High Altitude Coal Mine Reclamation: An Ecological Audit of Regulatory Requirements, Planning Information and Participant Attitudes.

by

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ABSTRACT

High altitude mine reclamation is a multidisciplinary environmental management problem that has accumulated a considerable amount of disjointed technical information. The fragmented nature of the knowledge-base has created a process (conceptual, regulatory, practical) which lacks a holistic focus. The purpose of this study was to examine the effect of sociopolitical control and extent of ecological concept integration within the process of high elevation reclamation.

The role of regulatory requirements and their impact on the design and implementation of high elevation coal mine reclamation programs was examined in nine mountainous western North American jurisdictions. This 'ecological audit' of regulatory requirements revealed that several jurisdictions are similar programatically in objectives but dissimilar substantively in regulatory provisions such as topographic modifications, revegetation, performance standards and enforcement. Information acquisition and dissemination also varied between jurisdictions. The current command-penalty model of environmental regulation results in adversarial interactions between government and industry in many of the jurisdictions and should be replaced by a formal negotiated system of regulation based on continuing research and adaptive management. Attention to aesthetics must be improved in all jurisdictions.

Ecosystem-based reclamation monitoring, a crucial part of regulatory enforcement and adaptive environmental management, is lacking in most jurisdictions. A long-term
hierarchical \textit{(population, community, ecosystem, landscape)} monitoring program is proposed. Fundamental to significant improvements in the overall high elevation reclamation process is an understanding of the role of the opinions and attitudes of the participants to the design of reclamation research and management programs. An attitude/opinion survey employing the \textit{Total Design Method (TDM)} was completed by 86\% of 116 potential respondents representing government regulators, suppliers and consultants and industry \textit{environmental} and \textit{engineering} personnel. A preoccupation with short-term economics was found as well as a general lack of agreement on many technical issues for which there is consensus in the international literature. \textit{Cognitive oversimplification} appears to a problem. It is recommended that all reclamation \textit{professionals} receive formal multidisciplinary training and \textit{accreditation}.

Adequate pre-disturbance \textit{baseline} information upon which to develop decisions is crucial to \textit{environmental impact assessment} and \textit{environmental management} of surface mines. Nineteen mine development or expansion \textit{Environmental Impact Statements} (EISs) from Alberta and British Columbia were reviewed critically to assess their adequacy: many conceptual and \textit{technical} aspects of EISs could be improved to facilitate reclamation \textit{planning}, implementation and monitoring.

Clarity of insight and depth of understanding is apparently lacking in several areas of reclamation practice. Proposals are made for improving the success of high-elevation reclamation programs by identifying reclamation objectives that incorporate ecological and technical knowledge balanced by social and political constraints.
An appendix is included (expanded in content from that of normal mining glossaries) to integrate the terminology used by the disciplines of geography, landscape ecology and conservation biology.

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**TABLE OF CONTENTS**

**TITLE** .............................................................................. i

**ABSTRACT** ........................................................................ ii

**TABLE OF CONTENTS** ............................................................. v

**LIST OF TABLES** ................................................................. vii

**LIST OF FIGURES** ................................................................. xi

**ACKNOWLEDGEMENTS** ........................................................ xii

**DEDICATION** ....................................................................... xiii

**CHAPTER I  INTRODUCTION**

1. **Overview** ................................................................. 1
2. **Mining Practices and the Post-Mining Landscape** .......... 2
3. **Reclamation Approaches** ................................................ 2
4. **Sociopolitical Milieu** ...................................................... 7
5. **General Research Objectives** .......................................... 11

**CHAPTER II  REGULATORY ENVIRONMENT FOR HIGH ELEVATION RECLAMATION**

1. **Introduction** ................................................................. 13
2. **Literature Review** .......................................................... 15
3. **Research Objectives** ...................................................... 22
4. **Methods** ......................................................................... 22
5. **Results and Discussion** .................................................. 24
6. **Summary** ......................................................................... 99

**CHAPTER III  ENVIRONMENTAL IMPACT ASSESSMENT AND RECLAMATION PLANNING**

1. **Introduction** ................................................................. 103
2. **Literature Review** .......................................................... 104
3. **Research Objectives** ...................................................... 116
4. **Methods** ......................................................................... 116
5. **Results** ........................................................................... 117
6. **Discussion** ....................................................................... 151
7. **Conclusion** ....................................................................... 170
LIST OF TABLES

Table

2.1 Listing of the legislation and administration in selected western states and provinces in the United States and Canada .......... 16
2.2 Performance bonds and bond release in selected jurisdictions of the mountainous coal producing regions of the western United States and Canada ........................................... 39
2.3 Reclamation plan requirements for permit applications within selected jurisdictions in the mountainous coal producing regions of the western United States and Canada ........................................... 45
2.4 Reclamation time schedule provisions in selected jurisdictions of the mountainous coal producing regions in the western United States and Canada ........................................... 47
2.5 Land-use provisions in the legislation of selected mountainous coal producing regions of the western United States and Canada ................. 50
2.6 Topographic modification requirements in selected jurisdictions of the mountainous coal producing regions of the western United States and Canada ........................................... 53
2.7 Topographic modification allowances in selected jurisdictions of the mountainous coal producing regions of the western United States and Canada ........................................... 56
2.8 Water control requirements in selected jurisdictions of the mountainous coal producing regions of the western United States and Canada ........................................... 59
2.9 Growing media requirements for reclamation in selected jurisdictions of coal producing regions in the western United States and Canada ........................................... 61
2.10 Revegetation - general vegetation requirements of selected jurisdictions in the mountainous coal producing regions of the western United States and Canada ........................................... 64
2.11 Revegetation requirements for reclamation in selected jurisdictions of coal producing regions in the western United States and Canada ........................................... 67
2.12 Permittee reclamation monitoring requirements in selected jurisdictions of the mountainous coal producing regions of the western United States and Canada ........................................... 81
2.13 Regulatory reclamation enforcement in selected jurisdictions of the mountainous coal producing regions in the western United States and Canada ........................................... 82
2.14 Participation (accredited individual) requirements for reclamation planning as determined by post-mining land-use ....................... 96
2.15 Disciplinary information, integration and synthesis in reclamation program design and planning ........................................... 97
3.1 Summary of legislation and guidelines which have been or are applicable to environmental impact assessment in Alberta and British Columbia ........................................... 111
3.2 Project names, locations, ownerships and descriptions for submitted EISs in Alberta and British Columbia ............................................. 118
3.3 List of reviewed environmental impact statements for expanding or proposed coal mines in Alberta and British Columbia .......... 122
3.4 Summary of abiotic parameters sampled for the environmental impact statements of proposed coal mines in Alberta and British Columbia .... 128
3.5 Summary of vegetation information provided in environmental impact statements of proposed or expanding coal mines in Alberta and British Columbia .......................................................... 130
3.6 Summary of 'game' fauna biophysical studies included in the environmental impact statements of expanding or proposed coal mines in Alberta and British Columbia ................................................. 132
3.7 Summary of 'non-game' fauna biophysical studies included in the environmental impact statements of expanding or proposed coal mines in Alberta and British Columbia .................................................. 134
3.8 Summary of biological impact mitigation measures for expanding or new coal mines in Alberta and British Columbia .......................... 138
3.9 Summary of growing media studies completed or proposed as part of the mine development approval process ........................................ 142
3.10 Summary of revegetation species research studies completed as part of the mine development approval process ................................. 143
3.11 Summary of pre-disturbance and proposed post-disturbance land-uses for nineteen expanding or proposed coal mine projects in Alberta and British Columbia ...................................................... 145
3.12 Summary of reclamation related activities described in the environmental impact statements ...................................................... 148
3.13 Summary of environmental impact statement information relevant to reclamation planning .............................................................. 154
4.1 Questionnaire response frequency ............................................................ 185
4.2 Responses of questionnaire sub-populations ........................................ 188
4.3 Sub-population response for each section of the survey questionnaire ... 189
4.4 Discriminant function analysis multivariate test statistics for occupation groupings ................................................................. 195
4.5 Educational background for the sub-populations of survey participants .. 196
4.6 Discriminant function analysis multivariate test statistics for education groupings ................................................................. 199
4.7 Mine reclamation instruction in Canadian mine engineering faculties ... 200
4.8 Discriminant function analysis multivariate test statistics for experience groupings ................................................................. 206
4.9 Percent utilization for identified reclamation information sources ......... 207
4.10 The most important environmental limitations to high elevation revegetation are ...................................................... 209
4.11 The most important provisions that government legislation, regulations or guidelines should provide are ................................. 210
4.12 The three most important planning considerations for high elevation coal mine reclamation programs should be ........................................ 211
4.13 The most important uses of commercially available plants (seeds or seedlings for reclamation are ........................................ 213
4.14 The most important benefits of native species in high elevation reclamation programs are .................................................. 214
4.15 The most important limitations to native species use in high elevation revegetation are ....................................................... 215
4.16 Attitudes of respondents toward statements concerned with reclamation legislation .......................................................... 222
4.17 Percentage response by sub-populations to the statement "All forms of surface mine disturbances should be revegetated" ............ 223
4.18 Percentage response by sub-populations to the statement "Variances should be granted for those portions of surface mine disturbances which are difficult to revegetate" .................................................... 224
4.19 Percentage response by sub-populations to the statement "More demanding reclamation legislation will improve the process of high elevation coal mine reclamation" ........................................ 226
4.20 Attitudes of respondents toward statements concerned with reclamation and economics .......................................................... 227
4.21 Response breakdown (percent) for those respondents who responded affirmatively to the statement that "Corporate responsibility should be restricted to a specific time period" .................. 228
4.22 Percentage response by sub-populations to the statement "Post-mining land-use objectives should be dictated solely by the economic feasibility of such objectives" .................................................. 230
4.23 Attitudes of respondents toward statements concerned with evaluating reclamation success ............................................... 231
4.24 Attitudes of respondents toward statements concerned with reclamation objectives and research programs ........................................ 233
4.25 Attitudes of respondents toward statements concerned with reclamation planning .................................................................. 234
4.26 Percentage response by sub-populations to the statement "Mine planners and reclamation planners should be jointly involved in the design of both mine and reclamation plans" .................. 236
4.27 Attitudes of respondents toward statements concerned with material management and mine reclamation ........................................ 237
4.28 Percentage response by sub-populations to the statement "Mine spoil resloping should only be considered for geotechnical or slope stability reasons" ............................................................ 239
4.29 Attitudes of respondents toward statements concerned with revegetation techniques ......................................................... 240
4.30 Percentage response by sub-populations to the statement "Enough attention is given to soil development in the planning of reclamation programs" ......................................................... 241
4.31 Attitudes of respondents toward statements concerned with selected biological topics and reclamation planning .................................................. 243
4.32 Percentage response by sub-populations to the statement "Populations of native plants and animals will establish on mine disturbances without the assistance of man" ................................................................. 245
4.33 Attitudes of respondents toward statements concerned with plant species selection for mine disturbance revegetation .................................................. 246
4.34 Percentage response by sub-populations to the statement "Agronomic species are only suitable as 'nurse' crops in reclamation programs" ......................... 247
4.35 Attitudes of respondents towards statements concerned with native plant species use in mine reclamation ................................................................. 249
4.36 Percentage response by sub-populations to the statement "Long-term re-establishment of vegetation on high elevation coal mine disturbances will only be possible with the extensive use of native species" ......................... 250
4.37 Attitudes of respondents toward statements concerned with the relationship between aesthetics and native species .................................................. 252
4.38 Attitudes of respondents toward commercial production of native species seed ........................................................................................................... 254
4.39 Percentage response by sub-populations to the statement "There is a market for expanded native species seed production in Alberta and British Columbia" ................................................................. 255
# LIST OF FIGURES

**Figure**

1.1 Cross-section diagrams of surface mine operations in mountainous terrain ................................................................. 3
1.2 A 3D view of a proposed pre-surface mining landscape .................................................. 4
1.3 A 3D view of a hypothetical post-mining landscape .................................................. 5
1.4 Diagram of the relationships between surface mine reclamation activities and participant perceptions and opinions ................. 8
2.1 Contemporary and proposed additional reclamation research categories .................................................................................. 31
2.2 Reclamation monitoring flowchart and regulatory command-penalty model ......................................................................... 75
2.3 Surface mine reclamation research description and timeline .................................................................................. 78
2.4 Reclamation planning, implementation and performance monitoring flowchart .................................................................................. 87
3.1 Mine development assessment model flowchart .................................................................................. 113
3.2 Flowchart of mine development engineering and environmental management .................................................................................. 152
4.1 Weekly questionnaire return rate frequency .................................................................................. 187
4.2 Canonical variates plots: occupational groupings of attitudinal responses toward reclamation legislation, regulations and guidelines .................................................................................. 191
4.3 Canonical variates plots: occupational groupings of attitudinal responses toward mine reclamation planning and techniques .................................................................................. 193
4.4 Canonical variates plots: education groupings of attitudinal responses toward reclamation legislation, regulations and guidelines .................................................................................. 198
4.5 Experience categories for sub-populations of questionnaire .................................................................................. 202
4.6 Canonical variates plots: experience groupings of attitudinal responses toward mine reclamation and planning .................................................................................. 204
4.7 Casement plot of dimensions representing latent structure of attitudinal responses toward reclamation legislation, regulations and guidelines as revealed by non-metric multidimensional scaling .................................................................................. 218
4.8 Casement plot of dimensions representing latent structure of attitudinal responses toward reclamation planning and techniques as revealed by non-metric multidimensional scaling .................................................................................. 219
4.9 Casement plot of dimensions representing latent structure of attitudinal responses toward plant materials as revealed by non-metric multidimensional scaling .................................................................................. 220
4.10 Relationship between attitudes/opinions and the reclamation process ........................................... 277
4.11 Information generation for regulatory policy and legislation formulation .................................................................................. 280
4.12 Hierarchical flowchart of reclamation information and innovation exchange .................................................................................. 282
4.13 Instructional training module descriptions and targeted occupational groups .................................................................................. 283
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DEDICATION

This dissertation is dedicated to the Lord for his imparted grace and wisdom, and to my wife, Aileen, whose encouragement, support and patience during its protracted gestation made completion possible.
CHAPTER I
INTRODUCTION

1. Overview

Increased energy and coking coal demands, primarily by the Japanese steel industry, stimulated mining activity in North America during the late 1960s and 1970s. In Canada, the result was renewed development of coal mining activity in the Rocky Mountains (Ross 1987). Initially, the re-development began in the historic coal-mining areas of the Crows Nest Pass and Luscar Cadomin Coal Basin of Alberta and the Elk Valley of British Columbia, but new areas were also developed in the early 1970s in northwest Alberta and in the early 1980s in northeastern British Columbia (Marshall 1991).

Many of these surface mining operations were developed within the subalpine and alpine zones of the Rocky Mountains of British Columbia. The large coal reserves within these zones in both provinces represent a considerable amount of surface area that has been, or may be, disturbed.

Surface mine reclamation within subalpine and alpine zones represents a particularly difficult problem which requires considerable inter-disciplinary involvement. An understanding of the sociopolitical and disciplinary influences on the development and application of ecological information is of particular importance and provides the overall context for this dissertation.
2. Mining Practices and the Post-Mining Landscape

The post-mining landscape is created by four basic methods of extraction: area strip, contour strip, open pit and mountaintop removal (Lyle 1987). Open pit and mountaintop removal are the typical mining methods in the mountainous terrain of the western United States and Canada. Cross-section diagrams of the various forms of surface mining relevant to mountainous terrain are provided in Figure 1.1. Three-dimensional views of pre- and post-surface mining landscapes are illustrated in Figures 1.2 and 1.3.

In general, the surface mining process involves drilling and blasting followed by waste (spoil) and coal removal by either bucket wheel excavator or dragline in level terrain and conventional truck/shovel operations in mountainous or rugged terrain. The coal is exposed in a pit while the overburden is piled aside for the duration of the mining operation (Sengupta 1993). The pit can be backfilled and the spoil reclaimed only after extraction is complete. However, some mine operations have a series of small pits which may be backfilled progressively whereas other mine operations consist of a single large pit which is too large to backfill; therefore, large spoil dumps must be reclaimed (Kent 1982).

3. Reclamation Approaches

The objective of mine reclamation in most jurisdictions involves the acceleration of the ecosystem recovery process through revegetation leading to the re-establishment of a self-sustaining ecosystem (Bradshaw 1984). The concept is to stimulate early
Figure 1.1 Cross Section Diagrams of Surface Mine Operations in Mountainous Terrain.

A. Mountain Top Removal

B. Mountain Bench/Internal Pit

C. Mountain Bench/Daylighted Pit

D. Mountainous Terrain/Daylighted Pit

Note: These drawings illustrate pit dump sequences in mountainous terrain.
Figure 1.2 A 3D view of a proposed pre-surface mining landscape.

Note: This drawing is a pre-disturbance digital terrain model of a proposed mine.
Figure 1.3 A 3D view of a hypothetical post-mining landscape.

Note: This drawing represents a digital terrain model of a post-mining landscape with a pit and dumps.
successional development through management activities. However, achievement of these objectives varies with location, disturbance type and management input.

High elevation reclamation poses special problems since topography and climate limit reclamation materials and practices. Therefore, considerable research has been directed towards technically-based initial ecosystem 're-assembly' issues, e.g., spoil dump design (Burns 1980), site conditions (Limbird and Headdon 1989), equipment selection (Adolfson et al. 1982), spoil amendments (Chambers et al. 1990), plant material selection (Acharya 1987), revegetation techniques (Cuany 1976), seeding rates (Chambers et al. 1988), revegetation timing (Urbanska 1986) and fertilizer formulations (Guillaume et al. 1986).

In contrast, research describing ecosystem 'response' has been limited to topics such as, soil-fungi (Allen and Allen 1980), soil-fauna (Lawrence 1984), and nutrient-cycling (Ziemkiewicz and Takyi 1990). Unfortunately, much of the ecosystem 'response' information is derived from unrelated chronosequence studies rather than from direct observations. Attempts to predict the trajectories of succession following management practices have not been satisfactory (Keammerer 1989).

Asking the right questions is necessary in seeking proper solutions. Although an impressive amount of technical knowledge has been accumulated, many of the problems associated with high elevation reclamation remain unresolved. Several of the technical problems may be related to non-technical issues associated with the attitudes and perceptions of participants. Consequently, regulatory control conflicts, inadequate
application of academic research and insufficient attention to creative imagination exists within the process.

4. *Sociopolitical Milieu*

In general, conventional reclamation research has focused on technical and practical concerns; however, reclamation also contains a latent sociopolitical component. A basic premise of this dissertation is that sociopolitical influences have far greater importance than generally acknowledged. The relationship between these components can be viewed as a set of overlapping circles (Figure 1.4). Within the large attitudinal/perceptual circle (P) are three smaller circles which represent regulations/legislation (L), techniques (T) and management planning (M). The inner circles actually represent individuals with very specialized tasks. The relationship between these smaller circles is one of positive and negative feedback. Unfortunately, the relationship between the inner circles and the large outer circle has been ignored. In the past, reclamation research has tended to concentrate on each of these inner circles (components) separately without considering fully the interaction between the perceptions and attitudes of the participants. A holistic approach, as suggested by Winterhalder (1988), has been lacking, and it is apparent that the reclamation process has been centered around technology rather than ecology. A greater appreciation of the interaction between socio-economic and environmental variables is necessary for all mine reclamation situations but is particularly important for the difficult problems encountered at high elevations. The process of mine reclamation, if viewed from a
Figure 1.4 Diagram of the relationships between surface mine reclamation activities and participant perceptions and opinions.

Legend:

- P - Perceptions/Opinions
- L - Legislation/Regulations
- T - Techniques (Reclamation)
- M - Management Planning
combined technological, ecological and sociopolitical perspective, would lead to a more holistic process.

Three specific content areas relating to the development and application of the existing knowledge provide the main focus for the dissertation. The first is regulatory control.

Recovery patterns in reclaimed ecosystems differ from ‘natural’ systems in that political and legal decisions are an intrinsic part of the recovery process (Thorhaug 1980). Regulatory requirements provide the necessary extrinsic motivation for environmental compliance by industry. Legislation and regulations have been developed and implemented with the objective of facilitating both short- and long-term objectives. Although broad reviews of existing regulatory programs have been published, the efficacy of the various approaches in directing ecologically-based management practices has not been described. In particular, the context-dependency of the regulatory requirements and the actual design and implementation of the reclamation programs needs study. The suggestion here is that policies and guidelines have a strong influence on reclamation plans, and it is uncertain whether these instruments, as they exist currently, facilitate or impede the reclamation process at high elevations. Regulatory instruments can be obstacles to creative reclamation. Furthermore, little is known about what constitutes an aesthetically pleasing rehabilitation project.

The second area of concern is baseline data and reclamation planning. Environmental Impact Statements (EISs) developed by multi-disciplinary teams during the project review process provide important information for the project approval process and should be useful for reclamation planning. However, the utility
of such baseline data for the purposes of designing reclamation plans is unknown (Cook 1988). The specific information contained within these documents has not been studied, especially with regard to ecosystem-based reclamation planning.

The final area of concern is opinions and attitudes of participants within the reclamation process. The ethos of all participants within the reclamation process dictates the direction and, ultimately, the success of any reclamation program. The attitudes or opinions of the various reclamation specialists establish the rules of adherence for individuals and corporations, determine which technical problems are selected for research and affect how experimental and experiential knowledge is incorporated into management planning. Therefore, it must be stressed that practical reclamation problems cannot be resolved solely by technological progress in a social vacuum and that value judgments are an integral part of the process.

To be effective, it is important for environmental professionals to understand the differences between the natural, structured and socioeconomic-political environment (Teater 1988). Much has been written on the influence of differing perceptions of professionals in decision-making, e.g., Sewell (1971), Saarinen (1976), Kennedy (1985), Bowonder (1987). However, none of these authors refer to reclamation professionals. Ziemkiewicz (1987) believes there are three types of reclamation specialists: regulators, field personnel and researchers. His experiential observations are useful in a general sense but do not address any of the specific issues relevant to high elevation reclamation. Therefore, it is necessary to examine how the attitudes and perceptions of reclamation professionals influence reclamation planning and program
implementation. Particular attention should be directed toward the conceptual understanding of ecological processes and management as influenced by participant experience, training and profession and jurisdictional context-dependency.

5. General Research Objectives

In general, reclamation research in the past has been technological rather than ecological. Although ecocentric studies have increased in recent years, pragmatic technical concerns continue to dominate, particularly for high elevation disturbances. A review of the literature portrays the existing reclamation paradigm as an image with an ill-defined sociopolitical foreground and an out-of-focus ecosystematic background.

As a result, three content areas related to the development and application of ecological information within the existing knowledge-base will be examined: (1) the sociopolitical regulatory milieu, (2) baseline data collection and (3) participant attitudes towards process components. More specific research objectives will be outlined within each of the chapters. The dissertation is framed within the geographical context of high elevation environments, with emphasis on the coal-producing regions of the Canadian Rockies.

If used correctly, the information presented here should improve the success of reclamation programs generally, and those at high elevation specifically, by identifying realistic reclamation objectives through balanced synthesis of ecological and technological knowledge viewed within a sociopolitical context.
Since the subject matter of the dissertation is diffuse, a synthesis chapter is provided at the end of the dissertation following discussion of each of the content areas, i.e., sociopolitical regulatory milieu, baseline data and attitudes.
CHAPTER II
RECLAMATION LEGISLATION AND REGULATIONS

1. Introduction

Prior to the environmental awakening of the 1960s, there was little concern for mining disturbances, and reclamation only became an issue when a potentially expensive liability appeared (Ludwig 1982). However, the renewed emphasis on coal mining both in the United States and in Canada during the 1960s and 1970s exposed the latent conflict between industry and the environment with respect to regulation. The environmental degradation and associated costs related to surface coal mining, e.g., reduction in air and water quality, were considered significant and could not be ignored by government regulatory agencies. Initially, the social and opportunity costs of not reclaiming versus internalizing reclamation costs were examined, and the latter was considered to be more socio-politically acceptable (Randall 1978). Internalization of reclamation costs within surface mining production costs was, therefore, one of the objectives of regulatory policy during this period and continues to be the focus of current policy (Jackson 1991).

Essentially, the objective of regulatory policy in Canada and the United States has not been to reduce surface mining but to minimize or eliminate land degradation. However, finding an optimal solution for the elimination of disturbances generated by surface mining is a particularly complex problem. In Canada, with the exception of the Yukon and Northwest Territories, mine reclamation is primarily a provincial responsibility.
Individual provinces have promulgated a mosaic of environmental legislation, dating from the 1960s and 1970s (Sage 1976). In contrast, the Department of Indian and Northern Affairs uses three federal acts to regulate mine reclamation in both the Yukon and Northwest Territories: (1) the Northern Inland Waters Act (NIWA), (2) the Fisheries Act (FA) and (3) the Territorial Land Act (TLA) (DIAND 1989). The process varies between jurisdictions; in general, mine operators must obtain a water license and must submit a reclamation plan.

Marshall (1983) described the regulatory experience in most jurisdictions in Canada as nascent, fragmentary and short-term in approach. While there are those who propose rigid requirements, Michaud (1981) did not consider standardized reclamation regulations desirable because of the range of mining methods and biophysical conditions within which mines operate. Consequently, the acts and regulations enacted by both federal and provincial legislators specify only general criteria for environmental impact assessment and reclamation of mining operations, with considerable ministerial discretion provided in each jurisdiction (Ziemkiewicz et al. 1988). Since the 1960s and 1970s, the governments of Alberta and British Columbia have promulgated legislation to provide minimum standards of air and water quality and to ensure that lands disturbed by resource extraction companies are returned to a condition comparable to their original state (Whitby-Costescu et al. 1977). The United States has led the world in environmental regulation legislation (Cocklin et al. 1992). Prior to 1977, coal mines were regulated by a patchwork of state and federal laws. In 1977, the United States government enacted the Surface Mine Control and Reclamation Act (SMCRA)
Public Law 95-87 through which Congress sought to establish a nationwide program (cooperative federalism) to protect people and the environment from the adverse effect of surface mining operations (McElfish and Beier 1990). The individual states were given the option of enacting their own legislation with equal requirements or of allowing the federal government to supersede state legislation.

2. Literature Review

Although there have been a number of comparative studies of reclamation regulation in the United States (Imes and Wali 1977, Gallaher and Lynn 1989) and Canada (Marshall 1983, Champigny et al. 1991, Champigny and Abbott 1992), most of these did not examine adequately the ecological implications of the legislation or regulations reviewed. International reviews by the above Canadian authors are particularly narrow and present a corporate financial and legalistic review of reclamation and environmental management. Legislation relevant to each jurisdiction is listed in Table 2.1, and a brief overview is provided in the following sections.

Province of Alberta

Historically, the province of Alberta was the first jurisdiction in Canada to develop reclamation regulatory policy (Johnson 1987). Land reclamation and certification began in Alberta with the enactment of the 1963 Surface Reclamation Act. The focus of this legislation was to ensure that the surface disturbances created by the oil and gas
<table>
<thead>
<tr>
<th>JURISDICTION</th>
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<td>1. UNITED STATES</td>
<td></td>
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<tr>
<td>1.1 ALASKA</td>
<td>ALASKA SURFACE COAL MINING CONTROL AND RECLAMATION ACT (AS 27.21) 1984, ANCHORAGE, 246PP.</td>
</tr>
<tr>
<td>1.2 COLORADO</td>
<td>COLORADO SURFACE COAL MINING RECLAMATION ACT 33-101 ET SEQ., C.R.S. 1983 (AMENDED), DENVER, 63PP.</td>
</tr>
<tr>
<td>1.3 FEDERAL</td>
<td>SURFACE MINING CONTROL AND RECLAMATION ACT OF 1977 CFR 30 CH. 7 PART 700 - END. WASHINGTON, 715PP.</td>
</tr>
<tr>
<td>1.4 MONTANA</td>
<td>STRIP AND UNDERGROUND MINE RECLAMATION ACT 1980 MINE RECLAMATION RULES AND REGULATIONS, MISSOULA 256PP.</td>
</tr>
<tr>
<td>1.5 NEW MEXICO</td>
<td>STATE OF NEW MEXICO SURFACE MINING ACT (SECTIONS 69-25A-1 ET. SEQ. NMSA 1978 AND STATE OF NEW MEXICO CSMC RULE 80-1 AMENDMENT NO. 6 1980), 1984, SANTA FE, 270PP.</td>
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<td>COAL MINING RECLAMATION ACT, 1979 GAS STATE OF UTAH R645 - COAL MINING RULES, 1991 SALT LAKE CITY, 135PP.</td>
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<td>2.2 BRITISH COLUMBIA</td>
<td>MINES ACT, S.B.C. 1992, C.56, VICTORIA, 430PP.</td>
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<td>DEPARTMENT OF INTERIOR, OFFICE OF SURFACE MINING RECLAMATION AND ENFORCEMENT</td>
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<td>DEPARTMENT OF STATE LANDS STRIP AND UNDERGROUND</td>
</tr>
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<td>2.2 BRITISH COLUMBIA</td>
<td>MINISTRY OF ENERGY, MINES AND PETROLEUM RESOURCES</td>
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industry did not affect adversely farming practices (Tracy 1985). Contouring and leveling of surface disturbances were the major requirements of this legislation.

In 1973, the Land Surface Conservation and Reclamation Act (LSCRA) was passed by the Alberta legislature and formed the regulatory framework for reclamation and land conservation practices for coal, oil sands, pipelines, and sand and gravel industries in the province.

The LSCRA required reclamation planning as part of the project development approval process, and provided for the establishment of the Development and Reclamation Review Committee (Bratton 1987). The Committee reviews all applications for development and reclamation, and, upon completion of the process, the Minister of the Environment issues an approval document. The Development and Reclamation Review requirements contained within the approval document form the foundation for industry practices and government regulatory activities (inspections and reclamation certification).

In 1976, the Coal Development Policy of Alberta stated for the first time, that 'equal capability' would be a requirement of coal mine reclamation (Government of the Province of Alberta 1976). The policy stated that the “primary objective in land reclamation is to ensure that the land will be returned to a state which will support plant and animal life or be otherwise productive or useful to man at least to the degree it was before it was disturbed.” Conservation and replacement of topsoil and the restoration of drainage systems became requirements in Alberta. The Coal Development Policy created a framework with guidelines which enabled regulatory continuity and provided
the basis for operational parameters or performance criteria. Where the prescribed post-disturbance land-use is the establishment of wildlife habitat, the mine operator is responsible for the establishment of various plant species and trees in the appropriate stocking density compatible with the ecological region and with the approving authority (ALCRC 1977). Since 1983, 'equivalent capability' has been a requirement of all reclaimed post-mining disturbances. Originally, this concept embraced the criterion of 'equal or greater than' productivity, but the inherent problems in measuring productivity (e.g., comparison of early successional disturbances with late successional undisturbed habitats) as well as the confounding effects of reclamation management intensity necessitated a change in philosophy (Railton 1987).

