [1] OR [2]";CHOOSE
80 PRINT:PRINT:PRINT:
   PRINT "          -----------------------------------------"
90 INPUT "PARAMETERS";P$
100 INPUT "INPUT FILE";INFILE$
110 INPUT "GROWING SEASON";GS
120 INPUT "ANNUAL PRECIPITATION";PR
130 WIDTH "LPT1:",132
140 CASES = 0
150 NCOUNT = 0
160 ICOUNT = 0
170 IR=0
180 TS=1
190 TL=1
200 IF CHOOSE = 1 THEN GOSUB 1080
210 OPEN "I",#1,INFILE$
220 IF EOF(1) THEN GOTO 1180
230 INPUT #1,ID,R,AGE,TPO,TSO,PH,TCLM,TPLM,TFERT,TMULC,POY,TVEG,TOTAL
240 CASES = CASES + 1
250 IF TOTAL > 100 THEN TOTAL = 100
260 PO=TPO*39.19
270 POR=PO
280 IF PO>450 THEN PO=450
290 SO=TSO*22.99
300 SOR=SO
310 IF SO>1000 THEN SO=1000
320 IF TPLM=6 THEN PLM=0 ELSE PLM=1
330 IF TFERT=0 THEN FERT=0 ELSE FERT=1
340 IF TMULC=0 THEN MULC=0 ELSE MULC=1
350 IF POY>227 OR POY<16 THEN ST=1 ELSE ST=0
360 GOSUB 740:GOSUB 920
370 IF Z>100 THEN Z=100
380 XT3=Z
390 GOSUB 800:GOSUB 920
400 IF Z>100 THEN Z=100
410 XT4=Z
420 IF TOTAL => XT3 - 17.5 AND TOTAL <= XT3 + 17.5
    THEN GOTO 430 ELSE GOTO 440
430 NCOUNT = NCOUNT + 1
440 IF TOTAL => XT4 - 19.2 AND TOTAL <= XT4 + 19.2
    THEN GOTO 450 ELSE GOTO 220
450 ICOUNT = ICOUNT + 1
460 IF CHOOSE = 2 THEN GOTO 220
470 LPRINT "!  ";
480 LPRINT USING "###  ";ID;
490 LPRINT USING"##  ";R;
```

```
500 LPRINT USING "#.#  ";AGE;
510 LPRINT USING "###  ¦  ";PDY;
520 LPRINT USING "# ";TCLM;
530 LPRINT USING "# ";TPLM;
540 LPRINT USING "# ";TMULC;
550 LPRINT USING "#  ¦  ";TFERT;
560 LPRINT USING "##### ";POR;
570 LPRINT USING "###### ";SOR;
580 LPRINT USING "#.#  ¦  ";PH;
590 TL$="X  "
600 IF PLM=1 THEN PLM$="X  " ELSE PLM$="-  "
610 TS$="X  "
620 IF FERT=0 THEN FERT$="-  " ELSE FERT$="X  "
630 IR$="-  "
640 IF MULC=0 THEN MULC$="-  " ELSE MULC$="X  "
650 IF ST=1 THEN ST$="X   ¦  " ELSE ST$="-   ¦  "
660 LPRINT TL$;PLM$;TS$;FERT$;IR$;MULC$;ST$;
670 LPRINT USING "##.#  ";TVEG;
680 LPRINT USING "###.#  ¦  ";TOTAL;
690 LPRINT USING "###  ";XT3;
700 LPRINT USING "###  ¦  ";XT4;
710 GOSUB 1160
720 GOTO 220
730 REM **SUBROUTINES
740 T=12.86572
750 AD(1)=-3.929149:AD(2)=-1.836147:AD(3)=6.056078:AD(4)=11.19705
760 AD(5)=.5945488:AD(6)=15.16765:AD(7)=-5.601713
770 AD(8)=8.918672E-02:AD(9)=-1.861335E-02:AD(10)=-4.176856
780 X=1.07686
790 RETURN
800 T=-74.25283
810 AD(1)=-10.02594:AD(2)=1.02198:AD(3)=.3622047:AD(4)=30.88224
820 AD(5)=15.06255:AD(6)=4.778853:AD(7)=18.96781
830 AD(8)=2.049003E-02:AD(9)=9.275586E-03:AD(10)=7.643977
840 X=.98256
850 RETURN
860 YPPR=(EXP(-(ABS((AGE/7-1)/.9)^4.6)))
870 IF GS>85 THEN GOTO 890
880 YPG1=2510*(EXP(-(ABS((GS/85-1)/.16)^4)))+940:YPG3=YPG1:
    GOTO 900
890 YPG2=1200*(EXP(-(ABS((GS/85-1)/.12)^4)))+2250:YPG3=YPG2
900 XT=YPPR*YPG3*6.18959E-03*PR^1.6:XT=XT*X
910 RETURN
920 AYP=1.8+EXP(-(ABS(((180-GS)/180-1)/.52)^15))
930 BYP=.29*(EXP(-(ABS((GS/180-1)/.5015)^12)))-.2
940 YPGS=100*(EXP(-(ABS((GS/180-1)/.78)^8)))
950 BGS=.23*(EXP(-(ABS(((180-GS)/180-1)/.36)^6.5)))+.1
960 AX=AYP*(1.1397*(EXP(-(ABS((AGE/10-1)/.88)^5.8)))-.1397)+1
970 BX=(BYP/10)*AGE+.38
980 AY=EXP(-(ABS(((AGE+1)/11-1)/(1-BGS))^10))
990 BY=EXP(-((1/(1-BGS))^10))
1000 YP=((AY-BY)/(1-BY))*YPGS
1010 TN=EXP(-(ABS((PR/26-1)/(1-BX))^AX))
```

```
1020 UN=EXP(-((1/(1-BX))^AX))
1030 PC=((TN-UN)/(1-UN))*YP
1040 XT=PC*X
1050 Z=XT+T+TL*AD(1)+PLM*AD(2)+TS*AD(3)+FERT*AD(4)+IR*AD(5)+
     MULC*AD(6)+ST*AD(7)+PO*AD(8)+SO*AD(9)+PH*AD(10)
1060 IF Z<0 THEN Z=0
1070 RETURN
1080 LPRINT "BELLE AYR DATA / USDA/FS REVEGETATION PREDICTION
     MODEL PROGRAM / B. A. MEIDINGER/KSU/";
1090 LPRINT DATE$
1100 LPRINT "-------------------------------------------------
     ---------------------------------------------"
1110 LPRINT
1120 LPRINT "|  ID   R   AGE  PDY  |  C P M F
     |  K     NA     pH   |  TL SM TS FR IR ML ST
     |  TVEG  TOTAL  |  N%C  I%C  |"
1130 GOSUB 1160
1140 GOSUB 1160
1150 RETURN
1160 LPRINT "|                    |
     |                |                         |
                    |              |"
1170 RETURN
1180 CLOSE
1190 PCN = INT(NCOUNT/CASES*100)
1200 PCI = INT(ICOUNT/CASES*100)
1210 LPRINT:
     LPRINT USING "\                                   \";P$
1220 LPRINT "NUMBER OF CASES: ";CASES
1230 LPRINT "   NCOUNT = ";
1240 LPRINT USING "     ###";NCOUNT;
1250 LPRINT USING "    ###";PCN;
1260 LPRINT "%"
1270 LPRINT "   ICOUNT = ";
1280 LPRINT USING "     ###";ICOUNT;
1290 LPRINT USING "    ###";PCI;
1300 LPRINT "%"
1310 END
```

Example of BELLE AYR/SEAM Program Printout (Partial Results)

BELLE AYR DATA / USDA/FS REVEGETATION PREDICTION MODEL PROGRAM / B. A. MEIDINGER/KSU/04-19-1986

ID	R	AGE	PDY	K	NA	pH	TL	SM	TS	FR	IR	ML	ST	TVEG	TOTAL	N%C	1%C
50	8	4.8	289	31	38	6.9	X	X	X	-	-	-	X	8.8	49.8	50	53
93	14	4.7	320	22	37	6.5	X	X	X	-	-	X	X	10.0	60.6	66	55
110	17	4.7	347	14	24	7.1	X	X	X	X	-	X	X	2.6	100.0	74	90
150	24	4.8	289	13	34	7.1	X	X	X	X	-	X	X	12.6	100.0	74	90
162	27	4.8	289	19	55	7.4	X	X	X	X	-	-	X	4.4	73.8	58	88
163	27	4.8	289	19	57	7.4	X	X	X	X	-	-	X	5.0	100.0	58	88
164	27	4.8	289	19	57	7.4	X	X	X	X	-	-	X	4.4	82.2	58	88
165	27	4.8	289	18	54	7.4	X	X	X	X	-	-	X	7.4	100.0	58	88
166	28	4.9	289	18	65	7.1	X	X	X	X	-	-	X	4.4	73.2	59	85
168	28	4.9	289	18	65	7.1	X	X	X	X	-	-	X	4.8	100.0	59	85
169	28	4.9	289	18	133	7.3	X	X	X	X	-	-	X	9.2	100.0	57	88
171	29	4.8	289	24	278	7.5	X	X	X	X	-	X	X	13.4	100.0	69	95
173	29	4.8	289	19	303	7.5	X	X	X	X	-	X	X	3.8	94.8	68	96