Information upon which regulatory and industry management decisions are made in Alberta is based on government funded or joint government/industry funded research and on extensive literature reviews such as those of Sims et al. (1984), Eccles et al. (1988) and Hardy BBT Limited (1989). Since the passage of the LSCRA in 1973, the province of Alberta has had the most active and consistently funded reclamation program in Canada (Government of Canada 1991).

In 1992, the Province of Alberta enacted the Environmental Protection and Enhancement Act (EPEA). This new omnibus legislation contains regulatory requirements and provisions for many aspects of environmental management and protection, including the requirements contained previously within the LSCRA (Province of Alberta 1992).
Province of British Columbia

Legislation governing mine reclamation in British Columbia was first introduced in 1969 when the existing mining legislation, Section 8 of the Coal Mines Regulation Act and Section 11 of the Mines Regulation Act, was amended to require reclamation for major coal mines and hardrock mines (McDonald 1978). In 1969, when the legislation was being amended, little was known about surface mine reclamation in British Columbia. Consequently, detailed reclamation regulations were not developed and considerable discretionary power was given to the Minister of Mines (Hogg 1971). The legislation was amended further in 1973 to include coal exploration, mineral exploration, sand and gravel pits and quarries (Errington 1990). In 1984, after consultation with industry and government agencies, the working policy on reclamation pursuant to Sections 7, 8, and 9 of the Mines Act was articulated in the form of guidelines (Rogers 1984). However, mining legislation in British Columbia remained unaltered from 1973 until the promulgation of the Mines Act [S.B.C 1989, c.56] in 1989. The amended Mines Act and its appurtenant regulatory Code now provides the framework for reclamation policy. Discretionary power now resides with the Chief Inspector rather than with the Minister of Energy, Mines and Petroleum Resources. Similar to that in Alberta and the United States, British Columbia legislation considers mining to be a temporary land-use and, consequently, requires all mining companies to conduct environmental protection and reclamation programs that will ensure that the post-mining landscape will be environmentally sound and productive (Province of British Columbia 1992a). Reclamation reports submitted prior to mine development are
reviewed by the Regional Mine Development Review Committee which is coordinated by the Reclamation Advisory Committee.

The British Columbia government has attempted to establish a framework within which both industry and government can function while achieving government policy on reclamation. The current legislation established broad reclamation standards in which it is incumbent upon the industry to be innovative and cost effective in meeting these standards. Therefore, site-specific, industry-based research is the primary source of information for reclamation practices in British Columbia. The stated ministerial objective is to base all regulatory decisions on the best available information which includes, therefore, significant input from industry.

United States

Regulatory controls in the United States are separated into coal and hardrock mining. Mining of hardrock minerals in the United States is regulated by the General Mining Law of 1872 (Burford 1990), and discussion of this legislation is peripheral to the content of this dissertation.

Historically, a few states had enacted coal mine reclamation legislation in the 1930s, but increasing public awareness during the 1950s and 1960s provided the impetus for passage of reclamation legislation in many of the western states (Harris et al. 1988). However, three important differences existed between states: (1) exclusivity of statutes (coal, uranium, both or all minerals), (2) regulations for surface and/or underground mines and (3) regulatory processes with and without performance standards. The
discrepancies resulted in production costs being lower in those states with less stringent standards (Kalt 1983).

The between-state variation in surface coal mine reclamation practice continued until 1977 when the United States Congress enacted the Surface Mining Control and Reclamation Act (SMCRA) (Brenner 1985). The passage of this law allowed for more uniform regulations regarding reclamation and bonding and also provided for greater public involvement in mine permitting and regulation enforcement.

In terms of legislation in the United States, the passing of Public Law 95-87, the SMCRA of 1977, was the legislative ‘turning point’ for reclamation (Grandt 1984). The SMCRA created two programs: (1) an environmental protection program to establish performance standards and procedures for permitting and inspection of surface coal mines and (2) a reclamation program for rehabilitation of pre-legislation coal mine disturbances (funded by royalties on coal production tonnage).

The SMCRA allowed individual states to submit their own legislative programs thus assuming regulatory authority or ‘primacy’ thereby avoiding total federal control by the Office of Surface Mine Reclamation and Enforcement (OSMRE). However, in practice, obtaining OSMRE approval of state reclamation was difficult (Carter 1989).

SMCRA performance standards were implemented by a detailed and comprehensive set of regulations which not only defined the environmental objectives but in some cases specified the design criteria to be adopted (Galloway and McAteer 1980). Many of the mining and reclamation techniques required by the SMCRA were unknown to large sections of the mining industry, and operational practices had to undergo significant
changes in order to accommodate environmental concerns (Daniels and Zipper 1988). The SMCRA created considerable controversy and was criticized because of onerous and costly provisions and the creation of a large regulatory bureaucracy (Murray 1988). However, the SMCRA stimulated valuable research by state and federal agencies (Brenner 1984).

3. **Research Objectives**

Although the objectives of regulatory legislation and policy are similar among the jurisdictions, differences may exist with respect to technical requirements and regulatory processes. This section of the thesis compares the regulatory requirements of western North American mountainous jurisdictions to examine their similarities and differences as well as examine the implications of such requirements for high elevation coal mine reclamation. Although other forms of government regulation (air and water pollution laws) affect mining developments, it is beyond the scope of this research to discuss them in detail.

4. **Methods**

**Information Analysis**

**Content analysis**, a systematic procedure for extracting information from various forms of communication (Stankey 1972) was chosen as the mechanism of data collection. For the purposes of this study, the text of legislation, regulations (code) and/or guidelines documents was examined for each of the selected jurisdictions. Four broad categories (planning, reclamation requirements, performance criteria and
enforcement) were selected on the basis of a review of the literature. These categories represent the complete range of reclamation activities from project commissioning to mine abandonment. Pre-development planning is described in Chapter 3.

**Research Population Identification**

'Population' identification (appropriate jurisdictions) and 'item' collection (regulatory documents) required written and verbal communication with government representatives from Alberta (Powter 1989), British Columbia (Errington 1989) and the United States Department of the Interior (Klein 1989). Communication with the provincial representatives was straightforward, and the appropriate government documents (legislation, code of regulations and guidelines) were provided immediately. However, 'population' identification discussions with the Office of Surface Mining Reclamation and Enforcement (Department of the Interior) were problematic. In the western states, only Alaska, Colorado, Montana, New Mexico, Utah and Wyoming had assumed primacy under the SMCRA. The states of Idaho and Nevada do not have coal mines and the states of Arizona, California, Oregon and Washington have chosen to allow the United States federal government to pre-empt state authority through the SMCRA rather than enact legislation. Following discussions with the OSMRE, each state was contacted, and the appropriate acts and regulations were provided.

**Coding**

Coding in content analysis is the process by which units of data are assigned to appropriate categories (Berelson 1954). Categories for the present study were
developed through a review of the 'items' or regulatory documents and an examination of the publications of Eichbaum and Buente (1980), and Imes and Wali (1978). **Thematic coding** (Holsti 1969) was chosen since each section of the regulatory document contains context-dependent and exclusive key words and phrases. Therefore, because of the format of the regulatory documents, the information was already pre-coded.

**Data Collection**

Presence or absence of pre-determined category codes was chosen as the unit of measurement. All documents were read three times after coding and prior to data collection in order to ensure reliability. Data were then collected and tabulated.

**Data Tabulation and Summarization**

Data analysis involved simple tabulations of the presence/absence data. In one specific case, the data were presented to include qualitative data on information format in addition to the presence/absence data.

5. **Results and Discussion**

Legislation, regulations and enforcement are an important driving force behind the protection of the environment and, therefore, provide the basis for decisions and activities of reclamation practitioners and regulators. Legislation establishes specific reclamation management systems with different levels of control and capital investment. Specific legislation or regulations that address high elevation coal mine reclamation are not part of the regulatory process in any of the jurisdictions reviewed although there are
sections within United States federal and state statutes which are applicable. Due to the complexities of the socio-political milieu, legislators and policy makers in the reviewed jurisdictions have developed broad regulations to cover reclamation activities. Therefore, much of the following discussion can be applied generally.

Several areas for discussion were identified by the review of regulations and legislation: (1) regulatory process, (2) performance bonding, (3) planning, (4) regulatory provisions, (5) performance standards, (6) reclamation monitoring and enforcement and (7) regulated professional participation.

The observed differences in regulatory approaches and requirements between different jurisdictions may be due to historically different land-use practices and political systems. In the United States, the demands on the land-base as well as the environmental damage caused by coal mining in the Appalachians have resulted in rigorously legislated land stewardship and conservation (Baldwin 1994). It is suggested here, that the dominant agricultural sector in Alberta has contributed to the pre-eminence of land conservation within industrial development while, historically, land stewardship has not been the focus of the dominant resource extraction industries (i.e., forestry, mining) in British Columbia.

**Regulatory Process**

The systems for regulating surface coal mines in the jurisdictions reviewed are very complex. Comparatively, the United States system is more reliant on statute and regulation than is either Alberta or British Columbia. Both Alberta and British
Columbia make use of less formal guidelines and procedures which are not detailed exhaustively in legislation. However, there is an important difference between the two Canadian jurisdictions reviewed. The Alberta system is based on regulations whereas the British Columbia system is based on code. This may be an important distinction since codes may have less legal force in comparison to regulations (Black et al. 1990).

In Alberta, anything that is considered certain in terms of practice or measurement is described in the regulations, and everything else is by ministerial discretion.

The SMCRA legislation has been criticized because Congress chose to draft regulations into the Act in legislative form rather than follow the usual approach of delegating the rule-making function to the regulatory agency (Rasnic 1983). The result of the legislative approach has been that ‘technological forcing’ is more pervasive within the SMCRA than its counterparts: the EPEA (formerly LSCRA) in Alberta and the Mines Act in British Columbia. ‘Technological forcing’ has often resulted in tension between industry and regulatory agencies (Dickson 1988). Examples of technological forcing are the Approximate Original Contour (AOC) requirement and native plant species procurement requirements of the SMCRA in the United States and the topsoil requirement of the reclamation guidelines in Alberta.

Legislative and regulatory control of surface mining in Alberta encompasses all forms of surface disturbance (coal mines, quarries and oil and gas) while in British Columbia, oil and gas disturbances are excluded. In contrast, a separate legislative document applies to each type of mineral resource extraction in the United States. Only coal surface mining is regulated federally. In terms of equitable treatment and prevention of
landscape degradation, the Alberta regulatory system is superior to all other jurisdictions reviewed. The inequalities of environmental regulation between hardrock and coal mining in the United States (Miller 1991) and between oil and gas and mining in British Columbia do not exist in Alberta with the broad regulatory framework of the former Land Surface Conservation and Reclamation Act (LSCRA) and the current omnibus EPEA.

While there is significant programmatic similarity between the jurisdictions reviewed, there are substantial differences in terms of regulatory process, performance standards and enforcement. At one end of the scale is the legislative, rigorously enforced American system of reclamation regulation and at the other end is the Canadian guidelines approach. The American federal system is very restrictive whereas the Alberta and British Columbia systems are flexible. For example, the AOC regulatory requirement, in particular, may discourage habitat diversity and innovation.

The extensive ecological details of the SMCRA have resulted in an emphasis on ecological concepts (species diversity, successional processes, soil biology and wildlife biology) within operational reclamation practice in the United States (Allen 1992). Ecological concepts are latent within the Alberta regulations and British Columbia code. Whether stated explicitly or implied, inclusion of ecological principles within each jurisdiction is predicated on an assumed knowledge of successional 'assembly rules' (Lawton 1987) and on a preoccupation with static end-products rather than with the process of developing end-products. This ecological audit of
jurisdictional regulations demonstrates a lack of ecological perspective in many reclamation practices, especially in British Columbia.

The guidelines approach in Alberta and British Columbia has established general objectives and performance standards by which reclamation is judged. Guidelines are important since they establish rules for government regulators and direct the attention of reclamation practitioners towards the broad objectives and goals of reclamation (McLellan 1985). However, in the absence of firm regulatory requirements and enforcement, guidelines can result in a form of disjointed incrementalism (sensu lato Hollick 1981a), a particular problem for an inter-disciplinary field such as mine reclamation. The Alberta regulatory system does not suffer from the disjointed incrementalism characteristic of the British Columbia system because of their coordinated government research and regulatory program. Essentially, the British Columbia code lacks sufficiently detailed information. A further complication is that the British Columbia system involves a disproportionate amount of industry-based consensus with, in the past, considerable ministerial discretion. However, to minimize regulatory abuse, code statements may be included in the reclamation permit since the requirements in this document may be more legally binding on the mining corporation (Errington 1994).

In addition to the aforementioned jurisdictional differences, three important concerns were identified: (1) industry/government interaction, (2) regulatory flexibility and (3) information acquisition.
Industry/Government Interaction: The interaction between government and industry in all jurisdictions reviewed is best described as adversarial, the cause of which may be due, in part, to mistrust. The legalistic format of the United States results in the most adversarial regulatory process with little flexibility. The statute/guidelines approach taken in Canada is much more flexible and incorporates a greater amount of negotiation between the regulatory agencies and the industry.

Negotiation between government regulators and individual companies is important in the regulatory process of all jurisdictions reviewed although it is transparent in the formal system of rules embedded within the statutes and regulations. Negotiations are often involved in matters that are essentially scientific. However, environmental programs frequently require a standard of proof or evidence that involves policy-based rather than science-based decisions, and this is particularly important where uncertainty is high. Reclamation of high elevation disturbances exemplifies a situation where considerable technical uncertainty exists. For example, very little is known about the effects of management practices on ecosystem responses such as plant population dynamics, species persistence, heterotrophic succession and neo-sol pedogenesis.

Judgment under uncertainty is particularly problematic where deep divisions exist between participants in the process (Tversky and Kahneman 1982). Resolution of such conflicts and differences may require adjudication by a panel of experts.

Governments must be prepared to defend such policies and legislation with scientific evidence (Fedkenheuer 1987). In Alberta, reclamation guidelines are continually undergoing revision as new information becomes available. This is a form of adaptive
environmental management (Holling 1978) which will stimulate innovative environmental management, provided there is a continual infusion of scientific information from basic and applied-basic research. Contemporary and proposed research areas related to reclamation are in Figure 2.1. Increased ecological and holistic research is necessary, especially in the development of alternative practices that can be defended with empirical data.

Dickson (1988) recommended an approach based on bipartisan discussions as an alternative to the conventional command-penalty model of environmental regulation. In the formal negotiated regulations model proposed herein, regulatory standards would be established in consultation with government, industry and the public. In negotiated regulations, all participants would be required to justify their positions or demonstrate ‘due diligence’ from a knowledge-base perspective.

Formalized involvement by appointed members of the general (local) public and attentive public would make both industry and government more accountable and could result in greater attention to aesthetics within the process. Short environment and reclamation training courses would empower these advocates for site visits and document reviews.

Although there is less conflict when the regulatory system is negotiated, there are attendant problems related to the difficulty of justifying new standards and the development of ‘agency capture’ (Fortmann 1990). In order to eliminate the potential for regulatory abuse, a public (individual and/or advocacy group) participation program and a strong research and reporting component must be included as part of any
Figure 2.1 Contemporary and Proposed Additional Reclamation Research Categories.

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<th>Category</th>
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<tr>
<td>Basic Research</td>
<td>• Plant Autecology and Synecology&lt;br&gt;• Soils (Chemistry, Physics, Biology)&lt;br&gt;• Invertebrate and Vertebrate Zoology&lt;br&gt;• Wildlife Ecology and Management&lt;br&gt;• Ecosystem Ecology&lt;br&gt;• Plant Population Dynamics&lt;br&gt;• Plant Reproductive Ecology&lt;br&gt;• Native Species Ecophysiology&lt;br&gt;• Succession (Autotrophic and Heterotrophic)&lt;br&gt;• Landscape Ecology</td>
</tr>
<tr>
<td>Applied/Basic Research</td>
<td>• Native Species Seed Production Techniques&lt;br&gt;• Native Species Establishment Techniques&lt;br&gt;• Plant Water Relations and Mineral Nutrition&lt;br&gt;• Soil/Spoil Physics and Chemistry&lt;br&gt;• Soil/Spoil Biology (Macro, Meso and Microfauna)&lt;br&gt;• Soil/Spoil Biochemistry&lt;br&gt;• Soil/Spoil Spatial Relationships&lt;br&gt;• Disturbed Ecosystem Processes&lt;br&gt;• Managed Succession of Revegetated Disturbances&lt;br&gt;• Post-Mining Landscape Aesthetics&lt;br&gt;• Predictive Process and Spatial Modeling&lt;br&gt;• Reclamation Practices and Longitudinal Ecological Research&lt;br&gt;• Reclamation Policy and Management</td>
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<tr>
<td>Applied Research</td>
<td>• Agronomic Species Selection and Establishment&lt;br&gt;• Fertilizer and Amendment Treatments&lt;br&gt;• Site Preparation Techniques&lt;br&gt;• Soil Analyses&lt;br&gt;• Reclamation Management Technique Monitoring</td>
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reclamation permit. Since there are significant gaps in the information base, reclamation decisions are based often on value judgments rather than on scientific evidence. Therefore, individuals directly or indirectly affected should have formal input into the development of regulations. Public input would alleviate the 'agency capture' problem and would also result in a greater integration of aesthetic concerns, an aspect of the regulatory process which is acknowledged only tacitly at present. To provide equity in positional justification, research would have to be performed by both government and industry.

In a negotiated system, acceptable management inputs and performance standards would be agreed upon mutually by all affected groups; therefore, the system would provide the trust and cooperation that is necessary while ensuring sufficient flexibility to respond appropriately to difficult situations. Essentially, negotiated policy decisions would provide the direction and rate of technological progress of mine reclamation practice in a more efficacious manner and would reduce the ad hoc nature of reclamation practice in British Columbia. Technical and ecological information would be developed through a combination of objective data analyses and subjective judgments of experts on reclamation as well as through subjective public evaluations. Subjective public intervention is important at both local and regional levels since it is difficult to overcome regulatory inertia without significant electoral influence.

The formal negotiated regulatory model would also be more equitable in dealing with the asymmetry between the societal risks and benefits of the alternative courses of regulatory action. A larger segment of society would be involved in deciding what are
acceptable levels of landscape alteration (degradation). Thus, such a process would truly acknowledge that reclamation is a socio-political process.

All jurisdictions have a formalized mine development review process within which proponent proposals are reviewed and accepted or rejected. Following project approval, a formalized industry/regulator reclamation monitoring and certification process is invoked.

**Regulatory Flexibility:** Flexibility is a necessary part of the regulatory process because of the site-specific nature of reclamation practice. In particular, flexibility in performance standards is necessary to ensure maximum development of the science and art of reclamation through innovation. Implementation of innovative practices is constrained by both a lack of flexibility (United States) and too much flexibility (British Columbia). Although less apparent, excessive flexibility constrains **innovation** development and adoption through inadequate regulatory incentives.

In addition to the flexibility afforded through the guidelines approach, two other forms of flexibility are provided to accommodate environment and mining practice differences. **Variance** provisions such as: (1) "... considers previous and potential use...", (2) "... unless these objectives can be otherwise achieved...", (3) "... can provide evidence which demonstrates to the satisfaction of the chief inspector the impracticality of doing so...", and (4) "... will not normally be accepted..." have been included as phrases in the regulations or guidelines of the jurisdictions reviewed.

Variance provision phrases as a form of regulatory flexibility provide the greatest potential for negotiations between the regulatory agencies and industry as well as the
greatest source of discretionary abuse. In areas such as high elevations where technical uncertainty exists, these phrases may be a source of facile justifications.

A final form of flexibility is in the recognition of special forms of mining practices. Variances to the SMCRA AOC requirement are granted under special considerations where (1) volumetric expansion of waste material has occurred, (2) alternative land-uses are proposed, or (3) special mining methods such as **augering**, **mountaintop removal** and steep slope mining are involved. These distinctions or special provisions are the only parts of regulations reviewed which have special reference to high elevation coal mining. In Alberta and British Columbia, special categories of mining are not designated in the legislation or regulations, but the mining practices at many of the mines in the foothills and mountainous regions of Alberta and British Columbia would be so designated.

Although regulatory intransigence (United States) is problematic, 'unrestricted' regulatory flexibility (British Columbia) also has negative side effects, especially when dealing with 'sympathetic administrations.' For example, the code in British Columbia provides for considerable regulatory discretion and potential systemic abuse. 'Agency capture' is a potential problem within this jurisdiction where the **engineering** profession subordinates ecological considerations.

Furthermore, variances can always be justified by monetary constraints, but this rarely translates to sound environmental practice. Where appropriate, the industry must be forced to demonstrate 'due diligence.' Situations where variances are granted easily inhibit the development of innovative reclamation practices. In the United States,
variances are granted only after empirical support while in Alberta and British Columbia, evidentiary support is only implied. However, Alberta with its excellent research program has the mechanism in place to develop consensus scientifically.

**Information Acquisition Approaches:** Research has an important role in influencing change in practices and in altering the regulatory ethos (Wali 1992). Research is the information generating component of the reclamation process. The recommendations resulting from research are often not very elaborate or expensive and, when applied effectively, can have significant results.

Without considerable regulatory guidance and pressure through legislation or guidelines, reclamation planning information will remain incomplete. Since reclamation research is jurisdictional context-dependent, each government has both cognitive and regulatory functions which must operate through the stimulation of research, provision of funds and facilities and the development of policies and minimum standards.

Within the jurisdictions reviewed, primary modes of information acquisition vary, and three models are suggested: (1) government, (2) industry and (3) combination.

Alberta represents the 'government model' whereby reclamation information is generated through either literature reviews and manuals published by the Land Conservation and Reclamation Council or laboratory and field studies undertaken by the Alberta Research Council. Although cooperative government/industry studies are undertaken, there is no regulated requirement for industry to undertake research although the mining industry must undertake compliance monitoring in order to satisfy permit obligations.
In Alberta, research is coordinated by the Reclamation Research Technical Advisory Committee (RRTAC) and implemented by the Alberta Research Council, academics and consultants. The Alberta Research Council has conducted surface mine reclamation research in upper montane and subalpine areas near Grande Cache since 1972. This research represents one of only a few long-term field studies in the Canadian Rockies (Macyk et al. 1991). Until 1994, the research program of the Alberta government was one of the most comprehensive and well funded in western North America.

The 'government model' represents a method of information acquisition which is scientifically rigorous and relatively unbiased. However, the model may not accommodate adequately the economic constraints of reclamation nor allow for serendipitous discoveries that might occur if more research were conducted by mining companies.

The 'industry model' is used by British Columbia and is a pragmatic approach to reclamation developed because of environmental variability and differences in mining practices within the province (Thirgood 1978). In this model, the industry must demonstrate competence in generating information for reclamation planning. Although this model was originally considered to be superior to that of specific legislation and regulations (Thirgood and Meagher 1972), this approach has resulted in a short-term and non-holistic approach which is inadequate in developing consensus on reclamation practice and regulatory requirements. The 'industry model' results in a disjointed approach to research and planning. Initially, this approach may have had merit, but considerable regulatory abuse is possible because of the ad hoc nature of data
collection, lack of empirical documentation of practices and questionable technical competence within industry.

Although the British Columbia Ministry of Energy, Mines and Petroleum Resources has long recognized the importance of research, direct funding has been limited since 1977. The Technical Research Committee on Reclamation Assessment (TRCR) coordinates research efforts with industry, government and universities and recommends research priorities based on political sensitivity and perceived needs (Errington 1988). The TRCR in British Columbia produces research priority lists and funds selected projects but has suffered from shortages in manpower and funding, unlike Alberta and the United States. As a result, many components of reclamation theory, practice and regulation in British Columbia have had a conceptual and developmental hiatus during the last decade with much of the research focused narrowly on selected concerns related to environmental ‘protection’ (rock drains, spoil dump stability, geohydrology, acid rock drainage, molybdenum toxicity) rather than on ecosystem development.

The ‘combination model’ is represented by the United States jurisdictions in which there is considerable coordination of academic, governmental and industry research. Although not specifically stated in either the SMCRA or the CFR 30, the performance criteria within the code have dictated not only the direction and magnitude of research but also the complexity. In the United States, reclamation research activities are coordinated through three regional centers associated with universities. A large number of cooperative research projects relevant to the reclamation of high elevation disturbances have been implemented by industry, government and academia, with
substantial involvement by the United States Department of Agriculture Forest Service. Considerable reclamation-related research and development is carried out by federal and state agencies, educational institutions and the mining industry in the United States (Baldwin 1994). The SMCRA also contains a provision for research and variance permission within the Experimental Practices in Section 711. United States’ coal producers have found that thorough research and persistence are the key components of successful innovation in reclamation practice although it has been difficult to overcome regulatory inertia (Lawson 1988). Innovative proposals and variances from regulatory norms require considerable gestation and knowledge that will develop only with adequate research and integration within a well designed and implemented monitoring process.

**Bonding**

Reclamation funding is an important issue for government regulators, mining executives and environmental groups, and substantial funds (e.g., cash, performance bonds) must be allocated at the beginning of operations to ensure fulfillment of environmental obligations (Zaluski et al. 1991). Enforcement in the form of security provisions or bonding is universal within the jurisdictions reviewed (Table 2.2), but there is considerable variability in the forms of bonding instruments (performance, collateral, self, combination) and bonding processes (full, cumulative and phased) (Carter 1994). The greatest range of bonding types and procedures is found in the
TABLE 2.2 PERFORMANCE BONDS AND BOND RELEASE IN SELECTED JURISDICTIONS OF THE MOUNTAINOUS COAL PRODUCING REGIONS OF THE WESTERN UNITED STATES AND CANADA.

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<th>DESCRIPTION</th>
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<td></td>
<td>ALBERTA</td>
<td>BRITISH COLUMBIA</td>
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**TYPES OF BONDS**

1. PERFORMANCE
   - SURETY
   - LETTER OF GUARANTEE
   - NEGOTIABLE BEARER BONDS

2. COLLATERAL
   - CASH
   - LETTER OF CREDIT
   - TERM SAVINGS CERTIFICATES
   - TERM DEPOSITS
   - NEGOTIABLE CERTIFICATES
   - GOVERNMENT BOND
   - REAL PROPERTY

3. SELF BOND

4. COMBINATION

**AMOUNT OF BOND**

1. AREA-BASED

2. INCREMENTAL-BASED
### PRODUCTION-BASED

3. **PRODUCTION-BASED**

### ACCOMODATION OF DEGREE OF DIFFICULTY

4. **ACCOMODATION OF DEGREE OF DIFFICULTY**

### BOND RELEASE

1. **PROVISION FOR BOND ADJUSTMENT AND RENEWAL**

   + + + + + + + + + + +

2. **PROVISION FOR PARTIAL BOND RELEASE**

   + + + + + + + + + + +

3. **DURATION OF RESPONSIBILITY (PERIOD OF BOND LIABILITY)**

   + + + + + + + + + + +

4. **PROVISION FOR BOND FORFEITURE**

   + + + + + + + + + + +

**KEY:** (+) - PROVISION; ( ) - NO PROVISION
United States' jurisdictions. Bonding amounts are generally area-based although Wyoming has an incremental-based bonding format and Alberta has a production-based bonding format. The Alberta approach is a hybrid of phase and cumulative bonding.

In the United States (Walker 1989) and in British Columbia (Errington 1995), there is a trend away from surety bonding because of the large number of defaults and the unwillingness of insurance companies to pay upon default or provide sureties. Although insurance companies have become reluctant to issue reclamation bonds due to depressed coal prices (Christensen 1986) or incorrect bond calculations (Coleman 1988), some form of reclamation bonding continues to be practiced.

Various methods of ensuring adequate funds for reclamation budgets have been developed, and some mines have established reclamation accrual accounts where funds for reclamation are accumulated by collecting a pre-determined payment for each tonne of clean coal produced (Lane and Berdusco 1988). The amount of the bonds is discretionary in British Columbia and the United States but has pre-determined increments in Alberta. This narrative description is consistent throughout the United States' jurisdictions reviewed although, in practice, bonding requirements range from a minimum of $10,000 (Hamm 1988) to a maximum of $24,700/hectare (Johnson 1988). In British Columbia, a statutory restriction of $2,500/hectare was placed on reclamation bonding, but this has since been changed to allow the government to secure fully the total cost of reclamation liability (Errington 1990). The bonding procedure in British Columbia now approximates more closely the discretionary format of the United States jurisdictions. Alberta is unique in its production-based format. A $25,000 deposit is
required plus an additional twenty-five cents per clean metric tonne of coal produced.

The incremental bond release program in Alberta provides incentive for contemporaneous reclamation while maintaining sufficient security to achieve reclamation objectives (Chymko and Brocke 1990). All jurisdictions provide for bond adjustment and renewal.

Initially, cost/benefit analysis of reclamation and willingness to pay were considered within the philosophical constraint that reclamation input costs should not exceed pre-disturbance land values (Bernard 1980). However, the current trend is toward pre-disturbance designation of post-mining land-use objectives and subsequent development of 'full' bonding procedures which are appropriate for the area disturbed and the degree of difficulty of reclamation. 'Full' bonding encourages rapid reclamation (Errington 1995). This trend has significance to high elevation mine disturbances since technical and logistical problems are generally greater than in other biomes.

Reclamation cost estimation is difficult, imprecise and varies considerably with post-mining land-use objectives (Ries and Hedin 1990). The mining industry is concerned with 'realistic reclamation costs' (Vincent 1990) and with the uncertainties as to the taxation status of environmental rehabilitation bonds (Stewart 1991). In British Columbia, Section 12 of the Mines Act [SBC 1989 c.56] now provides a mine-specific bonding program with taxation benefits (MEMPR 1995). Research that examines reclamation costs as a basis for bonding is being studied currently.

All jurisdictions reviewed consider reclamation to be a continuous responsibility with regulated liability extending beyond mine closure. In general, the mining industry
prefers some form of short-term responsibility or 'sunset clause' as to when liability will cease. The duration of responsibility or period of bond liability is a specifically stated time limit in all jurisdictions except British Columbia and Utah. Duration of responsibility in the United States has a specified time period of 5-10 years. For mine disturbances in areas with greater than 26 mm of annual precipitation, the time limit is 5 years, and for lower precipitation levels, the 10-year limit is stated. In Alberta, the time period is 4-8 years depending on tree seedling transplant performance. Duration of corporate responsibility is dependent upon the magnitude of management input, but these arbitrary time limits have little relevance to sustainability or successional processes at high montane, subalpine or alpine areas. The duration of bonding liability must be commensurate with observed rates of ecosystem succession.