174	29	4.8	289	19	303	7.5	X	X	X	X	-	X	X	3.2	99.8	68	96
181	31	3.8	289	7	41	7.3	X	X	X	X	-	X	X	7.6	100.0	71	90
184	31	3.8	289	7	41	7.3	X	X	X	X	-	X	X	11.6	100.0	71	90
185	31	3.8	289	7	41	7.3	X	X	X	X	-	X	X	12.2	100.0	71	90
206	36	3.8	289	7	49	7.3	X	X	X	X	-	X	X	7.8	90.4	71	90
207	36	3.8	289	7	49	7.3									0.0	71	90
209	36	3.8	289	7	49	7.3									0.0	71	90
210	36	3.8	289	7	49	7.3									0.0	71	90
211	37	3.8	289	6	17	7.0									0.0	73	88

100 SELECTED TEST PLOTS

GROWING SEASON = 125
PRECIPITATION = 15

NUMBER OF CASES: 100

NCOUNT = 23 23%
1COUNT = 50 50%

Appendix E

BELLE AYR DATA: ANALYTICAL STUDIES AND TESTS

Table E.1. Descriptive Statistics for Selected Variables for 100 Selected Test Plots

Name	Mean	Std. Dev.	Minimum	Maximum
ID	250.8900	104.0428	47.0000	443.0000
PDY	209.0000	92.2633	75.0000	347.0000
PDYSF	1.5400	.5009	1.0000	2.0000
AGE	2.9550	1.3400	1.3000	4.9000
ASP	202.9500	110.8737	.0000	360.0000
ASP2	1.5300	.5016	1.0000	2.0000
ASPEW	98.0600	140.5102	.0000	360.0000
FERT	.8100	.3943	.0000	1.0000
MULCH	.5900	.4943	.0000	1.0000
CC	.8200	.3861	.0000	1.0000
SAND	50.2945	15.8802	15.8000	80.2000
SILT	29.4155	11.7548	9.1000	65.1000
CLAY	20.2510	7.5015	6.9000	40.0000
N	3.6579	1.9860	1.6700	10.4000
K	.2975	.1438	.1200	.7900
NA	1.9813	2.4134	.4700	13.2000
CARB	1.3006	.7952	.3000	3.4000
PH	7.2930	.2999	6.5000	7.9000
TVEG	7.2820	4.9315	1.6000	28.6000
LITTR	72.1480	27.0416	5.4000	98.8000
ADTOT	78.0440	26.6606	10.2000	100.0000
PCTVTOT	11.2409	9.8312	1.6194	48.1481
PCAI	16.3151	22.5557	.0000	92.8571
PCAD	6.0826	11.2856	.0000	55.5556
PCAS	2.1532	7.2283	.0000	40.9836
PCAT	10.7466	15.0296	.0000	60.0000
PCMO	2.6533	8.2723	.0000	50.0000
PCMS	10.7677	17.6573	.0000	100.0000
PCSV	2.0761	4.8454	.0000	27.2727

Table E.2. Frequency Distributions for Predictor Variables based on 100 Selected Test Plots

VARIABLE: Planting Date/PDY (Julian dates)

```
=====CLASS LIMITS====  FREQUENCY ..............................
       75.00                  4 |==
      105.00                  5 |===
      111.00                 26 |===============
      118.00                  7 |====
      136.00                  4 |==
      289.00                 48 |==============================
      320.00                  5 |===
      347.00                  1 |
```

VARIABLE: Planting Date -- Spring or Fall/PDYSF
(1 = spring, 2 = fall)

```
=====CLASS LIMITS====  FREQUENCY ..............................
        1.00                 46 |=========================
        2.00                 54 |==============================
```

VARIABLE: AGE

```
=====CLASS LIMITS====  FREQUENCY ..............................
        1.30                  7 |=======
        1.40                 26 |==============================
        1.90                  3 |===
        2.70                  6 |======
        2.80                 13 |==============
        3.40                  9 |==========
        3.80                  9 |==========
        4.20                  4 |====
        4.70                  6 |======
        4.80                 14 |===============
        4.90                  3 |===
```

VARIABLE: Aspect/ASP (Compass degrees, 0 = flat, 360 = north)

```
=====CLASS LIMITS====  FREQUENCY ..............................
         .00                  8 |==========
       45.00                  1 |=
       90.00                 19 |=========================
      135.00                  6 |=======
      180.00                 18 |=======================
      225.00                  5 |======
      270.00                 22 |==============================
      315.00                  3 |===
      360.00                 18 |=======================
```

Table E.2 (continued)

VARIABLE: Aspect/ASP2 (1 = NW, N, NE, E; 2 = SE, S, SW, W)

=====CLASS LIMITS====	FREQUENCY
1.00	47
2.00	53

VARIABLE: East/West Aspect/ASPEW (1 = east, 2 = west)

=====CLASS LIMITS====	FREQUENCY
1.00	26
2.00	30

VARIABLE: Fertilizer/FERT (0 = not fertilized, 1 = fertilized)

=====CLASS LIMITS====	FREQUENCY
.00	19
1.00	81

VARIABLE: MULCH (0 = not mulched, 1 = mulched)

=====CLASS LIMITS====	FREQUENCY
.00	41
1.00	59

VARIABLE: Cover Crop/CC (0 = no cover crop, 1 = cover crop)

=====CLASS LIMITS====	FREQUENCY
.00	18
1.00	82

VARIABLE: SAND (percent)

=====CLASS LIMITS====	FREQUENCY
15.00 < 20.00	3
20.00 < 25.00	3
25.00 < 30.00	6
30.00 < 35.00	4
35.00 < 40.00	8
40.00 < 45.00	15
45.00 < 50.00	15
50.00 < 55.00	10
55.00 < 60.00	7
60.00 < 65.00	3
65.00 < 70.00	10
70.00 < 75.00	12
75.00 < 80.00	3
80.00 < 85.00	1

Table E.2 (continued)

VARIABLE: SILT (percent)

=====CLASS LIMITS====			FREQUENCY	....
5.00	<	10.00	1	=
10.00	<	15.00	4	=====
15.00	<	20.00	13	================
20.00	<	25.00	23	==============================
25.00	<	30.00	16	====================
30.00	<	35.00	17	=====================
35.00	<	40.00	16	====================
40.00	<	45.00	2	==
45.00	<	50.00	2	==
50.00	<	55.00	0	
55.00	<	60.00	3	===
60.00	<	65.00	0	
65.00	<	70.00	3	===

VARIABLE: CLAY (percent)

=====CLASS LIMITS====			FREQUENCY	....
5.00	<	10.00	4	====
10.00	<	15.00	26	==============================
15.00	<	20.00	20	======================
20.00	<	25.00	17	==================
25.00	<	30.00	22	========================
30.00	<	35.00	6	======
35.00	<	40.00	4	====
40.00	<	45.00	1	=

VARIABLE: Nitrogen/N (ppm)

=====CLASS LIMITS====			FREQUENCY	....
1.00	<	2.00	3	==
2.00	<	3.00	42	=============================
3.00	<	4.00	36	========================
4.00	<	5.00	11	=======
5.00	<	6.00	0	
6.00	<	7.00	1	
7.00	<	8.00	0	
8.00	<	9.00	0	
9.00	<	10.00	0	
10.00	<	11.00	7	====

VARIABLE: Potassium/K (meq/l)

=====CLASS LIMITS====			FREQUENCY	....
.10	<	.20	24	================
.20	<	.30	41	==============================
.30	<	.40	12	========
.40	<	.50	15	==========
.50	<	.60	5	===
.60	<	.70	1	
.70	<	.80	2	=

Table E.2 (continued)

VARIABLE: Sodium/NA (ppm)

```
 =====CLASS LIMITS====  FREQUENCY .............................
       .00 <      1.00        33 |======================
      1.00 <      2.00        42 |============================
      2.00 <      3.00        16 |===========
      3.00 <      4.00         3 |==
      4.00 <      5.00         1 |
      5.00 <      6.00         1 |
      6.00 <      7.00         0 |
      7.00 <      8.00         0 |
      8.00 <      9.00         0 |
      9.00 <     10.00         0 |
     10.00 <     11.00         0 |
     11.00 <     12.00         0 |
     12.00 <     13.00         1 |
     13.00 <     14.00         3 |==
```

VARIABLE: Carbonates/CARB (percent)

```
 =====CLASS LIMITS====  FREQUENCY .............................