**Planning**

Reclamation planning should be an intrinsic part of mining and not an adjunct to closure engineering (Miller 1991). In the United States, the intent of the federal statute and, therefore, state regulations was for the applicant to demonstrate compliance capability with the environmental standards (Kline 1987). This requirement necessitates considerable pre-planning on the part of the applicant. Pre-planning for reclamation in Alberta and British Columbia is part of the mine development review process and specific information is included in both the Environmental Impact Assessment and permitting stages.
From an ecological perspective, the approval of mining and reclamation plans by a regulatory agency is a critical point in the regulatory process. During the planning process, biophysical parameters are examined and development plans modified and finally accepted. At this point, performance bonds are established to ensure compliance with the approved plans. Consequently, these plans are important for enforcement of post-mining reclamation.

All jurisdictions require contemporaneous reclamation (Table 2.3) although this requirement is regulated more strictly in the United States. Deadlines for equipment work and revegetation are specifically stated in Montana and Alberta whereas most jurisdictions simply provide a general requirement as a moderate incentive to practice concurrent reclamation. The primary requirement of contemporaneous reclamation is to control surface erosion and the loss of suitable growing media (Halverson and Sidle 1992). The requirement of progressive reclamation is common now in many jurisdictions in North America.

Reclamation plan requirements (Table 2.4) are consistent between jurisdictions with only a few exceptions. All of the jurisdictions reviewed require some form of reclamation planning prior to mine development, but the extent of the plans varies. The majority simply require conceptual plans, but there are subtle jurisdictional differences in terms of the exclusiveness of reclamation requirements or the portions of the post-mining landscape that are excluded from reclamation. Plans for engineered structures (pit backfilling, topographic modifications, water control) are consistently required in all jurisdictions reviewed. The information required in the United States jurisdictions
TABLE 2.3 RECLAMATION PLAN REQUIREMENTS FOR PERMIT APPLICATIONS WITHIN SELECTED JURISDICTIONS IN THE MOUNTAINOUS COAL PRODUCING REGIONS OF THE WESTERN UNITED STATES AND CANADA.

<table>
<thead>
<tr>
<th>RECLAMATION PLAN REQUIREMENTS</th>
<th>CANADA</th>
<th>UNITED STATES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ALBERTA</td>
<td>BRITISH</td>
</tr>
<tr>
<td></td>
<td>COLUMBIA</td>
<td>ALASKA</td>
</tr>
<tr>
<td>1. IDENTIFICATION, SIZE, SEQUENCE AND DURATION OF OCCUPANCY OF PERMIT AREA</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>2. CONDITION OF PERMIT LAND PRIOR TO DISTURBANCE</td>
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<td>+</td>
</tr>
<tr>
<td>- BIOPHYSICAL INVENTORY</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>- PREVIOUS OR EXISTING USES OF LANDS PRIOR TO DISTURBANCE</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>- LAND CAPABILITY OF THE LAND PRIOR TO MINING</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>- PRODUCTIVITY OF LANDS PRIOR TO MINING</td>
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<td>+</td>
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<tr>
<td>3. PROPOSED POST-MINING LAND-USE</td>
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<td>+</td>
</tr>
<tr>
<td>4. LIFE-OF-MINE CONCEPTUAL RECLAMATION PLAN</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>5. DETAILED DESCRIPTION OF HOW POST-MINING LAND-USE WILL BE ACHIEVED</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>6. DETAILED TIME TABLE OF RECLAMATION PLAN</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>7. ENGINEERING TECHNIQUES PROPOSED TO BE USED IN MINING AND RECLAMATION AND A DESCRIPTION OF THE MAJOR EQUIPMENT</td>
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<td>+</td>
</tr>
<tr>
<td></td>
<td>STEPS TO BE TAKEN TO ENSURE COMPLIANCE WITH AIR AND WATER QUALITY LAWS</td>
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<th>A PLAN FOR WASTE DUMP (SPOIL, COARSE REJECTS) TOPOGRAPHIC MODIFICATION</th>
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<th>ENDANGERED SPECIES PROTECTION AND HABITAT ENHANCEMENT</th>
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<th>ANNUAL RECLAMATION REPORT - PLAN FOR RECLAMATION RESEARCH MONITORING</th>
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**KEY:** (+) - REQUIRED; (*) - NOT ALWAYS REQUIRED; ( ) - NOT REQUIRED
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<td>UNITED STATES</td>
<td></td>
<td></td>
</tr>
<tr>
<td>FEDERAL</td>
<td>30 USC 1265 SEC. 515</td>
<td>&quot;AS CONTEMPORANEOUSLY AS PRACTICAL WITH OPERATIONS . . .&quot;</td>
</tr>
<tr>
<td>ALASKA</td>
<td>11 AAC 90.441</td>
<td>&quot;RECLAMATION, INCLUDING BACKFILLING AND GRADING, TOPSOIL REPLACEMENT AND REVEGETATION MUST OCCUR AS CONTEMPORANEOUSLY AS PRACTICABLE WITH MINING OPERATIONS.&quot;</td>
</tr>
<tr>
<td>COLORADO</td>
<td>34-33-120 2 P</td>
<td>&quot;ENSURE THAT ALL RECLAMATION EFFORTS PROCEED IN AN ENVIRONMENTALLY SOUND MANNER AND AS CONTEMPORANEOUSLY AS PRACTICABLE WITH THE SURFACE COAL MINING OPERATIONS . . .&quot;</td>
</tr>
<tr>
<td>MONTANA</td>
<td>26.4.513</td>
<td>&quot;FINAL GRADING SHALL BE KEPT CURRENT WITH MINING OPERATIONS.&quot;</td>
</tr>
<tr>
<td>NEW MEXICO</td>
<td>RULE 80-1 20-100</td>
<td>&quot;RECLAMATION EFFORTS, INCLUDING, BUT NOT LIMITED TO, BACKFILLING, GRADING, TOPSOIL REPLACEMENT AND REVEGETATION, OF ALL LAND THAT IS DISTURBED BY SURFACE COAL MINING OPERATIONS SHALL OCCUR AS CONTEMPORANEOUSLY AS PRACTICABLE WITH MINING OPERATIONS.&quot;</td>
</tr>
<tr>
<td>UTAH</td>
<td>R645 - 301-352</td>
<td>&quot;REVEGETATION ON ALL LAND THAT IS DISTURBED BY COAL MINING AND RECLAMATION OPERATIONS, WILL OCCUR AS CONTEMPORANEOUSLY AS PRACTICABLE WITH MINING OPERATIONS, EXCEPT WHEN SUCH MINING OPERATIONS ARE CONDUCTED IN ACCORDANCE WITH A VARIANCE FOR COMBINED SURFACE AND UNDERGROUND COAL MINING AND RECLAMATION ACTIVITIES . . .&quot;</td>
</tr>
<tr>
<td>WYOMING</td>
<td>SECTION 2(K)(I)</td>
<td>&quot;RECLAMATION MUST BEGIN AS SOON AS POSSIBLE AFTER MINING COMMENCES AND MUST CONTINUE CONCURRENTLY UNTIL SUCH TIME THAT THE MINING OPERATION IS TERMINATED AND ALL OF THE AFFECTED LAND IS RECLAIMED.&quot;</td>
</tr>
<tr>
<td>CANADA</td>
<td>39 (2-5 1)</td>
<td>&quot;... RECLAMATION SHOULD BE CONCURRENT WITH DEVELOPMENT SO THAT THE RATE OF RECLAMATION CAN KEEP PACE WITH THE RATE OF DISTURBANCE.&quot;</td>
</tr>
</tbody>
</table>
"IT IS THE DUTY OF EVERY OWNER, AGENT AND MANAGER TO INSTITUTE AND DURING THE LIFE OF THE MINE TO CARRY OUT A PROGRAM OF ENVIRONMENTAL PROTECTION AND RECLAMATION . . ."

SEE TABLE 2.1 FOR REFERENCES.
is again in the form of 'narrative descriptions' whereas the information presentation format is not stated in Alberta or British Columbia. However, a review of several mine development EISs from Alberta and British Columbia (Chapter 3) indicates a similar response to that of the United States.

In each of the jurisdictions reviewed, land-use provisions require the post-mining landscape to have either equal or better use (Table 2.5). At present, pre-disturbance productivity requirements are not required in Alaska, Alberta, British Columbia and Wyoming although land capability descriptions are required in all jurisdictions. Narrative descriptions are the norm in all jurisdictions. In Canada, land capability is determined through the use of Canada Land Inventory (CLI) maps for specific land-uses. In all jurisdictions, the designation of equal or better for post-mining land-use values reflects a 'no net loss' approach in the practical use of the land prior to mining rather than the re-creation of historic or pre-human habitation landscapes.

In British Columbia, because the terrain and environment are altered so extensively and because regulations are inadequately enforced, the development of pre-disturbance productivity is not attainable on a total landscape basis. Reclamation regulation in British Columbia is predicated essentially on the 'reclamation potential' of the post-mining landscape rather than on integrative congruent planning, and as such, is similar to the concepts of 'present optimum vegetation' (Rijmenams et al. 1985) or 'potential natural vegetation' (Ide and Takeuchi 1984). Under these conditions, it is better to consider 'alternative endpoints' (Bradshaw 1988), 're-allocation' (Aronson et al. 1993) or 'opportunity landscapes' (Baker and Jackson 1994).
TABLE 2.5 LAND-USE PROVISIONS IN THE LEGISLATION OF SELECTED MOUNTAINOUS COAL PRODUCING REGIONS OF THE WESTERN UNITED STATES AND CANADA.

<table>
<thead>
<tr>
<th>JURISDICTION</th>
<th>LEGISLATION</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UNITED STATES</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FEDERAL</td>
<td>30 USC 1265 SEC 515 B 1</td>
<td>&quot;RESTORE THE LAND AFFECTED TO A CONDITION CAPABLE OF SUPPORTING THE USES WHICH IT WAS CAPABLE OF SUPPORTING PRIOR TO ANY MINING, OR HIGHER OR BETTER USES OF WHICH THERE IS A REASONABLE LIKELIHOOD SO LONG AS SUCH USES DO NOT PRESENT ANY ACTUAL OR PROBABLE HAZARD TO PUBLIC HEALTH OR SAFETY OR POSE ANY ACTUAL OR PROBABLE THREAT OF WATER DIMINUTION OR POLLUTION WHICH WOULD BE CONTRARY TO STATE OR FEDERAL LAWS, RULES OR REGULATIONS, AND SO LONG AS . . . THE DECLARED PROPOSED LAND-USE FOLLOWING RECLAMATION IS NOT DEEMED TO BE IMPractical OR UNREASONABLE . . .&quot;</td>
</tr>
<tr>
<td>ALASKA</td>
<td>11 AAC 90.481</td>
<td>&quot;ALL DISTURBED AREAS MUST BE RESTORED IN A TIMELY MANNER TO CONDITIONS THAT ARE CAPABLE OF SUPPORTING (1) THE USES WHICH THEY WERE CAPABLE OF SUPPORTING BEFORE ANY MINING, OR (2) HIGHER OR BETTER USES ACHIEVABLE UNDER THE PROVISIONS OF THIS SECTION.&quot;</td>
</tr>
<tr>
<td>COLORADO</td>
<td>34-32-103 13</td>
<td>&quot;RESTORE LAND AFFECTED TO A CONDITION CAPABLE OF SUPPORTING THE USES WHICH IT WAS CAPABLE OF SUPPORTING PRIOR TO ANY MINING; OR HIGHER OR BETTER USES OF WHICH THERE IS REASONABLE LIKELIHOOD, SO LONG AS SUCH USE OR USES DO NOT PRESENT ANY ACTUAL OR PROBABLE HAZARD TO PUBLIC HEALTH OR SAFETY OR POSE ANY ACTUAL OR PROBABLE THREAT OF WATER DIMINUTION OR POLLUTION WHICH WOULD BE CONTRARY TO STATE OR FEDERAL LAWS, RULES OR REGULATIONS, AND SO LONG AS . . . THE DECLARED PROPOSED LAND-USE FOLLOWING RECLAMATION IS NOT DEEMED TO BE IMPractical OR UNREASONABLE . . .&quot;</td>
</tr>
<tr>
<td>MONTANA</td>
<td>26.4.762</td>
<td>&quot;THE POST-MINING LAND-USE SHALL BE LIVESTOCK AND WILDlIFE GRAZING . . . UNLESS AN ALTERNATE LAND-USE IS APPROVED UNDER RULE 26.4.823.&quot; &quot;EACH OPERATOR WHO DESIRES TO CONDUCT ALTERNATE RECLAMATION PURSUANT TO SECTION 82.4.233 SHALL SUBMIT HIS PLANS TO THE DEPARTMENT.&quot;</td>
</tr>
<tr>
<td>NEW MEXICO</td>
<td>20-133</td>
<td>&quot;ALL SURFACE LAND AREAS AFFECTED SHALL BE RESTORED IN A TIMELY MANNER: (1) TO CONDITIONS THAT ARE CAPABLE OF SUPPORTING THE USES WHICH THEY WERE CAPABLE OF SUPPORTING BEFORE ANY MINING; OR (2) TO HIGHER OR BETTER USES ACHIEVABLE UNDER CRITERIA AND PROCEDURES OF SECTION 20-133.&quot;</td>
</tr>
<tr>
<td>UTAH</td>
<td>413.100, 110</td>
<td>&quot;ALL DISTURBANCE AREAS WILL BE RESTORED IN A TIMELY MANNER TO CONDITIONS THAT ARE CAPABLE OF SUPPORTING BEFORE ANY MINING; OR HIGHER OR BETTER USES.&quot;</td>
</tr>
</tbody>
</table>
Wyoming
SEC. 2(A)(1)  "RECLAMATION SHALL RESTORE THE LAND TO A CONDITION EQUAL TO OR GREATER THAN THE HIGHEST PREVIOUS USE."

Canada

Alberta
39(2-2 SEC.A)  "... OVERALL LAND CAPABILITY WILL BE EQUIVALENT TO PRE-DISTURBANCE CAPABILITY."

British Columbia
10.6.3
10.6.4  "THE LAND SURFACE SHALL BE RECLAIMED TO AN ACCEPTABLE USE THAT CONSIDERS PREVIOUS AND POTENTIAL USE."  "THE LEVEL OF LAND PRODUCTIVITY TO BE ACHIEVED ON RECLAIMED AREAS SHALL NOT BE LESS THAN EXISTED PRIOR TO MINING OR AN AVERAGE PROPERTY BASIS UNLESS THE OWNER, AGENT, OR MANAGER CAN PROVIDE EVIDENCE WHICH DEMONSTRATES TO THE SATISFACTION OF THE CHIEF INSPECTOR THE IMPRACTICALITY OF DOING SO."

See Table 2.1 for references.
Although aesthetics is considered an important component of reclamation programs (Kiegley 1988), only Alberta states specific requirements for visual quality (Table 2.4). No reference to aesthetics is made in the other jurisdictions although the requirement that the post-mining landscape must ‘blend in’ with the surrounding topography in the United States suggests this may be inferred. This omission is serious and reflects a lack of integration of ecological and social concerns within the process. Landscape aesthetics is allied closely with long-term ecosystem stability (Tate 1985) and, when applied properly, can enhance greatly reclamation and restoration programs (Schulhof 1989). Amendments should be made to the regulatory process to include a formalized process for incorporating landscape aesthetics in both the planning and monitoring phases of reclamation regulation.

Regulatory Provisions

Several regulatory requirements are outlined in each jurisdiction reviewed. These provisions are compared and contrasted in the following section.

Topographic Provisions: Regrading, topsoiling, pit backfilling and other topographic modifications enhance significantly the establishment of vegetation (Brown et al. 1986). All jurisdictions have topographic provisions although the SMCRA contains the most demanding and restrictive requirements (Table 2.6). Re-creation of the AOC is required by the Federal Act 96-87 for all surface coal mines in the United States [515(b) (3)] and includes both pits and engineered waste disposal structures.
<table>
<thead>
<tr>
<th>Description</th>
<th>Canada</th>
<th>United States</th>
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<tbody>
<tr>
<td></td>
<td>Alberta</td>
<td>British Columbia</td>
</tr>
<tr>
<td>GENERAL REQUIREMENTS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- CONTOURING AND GRADING</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>PITS</td>
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<td></td>
</tr>
<tr>
<td>- HIGHWALL REDUCTION</td>
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<td>+</td>
</tr>
<tr>
<td>- BACKFILLING</td>
<td>+</td>
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</tr>
<tr>
<td>- APPROXIMATE ORIGINAL CONTOUR</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>- APPROPRIATE FACTOR OF SAFETY</td>
<td>+</td>
<td>+</td>
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<tr>
<td>- MAXIMUM SLOPE ANGLE</td>
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<td>+</td>
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<tr>
<td>- PLACEMENT AND DISPOSAL OF OVERBURDEN OR INTERBURDEN</td>
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<td>+</td>
</tr>
<tr>
<td>- BURIAL AND TREATMENT OF TOXIC WASTE MATERIALS</td>
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<td>+</td>
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<tr>
<td>- USE OF WASTE FOR FILL</td>
<td>+</td>
<td>+</td>
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<tr>
<td>- DISPOSAL OF NON-COAL WASTES</td>
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</table>
**DISPOSAL OF WASTE MATERIAL (SPOIL, COARSE REJECTS AND TAILINGS)**

<table>
<thead>
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<th>Description</th>
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<tbody>
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<td>- APPROPRIATE FACTOR OF SAFETY</td>
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<tr>
<td>- MAXIMUM SLOPE ANGLE</td>
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<td>- PLACEMENT AND DISPOSAL OF OVERBURDEN OR INTERBURDEN</td>
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<td>- BURIAL AND TREATMENT OF TOXIC WASTE MATERIALS</td>
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</tr>
<tr>
<td>- DISPOSAL OF NON-COAL WASTES</td>
<td>+</td>
</tr>
</tbody>
</table>

KEY: (+) - REQUIRED; (V) - VARIANCE GRANTED; ( ) - NOT REQUIRED.
Highwalls, spoil piles and depressions must be eliminated, but an exception may be possible for small moisture retention depressions (Table 2.7).

In Alberta, the reclamation guidelines require that all excavations be filled and/or graded to contours that are compatible with the approved post-development land capability. The inclusion of highwall reduction and pit backfilling in Alberta brings this jurisdiction in line with those in the United States although the requirement is in the form of guidelines rather than legislation. Also similar to the United States, variances can be granted for highwall and pit backfilling although equivalent land-use capability must still be achieved. In some cases, due to terrain and mining sequences, a pit cannot be backfilled or backsloped, so attempts are made to turn these landforms into productive lakes (Beddome 1987). When slopes steeper than 27° are proposed, they must be stable geotechnically and be compatible with the approved post-development land capability.

The Alberta regulatory system appears to have the most balanced approach with regard to topographic modifications. The primary focus of the Alberta legislation and guidelines is the return of the land base to a condition which would allow for ‘equivalent capability.’ The Alberta guidelines require pit backfilling and waste dump modification while not being restrictive in methodology.

British Columbia has the least specifically-regulated topographic modification requirements of the jurisdictions reviewed with pit walls ‘constructed’ in rock and steeply sloping footwalls ‘practically’ excluded from reclamation. Moreover, British Columbia does not have any provisions for maximum slope angle (Table 2.6) although interim waste dump guidelines in 1989 indicated that waste dumps with vertical lift
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<tr>
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<th>UNITED STATES</th>
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<td>ALASKA</td>
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<td>COLORADO</td>
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<td>FEDERAL</td>
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<td>MONTANA</td>
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<td>NEW</td>
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<td>MEXICO</td>
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<td>UTAH</td>
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<tr>
<td>WYOMING</td>
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</table>

**PITS**
- CUT AND FILL TERRACES + + + + +
- SMALL DEPRESSIONS      + + + + +

**DISPOSAL OF WASTE MATERIAL (SPOIL, COARSE REJECTS AND TAILINGS)**
- SPOIL PILE COMPACTION + + + +
- CUT AND FILL TERRACES + + + + +
- SMALL DEPRESSIONS     + + + + +

KEY: (+) - REQUIRED; (V) - VARIANCE GRANTED; ( ) - NOT REQUIRED.
heights in excess of 50 - 60 meters would have to be contoured for geotechnical reasons (MEMPR 1991).

Static factors of safety for engineered structures such as regraded spoil dumps, where required, are usually 1.3 or 1.5 in the United States jurisdictions. None of the jurisdictions reviewed allow structures to exceed the angle of repose (37°). Steep slopes in the United States are defined as those slopes greater than or equal to 20° while 27° is considered the cutoff angle in Alberta. No such cutoff angle exists in British Columbia. However, the 27° angle has been referred to as the 'biological angle of repose,' the angle beyond which revegetation is difficult (Harrison 1977, Dick 1979).

The 'biological angle of repose' concept is not an issue in the United States jurisdictions where a slope of 20° has been considered the critical revegetation threshold since 1967 (USDI 1967). However, in British Columbia, the subject of 'biological angle of repose' remains the focus of considerable polemics. Significant topographic exclusions are included within the regulations of British Columbia. The absence of a revegetation requirement for highwall and steeply sloping footwalls will result in a post-mining landscape which is composed of a patchwork of productive or semi-productive and non-productive landscape units. Therefore, it is difficult to reconcile the programmatic focus of 'temporary land-use' and 'sustainable development' embraced by the mining industry. Mining representatives often do not understand causal relationships between development and environmental planning and express frequently attitudes which are antithetical to the concept of sustainable development. As suggested by Lavkulich (1991), the concept of sustainable development as applied to non-renewable resources
is in need of a workable definition. Perhaps, where non-renewable resource extraction requires a re-allocation of land-use for the post-mining landscape, the concept of sustainable development should be replaced with that of sustainable landscape re-creation.

Topographic modification allowances such as cut-and-fill terraces and small depressions (Table 2.7) are described in the United States but are inappropriate for the generalist guidelines approach taken in Alberta and British Columbia.

Hydrologic Provisions: Hydrologic problems are an area where overlap with other legislation occurs, and the potential for costly litigation is high (Pelletier and Dushnisky 1989). Due to the externalities of inadequate attention to hydrologic concerns, all jurisdictions reviewed have extensive regulatory requirements concerning control of surface water (Table 2.8). Several hydrologic impacts may occur during and after mining. Runoff from surface mines can contribute significant amounts of suspended solids and soluble salts to the receiving environment (Kilmartin 1989). In general, operators must minimize or eliminate surface disturbances in order to satisfy hydrologic impact concerns. The universality and comprehensiveness of hydrologic regulations may reflect the mining industry’s concern for water quality deterioration (the initial stimulus for environmental regulation of the mining industry), the existence of measurable standards and the willingness of the engineering profession to implement practices which are more self-evident or represent more immediate concerns than
TABLE 2.8 WATER CONTROL REQUIREMENTS IN SELECTED JURISDICTIONS OF THE MOUNTAINOUS COAL PRODUCING REGIONS OF THE WESTERN UNITED STATES AND CANADA.

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<th>DESCRIPTION</th>
<th>CANADA</th>
<th>UNITED STATES</th>
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<tbody>
<tr>
<td></td>
<td>ALBERTA</td>
<td>BRITISH COLUMBIA</td>
</tr>
<tr>
<td>1. HYDROLOGIC BALANCE</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>2. WATER QUALITY STANDARDS</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>3. GROUNDWATER PROTECTION</td>
<td>+</td>
<td>+</td>
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<tr>
<td>4. PERMANENT IMPoundMENTS</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>5. PREVENTION OF LEASHING</td>
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</tbody>
</table>

KEY: (+) - REQUIREMENT; (V) - VARIANCE GRANTED; ( ) - NOT REQUIRED
reclamation activities (e.g., contamination of receiving environment). Conspicuously, **groundwater** protection is not regulated universally within the jurisdictions reviewed.

**Suitable Plant Growth Material:** The provision of suitable plant growth material is a prerequisite of reclamation practice in all jurisdictions. Comparison of growing media requirements between jurisdictions revealed many substantive differences (Table 2.9). The primary difference between jurisdictions with respect to growing media relates to regulatory enforcement and evidentiary support. The removal, segregation and replacement of topsoil on mined areas is a requirement of both the federal and state jurisdictions in the United States as well as in Alberta. The regulations in the States are very specific with regard to topsoil removal, storage and placement. Generally, removed soil materials are to be placed immediately on regraded areas unless sufficient regraded areas are unavailable. Topsoil substitution is allowed in the states surveyed as well as in Alberta, but this is conditional upon a quantitative determination of topsoil reserves. In Wyoming, “the department may also require that results of field site trials or greenhouse tests be used to demonstrate the feasibility of using such overburden materials” while other jurisdictions simply state that the operator must demonstrate that these will be suitable. In British Columbia, regulatory requirements for growing media are weak relative to the other jurisdictions reviewed. Part 10.6.7 of the reclamation code states, “All surficial soil material removed for mining purposes shall be saved for use in reclamation programs unless these objectives can be otherwise achieved.” While this definition is an improvement over that outlined in the previous reclamation
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<th>DESCRIPTION</th>
<th>CANADA</th>
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<td></td>
<td>ALBERTA</td>
<td>BRITISH</td>
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<tr>
<td><strong>TOPSOIL</strong></td>
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<td></td>
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<tr>
<td>- DEFINED</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>- REMOVAL OF TOPSOIL</td>
<td>+</td>
<td>+</td>
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<tr>
<td>- TOPSOIL REDISTRIBUTION PROCEDURES</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>- TOPSOIL STOCKPILING PROCEDURES</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>- PROTECTION FOR TOPSOIL STOCKPILES</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>- CHEMICAL PROPERTIES</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td><strong>SUBSTITUTION OF OTHER MATERIALS FOR TOPSOIL</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- REDISTRIBUTION PROCEDURES</td>
<td>+</td>
<td>+</td>
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<tr>
<td>- DEPTH</td>
<td>+</td>
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<tr>
<td>- PHYSICAL PROPERTIES</td>
<td>+</td>
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<td>- CHEMICAL PROPERTIES</td>
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<td>Category</td>
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<td>----------------------------------------------</td>
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<td></td>
</tr>
<tr>
<td>Acid formation and toxicity</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Eradication of rills and gullies</td>
<td>+</td>
<td></td>
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<tr>
<td>Soil amendments</td>
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<td></td>
</tr>
<tr>
<td>Fertilizer</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Lime</td>
<td>+</td>
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<tr>
<td>Organic material</td>
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**Key:** (+) - required; ( ) - not required.
Topsoil storage and replacement in reclamation planning is one area which is of significance to mountainous reclamation because pre-disturbance soils are often shallow and stony. Logistical and technical problems are often associated with topsoil salvage and storage under these conditions. However, studies in the United States and Alberta indicate that topsoil usage is very important for successful reclamation (Brown and Chambers 1989). Topsoil is well defined in all jurisdictions reviewed except Alberta, British Columbia, Utah and Wyoming. Without a proper definition, considerable variability in topsoil quality is possible.

Revegetation: General revegetation requirements for each jurisdiction are presented in Table 2.10. All jurisdictions reviewed, except British Columbia, require complete revegetation. Therefore, significant portions of surface disturbances in British Columbia will remain in an unproductive state relative to pre-disturbance conditions. In Alberta and British Columbia, revegetation must simply satisfy the stated post-mining land-use objectives and be self-sustaining. However, in the United States, very specific requirements concerning plant species selection (introduced versus natives), productivity, diversity and wildlife usage are detailed within the regulations. Only New Mexico, Utah and Wyoming have endangered species protection requirements included formally in the reclamation planning and permitting process. Specific mention of native species use is made as well as references to plant succession (Table 2.11). Utah has the most rigorous requirements with respect to revegetation. The absence of native species
TABLE 2.10 REVEGETATION - GENERAL VEGETATION REQUIREMENTS OF SELECTED JURISDICTIONS IN THE MOUNTAINOUS COAL PRODUCING REGIONS OF THE WESTERN UNITED STATES AND CANADA.

<table>
<thead>
<tr>
<th>JURISDICTION</th>
<th>LEGISLATION</th>
<th>DESCRIPTION</th>
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<tbody>
<tr>
<td>UNITED STATES</td>
<td>30 USC 1265</td>
<td>&quot;ESTABLISH ON THE REGRADED AREAS, AND ALL OTHER LANDS AFFECTED, A DIVERSE, EFFECTIVE AND PERMANENT VEGETATIVE COVER OF THE SAME SEASONAL VARIETY NATIVE TO THE AREA OF LAND TO BE AFFECTED AND CAPABLE OF SELF-REGENERATION AND PLANT SUCCESSION AT LEAST EQUAL IN EXTENT OF COVER TO THE NATURAL VEGETATION OF THE AREA; EXCEPT, THAT INTRODUCED SPECIES MAY BE USED IN THE REVEGETATION PROCESS WHERE DESIRABLE AND NECESSARY TO ACHIEVE THE APPROVED POSTMINING LAND USE PLAN . . .&quot;</td>
</tr>
<tr>
<td>ALASKA</td>
<td>11 AAC 90.451</td>
<td>&quot;(A) THE OPERATOR SHALL ESTABLISH ON ALL AFFECTED LAND, IN ACCORDANCE WITH THE APPROVED PERMIT, A VEGETATION COVER THAT IS (1) DIVERSE, EFFECTIVE AND PERMANENT; (2) COMPRISED OF SPECIES NATIVE TO THE AREA OR OF INTRODUCED SPECIES IF APPROVED BY THE COMMISSIONER AS MEETING THE REQUIREMENTS OF THIS SECTION BASED ON APPROVED FIELD TRIALS; (3) AT LEAST EQUAL IN EXTENT OF COVER TO THE NATURAL VEGETATION OF THE AREA; AND (4) CAPABLE OF ACHIEVING PRODUCTIVITY LEVELS COMPATIBLE WITH THE APPROVED POST-MINING LAND-USE. (B) WHETHER INTRODUCED OR NATIVE, THE RE-ESTABLISHED PLANT SPECIES MUST (1) BE NECESSARY TO ACHIEVE THE APPROVED POST-MINING LAND-USE; (2) HAVE THE SAME SEASONAL CHARACTERISTICS OF GROWTH AS THE ORIGINAL VEGETATION; (3) BE CAPABLE OF STABILIZING THE SOIL SURFACE FROM EROSION AND CAPABLE OF SELF-REGENERATION AND PLANT SUCCESSION; (4) BE COMPATIBLE WITH THE PLANT AND ANIMAL SPECIES OF THE AREA; AND MEET THE REQUIREMENTS OF APPLICABLE STATE AND FEDERAL LAWS AND REGULATIONS REGULATING SEED AND INTRODUCED SPECIES.&quot;</td>
</tr>
<tr>
<td>COLORADO</td>
<td>34-33-120</td>
<td>&quot;ESTABLISH ON THE REGRADED AREAS, AND ALL OTHER LANDS AFFECTED, A DIVERSE, EFFECTIVE, AND PERMANENT VEGETATIVE COVER OF THE SAME SEASONAL VARIETY NATIVE TO THE AREA OF LAND TO BE AFFECTED AND CAPABLE OF SELF-REGENERATION AND PLANT SUCCESSION AT LEAST EQUAL IN EXTENT OF COVER TO THE NATURAL VEGETATION OF THE AREA; EXCEPT THAT INTRODUCED SPECIES MAY BE USED IN THE REVEGETATION PROCESS WHERE DESIRABLE AND NECESSARY TO ACHIEVE THE POST-MINING LAND-USE SPECIFIED IN THE APPROVED RECLAMATION PLAN . . .&quot;</td>
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MONTANA 26.4.711
"A DIVERSE, EFFECTIVE, AND PERMANENT VEGETATIVE COVER OF THE SAME SEASONAL VARIETY NATIVE TO THE AREA OF LAND TO BE AFFECTED AND CAPABLE OF MEETING THE CRITERIA SET FORTH IN 82-4-233 SHALL BE ESTABLISHED ON ALL AREAS OF LAND AFFECTED EXCEPT WATER AREAS AND SURFACE AREA OF ROADS THAT ARE APPROVED AS A PART OF THE POST-MINING LAND-USE. VEGETATIVE COVER WILL BE CONSIDERED OF THE SAME SEASONAL VARIETY WHEN IT CONSISTS OF A MIXTURE OF SPECIES OF EQUAL OR SUPERIOR UTILITY WHEN COMPARED WITH THE NATURAL VEGETATION DURING EACH SEASON OF THE YEAR."