       .00 <       .50        15 |=============
       .50 <      1.00        32 |============================
      1.00 <      1.50        17 |===============
      1.50 <      2.00        13 |===========
      2.00 <      2.50        13 |===========
      2.50 <      3.00         6 |=====
      3.00 <      3.50         4 |===
```

VARIABLE: pH/PH

```
 =====CLASS LIMITS====  FREQUENCY .............................
      6.50 <      6.60         5 |======
      6.60 <      6.70         3 |===
      6.70 <      6.80         1 |=
      6.80 <      6.90         1 |=
      6.90 <      7.00         2 |==
      7.00 <      7.10         4 |=====
      7.10 <      7.20         5 |======
      7.20 <      7.30         6 |=======
      7.30 <      7.40        22 |=============================
      7.40 <      7.50        22 |=============================
      7.50 <      7.60        16 |=====================
      7.60 <      7.70         9 |===========
      7.70 <      7.80         1 |=
      7.80 <      7.90         2 |==
      7.90 <      8.00         1 |=
```

Table E.3. Ranked and Unranked Correlation Results: Soil Factors with Selected Percentage of Cover Values

	Unranked Correlation	Ranked Correlation
Total Cover		
Percent Sand	-.407	-.417
Percent Silt	.325	.418
Percent Clay	.348	.349
Sodium	.168	.431
Total Vegetative Cover		
Percent Sand	.258	--
Percent Silt	.238	.168
Percent Carbonates	-.236	.213
pH	--	.199
Sodium	-.190	--
Intermediate wheatgrass		
Percent Silt	-.171	-.237
Nitrogen	.214	--
Percent Carbonates	-.241	-.217
Sodium	--	-.314

Note. n = 100, Critical Value = + or - .165 (1-tail, .05)
+/- .196 (2-tail, .05)

Values range from 0 to 1. A value exceeding the Critical Value indicates that there is reasonable evidence of relationship between the two variables. The higher the value, the stronger the evidence. This table lists only those values which exceed the Critical Value.

Table E.3 (continued)

Thickspike wheatgrass		
Percent Sand	.463	.516
Percent Silt	-.387	-.470