NEW MEXICO 20.111
"EACH PERSON WHO CONDUCTS SURFACE COAL MINING OPERATIONS SHALL ESTABLISH ON ALL AFFECTED LAND A DIVERSE, EFFECTIVE, AND PERMANENT VEGETATIVE COVER OF THE SAME ASPECTION NATIVE TO THE AREA OF DISTURBED LAND OR SPECIES THAT SUPPORTS THE APPROVED POST-MINING LAND-USE. ALL REVEGETATION SHALL BE IN COMPLIANCE WITH THE PLANS . . . AS APPROVED BY THE DIRECTOR IN THE PERMIT, AND CARRIED OUT IN A MANNER THAT ENCOURAGES A PROMPT VEGETATIVE COVER AND RECOVERY OF PRODUCTIVITY LEVELS COMPATIBLE WITH THE APPROVED POST-MINING LAND-USE."

UTAH R645 - 301, 353.100 - 353.250
"THE PERMITTEE WILL ESTABLISH ON REGRADED AREAS AND ON ALL OTHER DISTURBED AREAS, EXCEPT WATER AREAS AND SURFACE AREAS OF ROADS THAT ARE APPROVED AS PART OF THE POST MINING LAND USE, A VEGETATIVE COVER THAT IS IN ACCORDANCE WITH THE APPROVED PERMIT AND RECLAMATION PLAN. THE VEGETATIVE COVER WILL BE: DIVERSE, EFFECTIVE AND PERMANENT; COMPRISED OF SPECIES NATIVE TO THE AREA, OR OF INTRODUCED SPECIES WHERE DESIRABLE AND NECESSARY TO ACHIEVE THE APPROVED POST-MINING LAND-USE AND APPROVED BY THE DIVISION; AT LEAST EQUAL IN EXTENT OF COVER TO THE NATURAL VEGETATION OF THE AREA; AND CAPABLE OF STABILIZING THE SOIL SURFACE FROM EROSION. THE ESTABLISHED PLANT SPECIES WILL: BE COMPATIBLE WITH THE APPROVED POST-MINING LAND-USE; HAVE THE SAME SEASONAL CHARACTERISTICS OF GROWTH AS THE ORIGINAL VEGETATION; BE CAPABLE OF SELF-REGENERATION AND PLANT SUCCESSION; BE COMPATIBLE WITH THE PLANT AND ANIMAL SPECIES OF THE AREA; AND MEET THE REQUIREMENTS OF APPLICABLE UTAH AND FEDERAL SEED, POISONOUS AND NOXIOUS PLANT; AND INTRODUCED SPECIES LAWS OR REGULATIONS.

WYOMING SEC. 2 (D)(1)
"THE OPERATOR SHALL ESTABLISH ON ALL AFFECTED LANDS A DIVERSE, PERMANENT VEGETATIVE COVER OF THE SAME SEASONAL VARIETY NATIVE TO THE AREA OR A MIXTURE OF SPECIES THAT WILL SUPPORT THE APPROVED POST-MINING LAND-USE."

CANADA

ALBERTA 39 (2-9 4.1)
"AS SOON AS POSSIBLE FOLLOWING CONTOURING AND SOIL REPLACEMENT, VEGETATION MUST BE ESTABLISHED ON THE DISTURBED LAND. REVEGETATION AND LAND MANAGEMENT MUST SUPPORT THE APPROVED POST-DEVELOPMENT LAND CAPABILITY, PROVIDE FOR WATERSHED MAINTENANCE AND PROTECTION; CONTROL WIND AND WATER EROSION; PREVENT AND CONTROL WEEDS"
AND PESTS; AND IMPROVE SOIL CONDITIONS. THE LAND MUST BE MAINTAINED AND MANAGED UNTIL A RECLAMATION CERTIFICATE IS ISSUED."

BRITISH COLUMBIA

"LAND SHALL BE REVEGETATED TO A SELF-SUSTAINING STATE USING APPROPRIATE PLANT SPECIES."

SEE TABLE 2.1 FOR REFERENCES.
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<th>DESCRIPTION</th>
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<th>UNITED STATES</th>
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<td></td>
<td>ALBERTA</td>
<td>BRITISH</td>
</tr>
<tr>
<td>1. USE OF INTRODUCED SPECIES IN Revegetation</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>2. USE OF NATIVE (INDIGENOUS) SPECIES IN Revegetation</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>3. SELECTION OF SPECIES FOR WILDLIFE</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>4. TIMING OF SEEDING AND PLANTING</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>5. COVER CROPS AND MULCHES</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>6. METHOD(S) OF Revegetation</td>
<td>+</td>
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**KEY**: (+) - REQUIRED; ( ) - NOT REQUIRED.
requirements in the Canadian jurisdictions may be due to participant ethos (government and industry) with regard to the benefits versus costs of native species use, of re-establishing biodiversity and of re-creating a functioning ecosystem (Chapter 4). The United States regulatory requirements approach ecological rehabilitation (restoration) in extent but not in intent when compared to the Canadian jurisdictions reviewed. Although more costly, the American approach is more likely to achieve stated end land-use objectives under low maintenance than those of the Canadian jurisdictions, particularly in the absence of appropriate monitoring.

**Performance Standards**

The selected jurisdictions have performance standards that function as guidelines. The standards are found both in statutes and in the regulations in the United States jurisdictions studied while standards are only included in the regulations or guidelines in the Canadian jurisdictions. The performance standards are variable and contain few ecosystem-based requirements.

The United States performance standards included in the SMCRA and subsequent state regulations have resulted in 'technological forcing.' In this situation, industry has been forced to respond to stringent regulations. By contrast, a more consultative process has been part of the performance criteria development in both Alberta and British Columbia.

Evaluation of reclamation success within the jurisdictions reviewed is variable, but all embrace two of the four components outlined by Ries and Hoffman (1984a): (1)
selection of post-mining land-use, (2) description of desirable reclaimed landscape characters, (3) standards for comparison and (4) methods of evaluation.

Current technological reclamation research has developed due to the enactment of legislation designed specifically to establish and enforce minimum standards of reclamation. The importance of a detached authority of objectively justifiable standards is fundamental to the reclamation regulatory process. Performance standards and requirements are the regulatory instruments used to indicate reclamation success or failure and to ensure that long-term environmental degradation is minimized or eliminated. However, often the objectives for ecosystem re-creation are ill-defined and criteria for evaluating alternative management practices poorly articulated. Specification of clear and concise measurement criteria are essential for evaluation of alternative reclamation approaches and subsequent bond release.

Surface mining is a temporarily exclusive land-use and determination of post-mining land-use objectives is the first step in evaluating reclamation success (Stott 1992). In all jurisdictions, temporary land-use is implicit and reclamation to an equivalent or 'higher' (anthropocentric) level of land-use is a requirement. The equivalency requirement varies from a very strict definition of equal productivity (SMCRA) to equivalent capability. Equivalency is either reclamation-based, as in the Alberta system, or is restoration-based, as in the United States. The Alberta system involves 'equivalent capability' in the form of a return to pre-disturbance landforms and soil productivity whereas the United States goes further in their biotic requirements (cover, biomass and species diversity) and the use of reference areas. SMCRA standards for determining
successful revegetation of mined lands require that both cover and production of living plants on revegetated areas shall not be less than 90% of a reference area or some other standard approved by the regulatory authority. The British Columbia regulatory requirements embrace both land capability as well as equivalent productivity, but the concepts are ill-defined and vague, much like those in the United Kingdom (Holmberg 1983).

Three approaches to equivalent or higher land-use have been categorized previously: (1) productivity approach (2) capability approach and (3) functional analysis approach (Fedkenheuer et al. 1987).

**Equivalent Productivity Approach:** The productivity approach has been based traditionally upon biomass production with concerns regarding soil or land productivity often incorrectly considered subordinate (Fedkenheuer et al. 1987). Regardless of interpretation, the equivalent productivity requirement is a complex issue which cannot be dissociated easily from the other performance criteria of self-sustaining vegetation cover and post-mining land-use objectives. Much of the equivalent productivity requirement is concerned with the ability of the post-mine landscape (growing media and topography) to support a specified land-use. However, predicting post-mining soil productivity levels is difficult because the reclaimed landscape contains neo-sols with unknown production potential and significant within- and between-landscape heterogeneity (Burley et al. 1989)

Nevertheless, the productivity approach is predicated on the assumption that vegetation is an integrative indicator of ecosystem performance and requires measurements of
selected vegetation performance indices such as biomass, cover, diversity and forage quality (Howard and Regele 1984). Although these indices are relatively simple to measure, they may not reflect how well an ecosystem is progressing towards nutrient self-sufficiency since these indices are poor indicators of soil quality (Bonham 1989). Frequently, high productivity as measured by above-ground phytomass may indicate poor nutrient-use efficiency (Ziemkiewicz 1979). Furthermore, the interpretation of productivity varies with the perspective and attitude of the individual (total above-ground phytomass versus usable forage) and is often dependent upon land-use objectives (Lang 1982).

In British Columbia, the average property basis requirement, as described in Part 10.6.4 of the Health, Reclamation and Safety Code, represents a variant of the general concept of equivalent productivity and poses severe methodological problems because of differing biomass allocation patterns in different ecosystems. Both above- and below-ground productivity must be determined when comparing high and low elevation habitats, but these data are not collected generally. Moreover, productivity measurements are inadequate or not completed during mine pre-development assessments (Chapter 3); therefore, references to which comparisons can be made for post-mining landscapes are invalid.

Maximizing productivity on favorable sites in order to offset productivity losses on unfavorable terrain causes reclamation practitioners to misdirect management practices toward high standing crop production and toward viewscapes developed with a
preoccupation towards verdancy. Such practices are often imical to important belowground nutrient cycling processes (Fyles et al. 1985, Ziemkiewicz and Takyi 1990).

Equivalent Capability Approach: The capability approach is utilitarian and demonstrably more anthropocentric than either the productivity or functional ecosystem approaches. The concept is based on a qualitative evaluation of biophysical attributes (topographic and edaphic) of the reclaimed landscape to meet stated land-use objectives.

The Alberta regulations utilize the concept of equivalent capability, a concept which is similar to the utilitarian land capability approach developed by Murdoch (1980) and implemented by Schuman et al. (1990). The critical features of capability are landscape form (primarily slope), drainage, and soil quality and quantity. In general, this approach adopts the view that the percentage of land in a given capability class prior to disturbance should be returned following mining. This concept is consistent with the practice of assessing pre-mining land-use capabilities using the CLI. Pre-disturbance 'productivity' is assessed indirectly through the biophysical approach of the CLI system. CLI provides resource (forestry, wildlife, agriculture) capability classes (low to high) for components of the landscape. However, the approach has limitations in that it lacks quantitative measurements and is not suitable for site-specific measurements.

Functional Analysis Approach: The functional analysis approach utilizes a number of parameters which are indicative of ecosystem functioning and is comparable to the method described by Munshower and Fisher (1984). The functional approach is based on the concept of a functional dynamic ecosystem in which the success of reclamation
practices is evaluated on the basis of efficient linkages between above-ground processes (primary production) and below-ground processes (organic matter decomposition and nutrient cycling). The functional analysis approach requires a hierarchical assessment program involving landscape, ecosystem, community and population level monitoring.

**Combination Approach:** Performance standards should focus on construction specifications derived from pre-mining conditions and involve two stages: (1) landshaping and soil reconstruction and (2) long-term ecological stability (Ferchau 1988).

Therefore, a two-stage combination approach is proposed in which the first stage focuses on the re-creation of negotiated landform modifications which may or may not provide the ‘habitat templates’ (*sensu* Southwood 1988) necessary for achieving pre-mining productivity or equivalent land capability. During this stage, measurement of topographic and soil properties would characterize capability or land-use potential independent of plant growth, and if acceptable, would result in partial bond release. The first stage of this approach embraces elements of both the capability and productivity approaches described previously whereas the second stage represents essentially the functional ecosystem approach.

Data collected during the second stage would be used to evaluate the functional capacity of the developing ecosystem and the trend towards metastability. Final bond release would only be permitted following a satisfactory evaluation of the monitoring
time series. A proposed integrated reclamation planning, monitoring and bond release flowchart is presented in Figure 2.2

Implicit within such a system is the assumption that surface mining should not proceed in areas where short-term environmental depredation or alternative reclamation endpoints are unacceptable. Some areas should not be disturbed because they are prime wildlife or wilderness lands, and alternative management options are inappropriate, whereas in other areas, appropriate reclamation technology is unavailable. Examination of the 'rehabilitation potential' (Newton 1993) or calculation of a 'recovery index' (Cairns and Dickson 1977) must be determined initially since the combination approach does not subscribe to 'technological determinism,' a belief system upon which conventional reclamation practice is based (Katz 1992). Moreover, the application of rigorous socioeconomic analyses and the creation of detailed ecological sensitivity maps must be undertaken prior to development since there is considerable flexibility and potential for discretionary abuse by 'sympathetic administrations' within this system.

Regulatory provisions for designation of lands as unsuitable for mining are present in variable forms in each of the jurisdictions reviewed. In the United States, Section 522(e) of the SMCRA allows regulatory agencies to designate areas as unsuitable for mining while in Alberta, the Coal Development Policy provides the regulatory control. In British Columbia, a regulatory framework is provided through the Environment and Land Use Act [RSBC 1979 c110]. However, the process in British Columbia may be strengthened by a provincial land-use strategy developed through the Commission on
Figure 2.2 Reclamation monitoring flowchart and regulatory command-penalty model.
Resources and Environment (CORE), the protected areas strategy and a standardized inventory process.

A further requirement of this system is the need for coordinated industry/government longitudinal studies. During the past several years, a number of researchers have concluded that an adequate understanding of ecosystem behavior cannot be derived from short-term studies and planning horizons (Burt 1994). Complex ecosystem phenomena such as episodic events, rare conditions, system inertia, time lags, slow phenomena, cumulative effects, threshold responses and transient dynamics create a latent structure which may require decades of monitoring to separate pattern from noise (Likens 1983). Long-term ecological studies have made important contributions to practical societal problems and the development of theory and are needed to verify models and test predictions (Risser 1991). Unfortunately, long-term studies (>15 years) on mine disturbances are few (Binns 1994).

Although monitoring the trajectory of succession with a more or less indeterminate endpoint is problematic for the mining industry (Inouye 1988), such studies are necessary to characterize the success of reclamation practices in developing ecosystem metastability. Therefore, a monitoring protocol is necessary in which sampling parameters and ‘indicator key areas’ or ‘ecological response units’ (Bonham et al. 1980) are selected jointly by both industry and regulatory agencies. Indicator areas would be representative of the post-mining landscape heterogeneity at each mine site. Thus, a monitoring network of spatially extensive sampling (industry) and intensive sampling (government) sites would be established. Monitoring locations which have
regional importance should be funded by regulatory agencies or joint industry/government organizations to develop consensus on the long-term effects of management practices. Government personnel, academics or consultants must be involved in the information gathering and analysis. Government institutional arrangements which promote long-term studies that span time scales longer than the short-term planning horizons of industry are essential. Regulatory agencies should be responsible for the more technically rigorous basic or applied-basic research, while industry would participate through linked applied studies. Figure 2.3 categorizes the research or monitoring studies which would be funded and undertaken by regulatory agencies and industry.

The long-term studies approach should include more ecologically-based sampling rather than programs developed around corporate self-interest. Review of methodology from the established Long-Term Ecological Research (LTER) program of the United States National Science Foundation described by Magnuson (1990) or that from the proposed Canadian Long-Term Ecological Research Program (CLERP) (Roberts-Pichette 1995) would be valuable in developing a comprehensive reclamation monitoring program.

Government participation and coordination is essential for quality control or continuity in performance monitoring and is also necessary for developing unbiased feedback for the formal negotiated regulatory system. The regulations (particularly performance standards) could then be modified or updated over time in a cooperative manner. In
Figure 2.3 Surface mine reclamation research description and timeline.

<table>
<thead>
<tr>
<th>RESEARCH TIMELINE</th>
<th>RESEARCH DESCRIPTION</th>
<th>PROCESS</th>
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<tbody>
<tr>
<td>Short-Term Studies</td>
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<tr>
<td>(1-5 years)</td>
<td>• Risk Assessment*</td>
<td></td>
</tr>
<tr>
<td><em>Industry, Consultants and/or Academia</em></td>
<td>• Acid Mine Drainage</td>
<td></td>
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<tr>
<td></td>
<td>• Landform Modification and Engineering</td>
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<tr>
<td></td>
<td>• Hydrology, Hydrogeology</td>
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<tr>
<td></td>
<td>• Site Preparation</td>
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<tr>
<td></td>
<td>• Topsoil Placement</td>
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</tr>
<tr>
<td></td>
<td>• Soil Analyses</td>
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<tr>
<td></td>
<td>• Spatial Distribution of Spoil Parameters</td>
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<tr>
<td></td>
<td>• Fertilizer Formulation and Application</td>
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<td></td>
<td>• Species Selection</td>
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<td></td>
<td>• Seeding Rates</td>
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<td>• Direct Seeding Methods</td>
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<td></td>
<td>• Transplant Survival</td>
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<td></td>
<td>• Natural Colonization by Flora and Fauna</td>
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<tr>
<td></td>
<td>• Microclimate</td>
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<td></td>
<td>• Aesthetics</td>
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<tr>
<td>Long-Term or Longitudinal Studies (6-100 years)</td>
<td>• Flora and Fauna Population Dynamics</td>
<td></td>
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<tr>
<td><em>Academia, Government or Consultants</em></td>
<td>• Pedogensis</td>
<td></td>
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<tr>
<td></td>
<td>• Soil Flora and Fauna Dynamics</td>
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<td>• Community and Guild Dynamics</td>
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<td>• Ecosystem Process Dynamics</td>
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<td></td>
<td>• Acid Mine Drainage</td>
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<tr>
<td></td>
<td>• Aesthetics</td>
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</table>

Note: Asterisk denotes atypical reclamation studies.
essence, the approach assumes that reclamation practices and regulations will evolve, and, therefore, it follows the adaptive management approach.

**Reclamation Monitoring and Enforcement**

Performance or compliance monitoring is the feedback mechanism necessary for ensuring that appropriate environmental management standards and decisions are made regarding impact and endpoint predictions on species, populations, ecosystems and landscapes. Lack of enforced monitoring generally results in permit non-compliance due to an absence of corporate incentive (Ostler et al. 1985). Performance monitoring is useful for preventing retrogression and prescribing remedial or aftercare measures (Edgar et al. 1985).

Well-designed and consistently-implemented objective monitoring programs are essential elements of comprehensive mine reclamation planning and regulatory programs without which bond release is subjective, and regulatory accountability is lacking. Vague, ill-defined or ambiguous monitoring methods based on interpreter judgment are subject to opinion and are difficult to replicate or substantiate (Colbert 1992). Clear definitions of measurement parameters, sampling procedures and statistical protocols are essential for reliable monitoring programs (Pratt and Stevens 1992).

Within the jurisdictions reviewed, considerable differences in monitoring and enforcement exist. The monitoring framework of the SMCRA is an important example of legislated standards for evaluating reclamation success. Legislated provisions for
regulatory monitoring, documentation and enforcement are more comprehensive and rigorous in the United States jurisdictions than in either Alberta or British Columbia (Table 2.12). In general, rigorous population-, ecosystem- and landscape-based monitoring is absent in the jurisdictions reviewed. Where described, monitoring reflects a static rather than dynamic view of ecosystems.

Monthly and annual regulatory inspections are part of the statutory requirements in the United States (Table 2.13). Both Alberta and British Columbia rely heavily on the observations and opinions of their reclamation officers or inspectors. Alberta has monthly inspections, but these are not required by legislation. In British Columbia, no reference to regulatory inspections are provided within the reclamation code although annual inspections are normal. In the United States, private individuals may file and request on-site visits at any time during the year. This requirement is important as a follow-up to the formal negotiated system of regulation, particularly with regard to aesthetics.

In the United States, revegetation success is determined through quantitative assessments of pre-disturbance vegetation cover, diversity and production, selection of a reference area representative of the post-mining land-use or another success standard consistent with the pre- and post-mining vegetation cover and productivity. The SMCRA places the assessment of reclamation performance, to a large extent, on the re-establishment of vegetation and emphasizes soil productivity as evaluated indirectly by sustained growth of required plant species.
<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>CANADA</th>
<th>UNITED STATES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ALBERTA</td>
<td>BRITISH COLUMBIA</td>
</tr>
<tr>
<td>1. GROUNDWATER MONITORING</td>
<td>A</td>
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<tr>
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<tr>
<td>3. MONITORING FOR SUBSIDENCE OR SETTLEMENT</td>
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<tr>
<td>4. MONITORING OF SOIL DEVELOPMENT</td>
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<td>A A</td>
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<tr>
<td>- PHYSICAL PROPERTIES</td>
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<td>A A</td>
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<tr>
<td>- CHEMICAL PROPERTIES</td>
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<tr>
<td>- SOIL BIOLOGY</td>
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<tr>
<td>5. MONITORING OF REVEGETATION</td>
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<tr>
<td>- USE OF REFERENCE AREAS</td>
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<td>- VEGETATION PRODUCTION REQUIREMENTS</td>
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<tr>
<td>- VEGETATION CANOPY COVER REQUIREMENTS</td>
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<tr>
<td>- PERMANENCE OF VEGETATION</td>
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<tr>
<td>- DIVERSITY OF VEGETATION</td>
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<tr>
<td>- SEASON OF USE</td>
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<tr>
<td>- ANALYSIS OF TOXICITY</td>
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<tr>
<td>- MEASUREMENT STANDARDS FOR TREES AND SHRUBS</td>
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</tbody>
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**KEY:** (A) - QUANTITATIVE DATA; (B) - QUALITATIVE DATA; (C) - ANECDOTAL; (D) - ILL-DEFINED REQUIREMENT; ( ) - NO REQUIREMENT.
TABLE 2.13 REGULATORY RECLAMATION ENFORCEMENT IN SELECTED JURISDICTIONS OF THE MOUNTAINOUS COAL PRODUCING REGIONS IN THE WESTERN UNITED STATES AND CANADA.

<table>
<thead>
<tr>
<th>RECLAMATION ENFORCEMENT</th>
<th>CANADA</th>
<th>UNITED STATES</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>ALBERTA</td>
<td>BRITISH COLUMBIA</td>
</tr>
<tr>
<td>1. ANNUAL RECLAMATION REPORT</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>2. ADEQUATE DOCUMENTATION (RECLAMATION DATA BASE)</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>3. REGULATORY INSPECTIONS (ON-SITE)</td>
<td></td>
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</tr>
<tr>
<td>MONTHLY (PARTIAL)</td>
<td></td>
<td></td>
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<tr>
<td>ANNUAL</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>4. CITIZENS REQUEST FOR INSPECTION</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>5. REVIEW OF ADEQUACY AND COMPLETENESS OF INSPECTIONS</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>6. REVIEW OF DECISION</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>7. INFORMATION AVAILABLE TO PUBLIC (LOCAL RESIDENTS OF AREAS OF MINING)</td>
<td>+</td>
<td>+</td>
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<tr>
<td>8. PERMIT REVISIONS</td>
<td>+</td>
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KEY: (+) - REQUIRED; ( ) - NOT REQUIRED
Reference areas are used in the United States as targets for measuring reclamation performance, and as general objectives, they have merit. However, the restrictive use of reference areas in the United States reflects the latent bias in the coal regulatory program of favoring establishing revegetation success criteria in terms of pre-mining baseline conditions. Parameters such as vegetation cover, plant species diversity and productivity must be determined quantitatively and compared with reference areas (Buckner 1989). The reference areas or remnant patches must be representations of the abiotic and biotic conditions and must have a minimal area in order to withstand natural as well as anthropogenic perturbation. The use of reference areas and their variants (extended reference areas, control areas, historical records, technical references) as a method of equivalency comparison for reclaimed land productivity levels is inflexible, expensive, and precludes the creation and evaluation of mined-land ecosystems that are different from those present originally (Doll and Wollenhaupt 1985). Furthermore, ecosystem comparisons of early successional post-mining landscapes with that of climax or late seral ecosystems lacks scientific validity (Cairns 1983). Moreover, hypothetical ‘target communities’ may be structurally or functionally similar yet dissimilar in species composition (Tausch et al. 1993). Essentially, the reference area concept does not recognize the fact that there are different functional processes in pre-disturbance and reclaimed landscapes.

In Alberta, a formal performance review is negotiated as part of the reclamation permit with specific quantifiable objectives such as landform shape, soil depth and vegetation growth. Although qualitative descriptions are in place for evaluating site preparation
performance in Alberta, monitoring methodology for long-term ecosystem stability has not been specified. Criteria for certification varies with the time of surface disturbance initiation and coincides with legislative chronology. The appointed reclamation officer judges that the reclaimed disturbance has the required biophysical characteristics for the return of 'equivalent capability.' Compliance with requirements of the Development and Reclamation Plan is monitored through regular inspections and review of the annual report. Reclamation officers are responsible for the issuance of reclamation certificates (Lulman 1987).

Formal and standardized monitoring procedures also are not included within the British Columbia code although general reporting requirements are stated. Mining companies in British Columbia must demonstrate that the revegetation is permanent, equivalent in productivity (average property basis) and satisfies land-use objectives. However, monitoring methodology is discretionary and often anecdotal. The absence of a formalized description of monitoring requirements in British Columbia makes performance justification during the bond release period difficult.

The dedication to empiricism as reflected in the performance standards and the frequency of regulatory inspections within the United States jurisdictions provides for very detailed monitoring of reclamation performance. In the United States, reclamation performance is recorded within general reports rather than a specific reclamation documents whereas both Alberta and British Columbia have specific annual reclamation report requirements. However, the detail and quality of information contained within these documents is not regulated rigorously, and therefore, may be suspect. The
monitoring requirements in Alberta and British Columbia are set at the development and reclamation approval and permit stages respectively although they can be revised. In light of the weak performance requirements of other aspects of reclamation regulation in British Columbia, these permits are unlikely to contain adequate prescriptions unless specific requirements are included.

Finally, reclamation monitoring and reporting imposes costs to both industry and government. The amount of these costs varies with the magnitude and extent of regulations. Government and industry costs, as reflected by regulatory requirements, are significant in both the United States and Alberta but much less so in British Columbia. However, the ad hoc nature of reclamation regulation in British Columbia imposes an indirect cost in the form of inconsistency in standards and enforcement as well as a potential loss of effectiveness in the pursuit of reclamation objectives.

Proposed Monitoring Program: Although the monitoring requirements of the SMCRA ‘embrace’ more ecologically-based concepts than those in the Canadian jurisdictions reviewed, the United States program is still not considered comprehensive enough to assess reclamation success adequately (Chambers and Wade 1992). Reclaimed system attributes used to evaluate long-term reclamation success generally include only those related to vegetation structure such as tree or shrub density, percent cover or biomass of herbaceous species or species diversity, but these parameters may not provide a reliable indication of actual successional trajectories (Kleinman 1984). In the United States, measurements of reclamation success such as diversity, phenology, stability, and production (SMCRA Sec 515 paragraph 19) characterize community-level
processes and refer to important ecological concepts. However, there are a number of structural and functional attributes of reclaimed communities for which measurements are not required. The holocoenotic nature of the plant community must be considered in the context of restoration and recovery processes. An understanding of the scale-dependency of ecological systems is important, particularly with respect to ecological monitoring.

Aronson et al. (1993) expanded the concept of ‘vital attributes’ posited by Noble and Slatyer (1980) to include ‘vital ecosystem attributes,’ and it is this ‘functional approach’ which should be adopted in long-term successional trend monitoring of post-mining landscapes. Although several authors have described discipline-specific monitoring procedures and protocols (Vogel 1987, Chambers et al. 1992, Allen and Friese 1992), an integrated hierarchical monitoring program which includes all abiotic and biotic components has not been described previously. The following desideratum represents an attempt to provide a comprehensive, ecologically-based successional monitoring program for reclamation practitioners and regulators. The monitoring program differs significantly from other proposed or implemented because it transcends disciplinary boundaries. Figure 2.4 describes an overall reclamation planning, implementation and performance monitoring flowchart in which proposed monitoring requirements are integrated. Only through the application of a well designed, holistic and empirically-based monitoring program will there be a re-direction away from the static short-term view of reclamation.
Figure 2.4 Reclamation planning, implementation and performance monitoring flowchart.

**Phase 1**
- Baseline Inventory (EIS)
  - Considerations
    - Ecological
    - Economic
    - Sociopolitical
- Constraints/Opportunities
- Formulation of Ecological Goals
- Land Use Objectives
  - Land Use Objectives
  - Equivalent Productivity
  - Equivalent Capability
  - Suitability
- Landscape Design (Operational Working Plans)
- Development of Amelioration Treatments (Fertilizer and Amendments)
- Development of Seeding and Planting Mixtures

**Phase 2**
- Engineering and Site Preparation
- Seed and Fertilizer Application
- Reclamation Monitoring

**Phase 3**
- Succession Management (Aftercare)
- Successful Reclamation
- Bond Release and/or Certification

**Monitoring Requirements**
- Temporal Dynamics of Soil Chemical and Physical Properties
- Soil Biology and Biochemistry
- Plant Species Abundance, Productivity, Diversity and Population Temporal Dynamics
- Invertebrate and Vertebrate Population Establishment and Habitat Development
- Ecosystem Spatial Dynamics
In the past, static performance or ‘snapshot’ monitoring has been the norm, but this approach does not provide an accurate representation of reclamation success of dynamic systems (Tyson 1984). Monitoring should be more concerned with trends. Therefore, the proposed monitoring program focuses on the trajectory or dynamics of successional development rather than on the end-product. The monitoring focuses on the ‘products’ of successional progression (e.g., percent cover, abundance, biomass, invertebrate species richness, soil C/N ratios, percent soil nitrogen, microbial biomass, microbial activity, et cetera) recorded at specific sampling intervals over several years. When examined, the result is a trend of succession ‘products’ indicating progression or retrogression. Detailed sampling parameters, research design, analysis and presentation format should be outlined in guidelines and operational field handbooks.

Detailed and comprehensive ecological monitoring and analytical procedures included as part of an improved reclamation guidelines program would empower reclamation practitioners, require ‘environmental due diligence’ on the part of mining companies and lead to higher professionalism and more consistent reporting. Although such a comprehensive monitoring program would result in ecologically-based reclamation practices, even if adopted, significant differences between jurisdictions would continue due to the methods of mining and the amount of the post-mining landscape excluded from rehabilitation. The approach would also result in a longer period of corporate responsibility (> 20 years), particularly at higher elevation and higher latitudes but would reduce the long-term financial liability to the public and minimize environmental degradation.
Vegetation Monitoring: Since vegetation is an integral component of soil stabilization and water quality, revegetation success monitoring following initial plant establishment is essential (Smith and Chambers 1993). Inferred successional trends (floristics and structure) are useful in understanding processes and in predicting outcomes necessary for regulatory enforcement and bond release (Keammerer 1989).

In many cases, patterns of successional change (inferred successional trends) must be made from vegetation chronosequences or space-for-time-substitutions (SFTs). Where such an approach is necessary, two caveats must be described. First, appropriate site preparation and revegetation techniques information must be provided since unreliable or inaccurate historical documentation can lead to erroneous conclusions regarding reclamation success. Second, altered mining practices may introduce confounding effects which may affect the interpretation of surface mine disturbance chronosequences (SFTs) as relatively straightforward examples of primary succession (Riley 1977).

No single vegetation parameter (e.g., percent cover, abundance, density, biomass) provides the best index of the vegetation condition, so collection of many types of vegetation data is necessary to detect spatio-temporal changes in vegetation.

The concepts of diversity and species composition are embodied in the legislation of coal mines in both the United States and United Kingdom (Palmer 1992) but are considered superfluous to reclamation programs in Alberta and British Columbia. However, all forms of biological diversity (alpha, beta and gamma) are important for ensuring reclamation success. The lack of focus on diversity demonstrates clearly
ignorance of ecosystem concepts such as stability and resilience and the role of ‘keystone species’ (Bond 1993) in ecosystem functioning.

Although, high levels of diversity can seldom be replicated economically on mined land, a functional diversity that includes species with different life forms and phenologies can be achieved. Recent research has shown that taxa may not be reliable units for quantifying ecological diversity (Wayne and Bazzaz 1991). Consequently, several authors have suggested that the functional group concept (species grouped by perceived similar effects on the ecosystem) may be the most appropriate method of assessing diversity (Körner 1993, Lawton and Brown 1993). The taxonomic approach to diversity is more concerned with phytocoenoses whereas the functional group is more inclusive and focused on biogeocoenoses. The functional group approach to diversity has benefits to both ecosystem reconstruction and monitoring of mine reclamation because it provides a pragmatic to approach species selection and performance monitoring. In addition, taxonomic (richness) and structural (patchiness and vertical distribution) diversity are both important considerations for reclamation and can be used to monitor the success of rehabilitation as habitat for fauna and the probability of colonization by desired animal species. Functional and structural diversity data collection and analysis should be formalized within all the jurisdictions reviewed.

Soil Microbiology Monitoring: The development of sustainable post-mining ecosystems is contingent upon the development of a series of ecosystem indicators which incorporate various spatio-temporal scales. A serious omission in many current evaluations of reclamation success is the absence of soil (physical, chemical and
biological) assessments (Allen and Friese 1992). In the past, reclamation success has been based upon annual measurements of vegetation coverage and productivity and has disregarded sub-surface components of the ecosystem that are indicative of the long-term consequences of successional management. Assessment of measures of ecosystem structure and function are needed to direct and assess the degree to which a rehabilitated site has developed a suitably complex and stable biotic community.

Measurement of soil physical properties such as *moisture* and *texture* and chemical properties such as total *nitrogen* and percent *organic carbon*, although sensitive measures of *pedogenesis*, are unable to provide an accurate summary of changes in restoration schemes (Harris and Birch 1990). However, indications of potential long-term vegetation productivity, successional trajectories and ecological functioning of such reclaimed landscapes may be provided when these parameters are used in conjunction with biological indices.

Measurements of functional capacity such as nutrient cycling are essential for measuring system dynamics. Several parameters have been used in the past to assess redevelopment of microbial activity in reclaimed mine soils; however, researchers now believe that soil biological parameters such as *microbial biomass*, *microbial activity*, microbial biomass to total carbon and *mycorrhizal* infection types and rates are the most important indicators of reclamation success (Ruzek 1994). Linkages between microbial activity and organic matter production provide the best approximation of overall system recovery while, at the microbial community level, species abundance distributions and the *annual variability (AV)* community descriptor provide the most
complete assessment of short- and long-term recovery rates in community structure and
stability (Zak et al. 1992).

Although a number of the aforementioned soil microbial sampling techniques require
considerable investment in time and expertise, once equipment is obtained and protocols
established, these methods should provide efficient short- and long-term monitoring of
reclamation success.

Invertebrate Monitoring: Animals perform important functions in ecosystem
restoration. Both vertebrates and invertebrates can be useful indicators of
developmental ecosystem status because like plants, their life cycles integrate a wide
variety of abiotic (site conditions) and biotic (host specificity) variables (Louda 1988).

Although studies which examine vertebrate community structure on reclaimed land can
provide important successional progression information, monitoring of rodent or
ungulate populations is problematic due to sample size and data interpretation problems
associated with large home ranges (Parmenter and MacMahon 1992). In contrast,
invertebrate population monitoring, primarily arthropods, can provide reliable data
with which to predict successional trajectories and evaluate reclamation success
(Chapin et al. 1992). As an alternative to existing non-holistic approaches, faunal
community development (trophic organization, species dominance hierarchies, guild
apportionments, population demographics and species turnover rates) should be used to
assess reclamation performance. Assemblages of taxa would be selected and monitored
as indicators of functional groups that influence ecosystem processes. Appropriate
groups or trophic guilds should include pollinators, dispersers, herbivores, granivores, predators, parasites and detritivores.

Relative abundances of these indicator assemblages can then be compared between sites to evaluate establishment and maintenance of processes and can be linked spatially to other levels in the monitoring hierarchy through georeferencing.

Vertebrate Habitat Monitoring: A majority of surface mines have wildlife habitat development as a post-mining land-use objective, but in the past, it has been difficult to establish and evaluate performance standards for wildlife habitat re-creation (Tomlinson 1984). However, relatively recent computer software developments by the United States Fish and Wildlife Service have provided programs which can generate habitat-type suitability indices for reclamation planning and for the evaluation of ecological performance of reclaimed lands (Rhodes et al. 1983). A slight modification of this program is proposed wherein monitoring data would be collected in several 'target years' and then integrated with GIS technology through software such as RAMAS/GIS to provide trend analysis monitoring.

Landscape Monitoring: Every surface mine creates a variety of land perturbations (exploration and access roads, haul roads, pits, adits, overburden and spoil dumps, tailings ponds, administrative areas); therefore, any holistic assessment or index of reclamation success must consider, explicitly or implicitly, landscape processes important in establishing and maintaining ecological systems. Patch shapes interdigitate with adjacent patch shapes and interact significantly with the orientation of directional forces in the landscape (Hardt and Forman 1989). Temporal changes in landscape
include: (1) patch number, (2) patch size (3) number and type of corridors (4) number and type of dispersal barriers and (5) probability and spread of disturbance. Examination of patch boundaries would provide a method of determining which elements (patches) or ecotesserae are expanding (convex) and which patches are relicts or diminishing (concave) in size.

Researchers have described methods for monitoring vegetation on disturbed lands by remote sensing (Grip and Bakken 1986, Allum and Dreisinger 1987). In particular, remote sensing techniques which are integrated with GIS technology and coupled with landscape ecology principles can improve greatly the reclamation monitoring process. Analysis of aerial photographs (1:10,000) can reveal temporal changes in vegetation spatial patterns (Game et al. 1982) and rates and frequency of change along different successional pathways (Lowell 1991). Franklin et al. (1994) have also demonstrated the value of mapping with satellite imagery (Landsat TM and Spot HRV) when combined with Digital Elevation Modeling (DEM). The effects of distance to seed source and landscape heterogeneity on vegetation succession may also be examined through analysis of aerial photographs (Green et al. 1993). Pixel resolution of 5m² is possible. Remote sensed data combined with GIS analysis and interpretation provides a synoptic view of the reclaimed landscape which can be used to improve management practices. Evaluation of spatial and long-term consequences of mining activities also includes parameters such as patch configuration and size, edge length and their configuration, and disturbance susceptibility. Remote sensed/GIS data, when integrated within the monitoring hierarchy, can perform an important synthetic or synoptic role for
examining and modifying, where necessary, the impacts of reclamation management practices.

**Regulated Professional Participation**

Consultation and cooperation improves the results of reclamation practice. Implicit within both the formal negotiated regulatory system and the proposed combination performance standard approach is the regulated requirement of certified multidisciplinary teams wherein specific discipline participation is dictated by land-use objectives (Table 2.14). Professional certification and codes of conduct are necessary in order to integrate information from a greater number of disciplines and eliminate facile attempts at positional justification. Each discipline has specific contributions to make to the reclamation process (Table 2.15). Currently, none of the jurisdictions reviewed have professional requirements as pre-conditions of participation. Although sound ecological management does not necessarily follow from individual accreditation (certification), such a process, if combined with an ecosystem-based practices code, would eliminate many of the current problems in the jurisdictions reviewed.

Currently, many individuals involved in surface mine reclamation are untrained or inexperienced (Burkhart 1988). Within British Columbia, there is a particular need for training and accreditation of multi-disciplinary professionals to reduce the asymmetric influence of the engineering profession upon the reclamation process. Professional hegemony is divisive and problematic for integrative reclamation practice. In general,
### TABLE 2.14  PARTICIPATION (ACCREDITED INDIVIDUAL) REQUIREMENTS FOR RECLAMATION PLANNING AS DETERMINED BY POST-MINING LAND-USE.

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<td>FORESTRY</td>
<td>RECREATION</td>
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<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
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<tr>
<td>2. BOTANIST (PLANT ECOLOGIST)</td>
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<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>3. FORESTER</td>
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<td></td>
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</tr>
<tr>
<td>4. GEOGRAPHER (GEOMORPHOLOGIST, HYDROLOGIST, AESTHETICIAN)</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
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</tr>
<tr>
<td>6. HORTICULTURALIST</td>
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<tr>
<td>7. LANDSCAPE ARCHITECT</td>
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<tr>
<td>8. LANDSCAPE ECOLOGIST</td>
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<td>9. MINING ENGINEER</td>
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<tr>
<td>10. PEDOLOGIST (AGROLOGIST)</td>
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<td>+</td>
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<tr>
<td>11. ZOOLOGIST (WILDLIFE BIOLOGIST)</td>
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<td>+</td>
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</tr>
</tbody>
</table>

**KEY:** ( ) - NO REQUIREMENT, (+) - REQUIRED PARTICIPATION.
<table>
<thead>
<tr>
<th>DISCIPLINE</th>
<th>INFORMATION CONTRIBUTION</th>
</tr>
</thead>
</table>
| AGRICULTURE / HORTICULTURE    | - AGRONOMIC SPECIES SELECTION  
                               | - SEED COLLECTION, PROCESSING AND STORAGE TECHNOLOGY  
                               | - TRANSPLANT STOCK PRODUCTION TECHNIQUES           |
| BOTANY (PLANT ECOLOGY)        | - SPECIES ECOPHYSIOLOGY (AUTECOLOGY)  
                               | - SYNECOLOGY  
                               | - POPULATION BIOLOGY (DEMOGRAPHICS, DYNAMICS, REPRODUCTION)  
                               | - NATIVE SPECIES SELECTION  
                               | - ECOSYSTEM PROCESSES  
                               | - AUTOTROPHIC SUCCESSION   |
| FORESTRY*                     | - LAND-USE PLANNING  
                               | - SILVICULTURAL PRACTICES                           |
| GEOGRAPHY                     | - AESTHETICS  
                               | - CLIMATOLOGY  
                               | - GEOMORPHOLOGY  
                               | - HYDROLOGY  
                               | - RESOURCE MANAGEMENT POLICY AND LAND-USE PLANNING   |
| MINE ENGINEERING             | - LANDFORM DESIGN  
                               | - MATERIAL PLACEMENT DESIGN AND SEQUENCING         |
| LANDSCAPE ARCHITECTURE       | - LANDSCAPE DESIGN  
                               | - TRANSPLANT AND SEEDING PROGRAM DESIGN            |
| LANDSCAPE ECOLOGY            | - LANDSCAPE LEVEL PROCESSES  
                               | - SPATIAL RELATIONSHIPS (FLORA AND FAUNA)           |
| PEDOLOGY (SOIL SCIENCE)      | - CHEMISTRY  
                               | - PHYSICS  
                               | - SOIL BIOLOGY  
                               | - NUTRIENT SUPPLEMENTATION REQUIREMENTS           |
|                               | - GROWING MATERIAL SPATIAL RELATIONSHIPS  
                               | - PEDOGENESIS                                      |
| ZOOLOGY (WILDLIFE BIOLOGY)   | - SPECIES POPULATION BIOLOGY (DEMOGRAPHICS, BEHAVIOR, REPRODUCTION)  
                               | - HABITAT REQUIREMENTS                             |
|                               | - HETEROTROPHIC SUCCESSION                                      |

* THE FORESTRY DISCIPLINE GENERALLY HAS ONLY PERIPHERAL INVOLVEMENT.
engineers do not receive the integrative training necessary for planning landscape/land-use changes.

Therefore, accreditation of reclamation professionals should become a regulatory requirement. The peer-reviewed process would ensure a knowledge-base sufficiency on the part of reclamation practitioners, researchers and consultants (Chapter 4), thereby raising and standardizing the quality of reclamation practice. Without such requirements, there is a tendency for 'regulatory functionaries' to dominate the reclamation process. Regulations and/or codes would be amended to require reclamation planning and program implementation involvement by accredited individuals (registered professionals or otherwise) with minimum requirements of experience and formal training in disciplines relevant to the stated post-mining land-use objectives of each project (Table 2.14).

Although establishing criteria to accredit practitioners with divergent backgrounds is problematic, a program which assigns a rating to the applicant based on education and professional experience can be implemented (Liabastre et al. 1992, Lemons 1994). Certification is currently a subject for debate within the Society for Ecological Restoration (Rieger 1992).

In addition, members of existing applied science or design professions must also be required to take formal environmental training. Reclamation and more general environmental management training for consulting or industry mining engineers should be required by regulation or code. Finally, a practices code with standardized practices and lexicon is necessary for ensuring environmental due diligence and regulatory
compliance. The practices rules would not replace codes of conduct for accredited reclamation professionals who are members of registered professional societies but would simply overlay the existing codes of these professional groups. The development of field guides to accompany the regulations would provide guidance for implementation of regulations and standards. Such guides currently exist within several jurisdictions but these contain dated information and lack an ecosystematic perspective towards reclamation. A formal, yet easily updated system, is necessary.

6. Summary

Legislation, regulations and enforcement are an important driving force behind the protection of the environment and, therefore, provide the contextual basis for all subsequent reclamation decisions and activities described in the accompanying chapters. The systems for regulating surface coal mines in the jurisdictions reviewed are very complex. The United States system is more reliant on statute and regulation than either Alberta or British Columbia. While there is significant programmatic similarity between the jurisdictions reviewed, there are substantive differences in terms of regulatory process, performance standards and enforcement. Several areas for discussion were identified by the review of the regulations and legislation: (1) regulatory process, (2) bonding, (3) planning, (4) regulatory provisions, (5) performance standards, (6) reclamation monitoring and enforcement and regulated occupational participation.

Within the regulatory process, three important concerns were identified: (1) industry/government interaction, (2) regulatory flexibility and (3) information acquisition. Negotiation between government regulators and individual companies is
important in the regulatory process of all jurisdictions reviewed although it is transparent in the formal system of rules embedded within the statutes and regulations. In negotiated regulations, formal empirically-based positional justifications are required.

Flexibility is important in the regulatory process, particularly where there is scientific uncertainty. However, regulatory flexibility also has negative side effects, especially when dealing with sympathetic administrations. Appropriate mechanisms to address variance requests are present in most jurisdictions, but where absent, 'agency capture' is possible.

Information acquisition is essential for the development of reclamation theory and practice. Within the jurisdictions reviewed, approaches to information acquisition are determined by regulatory approaches. Three models were identified: (1) government, (2) industry and (3) combination. The government and combination models are superior to the industry-based approach because of the ad hoc nature of information collection and questionable technical competence of the industry personnel. Government-industry coordinated research is favored strongly by survey respondents (Chapter 4).

In each of the jurisdictions reviewed, land-use provisions require the post-mining landscape to have either 'equal' or 'better' use. However, where there are minimally enforced requirements, it is better to consider alternative land-uses. Although aesthetics is considered an important component of reclamation programs, formalized planning for aesthetics is only implied in most jurisdictions. Amendments should be made to the regulatory process to include a formalized process for incorporating
landscape aesthetics in both the planning and monitoring phases of reclamation regulation. Congruence or fittingness of the reclaimed landscape with the surrounding undisturbed landscape would be the main decision criterion.

All of the jurisdictions reviewed have provisions or requirements regulating topographic and hydrologic modifications, suitable growth materials and revegetation. These provisions influence the achievement of land-use objectives significantly. Where provision requirements are relatively lax, it is difficult to reconcile stated land-use objectives and sustainable development with actual reclamation practice.

Evaluation of reclamation success is an important part of the regulatory process. However, some of the jurisdictions have poorly described or inadequate requirements while others have unrealistic requirements. Therefore, a combination approach to reclamation success is proposed which integrates the capability and functional analysis approaches described previously. The proposed process better integrates also with the phased bond release process that addresses the mining industry’s financial concerns.

Performance or compliance monitoring is the feedback mechanism necessary for ensuring reclamation success. However, monitoring programs in the jurisdictions need to include more ecological variables than are sampled currently and over a longer period of time. Therefore, a long-term, hierarchical ecologically-based monitoring program has been described. Reclamation practices and regulatory control in each jurisdiction would be greatly improved by effective long-term monitoring.

Finally, none of the jurisdictions reviewed have training and experience requirements as pre-conditions of participation. Although sound ecological management does not
necessarily follow from accreditation, regulated participation combined with an ecosystem-based practices code would eliminate many of the current problems.

In general, all jurisdictions need an injection of applied socio-ecological research. Regulations and practices would benefit greatly from an infusion of successional theory, population dynamics, landscape ecology and aesthetics.
1. Introduction

Although reclamation is frequently considered as a separate issue temporally detached from the immediate concerns of the project review process, it is, nevertheless important to be included as part of the Environmental Impact Assessment (EIA) decision-making process (Haigh 1993). Since reclamation of high elevation surface mine disturbances is difficult and successful reclamation not a certainty, the time to assess and minimize the risk of unsuccessful reclamation is when engineers are developing their conceptual designs (Ripley et al. 1982). As part of a comprehensive environmental program, reclamation potential should receive special consideration in the mine development approval process because landscape reclamation is influenced by, and is influential upon, the social, economic and physical milieu of the mine development surroundings.

Adequate information upon which to base decisions is crucial to the impact assessment and environmental management of surface mines (Maguire 1988). The environmental information collected during the EIA process or feasibility phase is also an asset to the coal development proponent in determining post-mining land-uses for reclamation (Adepoju and Fleming 1987, Carolan 1992).
The primary purpose of this chapter is to examine the information contained in mine-specific EISs and determine its applicability to post-development reclamation planning. The objective of the review is not to comment on the regulatory process but rather to examine the information content of the EISs with specific reference to reclamation planning.

2. Literature Review

Reclamation planning as a component of the mine development review process can be understood best by an examination of the relationship between the conventional views of EIA and environmental management, and that of surface mine reclamation practice. The following text describes this relationship.

Environmental Impact Assessment Process

EIA can be defined as a systematic process whose purpose is to inform decision-makers of the potential effects that a program or project might have on the biophysical environment (Rovet 1988). In general, not all projects, and not all impacts of any one project, need to be comprehensively and intensively examined but rather only those poorly understood or important to decision-making (Moore and Mills 1977). However, the completeness of an EIA is often determined by administrative, socio-political and information factors (Hirst 1984b).

EIA can be seen as a ‘planning tool’ and a ‘decision-making model’ that measures the direct and indirect costs of a project in terms of environmental degradation, resource use and social disruption (Mitchell and Turkheim 1977). In general, EIAs are
conducted at the same time as engineering, economic and socio-political assessments (Hollick 1986). Essentially, EIA is an instrument of ‘minimum regret planning’ in which common sense concerns are central (Meredith 1991).

The specific functions of impact assessment are to reduce the frequency of unexpected change, to reduce unexpected and undesirable consequences of developments, and to develop mitigation planning for unavoidable negative changes (Findley 1982). EIAs should include studies of all relevant physical, biological, economic and social factors. Planning and implementation of appropriate mitigation measures for adverse biological impacts represent important activities in the environmental impact process (Canter et al. 1991). Project proponents have discovered over the years that success in securing permits or regulatory approval for projects is often contingent upon the ‘mitigation’ of adverse impacts (Savage 1986). Although not generally discussed in environmental management literature, mine reclamation is a form of mitigation. Within the traditional EIA lexicon, reclamation and monitoring would represent mitigation and post-audit programs, respectively. Reclamation is defined as mitigation according to the United States Council on Environmental Quality (CEQ) (1978) regulations NEPA (40 CFR 1508.20): “... rectifying the impact by repairing, rehabilitating, or restoring the affected environment.”

EIA has been a major force in the broadening of project planning to encompass non-technical and non-economic issues which require interdisciplinary study (Wright and Greene 1987). Similar results have been observed for EIA as part of the mine development review process (Ross and Hunter 1984).
Although there have been positive aspects to EIA, there have been notable problems: (1) the process is reactive rather than pro-active (Buckley 1991), (2) it frequently lacks a scientific basis for impact prediction and management (Duinker and Baskerville 1986), (3) it does not recognize that ecosystems are dynamic (Hirst 1984a), and (4) the process and resultant predictions are often not evaluated systematically (O’Riordan 1986).

Environmental Impact Statement

The EIS is an administrative tool used in most jurisdictions as part of the formal phase of assessment and is the source of information for regulatory decision-making (Wescott 1992). For a project which eventually proceeds, the EIS should aid regulators in the environmental management of the project (Ross 1987). The preparation of EISs involves the assimilation and presentation of salient socio-economic and ecological data from a variety of sources and consequently, considerable time and money is invested. Often, proponents judge such inventories to be efficient by the amount of time they consume rather than by their quality (Buckley and Forbes 1978/1979).

Cairns (1987) has suggested that despite the original intention of EISs requirements, preparation of the reports in the United States has deteriorated into a “ritualized fulfillment of legalized requirements.” Similar complaints have been directed towards EISs in Canada (Mitchell 1989). In general, EISs have been criticized for a lack of discrimination with respect to data collection and an absence of sufficient analysis and interpretation, so they have tended to be encyclopedic and descriptive rather than analytical (Marshall and Wolfe 1985). A lack of standards or guidelines on which to
judge their adequacy has further exacerbated the problem (MacDougall 1975). EISs are also considered to be inadequate scientifically because the institutional framework for EIA was developed without sufficient scientific support; they lack synthesis and are essentially a collection of specialist studies (Robinson 1992). Environmental impact assessment studies are seldom subjected to peer review, and the results rarely appear in the scientific literature (Ellis 1989).

Specific problems associated with impact statements include prevalence of inadequate impact scoping (Kennedy and Ross 1992), unrealistic time constraints and questionable ethics (Schindler 1976), poor research design, analysis and prediction (Bonnicksen and Becker 1983), and too much emphasis on descriptive surveys (Beanlands 1988). In particular, the fauna component of the baseline studies has been criticized (Hilborn and Walters 1981). The physical and biological inventories implemented for EIS preparation are generally qualitative, short-term and segmented, and frequently encourage the qualitative checklist approach to resource inventory. As such, these inventories convey a false sense of ecological stability. Baseline studies of natural ecosystems can and should be used as comparative and predictive instruments rather than as static descriptions of existing conditions (Cairns 1981). However, this is rarely attempted in practice because to do so requires a good understanding of the ecological processes mediating temporal environmental change (Lee 1983).

In addition to the general biophysical inventories and impact information, EISs for mine developments include site-specific reclamation assessments (Vizayakumar and Mohapatra 1989/1990). Pre-mining assessments of reclamation potential should
include attributes of the physical environment which may influence the success of stabilization and revegetation at a given site. To assess reclamation potential, knowledge of hydrology, erosion, geology and climate must be applied to the problems of stabilizing mine waste materials (Snyder and Potter 1981). Assessments of reclamation potential within the EIS document should provide a comprehensive overview because unexpected difficulties and expenses may reduce the benefit-cost ratio of mining as a land-use (Newton 1993).

**Post-audit Program**

The complexity of natural processes means that there will always be a substantial degree of uncertainty in the accuracy of predictions (Ludwig 1993). Monitoring and audits are not only necessary for compliance but also for assessing the performance of mitigation (reclamation plans and techniques). Monitoring is a response to the uncertainty of continued ecosystem functioning when faced with developmental perturbations.

Reliance on the EIS stage to control environmental degradation is simplistic or naïve (Dorney 1989). Although monitoring of the post-development phase has traditionally been considered separate from the EIS phase, this conceptualization has been rejected by Duinker (1985). EIA monitoring procedures should be integrated with environmental protection and development control programs as a method of reducing costs to project proponents while eliminating liabilities for the public. Post-EIS environmental monitoring can also improve the quality of mitigation measures (Canter and Fairchild 1986).
Effects monitoring not only involves a time series of integrated physical/chemical and biotic response measurements in a disturbed area, but also includes adequate pre-disturbance measurements and concomitant measurements in similar areas that will not be disturbed (Hirsch 1980). Although any program involving repetitive measurements of environmental variables can be considered environmental monitoring, comparisons of measured values with compliance standards is not effects monitoring. Such monitoring has been referred to as compliance monitoring or regulatory monitoring (Harvey 1981).

The preferred monitoring approach is dependent, to some extent, upon value judgments and factors that cannot be quantified; therefore, decisions are often based on political processes rather than on quantitative evaluation (Hirst 1984a). Since satisfactory quantitative evaluation methods are virtually impossible, the acceptance of qualitative assessment is necessary (Hollick 1981b). However, optimal sampling for effects should at least include both pre-development and post-development measurements in both disturbed and undisturbed (control) sites (Green 1979).

Most EIA procedures administered by provincial and federal governments in Canada have some form of 'requirement' that monitoring be undertaken following project approval. Yet the formal review mechanisms included within general EIAs usually terminate at the project approval stage (Armour 1988). In contrast, the mine permitting processes in Alberta (ALCRC 1991) and British Columbia (MEMPR/MELP 1992) as well as Ontario (McLellan 1995) have compliance monitoring for air and water quality
as well as effects monitoring for reclamation. Reclamation permit monitoring is essentially a hybrid of effects and compliance monitoring.

**Legislative Requirements of Environmental Assessment for Mine Development**

EIA requirements for coal mine developments in North America are variable. Formally structured EIA is not necessarily a requirement of the coal mine development process in the United States except on federal leases of coal and mineral resources (NEPA) (P.L. 91-190) (USDA 1979a). However, in the United States, many of the requirements under Section [740.13] of the CFR 30 are equivalent to the informational content requirements of EISs in Canada. Since the SMCRA is inclusive of both federal, state and private lands, essentially all proposed coal mine developments in the United States complete EISs. In Canada, federal and provincial regulations set general criteria for the needs of an environmental impact assessment of mining operations and for the reclamation of mine sites.

Currently, the mine development process as implemented in Alberta and British Columbia is a variant of the EIA process; it contains many similarities with the conventional EIA process but has some very specific differences in terms of the recognition of temporally exclusive land-use and in the post-audit follow-up. The legislation governing or related to EIA requirements in Alberta and British Columbia is listed in Table 3.1.

The project review process for mine developments is similar in both Alberta and British Columbia. Regulatory requirements within both jurisdictions include a process in which
### TABLE 3.1 SUMMARY OF LEGISLATION AND GUIDELINES WHICH HAVE BEEN OR ARE APPLICABLE TO ENVIRONMENTAL IMPACT ASSESSMENT IN ALBERTA AND BRITISH COLUMBIA.

<table>
<thead>
<tr>
<th>GOVERNMENT</th>
<th>MINISTER AND MINISTRIES RESPONSIBLE FOR ENVIRONMENTAL IMPACT ASSESSMENT</th>
<th>MAJOR ENVIRONMENTAL ASSESSMENT LEGISLATION/POLICIES</th>
<th>GUIDELINES</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALBERTA</td>
<td>ALBERTA ENVIRONMENT</td>
<td>- ENVIRONMENTAL PROTECTION AND ENHANCEMENT ACT 1992</td>
<td>- ENVIRONMENTAL IMPACT ASSESSMENT GUIDELINES</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- GUIDELINES FOR LAND CONSERVATION AND RECLAMATION IN ALBERTA</td>
<td></td>
</tr>
<tr>
<td>BRITISH COLUMBIA</td>
<td>MINISTRY OF ENVIRONMENT</td>
<td>- ENVIRONMENT AND LAND USE ACT 1979, 1987</td>
<td>- COAL DEVELOPMENT GUIDELINES</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- ENVIRONMENTAL MANAGEMENT ACT 1981, 1989</td>
<td>- GUIDELINES FOR ENVIRONMENTAL IMPACT CONTROL OF DEVELOPMENT ON B.C. CROWN LANDS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- LAND ACT 1979, 1989</td>
<td>- ENVIRONMENTAL AND SOCIAL IMPACT COMPENSATION/MITIGATION GUIDELINES</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- WATER ACT R.S. 1960, 1979, 1988</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>- WASTE MANAGEMENT ACT 1982, 1990</td>
<td></td>
</tr>
<tr>
<td>MINISTRY OF ENERGY, MINES AND PETROLEUM RESOURCES</td>
<td></td>
<td>- COAL MINES REGULATION ACT 1969</td>
<td>- HEALTH, RECLAMATION AND SAFETY CODE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- MINES REGULATION ACT, 1967 (FOR LAND SURFACE RECLAMATION)</td>
<td>- RECLAMATION PERMIT REQUIREMENTS, 1991</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- MINES ACT, S.B.C. 1989 (AMENDMENT)</td>
<td>- GUIDELINES FOR THE DESIGN, CONSTRUCTION, OPERATION AND ABANDONMENT TAILINGS IMPOUNDMENTS, 1983</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- MINE DEVELOPMENT ASSESSMENT ACT 1991</td>
<td>- INVESTIGATION AND DESIGN OF MINE DUMPS (INTERIM GUIDELINES, 1991)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- OPERATION AND MONITORING OF MINE DUMPS (INTERIM GUIDELINES, 1991)</td>
</tr>
</tbody>
</table>
sociopolitical, economical and environmental concerns are addressed in stages (Figure 3.1). Both jurisdictions have important feedback loops for proposal modification. In addition, the input requirements of an EIS in both Alberta and British Columbia are similar and are consistent with the list suggested by McLellan (1981) for aggregate surface mine operations in Ontario.