Percent Clay	-.373	-.436
Potassium	-.215	-.219
Sodium	-.270	-.647
Western Wheatgrass		
Percent Sand	-.226	-.208
Percent Clay	.223	.227
Percent Carbonates	--	-.201
Slender Wheatgrass		
Potassium	-.259	-.317
Sodium	-.198	-.274
Yellow Sweetclover		
Percent Sand	.286	.366
Percent Silt	-.219	-.327
Percent Clay	-.262	-.341
Sodium	--	-.361
pH	--	.168

Table E.3 (continued)

Alfalfa		
Percent Sand	-.238	-.224
Percent Silt	.234	.242
Nitrogen	.303	.213
Potassium	.261	.191
Sodium	--	.194
pH	--	.185
Green Needlegrass		
Percent Silt	.225	--
Sodium	.196	

Table E.4. Regression Tests to Determine Total Cover for 100 Selected Test Plots

KEY To Statistical Terms

n = number of test plots (out of 100 selected test plots)

r^2 = coefficient of determination (may assume any value between 0 and 1; as the values increase, so does the probable accuracy of the predictions

SE = standard error-of-estimate

Statistical significance of all tests = .05

<u>All Test Plots</u> (n=100)

21.925 [constant] + 21.101 (x PDYSF) + 14.529 (x FERT) + 20.091 (x MULCH) = Total Adjusted Cover/ADTOT

(r^2 = .321 SE = +/- 22.31)

<u>Clay < 20%</u> (n=50)

41.017 [constant] + 34.884 (x MULCH) + 10.284 (x CARB) = Total Adjusted Cover/ADTOT

(r^2 = .313 SE = +/- 25.02)

<u>Clay > 20%</u> (n=50)

30.994 [constant] + 15.349 (x PDYSF) + 17.068 (x FERT) + 17.962 (x CC) = Total Adjusted Cover/ADTOT

(r^2 = .322 SE = +/- 17.61)

Table E.4 (continued)

<u>Not Mulched</u> (n=41)

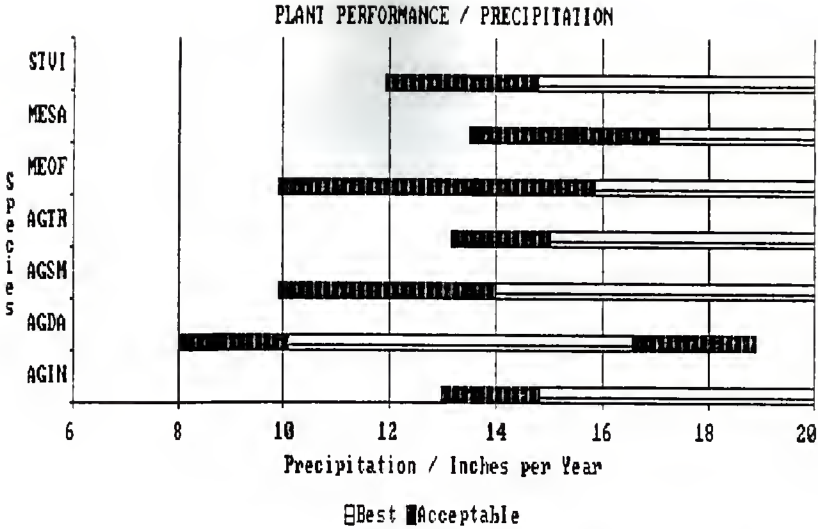
11.8 [constant] + 49.308 (x PDYSF) - 92.011 (x K) + 8.712 (x CARB) = Total Adjusted Cover/ADTOT

(r^2 =.497 SE = +/- 20.74)

<u>Mulched</u> (n=59)

97.17 [constant] - 28.103 (x K) = Total Adjusted Cover/ADTOT

(r^2 =.063 SE = +/- 18.52)



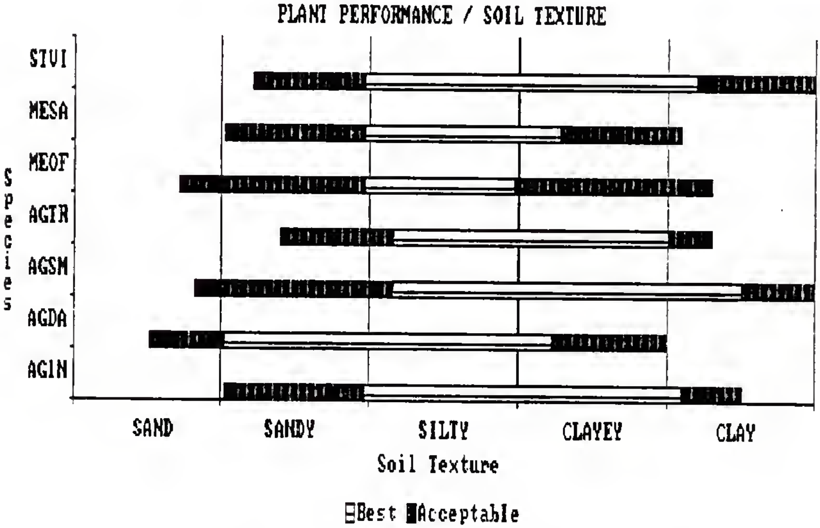


Figure E.1. Characteristics of Selected Species in Relationship to Annual Precipitation and Soil Texture

Source: Adapted from Plant Materials for Use on Surface-Mined Lands in Arid and Semiarid Regions (Soil Conservation Service, 1982, pp. 80-83.