**Alberta:** In the past, impact assessments in Alberta were conducted at the Minister of the Environment’s discretion under authority conferred by the Land Surface Conservation and Reclamation Act (LCRA) of 1973 (Alberta Environment 1977). However, environmental impact assessments are now required by the omnibus Environmental Protection and Enhancement Act which was promulgated in 1992. In general, the function of the EIA process in Alberta is to provide comprehensive information for the early detection and resolution of potentially adverse environmental effects of proposed resource developments (ALCRC 1991). Once an assessment has been requested, a complex and lengthy review process is undertaken. The review and approval processes provide a mechanism for industry, public and government to interact and develop specific methods for improving reclamation (Bratton 1987).

**British Columbia:** In British Columbia, environmental impact assessments were originally conducted by technical committees appointed by the Environment and Land Use Committee (ELUC). The British Columbia Coal Development Review Process was established by ELUC of Cabinet which was itself established by the Environment and Land Use Act, [RSBC 1979, c110]. In 1976, ELUC established the Guidelines for
Figure 3.1 Mine development assessment model flowchart.
Coal Development and in 1979 the Ministry of Energy, Mines and Petroleum Resources published the Procedures for Obtaining Approval of Metal Mine Developments. Both new mine developments and major expansions of existing mines were subject to review. In the early 1980s, the ELUC secretariat was disbanded and lead agencies (e.g., Ministry of Energy, Mines and Petroleum Resources) were given the responsibility for reviews.

As part of the development review, preliminary impact studies were undertaken by the proponent or consultant(s) before various project development permits, licenses and leases were issued (MABC/MSCCABC 1993). The original process involved a multi-stage procedure based on project size (Crouse 1978). Stage I involved a project description, an environmental inventory and the selection of a preferred alternative. Stage II was the preparation and submission of a detailed EIS. To facilitate decision-making at Stage II, broad regional assessment guidelines were formulated so that a comprehensive matrix of information could be employed with a number of projects. A preferred project design was selected for final design in Stage III. Site-specific impacts and possible mitigation measures or compensation were identified at this stage. Where necessary, compensation was implemented because of a failure to mitigate a particular environmental or social impact. Rehabilitation efforts were then monitored during and following project construction.

In 1991, the Mine Development Review Process (MDRP), in guideline form, was replaced with the Mine Development Assessment Act. Bill 59 formalized the fourteen-year old non-legislated MDRP and provided a legal basis for increased public
consultation within the review process (Searle and Bingham 1991). Under the new act, a mine project proponent needed a ‘mine development certificate’ before commencing construction. The new mine development certificate replaced the ‘approval-in-principle’ in the previous MDRP. Control of the assessment process remained with the Ministry of Energy, Mines and Petroleum Resources, although the minister of Environment, Lands and Parks cosigned the certificate.

However, the mine development review process has been altered again and is now part of a more inclusive impact assessment process. Improved public participation, a ‘one-window’ contact, a single review process and specific timelines are important features of the new legislation (Morgan and Dryden 1993). The Act is administered through the Environmental Assessment Office, a neutral agency within the Ministry of Government Services (Province of British Columbia 1995). In the future, harmonization with the federal legislation (Canadian Environmental Assessment Act) (Sheehan 1994), and specific EIS biophysical inventory and reclamation planning guidelines that are under development (MEMPR 1992) will likely alter the process.

Within the literature reviewed, a consistent pattern was observed. Although the implementation of EIA has improved environmental planning, the entire process has suffered from inadequate impact scoping, incomplete application of ecological principles and a lack of post-development monitoring (O’Riordan 1986). Thus, the problems associated with the general EIA process have been noted with the mine development process as well. However, the role of the EIA process and more specifically, the EIS as a reclamation planning document, has not been studied (Potter...
1986). Most of the EIA related research has been directed towards institutional concerns such as process efficiency and improved public involvement rather than toward technical or methodological concerns (O’Riordan and O’Riordan 1993). The technical basis of the EIS document needs to be examined with specific reference to applicability to reclamation planning. Furthermore, since the greatest potential environmental impact of surface coal mining is the post-mining landscape (Haigh 1993), the importance of ‘reclamation potential’ to project approval or rejection also needs to be examined.

3. Research Objectives

The objective of this chapter is to determine the relevance and utility of the technical information contained within mine development EISs for reclamation planning.

4. Methods

EISs prepared for either new mine projects or mine expansions were identified through personal communication (Errington 1990, Powter 1990, Paul 1991). A computer-retrieved bibliographic search (SCITECH Data Literature Review) was also employed to confirm personal communications. EIS documents were obtained from both the Alberta Environment Library and the British Columbia Ministry of Energy, Mines and Petroleum Resources Library.

A total of 19 new project and/or project expansion EISs were obtained and their environmental information content and applicability to post-development reclamation planning reviewed. The criteria (parameters) examined are those outlined in the
guideline documents for Alberta (ERCB 1978). The parameters are similar in British
Columbia. Because of the project review process, most of the documents reviewed are
referred to as Stage II documents in British Columbia and EISs in Alberta.

Content analysis was chosen as the mechanism of data collection. Vizayakumar and
Mohapatra (1989/1990) used a similar approach in their environmental impact study in
India. Thematic coding (Holsti 1969) was considered appropriate for this form of
research. The content categories were developed through a review process and were
essentially expanded (more detailed components of the parameters described) by Ward

The data collected were qualitative in nature with presence or absence of pre-
determined category codes chosen as the units of measurement. All documents were
read three times after coding and prior to data collection in order to ensure reliability.
Data summarization involved simple tabulations of the presence/absence data.

5. Results

Project Descriptions

Seven EISs were reviewed from Alberta and twelve from British Columbia (Table 3.2).
The documents used are listed in Appendix 3.0. Only two of the Alberta EISs were
new projects whereas eleven of the British Columbia EISs were new. Eleven of the
proposed projects reviewed eventually proceeded to the permitting and operational
phase. Seventeen of the projects reviewed are surface coal mines with the majority
being conventional truck and shovel open pit operations. The sizes of the various
### TABLE 3.2 PROJECT NAMES, LOCATIONS, OWNERSHIPS AND DESCRIPTIONS FOR SUBMITTED EIS IN ALBERTA AND BRITISH COLUMBIA.

<table>
<thead>
<tr>
<th>PROJECT TITLE</th>
<th>PROJECT LOCATION</th>
<th>OWNERSHIP (HEAD OFFICE)</th>
<th>TYPE OF COAL</th>
<th>METHOD OF MINING</th>
<th>PROPOSED CUMULATIVE DISTURBANCE (HECTARES)</th>
<th>NUMBER OF YEARS OF OPERATION</th>
<th>YEAR OF EIS SUBMISSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>COAL VALLEY COAL (EXTENSION)</td>
<td>HINTON</td>
<td>LUSCAR STERCO, (EDMONTON)</td>
<td>BITUMINOUS (THERMAL)</td>
<td>OPEN PIT (DRAGLINE)</td>
<td>1230.00</td>
<td>-</td>
<td>1990</td>
</tr>
<tr>
<td>GRASSY MOUNTAIN (EXPANSION)</td>
<td>BLAIRMORE</td>
<td>CONSOLIDATION COAL (CALGARY)</td>
<td>BITUMINOUS (METALLURGICAL)</td>
<td>OPEN PIT (TRUCK/SHOVEL)</td>
<td>177.00</td>
<td>-</td>
<td>1975</td>
</tr>
<tr>
<td>GREGG RIVER RESOURCES (NEW PROJECT)</td>
<td>HINTON</td>
<td>MANALTA COAL (CALGARY)</td>
<td>BITUMINOUS (METALLURGICAL)</td>
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surface coal mine disturbances were considerably larger than the estimated surface disturbance created by the two proposed underground mines (Table 3.2). Projected cumulative disturbance over the life of each respective mine varied from 36.5 hectares for the Willow Creek Project to 2662.00 hectares for the Monkman Project. Total surface disturbance is dictated by contract tonnage as well as stripping ratio and, consequently, waste material disposal. Mainly montane and subalpine vegetation would be disturbed by the mining activities of these mines although significant above treeline disturbance is part of the Quintette Coal Mine. All of the EISs reviewed were prepared prior to recent legislative and procedural changes in the respective jurisdictions. However, none of the changes would have altered the information content of the EISs reviewed.

Coordination for all aspects of project EIS development and regulatory approval was provided frequently by the proponent whereas engineering design and environmental planning was often sub-contracted to consultants. Generally, several environmental consultants were involved in the development of the biophysical inventories, impact assessments and reclamation plans (Table 3.3). Patterns emerged with respect to certain analytical techniques or field and laboratory practices.

In general, new project EISs contained more comprehensive biophysical inventories and were based on project proponent initiated studies rather than on literature or unpublished data supplied from external sources. Hence, information quality within the reviewed EISs was variable. Consistent omissions and poor quality information were
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prevalent with the paraphrasing of general ecology textbooks used frequently to describe successional or population processes.

The methodology of impact assessment (e.g., *ad hoc*, checklist, matrix, network, modeling) (Meredith 1991) was not documented. None of the EISs reviewed contained tables or appendices of salient information that would facilitate assessment by reviewing agencies. Impacts were simply identified through narrative descriptions.

**General Observations**

Although regulation-based EIA requirements specifically directed towards mining in Alberta and British Columbia have changed since their introduction, comparisons are possible because the focus has not changed significantly with the new or amended regulatory requirements. The changes in regulatory guidelines and practices have been primarily process-oriented rather than content-oriented and directed, for the most part, toward a formalization of the process, particularly with respect to public involvement.

However, several consistent patterns emerged from the content analysis of the environmental impact statements. The quality of the information was very difficult to determine because of the paucity of methodological descriptions. Descriptions of the design, number, frequency and timing of field sampling programs was often omitted, so it would be impossible to authenticate or replicate results. Experimental designs were generally not provided. Programmatic statements were often made without adequate support, and their frequency was higher when attempting to minimize the impacts of a particular operational practice (e.g., "... few significant wildlife habitats will be lost..."
permanently") (Sage Creek Coal Limited 1982). These programmatic statements lacked substance and/or support (e.g., empirical, conceptual) and simply indicated to the reader that only brief attention was directed towards the issue.

Since the mine plans developed at this stage of project development are tenuous due to incomplete geological information and the dynamic nature of mine planning, several EIS's provided only very general reclamation planning information and were not willing to commit to particular practices. For example, vague reclamation plan descriptions were provided in the Klappan Project document (e.g., “reclamation . . . will seek to control erosion and develop productive ecosystems . . .”) (Gulf Canada Resources Incorporated 1986).

In some cases, programmatic statements made were entirely dependent upon future technological innovation. For example, Fording Coal Limited (1983) made the statement that “. . . techniques will likely be modified to correspond with advances in reclamation technology through research at Fording and elsewhere . . .” This is an example of tacit acceptance of the existing technological paradigm and raises serious questions about project approval based on potential future innovation. Project approval based upon conjecture is suspect. Much of this approach is implied in many of the other EIS's reviewed.

Discussion with regard to environmental impact identification and mitigation was, for the most part, spread throughout the text rather than in a separate section. The notable exception was the Teck Bullmoose Operating Corporation EIS which provided a detailed narrative description of impacts and proposed mitigation measures.
Abiotic Baseline Inventories

Abiotic biophysical inventory requirements are well outlined by the guidelines provided in Alberta and British Columbia. However, the methodology for information collection and summarization varied with project proponent. Detailed field sampling was the most frequent method used in the EISs for obtaining information on bedrock and surficial geology (95%), soils (94%), and hydrology (88%) while a variety of information sources were utilized for the other biophysical parameters (Table 3.4). Project expansions generally utilized internally generated corporate documents as sources of information. The Eagle Mountain project of Fording Coal and the No. 8 Expansion at the Smoky River Coal projects are examples where climatological and hydrological reports were used extensively.

Soils information focused primarily on classification (94%) and, to a lesser extent, on the physical (63%) and chemical (63%) parameters of the classified soils. Soil moisture and temperature information, particularly important to high elevation reclamation, were collected infrequently (Table 3.4).

Climate information (e.g., precipitation, wind, air quality) was obtained usually from proponent established stations although secondary information sources such as regional Atmospheric Environment Service stations were used as well (Table 3.4). The type and source of climate information collected was relatively consistent although, due to location, most of the stations are not representative of higher elevation locations.
TABLE 3.4 SUMMARY OF ABIOTIC PARAMETERS SAMPLED FOR THE ENVIRONMENTAL IMPACT STATEMENTS OF PROPOSED COAL MINES IN ALBERTA AND BRITISH COLUMBIA.

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PROJECT CODE: 1-CVC; 2-GM; 3-GRR; 4-LS; 5-OMC; 6-SR-12 (1986); 7-SR-12 (1989); 8-BPS; 9-EM; 10-ER; 11-GM; 12-KC; 13-LCR; 14-MC; 15-QCL; 16-SC; 17-TBC; 18-TCP; 19-WCC. INFORMATION SOURCE CODE: A-DFS; B-IFO; C-PL; D-UD; E-CLI; (SUPERSCRIPT - SECONDARY INFORMATION).
The frequency of sampling versus literature-based hydrological (stream and groundwater discharge and water quality) information collected was high (88%) with only project expansions utilizing literature or unpublished data sources (Table 3.4).

**Biotic Baseline Inventories**

**Flora:** A summary of the vegetation information contained in the reviewed EISs is provided in Table 3.5. The majority of the proponents (79%) collected their own vegetation data rather than relying on published or unpublished information. Traditional reconnaissance and phytosociological (relevé, and transect) methods were used in each project, so that the descriptions were simply community- or vegetation-type classifications. The vegetation information contained within each EIS was used extensively with wildlife habitat description, impact assessment and mitigation. Most of the EISs (79%) did not determine the presence (field sampling) or potential presence (published literature) of *rare* or *endangered species*. There was a paucity of information (21%) regarding vegetation productivity. When present, vegetation productivity information consisted of merchantible forest tree site indices or Canada Land Inventory map interpretations. The applicability of this information added little to the evaluation of pre-disturbance vegetation productivity, particularly for high elevations.

Generally, information concerning vegetation processes was lacking (Table 3.5). No information regarding plant population and reproductive ecology was presented while only one EIS (Elco Mining Limited 1978) contained any reference to plant diversity.
| TABLE 3.5 SUMMARY OF VEGETATION INFORMATION PROVIDED IN ENVIRONMENTAL IMPACT STATEMENTS OF PROPOSED OR EXPANDING COAL MINES IN ALBERTA AND BRITISH COLUMBIA. |
| EXPANDING OR PROPOSED COAL MINES |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| VEGETATION TYPES | A | A | A | A | A | A | C | A | A | A | A | A | A | A | A | A | C | A | A | C |
| RARE/ENDANGERED SPECIES | A | A | D | B |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| VEGETATION PRODUCTIVITY |     | B |     |     | E | C |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| POPULATION ECOLOGY |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| REPRODUCTIVE ECOLOGY |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| DIVERSITY |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| SUCCESSION |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| PRIMARY |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| SECONDARY |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |     |
| PROJECT CODE: 1 - COAL VALLEY COAL; 2 - GRASSY MOUNTAIN; 3 - GREGG RIVER RESOURCES; 4 - LUSCAR STEICO; 5 - OBED-MARSH THERMAL COAL; 6 - SMOKY RIVER NO. 12 (1986); 7 - SMOKY RIVER NO. 12 (1989); 8 - BP SUKUNKA; 9 - EAGLE MOUNTAIN; 10 - ELK RIVER; 11 - GREENHILLS MINE; 12 - KLAPPAN COAL; 13 - LINE CREEK MINE; 14 - MONKMAN COAL; 15 - QUINTETTE COAL; 16 - SAGE CREEK COAL; 17 - TECK BULLMOOSE COAL; 18 - TELKWA PROJECT; 19 - WILLOW CREEK COAL. |

INFORMATION SOURCE CODE: A - DETAILED FIELD SAMPLING; B - INFORMAL FIELD OBSERVATIONS; C - PUBLISHED LITERATURE; D - UNPUBLISHED DATA; E - CANADA LAND INVENTORY MAP INTERPRETATIONS.
Only a small number (42%) of EISs discussed vegetation dynamics and, where discussed, involved general textbook descriptions of vegetation succession for idealized vegetation types. Furthermore, most of the information described secondary and not primary succession; therefore, it has little relevance to mine reclamation.

Fauna: Information pertaining to wildlife studies was divided into game and non-game species (Tables 3.6 and 3.7). In general, studies undertaken to characterize the more ‘important’ game species involved the more detailed field studies. Aerial and ground radiotelemetry studies as well as pellet group transects and observational transects were frequently part of studies implemented to characterize ungulate population demographics. Ungulate habitat studies varied from informal field observations (signs, census transects) complemented by phytosociological studies to the evaluation of biophysical capability based upon Canada Land Inventory (CLI) maps.

Census studies of furbearers (bears, mink, fox) were similar to the ungulate studies except that more EISs contained studies in which population demographics were based primarily on informal field observations. Habitat studies were similar to those of the ungulates.

Waterfowl (e.g., ducks, Canada geese) and upland ‘game’ bird (e.g., grouse, ptarmigan) studies typically involved informal field observations (41%) and the use of CLI maps (50%) to provide information on populations and habitat capability. Only one EIS (Elco Mining Limited 1978) contained information obtained from detailed field sampling. Two EISs (Smoky River Coal Limited 1986, Gulf Canada Corporation
<p>| TABLE 3.6 SUMMARY OF 'GAME' FAUNA BIOPHYSICAL STUDIES INCLUDED IN THE ENVIRONMENTAL IMPACT STATEMENTS OF EXPANDING OR PROPOSED COAL MINES IN ALBERTA AND BRITISH COLUMBIA. |
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PROJECT CODE: 1 - COAL VALLEY COAL; 2 - GRASSY MOUNTAIN; 3 - GREGG RIVER RESOURCES; 4 - LUSCAR STERCO; 5 - OBED-MARSH THERMAL COAL; 6 - SMOKY RIVER NO. 12 (1986); 7 - SMOKY RIVER NO. 12 (1989); 8 - BP SUKUNKA; 9 - EAGLE MOUNTAIN; 10 - ELK RIVER; 11 - GREENHILLS MINE; 12 - KLAPPAN COAL; 13 - LINE CREEK MINE; 14 - MONKMAN COAL; 15 - QUINTETTE COAL; 16 - SAGE CREEK COAL; 17 - TECK BULLMOOSE COAL; 18 - TELKWA PROJECT; 19 - WILLOW CREEK COAL.

INFORMATION SOURCE CODE: A - DETAILED FIELD SAMPLING; B - INFORMAL FIELD OBSERVATIONS; C - PUBLISHED LITERATURE; D - UNPUBLISHED DATA; E - CANADA LAND INVENTORY MAP INTERPRETATIONS. (SUPERSCRIPT LETTERS INDICATE SECONDARY INFORMATION SOURCES).
TABLE 3.7 SUMMARY OF 'NON-GAME' FAUNA BIOPHYSICAL STUDIES INCLUDED IN THE ENVIRONMENTAL IMPACT STATEMENTS OF EXPANDING OR PROPOSED COAL MINES IN ALBERTA AND BRITISH COLUMBIA.

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### REPTILES AND AMPHIBIA
- CENSUS STUDIES
- HABITAT STUDIES

### INVERTEBRATES
- CENSUS STUDIES
- HABITAT STUDIES

**PROJECT CODE:**

**INFORMATION SOURCE CODE:**
A. DETAILED FIELD SAMPLING; B. INFORMAL FIELD OBSERVATIONS; C. PUBLISHED LITERATURE; D. UNPUBLISHED DATA; E. CANADA LAND INVENTORY MAP INTERPRETATIONS; F. PROPOSED STUDY(S) (SUPERScript LETTERS INDICATE SECONDARY INFORMATION SOURCES).
1986) did not provide information for waterfowl and upland 'game' birds. The absence of waterfowl studies in some cases was due to the inappropriateness of such studies. However, in some cases, the omission represents a deficiency which was overlooked when the biophysical inventory program was designed.

'Game' fish (e.g., trout, grayling, whitefish) studies consistently involved detailed field sampling and extensive information gathering. Where appropriate, field sampling (e.g., electrofishing, seining) was undertaken to provide population estimates of species present. Detailed field sampling of stream habitat capabilities and sensitivities for stream sections (reaches) were also undertaken for all EISs.

'Non-game' studies (Table 3.7) were essentially appurtenant to the 'game' species studies. Census and habitat data collected for 'non-game' furbearers (e.g., squirrels, pikas, marmots) and avifauna (e.g., hawks, eagles, Clark's nutcracker) were collected as part of the informal field observations of the same group of 'game' species. In general, the EISs reviewed did not contain information on passerine avifauna. Many of the terrestrial studies (49%) involved informal field observations while relatively few of the studies (15%) used detailed field sampling techniques.

'Non-game' fish studies were also simply an adjunct to their 'game' counterparts, but unlike that for the 'non-game' terrestrial species, most of the studies (82%) employed detailed field sampling. The majority of fish studies (77%) involved census data collection. The aquatic invertebrate studies were part of the 'game' fish habitat
characterization studies. Detailed **benthic** invertebrate species identification was part of all EISs for which there was the potential to impact the fishery.

The most notable observation from the review of faunal studies was the absence of studies on **reptiles**, **amphibians** and terrestrial invertebrates. The absence of such studies reflects a non-holistic approach to EISs and a preoccupation with value as expressed in human activity terms within the project development review process.

**Impact Assessment and Mitigation**

Considerable overlap exists between impact mitigation as perceived in traditional EISs, and reclamation practices within mine development project proposals. Contemporaneous reclamation or continual mitigation is a requirement in both Alberta and British Columbia and all other jurisdictions reviewed in Chapter 2. Therefore, impact mitigation is considered to be a part of both the short- and long-term benefits of successful reclamation.

Table 3.8 contains a summary of the identified impacts and general mitigation measures proposed. The most common mitigation measure proposed was re-establishment of pre-mining productivity (95%). A number of proponents (84%) proposed the use of native species in revegetation programs while several proponents (68%) described revegetation practices designed for wildlife habitat re-creation. Most of the EISs examined proposed measures which fit the three categories identified although the specific details varied in accordance with mining practices. For example, only the Sage Creek Coal project stated that operations would be altered seasonally in order to avoid
### TABLE 3.8 SUMMARY OF BIOLOGICAL IMPACT MITIGATION MEASURES FOR EXPANDING OR PROPOSED NEW COAL MINES IN ALBERTA AND BRITISH COLUMBIA.

| IMPACT                                    | MITIGATION MEASURE                                                                 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|-------------------------------------------|------------------------------------------------------------------------------------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|
| 1. DESTRUCTION OF VEGETATION             | - LIMITATIONS ON SURFACE DISTURBANCE                                               |   |   |   |   |   |   |   |   |   | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
|                                           | - AFFECTED LAND MUST BE RESTORED TO PRE-MINING PRODUCTIVE CAPACITY                  |   |   |   |   |   |   |   |   |   | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
|                                           | - TOPSOIL WILL BE REMOVED, SEGREGATED, STORED AND REDISTRIBUTED AFTER MINING       |   |   |   |   |   |   |   |   |   | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
|                                           | - ESTABLISH NATIVE VEGETATION OR APPROPRIATE SUBSTITUTES AFTER MINING              |   |   |   |   |   |   |   |   |   | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
|                                           | - MANAGEMENT OF RECLAIMED LAND                                                     |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
| 2. DISTURBANCE OF WILDLIFE                | - EMPLOYEE AWARENESS AND MONITORING PROGRAMS                                       |   |   |   |   |   |   |   |   |   | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
|                                           | - MODIFICATION OF WORKER TRANSPORTATION TO REDUCE NUMBER OF ROAD KILLS             |   |   |   |   |   |   |   |   |   | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
|                                           | - STRUCTURES TO PROTECT ANIMALS                                                    |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
|                                           | - OPERATIONS MODIFIED TO AVOID SENSITIVE HABITAT AND/OR SEASONAL ACTIVITIES (BUFFER ZONES) |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
|                                           | - REVEGETATION WILL USE PLANT SPECIES WITH HIGH NUTRITIONAL OR COVER VALUE         |   |   |   |   |   |   |   |   |   | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
| 3. EROSION, SEDIMENTATION, WATER QUALITY AND HABITAT DESTRUCTION | - BUFFER ZONES ALONG STREAMS                                                      |   |   |   |   |   |   |   |   |   | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
|                                           | - USE OF SEDIMENTATION PONDS AND/OR DITCHES                                        |   |   |   |   |   |   |   |   |   | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
|                                           | - DISTURBED SOILS WILL BE REVEGETATED                                              |   |   |   |   |   |   |   |   |   | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ | ++ |
|                                           | - MODIFICATION OF OPERATIONS DURING SPAWNING DESTRUCTION SEASONS                   |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |
SLOPE RECONTOURING + + + + + + + + + + + +
STREAM RECONSTRUCTION + + + + + + + + + + + +

PROJECT CODE: 1 - COAL VALLEY COAL; 2 - GRASSY MOUNTAIN; 3 - GREGG RIVER RESOURCES; 4 - LUSCAR STERCO; 5 - OBEED-MARSH THERMAL COAL; 6 - SMOKY RIVER NO. 12 (1986); 7 - SMOKY RIVER NO. 12 (1989); 8 - BP SUKUNKA; 9 - EAGLE MOUNTAIN; 10 - ELK RIVER; 11 - GREENHILLS MINE; 12 - KLAPPAN COAL; 13 - LINE CREEK MINE; 14 - MONKMAN COAL; 15 - QUINTETTE COAL; 16 - SAGE CREEK COAL; 17 - TECK BULLMOOSE COAL; 18 - TELKWA PROJECT; 19 - WILLOW CREEK COAL.

INFORMATION SOURCE CODE: (+) - INDICATES MITIGATION MEASURE SUGGESTED IN EIS.
fish spawning periods. This may be due to the politically sensitive nature of this proposed project or the lack of relevance in other projects.

The use of water control structures and slope reconstruction to minimize erosion and water quality problems was outlined in all EISs.

Mitigation measures which would require modifications to conventional engineering design and operating practices or integrative management were not mentioned in the EISs reviewed. Particular measures such as limitations on surface disturbance, reclamation land management or modifying operations to avoid sensitive habitat were typically excluded from consideration.

Due to political sensitivities or the potential for significant externalities, some proponents proposed activities exceeding minimal regulatory requirements. For example, the Sage Creek Coal Limited proposed an Environment Enhancement Program in addition to the company’s reclamation mitigation measures. The objective was to enhance the environment for fish and wildlife through the allocation of $0.10/tonne of clean coal produced. This form of progressive corporate responsibility was not included in any other project and represents a ‘net gain’ in terms of environmental enhancements.

Only a few of the EISs (32%) contained information describing monitoring and management programs for wildlife affected by surface mining operations.

Reclamation Research Studies
Reclamation research studies were categorized according to their emphasis on either growing media suitability or plant species selection. None of the EISs addressed special engineering requirements (contouring, resloping, ripping, scarifying) which are of special concern to mountainous coal mining although reclamation of this form of mining is known to have these requirements as prerequisites.

Table 3.9 contains the information on growing media studies. No patterns emerged with regard to information source although the spoil toxicity studies described consistently (90%) involved detailed laboratory analyses. Studies examining spoil weathering were absent from most of the Alberta EISs. This is a reflection of the regulatory differences in providing topsoil as a growing medium for revegetation. Although the usage of topsoil is generally considered uneconomical in British Columbia, several EISs (67%) within this jurisdiction included studies of topsoil availability. Much of the topsoil information was derived from the surficial geology and soil mapping undertaken as part of the biophysical inventory studies.

The incorporation of weathering studies as well as soil physical and chemical analyses within the EISs reviewed was sporadic although; when present, these studies were quantitative. In some cases, detailed laboratory studies were proposed for the subsequent stage in the project review process (e.g., Consolidation Coal Company of Canada 1975).

Table 3.10 contains the information on plant species selection studies. A significant proportion (69%) of the study information devoted to species selection was derived from published literature although a few EISs (38%) contained detailed species
## TABLE 3.9 SUMMARY OF GROWING MEDIA STUDIES COMPLETED OR PROPOSED AS PART OF THE MINE DEVELOPMENT APPROVAL PROCESS.

<table>
<thead>
<tr>
<th>STUDIES EXPANDING OR PROPOSED COAL MINES</th>
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<tr>
<td>1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19</td>
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</table>

**GROWING MEDIA - SPOIL (WASTE ROCK)**

- Weathering Rate Trial
- Physical Analyses
- Chemical Analyses
- Temperature
- Organisms
- Toxicity

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A |

**GROWING MEDIA - TOPSOIL OR REGOLITH**

- Depth
- Volume Available
- Storage Location
- Placement
- Physical Analyses
- Chemical Analyses
- Organisms

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A | A |

**PROJECT CODE:**

1 - Coal Valley Coal; 2 - Grassy Mountain; 3 - Greggs River Resources; 4 - Luscar Sterco; 5 - Obed-Marsh Thermal Coal; 6 - Smoky River No. 12 (1986); 7 - Smoky River No. 12 (1989); 8 - BP Sukunka; 9 - Eagle Mountain; 10 - Elk River; 11 - Greenhills Mine; 12 - Klappan Coal; 13 - Line Creek Mine; 14 - Monkmann Coal; 15 - Quintette Coal; 16 - Sage Creek Coal; 17 - Teck Bullmoose Coal; 18 - Telkwa Project; 19 - Willow Creek Coal.

**INFORMATION SOURCE CODE:**

A - Detailed Field or Laboratory Sampling; B - Informal Observations; C - Published Literature; D - Unpublished Data; E - Proposed Study(s).
TABLE 3.10 SUMMARY OF REVEGETATION SPECIES RESEARCH STUDIES COMPLETED AS PART OF THE MINE DEVELOPMENT APPROVAL PROCESS.