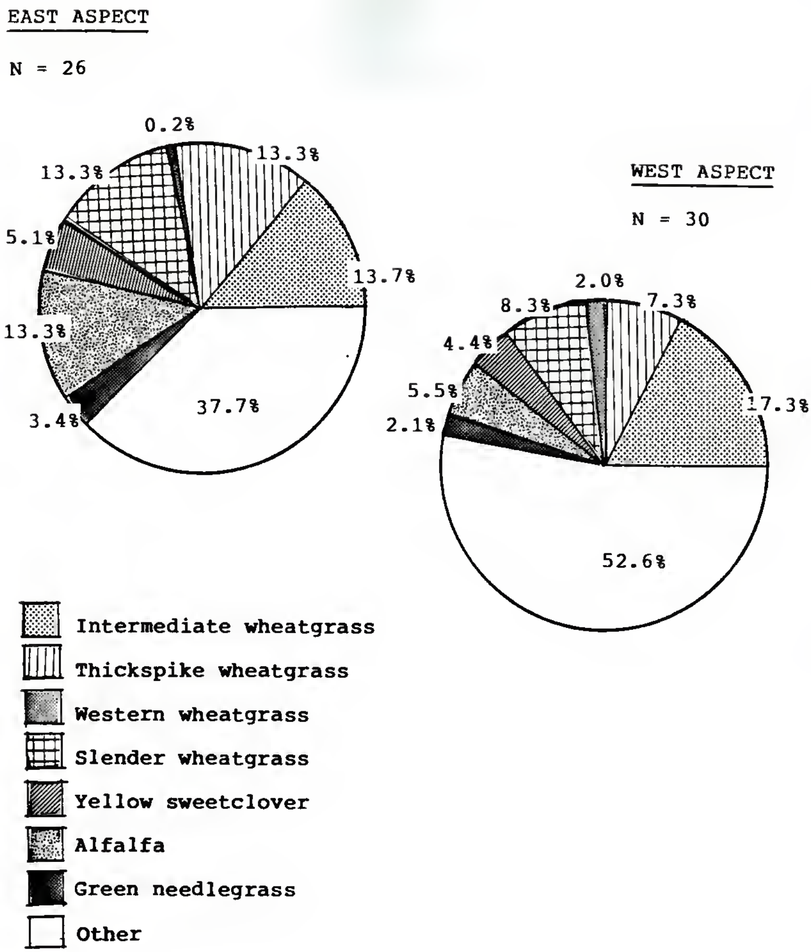


Figure E.2. Comparison of Percentage of Vegetative Cover for Selected Species Based on the Topographical Aspect of Belle Ayr Test Plots.

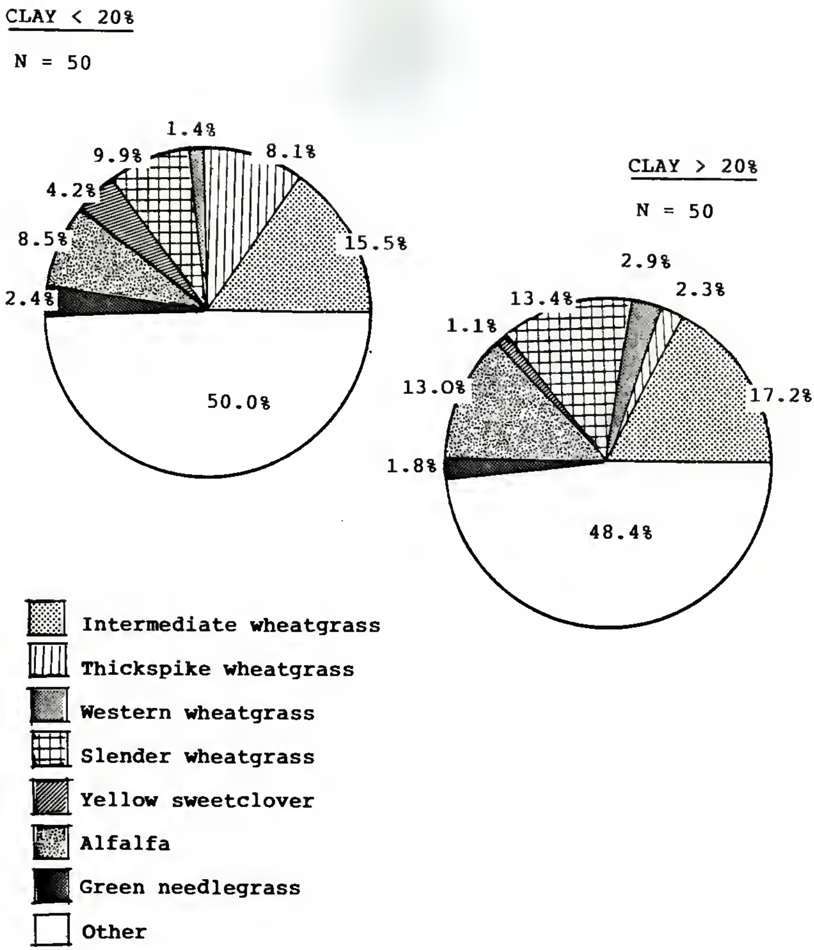


Figure E.3. Comparison of Percentage of Vegetative Cover for Selected Species Based on the Clay Content of the Soil from Belle Ayr Test Plot Sites.