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<tr>
<th>STUDIES</th>
<th>EXPANDING OR PROPOSED COAL MINES</th>
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<td>1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19</td>
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<tr>
<td>AGRONOMIC SPECIES</td>
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<td>- PROSPECTIVE CANDIDATE LIST</td>
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<td>- FIELD SPECIES TRIAL</td>
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<td>- GROWTH CHAMBER OR GREENHOUSE SPECIES TRIAL</td>
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<td>- FIELD FERTILIZER TRIAL</td>
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<td>NATIVE SPECIES</td>
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PROJECT CODE: 1 - COAL VALLEY COAL; 2 - GRASSY MOUNTAIN; 3 - GREGG RIVER RESOURCES; 4 - LUSCAR STERCO; 5 - OBED-MARSH THERMAL COAL; 6 - SMOKY RIVER NO. 12 (1986); 7 - SMOKY RIVER NO. 12 (1989); 8 - BP SUKUNA; 9 - EAGLE MOUNTAIN; 10 - ELK RIVER; 11 - GREENHILLS MINE; 12 - KLAPPAN COAL; 13 - LINE CREEK MINE; 14 - MONKMAN COAL; 15 - QUINTETTE COAL; 16 - SAGE CREEK COAL; 17 - TECK BULLMOOSE COAL; 18 - TELKWA PROJECT; 19 - WILLOW CREEK COAL.

INFORMATION SOURCE CODE: A - DETAILED SAMPLING; B - INFORMAL OBSERVATIONS; C - PUBLISHED LITERATURE; D - UNPUBLISHED DATA; E - PROPOSED STUDY(S). (SUPERScript LETTERS INDICATE SECONDARY INFORMATION SOURCES).
sampling studies. Also, a few of proponents (19%) indicated that species selection studies would be completed during the next stage of the development review process. Most project proponents (84%) provided prospective species lists for both agronomic and native species. Field fertilizer trials were the most common agronomic trials undertaken (33%) whereas field species trials (33%) were only undertaken for native species.

The Line Creek Project contained the most comprehensive agronomic and native species selection and growing media trials of all projects reviewed. However, the Elk River Project proposed the most progressive program for native species usage in mine reclamation. The proponent in this case proposed the establishment of a native species 'multiplication' facility in which large volumes of native species seed would be produced under intensive management.

Reclamation Planning

Pre- and post-disturbance land-use planning for each of the EISs is listed in Table 3.11. Forestry (95%) and wildlife habitat (90%) were the two most frequently stated pre-disturbance land-uses cited by proponents. Both forestry (58%) and wildlife habitat (74%) were considered to be the most important end land-uses by proponents. Recreation, angling and hunting were also cited frequently. However, recreation, aesthetics, angling, guiding, hunting and trapping are not mutually exclusive, so there is an overlap in terminology. Recreational land-use was frequently used as a vague generalization. Canada Land Inventory was the primary source of information although
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<th>TRAPPING</th>
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<th>ANGLING</th>
<th>VISUAL (AESTHETICS)</th>
<th>RECREATION</th>
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**PROJECT CODE:** 1 - COAL VALLEY COAL; 2 - GRASSY MOUNTAIN; 3 - GREGS RIVER RESOURCES; 4 - LUSCAR STERCO; 5 - OBED-MARSH THERMAL COAL; 6 - SMOKY RIVER NO. 12 (1986); 7 - SMOKY RIVER NO. 12 (1990); 8 - BP SUKUNKA; 9 - EAGLE MOUNTAIN; 10 - ELK RIVER; 11 - GREENHILLS MINE; 12 - KLAPPAN COAL; 13 - LINE CREEK MINE; 14 - MONKMAN COAL; 15 - QUINTETTE COAL; 16 - SAGE CREEK COAL; 17 - TECK BULLMOOSE COAL; 18 - TELKWA PROJECT; 19 - WILLOW CREEK COAL.

**LAND-USE CODE:** (+) - PRE-DISTURBANCE; (-) - POST-DISTURBANCE; ( ) - NO DISCUSSION.
anecdotal descriptions and informal field observations were used as supplementary support.

The majority of the EISs stated that the objective of reclamation was the re-integration of mined land with the surrounding terrain. The initial objectives of reclamation were to ensure that the effects of developments are minimized by providing stable revegetated land surfaces. The reclamation programs were designed to accommodate land and resource use options.

Reclamation planning information presented in each EIS was divided into four categories: (1) areas to be reclaimed, (2) post-mining landscape design, (3) engineering requirements and (4) revegetation (Table 3.12). The reclamation related activities described in each EIS reflected jurisdictional differences in regulatory requirements. Environmental impact statements reviewed from Alberta described reclamation activities for pit disturbances whereas only the Telkwa project from British Columbia discussed pit reclamation. The Telkwa Project is a special instance where the mining sequence allowed for in-pit dumps as opposed to the conventional ex-pit dumps found in the majority of the coal mines in British Columbia.

Reclamation of tailings impoundments, coarse rejects piles and infrastructure was not discussed in the mine expansion EISs since these structures would have been discussed in previous EISs. For obvious reasons, the EISs representing underground projects did not describe reclamation of pits or large waste dump structures.

Typically, reclamation designs involved illustrations of simplistic reclaimed landscape units superimposed on the post-mining topography. Each EIS attempted to present a
TABLE 3.12 SUMMARY OF RECLAMATION RELATED ACTIVITIES DESCRIBED IN THE ENVIRONMENTAL IMPACT STATEMENTS.

<table>
<thead>
<tr>
<th>RECLAMATION PLANNING</th>
<th>EXPANDING OR PROPOSED COAL MINES</th>
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<tbody>
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<td>1</td>
</tr>
<tr>
<td>1. AREAS TO BE RECLAIMED</td>
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<tr>
<td>COARSE REJECTS</td>
<td>+</td>
</tr>
<tr>
<td>INFRASTRUCTURES</td>
<td>+</td>
</tr>
<tr>
<td>2. POST-MINING LANDSCAPE DESIGN</td>
<td></td>
</tr>
<tr>
<td>CONCEPTUAL RECLAMATION PLAN</td>
<td>+</td>
</tr>
<tr>
<td>RECLAMATION ACTIVITY TIMELINE</td>
<td>-</td>
</tr>
<tr>
<td>3. ENGINEERING REQUIREMENTS</td>
<td></td>
</tr>
<tr>
<td>PIT BACKFILLING</td>
<td>-</td>
</tr>
<tr>
<td>WASTE DUMP RESLOPING</td>
<td>+</td>
</tr>
<tr>
<td>ROADS</td>
<td>+</td>
</tr>
<tr>
<td>'TOPSOIL' PLACEMENT</td>
<td>+</td>
</tr>
<tr>
<td>OVERBURDEN PLACEMENT</td>
<td>-</td>
</tr>
<tr>
<td>RECONTOURING</td>
<td>+</td>
</tr>
<tr>
<td>MICROSITE MODIFICATION</td>
<td>-</td>
</tr>
<tr>
<td>4. REVEGETATION</td>
<td></td>
</tr>
<tr>
<td>ENVIRONMENTAL FACILITIES</td>
<td>-</td>
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<td>--------------</td>
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</tr>
<tr>
<td>Source Code</td>
<td>(+) - Discussed</td>
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</tbody>
</table>

**Environmental Staff**

**Seeding Methods**

**Transplanting**

**Physical Amendments**

**Chemical Amendments**
mosaic of land and resource uses based on current and projected uses. Narrative or occasionally tabular descriptions of the reclaimed landscape units consisted of information pertaining to growing material types, dominant and sub-dominant plant species and potential land-use capability. Conceptual reclamation plans were included in British Columbia EISs, but not those from Alberta. In Alberta, these requirements have not been part of the mine development review process. Only the Elk River Project EIS contained a detailed reclamation timeline. The relatively simple multiple seam mining of the Elk River project is in contrast to most of the other projects reviewed, so the certainty of the mining method may have allowed the proponents to develop a detailed reclamation timeline. The Teck Bullmoose mine is an example of a poorly developed conceptual reclamation plan and timeline. In this EIS, reclamation planning can be described by the following quotation “. . . reclamation planning and practices will occur more or less concurrently with mining progression.”

Several EISs contained incomplete descriptions of engineering requirements although these descriptions are required as part of the review process. Furthermore, specific details were often avoided, so much of the text contained vague generalizations such as “. . . upper waste dumps in the subalpine area will complicate the reclamation procedures” (Teck Bullmoose Corporation 1982).

With the exception of pit backfilling and ‘topsoil’ replacement, engineering requirements are similar in Alberta and British Columbia. Although pit backfilling is not a requirement in British Columbia, the concept was discussed frequently with regard to
economic expediency and less frequently with regard to potential 'sterilization' of the resource (coal).

Revegetation planning information was sparse except where seeding and transplanting methods were concerned. Much of the revegetation information developed as part of the research studies was tentative and, therefore, not discussed in most EISs. Three proponents (Teck Bullmoose, David Minerals - Willow Creek and Sage Creek) proposed that more comprehensive revegetation information would be forthcoming in the Stage III phase of the project review process.

6. Discussion

The mine development review process in both Alberta and British Columbia is essentially a variant of conventional EIA with significant alterations to include reclamation (Figure 3.2). The EIS used within this process contains three sections which are directly related to reclamation planning: (1) baseline data inventories, (2) impact identification and (3) impact mitigation. Reclamation is included as a component of impact mitigation.

Unfortunately, the EIS as a planning document within these jurisdictions is directed primarily toward project review (impact identification and superficial mitigation) and only secondarily towards reclamation planning. The EIA stage is crucial to the minimization or elimination of long-term landscape degradation. Therefore, reclamation planning should receive greater attention within the EIS document.
Figure 3.2 Flowchart of mine development engineering and environmental management.

**Mine Development**

- Geological Exploration
  - Conceptual Design
    - Baseline Inventory
    - Pre-mining Monitoring
    - Pre-stripping and Infrastructure Construction
    - Commissioning
    - Mine Operations
      - Operational Reclamation (Contemporaneous)
      - Mine Closure
        - Final Reclamation and Decommissioning

**Environmental Management**

- Environmental Engineering
  - Impact Assessment
  - Conceptual Reclamation Planning
  - Construction Impact Monitoring
  - Compliance Monitoring
  - Impact Monitoring
  - Reclamation Research, Planning and Monitoring

- Reclamation Monitoring
In the current study, pre-project investigations usually consisted of no more than reconnaissance studies and species abundance/distribution surveys. Experiments were seldom conducted, and statistically adequate baselines, against which subsequent changes could be detected through monitoring, were rare. Predictions normally amounted to vague generalizations and often future work was proposed, apparently to satisfy regulatory concerns. Proposals for mitigation were generally limited to statements of known ‘good’ engineering and construction practice. Spatial and temporal boundaries for the assessments were usually restricted to the extent and duration of the project under review.

Ross (1987) suggested three criteria for EIS acceptability: (1) focus, (2) clarity of presentation and (3) scientific and technical soundness. These criteria are applicable to the present study and form the basis of discussion in the following text (Table 3.13).

Focus and Clarity of Presentation

Readability and comprehension of environmental plans and EIS documents are important in communicating technical information to an audience with different levels of cognition and areas of expertise (Gallagher and Jacobsen 1993). Communication with the general public is particularly problematic.

In general, the EISs reviewed tended to be unquantified and discursive with much of the impact identification in the form of vague narrative generalizations. Consequently, considerable subjectivity is present within the EIS evaluation processes of Alberta and
### Table 3.13 Summary of Environmental Impact Statement Information Relevant to Reclamation Planning

<table>
<thead>
<tr>
<th>Impact</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Focus and Clarity of Presentation</strong></td>
<td>- Unquantified</td>
</tr>
<tr>
<td></td>
<td>- Discursive</td>
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<tr>
<td></td>
<td>- Vague narrative generalizations</td>
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<td></td>
<td>- Inadequate conceptualization</td>
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<td></td>
<td>- Poorly stated objectives</td>
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<tr>
<td></td>
<td>- Inadequate predictive techniques</td>
</tr>
<tr>
<td></td>
<td>- Inadequate impact scoping</td>
</tr>
<tr>
<td><strong>2. Scientific and Technical Soundness</strong></td>
<td>- Low information quality</td>
</tr>
<tr>
<td></td>
<td>- Lack of integration of ecological concepts</td>
</tr>
<tr>
<td><strong>3. Applicability of Baseline Information</strong></td>
<td></td>
</tr>
<tr>
<td><strong>3.1 Land-Use</strong></td>
<td>- CLI used extensively</td>
</tr>
<tr>
<td></td>
<td>- Inappropriate scale for classification and mapping</td>
</tr>
<tr>
<td><strong>3.2 Geology and Soils</strong></td>
<td>- Vague descriptions</td>
</tr>
<tr>
<td></td>
<td>- Detailed sampling, geostatistical, and GIS techniques required</td>
</tr>
<tr>
<td><strong>3.3 Vegetation</strong></td>
<td>- Absence of rare and endangered species lists</td>
</tr>
<tr>
<td></td>
<td>- Absence of productivity and phenology information</td>
</tr>
<tr>
<td><strong>3.4 Fauna</strong></td>
<td>- Census studies with inadequate habitat information</td>
</tr>
<tr>
<td></td>
<td>- Restricted in focus</td>
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<tr>
<td></td>
<td>- Anecdotal observations of non-game species</td>
</tr>
<tr>
<td><strong>3.5 Ecosystem Processes</strong></td>
<td>- Absence of studies or descriptions of pedogenesis, succession, nutrient cycling and population dynamics</td>
</tr>
<tr>
<td><strong>3.6 Reclamation Research</strong></td>
<td>- Limited value (time constraints and transferance)</td>
</tr>
<tr>
<td><strong>4. Information Quality</strong></td>
<td>- Descriptive and anecdotal</td>
</tr>
<tr>
<td></td>
<td>- Absence of conceptual and methodological citations</td>
</tr>
<tr>
<td></td>
<td>- Absence of statistics and quantitative measures</td>
</tr>
<tr>
<td><strong>5. Predictive Power</strong></td>
<td>- Vague descriptions</td>
</tr>
<tr>
<td><strong>6. Risk Assessment (Reclamation)</strong></td>
<td>- Not provided</td>
</tr>
<tr>
<td><strong>7. Post-Development Monitoring</strong></td>
<td>- Variable information due insufficiently detailed guidelines</td>
</tr>
</tbody>
</table>
British Columbia. Similar observations of non-mining projects have been reported in other parts of the world (Baggs 1983).

Clearly stated objectives improve greatly the contents of an EIS (Schmidt 1988). The EISs reviewed suffered from inadequate conceptualization, poorly stated objectives and an inadequate use of predictive techniques. All EISs should include a brief statement of the underlying purpose and the need to which the regulatory agency is responding in proposing the alternatives (including the proposed action).

Although an examination of the EIS review mechanism was beyond the scope of this discussion, the reclamation information contained within the EISs reviewed lacked sufficient detail for the project approval decision-making process. In fact, reclamation feasibility is not really an issue in the EIA project acceptance or rejection process; however, it was tacitly accepted. Unfortunately, the process embraces the technocentric paradigm even though considerable uncertainty surrounds reclamation of high elevation mine disturbances.

Conover et al. (1985) in their EIA framework stated that spatial, temporal and population boundaries as well as environmental attributes must be predetermined. However, most of the EISs reviewed lacked adequate impact scoping and selection of appropriate environmental attributes for reclamation planning. Boundaries are important not only for the identification of effects but also in the mitigation of these effects through reclamation. Although both jurisdictions claim to have a mechanism for deciding which parameters should be sampled, this mechanism is weak with respect to the integration of ecological concepts within reclamation planning. Insufficiently
detailed guidelines for preparation of general EISs are the norm (McAllister 1980), and
the mining-specific research described here supports this view.

Changes in the information content would greatly improve the relevance of the EIS to
reclamation planning. Technically-competent steering committees should be established
to identify environmental attributes and respective sampling designs and analysis or
modeling programs with specific emphasis on reclamation planning.

Scientific and Technical Soundness

In practice, it is very difficult to evaluate or check the conclusions of a technical analysis
due to methodological assumptions and analytical interpretations (Majone 1979).
However, certain attributes can be used to gauge the reliability of the information
presented and summarized.

Information Collection Process: Individuals or groups involved in EIAs have differing
opinions as a result of their roles within the process. Government regulators administer
the EIA procedural machinery and focus on guidelines and review processes while
project proponents seek approvals and licenses. Public relations are important to
project proponents, but scientific concern is only limited to the extent necessary to
obtain project approval (Gilbert and Dodds 1992). Consultants are caught between the
regulators and the proponents, and are required to translate vague guidelines into a
study program. In effect, they are expected to practice science in a politically motivated
process. Within the EISs reviewed, information content and quality was variable and
often questionable in terms of reliability. As part of an improved EIS generating
process, consultants must be empowered by rigorously regulated impact scoping and information gathering techniques. Not only should the regulatory agencies be screening EISs for adequacy of research studies, but reclamation personnel should be involved in selecting specific parameters for investigation and sampling methodologies through the use of much better designed guidelines and handbooks.

EISs are generally completed by a multidisciplinary team of professionals that include individuals with formal training in several of the environmental and social sciences. Jones (1992) has suggested that a project proponent should be required to select consultants from a register of those known to be unbiased, technically competent and capable of participating in an interdisciplin ary design team. In this study, most of the EISs reviewed employed a number of consultants. Although the qualifications of these individuals or organizations may have been stated during the EIS tendering process, there was no guarantee of technical competence, particularly regarding reclamation planning and practices. The low information quality of the reviewed EISs suggests, among other things, that these individuals should have instruction in reclamation which overlays their formal disciplinary training (Chapter 4).

The inter-disciplinary nature of environmental assessments imposes time constraints on all participants in the process. The time constraints often result in changes in information gathering without appropriate attention to the accuracy and representativeness of the data. It is unrealistic to expect proponents or consultants to establish a comprehensive data bank on biophysical, recreational and archaeological resources. Comprehensive information such as this should be a government function as
part of cumulative effects assessment (Gilpin 1995). Once established, it would be
necessary to stipulate that all relevant data gathered in the course of EIA and
monitoring should be made available in a suitable format for inclusion in the system in
order to keep current.

EIAs in North America have guidelines which are, for the most part, designed to
facilitate and standardize the processing of information between development
proponents, on the one hand, and the licensing, permitting and approving agencies and
higher authorities on the other. Guidelines and similar bureaucratic specifications
normally emphasize the end-products of the various levels of the planning and
assessment processes, and leave the proponents free to provide the required information
by whatever means they feel appropriate. If EISs are to be credible, guidelines and
standards are essential.

Applicability of Baseline Information

Land-Use: All of the EISs reviewed made extensive use of the CLI System. Within the
mine development review process in Canada, the CLI system is used as a reference for
developing post-mining land-use objectives. Apparently, the CLI system was used
extensively to reduce the costs associated with field data collection. However, in many
cases, pre-disturbance conditions may not be the optimum conditions for the post-
mining landscape (LaFevers 1978). In such situations, land capability analyses are
ineffectual except where generalized impact identification and mitigation are concerned.
Perhaps what would be more effective would be to perform environmental sensitivity
mapping \textit{(sensu} Rowe 1977\textit{)} during the early stages of project development. If technical and land-use decision are favorable for project development, then \textbf{suitability analyses} could be performed on the proposed post-mining biophysical environment to determine land-use objectives.

In Canada, classification and mapping of terrestrial ecosystems are undertaken at various scales depending on classification objectives, but the EISs reviewed were generally at scales of 1:20,000 to 1:50,000. The scale of such maps do not truly reflect actual land-use capabilities. In general, wildlife densities and habitat capabilities are overestimated within the CLI system due to inaccuracies resulting from the large mapping scale and an inadequate data base. A mapping scale of 1:2,500 to 1:10,000 would be more appropriate for reclamation planning. However, caution must be exercised because such maps must not be regarded as templates for post-development planning.

Classification and mapping of ecological systems are based upon homogeneity of resources, but they convey a sense of ecological stability, particularly to the non-ecologist, and they encourage the checklist inventory approach characterized by brief surveys, species lists and a general emphasis on static variables with a concomitant de-emphasis of process variables such as resilience and stability. In the future, ecosystem-based mapping approaches should be followed rather than the derivative mapping of the CLI.

Superficial attention to aesthetics was consistent within all EIS reviewed. Landform and vegetation contribute to the spatial definition and light quality color of the visual
landscape. Naturalness of a landscape is generally associated with high visual quality (McBride 1977). If the naturalness of the landscape is maximized or optimized during the reclamation planning process, a higher visual quality and improved reclamation product would result.

Geology and Soils: EIS surficial geology and soil survey data have been presented typically in the form of maps. However, these maps and their accompanying reports are generally pedological in nature and have not been utilized fully by surface mine operations (Gould and Brown 1983). In the present study, all of the EIS reviewed provided surficial geology and/or soils maps as well as reclamation capability indices. In the older EISs, the capabilities were simply vague descriptions, but in the more recent EISs, more detailed parameters (texture, consistence, coarse fragment content, waterholding capacity, pH, electrical conductivity, exchangeable sodium, soil depth, slope, erosion, permeability and drainage) were utilized. Bulk sampling during the project review phase provides an early assessment of material handling requirements and a mechanism for assessing growing media capability.

Increasingly, mining companies in the United States are being required to document their post-mine soil condition in order to verify compliance with regulatory standards. Abbott et al. (1982) developed drill patterning techniques (kriging) for assessing and implementing a selective overburden handling program. Such methodology, if applied as part of the mine development review process, would greatly improve the quality of growing material suitability information.
Although GIS technology was not in widespread use when these reports were generated, future EISs should, as a matter of practice, employ this technology. Lack of familiarity with GIS and the cost of creating databases has limited the use of this technology in the past (Schori et al. 1989).

**Vegetation:** A logical interconnection exists between vegetation information and pre- and post-mining land-use information in developing revegetation plans and evaluating revegetation success for release of vegetation liability. Planning for revegetation of lands disturbed by coal mining requires an evaluation of pre-mining vegetative cover and productivity, pre- and post-mining land-use(s), determination of overburden and topsoil/subsoil quality and quantity as well as species mix selections. Most of the EISs reviewed satisfied only a small part of this requirement. For example, the Klappan and Quintette Coal Projects provided information on rare and endangered species but omitted vegetation productivity data whereas the Coal Valley Coal and Telkwa projects were the only EISs with field-based vegetation productivity data.

None of the EISs reviewed sampled specifically for species that are rare (small or sparsely distributed populations) or endangered (potential extirpation). The identification of rare and endangered species is important for impact assessment because project development should not proceed where they occur. However, vegetation sampling methods used most frequently are not conducive to the identification and assessment of rare or endangered plant species habitat (Goldsmith 1991). Sampling programs specifically designed to locate habitats which could contain rare species must be implemented in conjunction with standard phytosociological investigations. Those
habitats which may contain rare or endangered species should be sampled separately and with greater frequency. When rare or endangered species are identified, subsequent reclamation activities, where appropriate, may be directed towards re-creation or enhancement of their habitats.

The absence of productivity information is inconsistent with the regulatory pre-disturbance/post-disturbance productivity requirements of reclamation (Chapter 2). This is particularly notable in British Columbia where the post-mining landscape must have equivalent productivity on an average property basis.

The lack of plant successional process descriptions is significant since plant community responses to disturbance are necessary to identify development impacts and make recommendations for approval or proposals for alternative development plans. Relevant chronosequence and perturbation response indices should be used.

The EISs reviewed attempted to describe the current characteristics of plant communities and, therefore, provide a reference for future comparison. However, ecosystems are dynamic, so short-term studies such as these do not describe fully the complexity of vegetation and, as a result, can be misleading. In addition to temporal variation in vegetation, spatial variation in species composition is probable. Therefore, sufficient sampling is necessary to compensate for both temporal and spatial heterogeneity. Appropriately designed sampling over a period of two years would achieve such objectives. The use of transects along environmental gradients would be useful in delineating vegetation environment relationships as well as productive potential of the land (Treshow and Allan 1985). These studies should collect
information on **phenology**, **physiognomy**, plant strategies and alpha (habitat), beta (between habitat) and gamma (landscape) diversity. This form of information would be more relevant to reclamation planning and would augment the **synecological** information used typically for impact identification.

**Fauna:** While the emphasis in pre-mining wildlife impact assessments has changed from the analysis of population census data to the delineation and description of habitat in the United States (Robison 1987), this was not the case for the EISs reviewed from Alberta and British Columbia. Faunal studies undertaken as part of the baseline data collection were census and home range in nature with very little habitat information. The majority of information was in the form of 'low-quality' anecdotal observations or simple literature reviews. In general, very little emphasis was placed on the animals as functional entities within ecosystems. Furthermore, significant components of the **trophic levels** were excluded or given only cursory mention. The paucity of non-game fauna information clearly makes the re-creation of functioning ecosystems difficult. Incorporation of insect fauna studies are particularly important since they are important indicators of ecosystem functioning (Rosenberg et al. 1986). In contrast, aquatic (fish and benthic invertebrate) surveys which were conducted for all EISs represent a hybrid of population census and aquatic ecosystem functioning analyses. However, the **index of biotic integrity (IBI)** may be more effective for impact identification rather than baseline information collection (Karr 1991).

The majority of the EISs reviewed proposed the re-creation of wildlife habitat as a post-mining land-use objective yet few of these studies contained detailed habitat studies or
literature reviews. The EISs concentrated on population studies and relied on the CLI or cursory observations for habitat information. This situation represents a systemic flaw for not only biological impact identification and mitigation planning prior to project approval but also for post-mining landscape planning and reclamation. If there is continued focus on habitat re-creation of target wildlife species in most jurisdictions, then the EISs should include the more rigorous methods of wildlife habitat description proposed by Atkinson (1985). More extensive use of the United States Habitat Evaluation Program (HEP) and Habitat Suitability Index (HSI) software and GIS technology is necessary. Furthermore, metapopulation modeling software that has been linked to GIS technology (RAMAS/GIS) may be of particular value in assessing impacts on large mammals and developing conceptual reclamation plans that integrate wildlife habitats in undisturbed and reclaimed landscapes.

The absence of post-development impacted wildlife monitoring and management programs within the EISs examined is problematic, and the absence of such programs is consistent with the literature for other forms of industrial developments (Ellis 1989).

Ecosystem Processes: The results of the review indicated the lack of an ecosystematic approach to baseline data collection, an observation consistent with that of Wallace (1984) for other resource sectors. In looking for applications of such ecological concepts as trophic levels and energy flow or nutrient cycling, there was little evidence that they had been incorporated into the design of studies and reclamation planning. Much of the information presented was in the form of static descriptions. The EIA
process and more specifically the mine development review process would be best served if the non-equilibrium nature of the environment were acknowledged.

The underlying objectives of these impact-oriented baseline studies appeared to be ecosystem characterization; however, important functional aspects of the described ecosystems were omitted. The paucity of quantitative data relevant to successional development and population studies serves only to perpetuate the 'product approach' to reclamation within the mine development process. Although the inclusion of reclamation species and growing media trials provided some information for reclamation planning, data quality was questionable and integration with baseline vegetation data was limited. By focusing on key processes (pedogenesis, succession, nutrient cycling, population dynamics), baseline information would improve not only environmental impact assessments but also develop a much more process-oriented approach to reclamation planning.

EISs should include a description of the 'natural' succession processes within the development area. An assessment of the native vegetation and soils found under disturbed conditions is useful in identifying potentially successful reclamation species. Baseline data collection should include a detailed study of local disturbances at equivalent altitudes and on similar material types in order to predict better the results of reclamation.

Two general approaches to pre-mining assessment are possible: (1) the conventional method (inductive approach) in which baseline data are collected and analyzed to provide predictions of reclamation potential and (2) the reverse method (deductive
approach) in which native vegetation and natural successional patterns are observed to deduce the influences and interactions of climate and substrate on vegetation. Both structural (descriptive) as well as functional (process prescriptive) should be included to improve the reclamation planning process. Physical/chemical, individual organism, population (species) community and ecosystem should be included. The deductive approach is proposed here to supplement a more focused conventional inductive approach. The deductive approach cannot replace the inductive approach because of an inability to adequately address the broader issue of comprehensive impact assessment.

Reclamation Research: The greenhouse (pot trials) and field species performance trials included in many of the EISs are of limited value because of information transferability and time constraints. Hypotheses developed from greenhouse species (Willey 1982) and fertilizer pot trials (Ekert and Bleak 1960) must ultimately be tested in the field under longer study time scales in order to adequately assess species performance due to differing ecological life histories. Government agencies are more appropriate in conducting studies which provide conceptual understanding and broad application (e.g., species responses to management practices), and the industry should undertake site specific studies (e.g., application of species responses to specific site conditions) during the project review process.

Information Quality

Since first introduced, the EIA process has been the subject of considerable debate regarding scientific validity (Ruckelshaus 1983). Fairweather (1989) has suggested that
the scientific validity of the EIA process is weak because the science used is dated. However, Geist (1994) suggests a more fundamental problem related to validity and reliability is the paucity of scientific literature references. The absence of conceptual and methodological reference citations was encountered frequently in the EISs reviewed. Commercial constraints in industry and environmental consulting firms make it extremely difficult for individuals to devote adequate time needed to maintain their scientific expertise. Accreditation and professional upgrading should be required of all participants in the process.

While the scope and completeness of the EIS in Alberta and British Columbia is determined through a regulatory/proponent consultative process, considerable variation in the quality of information is possible. Many of the EISs reviewed were entirely descriptive and very often involved anecdotal observations. The paucity of sampling method descriptions limits the ability of reviewing agencies to repeat observations or assess the completeness of the information provided. In the absence of a detailed description of activities undertaken, the potential for minimization of impacts is high. Furthermore, the reliability issue of EIS information is not only important for overall project development but is crucial also to reclamation planning of the post-mining landscape.

Regulatory agencies, private companies, environmental groups and individuals concerned with the exploitation and rehabilitation of ecosystems would benefit from detailed protocols for gathering information and making land management decisions (e.g., sample variables, sampling designs, analytical procedures). Presently, information
acquisition involves facile experiments or field studies. Therefore, the information acquired does not necessarily capture the complexity or uniqueness of ecosystem rehabilitation decisions.

A further problem related to information quality is that of statistical significance. Statistical significance should be used in identifying environmental impacts where appropriate (Bernstein and Zalinski 1983), but important methodological constraints may limit the value of statistical techniques in reclamation planning. Caution must be exercised because quantitative methods may obfuscate important ecosystem components. It is important to reclamation planning that ecosystem attributes be measured or investigated with the appropriate sampling design and intensity in order to describe adequately the ecological processes occurring at the development site. Attempts must be made to include spatio-temporal considerations in all of the attributes measured. What is needed is a technique or group of techniques which clearly differentiate between the subjective and objective elements of ecological evaluation.