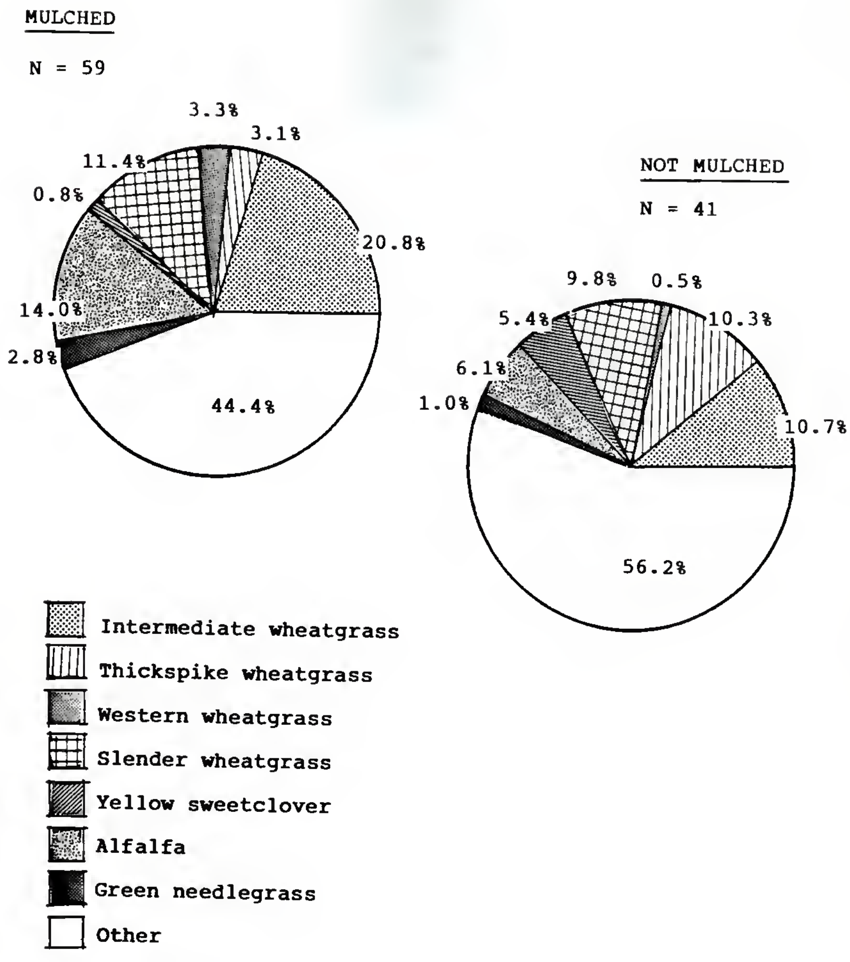


Figure E.4. Comparison of Percentage of Vegetative Cover for Selected Species on Mulched and Unmulched Belle Ayr Test Plots.

Appendix F

COMPUTER HARDWARE AND SOFTWARE

Description of Computer Hardware and Software

Hardware

COMPAQ DESKPRO Personal Computer

- One diskette drive
- One 10-megabyte fixed disk drive
- 640-Kbyte random-access memory

Software

FAST GRAPHS Graphing Program (Innovative Software, 1983)

MICROSTAT Statistical Package (Ecosoft, 1984)

MS-DOS BASICA 2.0 Programming Language (Microsoft, 1984)

RBASE 5000 Database Manager (Microrim, 1985)

WORDSTAR 3.31 Word Processor (Micropro, 1984)

MINED-LAND REVEGETATION STUDIES AND DESCRIPTIVE PREDICTION MODELS

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AN ABSTRACT OF A MASTER'S THESIS

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ABSTRACT

The rehabilitation of mined lands presents an opportunity to investigate the effects of severe disturbances caused by human intervention in the processes of natural ecosystems. Mathematical prediction models have proven useful in evaluating post-mining potentials and treatment alternatives. These are most appropriate for studies involving plant growth response and revegetation practices. An understanding of the purpose, structure, and processes involved in creating these models, and an understanding of their advantages and limitations, is essential for anyone involved in their application or development. Toward this goal, an overview of the modeling process is presented, followed by a descriptive analysis of a set of existing models that were created to provide guidelines for mined-land revegetation in the western United States. Through the development of a series of computer programs, these models are tested using data collected at the Belle Ayr Mine in northeastern Wyoming. These results indicate the models are too generalized to provide adequate information for predicting site-specific responses. Further analysis of the Belle Ayr data leads to suggestions for future data collection and interpretation, and for alternative approaches to creating models more suited to site-specific parameters.