**Predictive Power**

Environmental impacts of developments can rarely be predicted with certainty (Culhane 1987), but an EIS must contain some form of systematic prediction of forecasts (inferences) of the outcomes of specific development alternatives. The EISs reviewed also reflect this problem with regard to reclamation planning. Many of the reclamation predictions were in the form of vague generalizations such as "... the end result is a topography which closely resembles the original and which is protected from erosion by a cover of vegetation" (Teck Bullmoose Corporation 1982). The conceptual
reclamation plan included as part of the mine development EIS is intended as a forecast of the appearance of the post-mining landscape and a general description of the required management practices. However, this information was so weak in most cases that it had little value. Application of the 'recovery or inertia index' or the 'rehabilitation potential' in conjunction with suitability analyses would improve greatly the predictive power of these conceptual plans.

Risk Assessment

Reclamation planning uncertainty is a function of ecosystem complexity and a lack of understanding of ecosystem perturbation response. As such, reclamation planning includes an element of environmental risk.

Risk is imposed by legislative constraints (Suter et al. 1990). If there is high uncertainty of successful reclamation due to lack of knowledge, then this should be incorporated into project approval. However, the risk of unsuccessful reclamation is currently not included in the mine development review process. The risk of reclamation failure is very high with subalpine and alpine mine disturbances. Therefore, similar to ecological risk assessment, the proponent should be required to indicate the probability that their reclamation efforts will be successful before project approval.

Post-Development (Reclamation) Monitoring

Monitoring is an important component of environmental management, and reclamation monitoring, as part of the generalized EIA post-audit review process is required in both Alberta and British Columbia. However, only the United States has rigorous
monitoring requirements. In both British Columbia and Alberta, the quality of monitoring information is variable due to a lack of specific and detailed guidelines. Appropriate sampling procedures and data management protocols are fundamental to environmental monitoring (Rose and Smith 1992). Reclamation monitoring completes the ‘feedback loop’ involving application planning, review, approval, construction and reclamation. In the absence of rigorous monitoring, the review and approval process lacks the capacity to assess environmental impacts or mitigation measures (reclamation success).

Assessment of successful reclamation depends upon pre-disturbance information, supervision of reclamation activities and monitoring of the reclaimed land. However, unlike conventional static post-development monitoring, trend analysis should be employed. Eberhardt (1976) stressed the importance of assessing ‘trends’ in important variables during EIAs. With surface mine reclamation, the assessment of ‘trends’ would cause a change in emphasis from product to process. A proposed government/industry longitudinal (successional trend) monitoring program would be the most appropriate method for accumulating information on reclamation planning and techniques (Chapter 2). The research studies undertaken by the proponent would provide complementary site-specific information.

7. Conclusion

Adequate information upon which to base decisions is crucial to impact assessment and environmental management of surface mines. The information collected during the EIA
process or feasibility phase is considered essential for reclamation planning. Several important conclusions regarding environmental management in general and reclamation specifically can be drawn from the examination of mine development EIS documents.

In general, the technical basis of the EIS document needs to be improved with specific reference to reclamation planning, implementation and monitoring. All of the EISs contained vague narrative generalizations based, for the most part, on poorly described methods. Important information on diversity, rare and endangered species, succession, spatial relationships of wildlife habitat was often lacking. The approaches taken reflected a static perspective of ecosystems, and the information collected appeared to be a part of a ritualized 'fill-in-the-blanks' process.

Although variable, most EISs did not contain sufficient information (content and quality) upon which to base project approval with respect to reclamation. Standardization of data collection parameters and methodology as well as the development of appropriate data analysis and presentation protocols is necessary. Recovery indices and chronosequence studies should be required as well as diversity studies and sampling programs for rare and endangered species.

Moreover, improved monitoring of impacts and reclamation mitigation measures (Chapter 2) are warranted with application of sensitivity mapping techniques and GIS technology of particular benefit. Finally, accreditation of individuals as suggested in Chapter 2 would also improve data gathering and synthesis in the EIS thus assuring environmental 'due diligence' within the regulatory approval process.
CHAPTER IV
ATTITUDES OF RECLAMATION PARTICIPANTS

1. Introduction

Reclamation planning is a form of environmental problem-solving and decision-making in which professionals must satisfy the concerns of government regulators and corporate executives. Like other forms of environmental management, reclamation requires that the values of specialists be assessed and integrated into collective preferences when making decisions. Attitudes of individuals and groups towards the environment and environmental issues is important (Mitchell 1989).

The ethos of participants within the reclamation process will dictate the direction and, ultimately, the success of any reclamation program. In particular, the attitudes, opinions and perceptions of the various specialists will determine which technical problems are selected for research, how the results are incorporated into management planning and the requirements of 'due diligence' and compliance. For example, both Alberta and British Columbia provide discretionary powers of interpretation and judgment to their Director and Chief Inspector, respectively (Chapter 2). The attitudes and opinions of such individuals are extremely important in the interpretation of regulatory requirements and reclamation practices. Therefore, the focus in this chapter is to characterize the attitudes of individuals involved in reclaiming high elevation coal mine disturbances and to examine the implications of their attitudes, particularly ecological, to the reclamation process. Where appropriate, solutions are proposed.
2. Literature Review

Much of the information concerning the attitudes of participants within the reclamation process is based upon anecdotal observations with little empirical support. The majority of environmental management attitudinal studies have investigated public or professional group differences in forest land management (Twight and Lyden 1989), land management and farming (Bernardo and Engle 1990), wildlife management and hunting (Peek 1986), land conservation (Haas 1988), water conservation (Richards and Huntsinger 1994), engineering and pollution (Staudt and Harris 1985), and aesthetics (Dearden 1984).

Although public attitudes toward the mining industry and environmental management issues such as land-use and pollution have been studied recently (Mining Association of Canada 1989, Connor 1991, Andrews 1994), the attitudes of those directly involved in mine reclamation have not been researched. Participant attitudes toward the mine development review process in British Columbia were studied by Gibson (1983), limitations of reclamation practices (colliery and metalliferous spoil) in Great Britain were studied by Kelcey (1978), attitudes of industry towards spoil dump management were described by NORECOL (1986) and reclamation research needs in Alberta were studied by Smith (1989), but little attention has been given to the attitudes of all groups of reclamation professionals toward the entire range of reclamation practices (Fedkenheuer 1987). A recent study in British Columbia examined the attitudes of mining industry and regulatory respondents toward aspects of environmental management (MABC/TRCR 1993), but the study was not ecologically-focused and
lacked sufficient detail to adequately describe specific technical issues; thus, it presented simply a consensus of the ability of the industry to 'manage' high profile concerns.

From a review of these attitudinal studies and related environmental management literature, it is apparent that the resolution of environmental management problems such as reclamation, may be possible only when the influences of professional groupings, disciplinary training, working environment (peer pressure) and experience are better understood.

Problem complexity and the multidisciplinary nature of environmental management necessitate the use of professional groups (Bryden 1992). However, the use of 'experts' is not without problems (Bastedo and Theberge 1983). Although many advancements have been made, problems within environmental management persist, possibly because the 'experts' disagree on science and technology and/or management objectives (Hansen and Jorgensen 1991). Two sources have been proposed for the disagreement. First, participants within the process have variable socioeconomic and environmental objectives resulting in different views toward perturbation responses by ecosystems (Wang et al. 1988). Often, individuals are unable to distinguish between value-laden and predominantly technical questions (Miller 1983b). A lack of discernment with respect to values and technical solutions is prominent particularly in the field of mine reclamation where decisions regarding land-use ethics, post-mining land-use objectives and the adequacy of management investment are concerned. Second, when situations are complex and strong belief and uncertainty exist, intuitive judgments are highly suspect and may create real or apparent problems (Evans 1982).
Environmental problems are perceived differently by individual professionals because of differing assumptions during the problem formulation stage, information selectivity, cognitive oversimplification, and temporal constraints (Miller 1983a, 1985a, 1985b). Acknowledged environmental management concerns are also related to disciplinary cognitive biases or styles (Fischhoff 1979), a lack of multidisciplinary understanding (Wenk 1979), an inability to perceive environmental component interdependencies (Conacher 1980), and problem compartmentalization (Miller 1985c).

Collectively, professional groups reflect the attitudes of their membership (Douglas 1987), with group norms being important determinants of professional judgment and actions (Davos 1986). Professions also possess specialized professional language that can be confusing and intimidating to other professionals and/or the public (Krupar and Krupar 1989). Technical jargon tends to isolate professions: a situation which is inimical to the requisite multi-disciplinary planning nature of mine reclamation and restoration activities. Lexicon is important since a lack of uniformity in terminology detracts from communication (Wali 1992).

Environmental education and training are often identified as key components of environmental problem awareness and management (Borden 1993). Attitudes are part of the education process because they influence the acceptance of new information (Kunda 1990) and the development of innovations (Brown 1981). Education is essential to the realization of goals in the reclamation field.

Disciplinary backgrounds are also important determinants of information acquisition and information processing. The reclamation field is not part of a clearly defined
discipline (Latimer and Beaulac 1989), but individuals involved in the reclamation process generally have formal training in one or more of the following disciplines: agriculture, botany, zoology, engineering, forestry, geography, geology, horticulture, landscape architecture or soil science (DePuit 1986). These disciplines aggregate representations of conceptual understanding and cognitive styles which provide the opportunity for different approaches to reclamation problem-solving and planning.

Finally, employer goals and practices (Noss 1991), the nature and structure of the working environment (Bultena and Hendee 1972), peer pressures (Witter and Shaw 1979) and experience (Hendee and Harris 1970) all interact to influence or bias the attitudes and perceptions of environmental management personnel.

3. Research Objectives

The objective of this chapter is to identify the opinions and perceptions of reclamation practitioners and examine how they influence such activities as legislation, baseline data collection (environmental impact statements), reclamation species selection, post-mining land-use objectives, and management planning. Since the attitudes and opinions of group members are influenced more by intra-group communication than by communication derived from external sources (Wilder 1990), an attitudinal survey focusing on technical issues should be representative of group consensus. Wilder (1990) has suggested that “. . perceivers process in-group messages carefully, which can expose weak arguments whereas out-group messages are given little thought.”
Within the special concern of high elevation mine reclamation, several questions emerged following a review of the technical literature. Do these individuals have different opinions? Are the opinions of various subgroups of the population similar? Does experience or training affect the opinions of the people?

To describe the general attitudes of reclamation practitioners and examine group differences, several specific statements were presented within a survey questionnaire.

4. Methods

A questionnaire survey was chosen to investigate the role of individuals and specific groups in high elevation reclamation practices.

Sample Population Description

The population under study was composed of six groups involved in some capacity with high elevation coal mine reclamation program development or implementation at active or proposed coal mines near or above treeline in the Canadian Rocky Mountains. Subpopulations were defined based upon professional group differences, occupation and role within the reclamation process as defined by Morrison (1987) and Ziemkiewicz (1987).

Survey population information was provided initially by lists from recent symposium proceedings and the membership lists of the Canadian Land Reclamation Association (CLRA 1990), the Coal Association of Canada (1990) and communication with C.B. Powter (Alberta Environment) and Dr. J.C. Errington (Ministry of Energy, Mines and Petroleum Resources). One hundred and thirty-eight individuals were contacted.
initially by telephone. With direct occupational involvement as the selection criterion, one hundred of the 138 individuals were identified and sent letters formally requesting survey participation (Appendix 4.1). The prospective respondents were asked to indicate their willingness to participate in the survey with a check mark (\(\checkmark\)). The letters were returned in self-addressed and stamped envelopes; all letters were returned with all individuals indicating their willingness to participate. Fourteen telephone conversations were received in order to answer questions from potential respondents. An additional eighteen individuals were added to the list of potential respondents as a result of telephone conversations and further discussions with industry and government officials. The interaction between environmental and mine planning personnel was highly variable between mines. Consequently, consultations with environmental and operational staff at the mines were undertaken, and it was agreed that only senior mine planning engineers should participate in the survey. The resultant population was re-defined to include 116 individuals (Appendix 4.2). The population was divided into six sub-populations (categories) based on occupation. Due to the volatility and uncertainty of the coal industry, several of the categories within the population are transient in nature. Therefore, individuals who were at the time not directly involved with the industry but who had been in the past were included because of the knowledge which they possessed. This was particularly the case with environmental consultants who have been under contract, from time to time, with the various mining companies. Two of the respondents changed jobs during the survey administration period.

_Survey Administration_
Questionnaires were administered to the entire population of 116 individuals. A personal interview survey, although considered to be the most appropriate survey mechanism for small populations (Sheskin 1985), was not used because of logistical concerns. Therefore, a dual survey mechanism (mail and telephone) was used to maximize survey response (Lovich and Pierce 1986). The survey participants were mailed a package which included a covering letter (Appendix 4.3), an informed consent form (Appendix 4.4), the questionnaire (Appendix 4.5) and separate stamped, self-addressed mailing envelopes for both the consent form and questionnaire. The questionnaire was accompanied by introductory letters of support from the Inspection and Engineering Branch of the British Columbia Ministry of Energy, Mines and Petroleum Resources, the Coal Association of Canada, Alberta Environment and the Mining Association of British Columbia.

Potential respondents were telephoned prior to mailing the questionnaire. All potential respondents who had not returned questionnaires after four weeks were contacted by telephone in order to ensure they had received a copy of the questionnaire. Several subsequent telephone conversations were needed to encourage a number of individuals to complete and return their questionnaires.

**Survey Instrument**

Each respondent completed a multi-part questionnaire (Appendix 4.5). The funnel-filter approach (Sheskin 1985) was included in the design of Sections A-D of the
questionnaire so that respondents were not required to complete sections for which they did not have a knowledge-base. The majority of the statements in each section were close-ended because the questions or statements were mainly technical and the potential responses of the respondents were well defined (Backstrom and Hursh-Cesar 1981). The important aspects of each question or statement were in bold face italics and sensitive questions were positioned near the end of each section.

Section A of the questionnaire contained statements and a series of responses from which each respondent was required to list three in order of priority. The respondents were also given the option, where necessary, to specify an item (category) not listed. The section proceeded from general reclamation interests to more specific questions.

Attitudes have two properties: (1) direction (positive or negative feelings or beliefs) (Olson and Zanna 1993) and (2) magnitude (degree of favorableness or unfavorableness) (Himmelfarb 1992). Therefore, Sections B, C and D of the questionnaire contained a series of statements where individuals were asked to respond to an attitudinal continuum between strongly disagree and strongly agree using the 5-point Likert rating 'scale' (Bailey 1987). Eleven general statements or questions were posed:

(1) Baseline information obtained for EIAs is adequate for the design and implementation of successful high elevation reclamation programs.

(2) The project review and regulatory process provides sufficient guidance for the design of reclamation plans by mining companies.
(3) The criteria used for the evaluation of successful reclamation and bond release (slope stability, equivalent productivity, self-sustaining vegetation cover and achievement of specified land-use objectives) are appropriate.

(4) Present government regulations are considered to be adequate.

(5) Successional processes are given enough attention in mine reclamation planning.

(6) The evaluation criteria used to assess reclamation success preclude the use of high elevation native plant species.

(7) The techniques of reclamation evaluation are appropriate.

(8) What do individuals involved in reclamation consider to be the most important aspects of high elevation reclamation?

(9) The expectations of government regulators are compatible with the present understanding of subalpine and alpine successional processes.

(10) Present revegetation techniques are considered to be satisfactory for the successful reclamation of mine disturbances.

(11) Are present plant species and varieties considered to be satisfactory for the successful reclamation of high elevation mine disturbances?

The scale was used to measure how strongly the respondents felt about a particular statement. A neutral alternative was included so that the respondents were not forced to make a choice. The statements in these sections were long, but they could not be reduced because of their technical nature. The sequence of statements in these sections progressed from technical to less technical and more controversial. Two forms of the questionnaire were developed to eliminate statement position effects on attitude.
responses and, thus, improve the reliability of the questionnaire. In both variants, the sequence of statements in Sections B, C, and D was altered. The two forms of the questionnaire were assigned in a quasi-stratified random manner to each subpopulation and jurisdiction.

Section E of the questionnaire contained a series of demographic questions which allowed for subpopulation identification. The demographic data was included to permit analysis of attitudes by education, profession, experience and regulatory jurisdiction groupings. This information was critical in attempting to ascertain the possible bias of each respondent and of the analyzed data. Questions were in a similar format to those of Section A.

*Pilot Study*

A pilot study was conducted using 15 individuals with experience relevant to most of the subpopulations within the main study. Unfortunately, the small size of the reclamation contractor and seed producer subpopulations precluded their involvement in the pilot study. The pilot study was conducted after review and acceptance of the research by the University of Victoria Human Subjects Committee. Following the return of the pilot study questionnaires, the data were input into a Lotus 123™ spreadsheet and then into SYSTAT™ to examine the internal reliability of the questionnaire and to correct any problems with data input and analysis. Questionnaire statements identified by respondents as ambiguous or difficult to understand were modified. The main study incorporated all of these changes. Most of the changes were
made in Section A of the questionnaire where phrasing of statements required alteration, and the number of required ranked responses was reduced from five to three. Pilot study participants consistently expressed considerable difficulty in ranking five items and suggested that three would be more appropriate.

Data Analysis

The data collected from the survey were nominal in form and pre-coded, so they were input into a Lotus 123™ spreadsheet without modification. The data were validated (computer input errors) following input in order to ensure reliability (Stoddard 1982). Data analysis for Section A of the questionnaire involved simple frequency tables to identify response priorities and a series of Kruskal-Wallis tests to examine subpopulation differences in the ranking of responses (Blalock 1979). Data analysis in sections B, C and D involved the production of cross-tabulation matrix-form tables of the number and percentage of respondents who answered particular questions. The existence of relationships between variables was explored using chi-square tests. Attitudinal responses to all of the statements in each section were first subjected to a goodness-of-fit test to determine if there were inter-provincial differences in attitudes, and then, where appropriate, responses to statements were pooled according to professional groups and subjected to a two-way contingency table analysis (Norcliffe 1982). Goodness-of-fit tests were performed as a means of pooling responses from both jurisdictions since the entire population size was small.
Where appropriate, graphic presentation was in the form of simple **histograms** as generated by SYGRAPH™. The Tables module of the SYSTAT™ Version 5.0 computer program was used to generate the above statistics.

**Non-metric multidimensional scaling** was used to examine the latent structure (Herzog 1987, Gobster and Chenoweth 1989) of opinions towards statements provided in Section B - Coal Mine Reclamation, Regulations, Guidelines and Review Process, Section C - Mine Reclamation Planning and Techniques, and Section D - Plant Materials Selection, irrespective of subgroup (subpopulation) membership.

Group membership was evaluated on the basis of attitudinal responses to the statements provided in each section of the questionnaire. **Discriminant function analysis** was performed using the statements within each section as predictor variables (Twight and Lyden 1989). Prior to analysis, the assumptions of **linearity**, **multivariate normality**, **multicollinearity** and **homogeneity of the variance-covariance matrices** were evaluated for each section of the questionnaire. All three of the data matrices had positive skewness and were log **transformed** (Wilkinson 1990). Only **canonical loadings** in excess of 0.30 were considered significant for **canonical variates** interpretation (Tabachnick and Fidell 1983).

5. **Results**

**Survey Response**

The total and sub-population percent response is listed in Table 4.1. Mean percent response rate for combined sub-populations was 86% and exceeds the 74% percent
TABLE 4.1 QUESTIONNAIRE RESPONSE FREQUENCY.

<table>
<thead>
<tr>
<th></th>
<th>Number of Potential Respondents</th>
<th>Number of Actual Responses</th>
<th>Percent Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOVERNMENT ENVIRONMENTAL</td>
<td>29</td>
<td>28</td>
<td>97</td>
</tr>
<tr>
<td>INDUSTRY ENVIRONMENTAL</td>
<td>27</td>
<td>21</td>
<td>78</td>
</tr>
<tr>
<td>NURSERY STOCK AND SEED SUPPLIERS</td>
<td>12</td>
<td>9</td>
<td>75</td>
</tr>
<tr>
<td>ENVIRONMENTAL CONSULTANTS</td>
<td>25</td>
<td>23</td>
<td>92</td>
</tr>
<tr>
<td>GOVERNMENT ENGINEERS</td>
<td>7</td>
<td>7</td>
<td>100</td>
</tr>
<tr>
<td>INDUSTRY ENGINEERS</td>
<td>16</td>
<td>12</td>
<td>75</td>
</tr>
<tr>
<td>TOTAL</td>
<td>116</td>
<td>100</td>
<td>86</td>
</tr>
</tbody>
</table>
recorded by Dillman (1978). Sub-population response rates varied between 75 and 100%. Government engineers were the highest while industry engineers and nursery stock and seed suppliers were the lowest. Jurisdictional differences in response rates were also evident (Figure 4.1). Alberta industry environmental personnel and environmental consultant response rates were greater than their counterparts in British Columbia while government environmental response was greatest in British Columbia (Tables 4.2 and 4.3).

Return rates were significant for industry environmental, nursery stock and seed suppliers and industry engineer sub-populations and highly significant for the government environmental, environmental consultant and government engineer sub-populations according to percentage response categories provided by Backstrom and Hursh-Cesar (1981).

Several respondents who had given prior consent to survey involvement declined to complete the questionnaires. Two reasons were given during follow-up telephone conversations: (1) the potential respondents were no longer employed and could not be contacted or (2) problems with work as well as staff reductions did not allow individuals time to complete the questionnaire.

In addition, 43% of the respondents provided written comments in the space provided at the end of the questionnaire.
Figure 4.1 Weekly Questionnaire Return Rate Frequency.
TABLE 4.2 RESPONSES OF QUESTIONNAIRE SUB-POPULATIONS.

<table>
<thead>
<tr>
<th>OCCUPATION</th>
<th>ALBERTA</th>
<th></th>
<th>BRITISH COLUMBIA</th>
<th></th>
<th>TOTAL</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NUMBER OF POTENTIAL RESPONDENTS</td>
<td>NUMBER OF ACTUAL RESPONSES</td>
<td>PERCENT RESPONSE</td>
<td>NUMBER OF POTENTIAL RESPONDENTS</td>
<td>NUMBER OF ACTUAL RESPONSES</td>
<td>PERCENT RESPONSE</td>
</tr>
<tr>
<td>GOVERNMENT ENVIRONMENTAL</td>
<td>18</td>
<td>17</td>
<td>94</td>
<td>11</td>
<td>11</td>
<td>100</td>
</tr>
<tr>
<td>INDUSTRY ENVIRONMENTAL</td>
<td>10</td>
<td>10</td>
<td>100</td>
<td>17</td>
<td>11</td>
<td>65</td>
</tr>
<tr>
<td>NURSERY STOCK AND SEED SUPPLIERS</td>
<td>4</td>
<td>3</td>
<td>75</td>
<td>8</td>
<td>6</td>
<td>75</td>
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<tr>
<td>ENVIRONMENTAL CONSULTANTS</td>
<td>11</td>
<td>11</td>
<td>100</td>
<td>14</td>
<td>12</td>
<td>86</td>
</tr>
<tr>
<td>GOVERNMENT ENGINEERS</td>
<td>1</td>
<td>1</td>
<td>100</td>
<td>6</td>
<td>6</td>
<td>100</td>
</tr>
<tr>
<td>INDUSTRY ENGINEERS</td>
<td>4</td>
<td>3</td>
<td>75</td>
<td>12</td>
<td>9</td>
<td>75</td>
</tr>
<tr>
<td>TOTAL</td>
<td>48</td>
<td>45</td>
<td>-</td>
<td>68</td>
<td>35</td>
<td>-</td>
</tr>
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### Table 4.3: Sub-Population Response for Each Section of the Survey Questionnaire

<table>
<thead>
<tr>
<th>Occupational Group</th>
<th>Section A</th>
<th>Section B</th>
<th>Section C</th>
<th>Section D</th>
<th>Section E</th>
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</thead>
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<tr>
<td></td>
<td>PART 1</td>
<td>PART 2 LEGISLATION, REGULATIONS AND GUIDELINES</td>
<td>RECLAMATION PLANNING</td>
<td>PLANT MATERIALS</td>
<td>DEMOGRAPHICS</td>
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<tr>
<td>Government Environmental</td>
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<td>24</td>
<td>28</td>
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<td>28</td>
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<tr>
<td>Industry Environmental</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>20</td>
<td>21</td>
</tr>
<tr>
<td>Nursery / Seed Producers</td>
<td>9</td>
<td>9</td>
<td>5</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>Environmental Consultants</td>
<td>23</td>
<td>23</td>
<td>20</td>
<td>23</td>
<td>22</td>
</tr>
<tr>
<td>Government Engineers</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Industry Engineers</td>
<td>12</td>
<td>10</td>
<td>12</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td><strong>94</strong></td>
<td><strong>93</strong></td>
<td><strong>97</strong></td>
<td><strong>91</strong></td>
</tr>
</tbody>
</table>
Respondent Sub-population Descriptions

Occupation Groups: Occupational sub-populations varied in size: government environmental (28), industry environmental (21), nursery stock/seed producers (9), environmental consultants (23), government engineers (7) and industry engineers (12).

Five discriminant functions were calculated for occupation group membership when analyzing the legislation, regulations and guidelines section of the questionnaire. However, only the first root was statistically significant ($X^2 = 95.91$, df=70, p=0.02).

The first two discriminant functions accounted for 39% and 28%, respectively, of the between-group variability. The first discriminant function maximally separated industry and government engineering whereas the second discriminant function separated the 'environmental' and engineering occupations (Figure 4.2).

Examination of the loading matrix of correlations between predictor variables and discriminant functions revealed that the primary variable distinguishing between occupations (first function) was attitude towards equivalent productivity as an appropriate criteria for satisfaction of reclamation success. Also contributing to discrimination between professions were the attitudes towards reclamation performance bonds. Only one predictor had loadings in excess of 0.30 in the second discriminant function which distinguished between engineers and 'environmental' occupations. The attitudes toward the economic feasibility of post-mining land-use objectives and the requirement of revegetation for all forms of surface disturbance were the important variables in the second function.
Figure 4.2 Canonical Variates Plots: Occupational Groupings of Attitudinal Responses Towards Reclamation Legislation, Regulations And Guidelines.
The stability of the classification procedure was checked with a classification table. Tabulation of actual group membership versus predicted \( (X^2=20.51, \text{ df}=5, p=0.001) \) indicated that occupational group classification was not stable for the legislation, regulations and guidelines section of the questionnaire.

Five discriminant functions were calculated for group membership based on the reclamation planning and techniques data although only the first two roots were statistically significant (factor 1 \( X^2=185.66, \text{ df}=110, p=0.00 \); factor 2 \( X^2=119.60, \text{ df}=84, p=0.00 \)). The first two discriminant functions accounted for 55% and 45%, respectively, of the between-group variability. The first discriminant function separated maximally industry environmental personnel from the other occupations while the second discriminant function discriminated between the ‘environmental’ group of occupations and engineering (Figure 4.3).

Using the loading matrix of correlations between predictor variables and discriminant functions, the primary variable distinguishing between occupations (first function) was attitude towards joint involvement of mine engineers and environmental personnel in reclamation planning. Also contributing to the distinction between occupations in the first discriminant function were the attitudes of participants toward the suitability of current reclamation techniques for high elevation reclamation and mulch application. In the second discriminant function, the primary distinguishing variable was the attitude towards re-established wildlife habitat evaluation of high elevation disturbances. Two secondary variables, attitudes toward mine spoil resloping and the alteration of mine plans to accommodate reclamation planning, also discriminated.
Figure 4.3 Canonical Variates Plots: Occupational Groupings of Attitudinal Responses Towards Mine Reclamation Planning and Techniques.
The stability of the classification procedure for group membership was tabulated. Tabulation of actual group membership versus predicted \( (X^2=1.85, \text{df}=5, p=0.869) \) indicated that occupational group classification was stable, and group membership based on the classification was reliable.

Examination of multivariate significance tests of occupational group membership based on attitudes toward plant materials (Table 4.4) indicated that it was not possible to discriminate professions on the basis of attitudes towards reclamation plant materials.

**Education:** The educational background of the survey participants is provided in Table 4.5. In total, 91% of the respondents were university trained. The formal training of government environmental personnel was variable, but the majority had training in the disciplines of general biology (20%), botany (16%), forestry (16%) and soil science (16%). The education of industry environmental personnel varied also: general biology (26%), forestry (17%), geography (13%) and technical environmental science (13%). The majority of nursery stock and seed producers (67%) had an agricultural background while the environmental consultants surveyed had backgrounds in either general biology (35%) or agriculture (21%). Mining engineering was the predominant training of both government engineers (86%) and industry engineers (84%).

Five discriminant functions were calculated for the education grouping based on attitudes toward legislation, regulations and guidelines. However, only the first root was statistically significant \( (X^2=142.54, \text{df}=112, p=0.02) \). The first two discriminant functions accounted for 38% and 37%, respectively, of the between-group variability. The first discriminant function separated maximally individuals with training in biology
<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>TEST</th>
<th>TEST STATISTIC</th>
<th>F-STATISTIC</th>
<th>DEGREES OF FREEDOM</th>
<th>PROBABILITY</th>
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<td>LEGISLATION</td>
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<td>1.418</td>
<td>70, 356</td>
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<td>REGULATION</td>
<td>PILLAI TRACE</td>
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<td>1.390</td>
<td>70, 390</td>
<td>0.029 *</td>
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<td>1.442</td>
<td>70, 362</td>
<td>0.018 *</td>
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<td></td>
<td>THETA (S=5, M=4.0, N=36.0)</td>
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<td>-</td>
<td>-</td>
<td>0.016 *</td>
</tr>
<tr>
<td>PLANNING/</td>
<td>WILK'S LAMBDA</td>
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<td>1.828</td>
<td>110, 347</td>
<td>0.000 **</td>
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<tr>
<td>TECHNIQUES</td>
<td>PILLAI TRACE</td>
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<td>1.815</td>
<td>110, 370</td>
<td>0.000 **</td>
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<td>1.833</td>
<td>110, 342</td>
<td>0.000 **</td>
</tr>
<tr>
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<td>THETA (S=5, M=8.0, N=34.0)</td>
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<td>-</td>
<td>-</td>
<td>0.006 **</td>
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<td>0.368</td>
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<td>0.347</td>
</tr>
<tr>
<td></td>
<td>THETA (S=5, M=5.0, N=34.0)</td>
<td>0.377</td>
<td>-</td>
<td>-</td>
<td>0.144</td>
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<tr>
<td>EDUCATION</td>
<td>OCCUPATION</td>
<td>MEAN</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------</td>
<td>------------</td>
<td>------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>GOVERNMENT</td>
<td>INDUSTRY</td>
<td>NURSERY/SEED</td>
<td>ENVIRONMENTAL</td>
<td>ENGINEERS</td>
</tr>
<tr>
<td>UNIVERSITY</td>
<td>ENVIRONMENTAL</td>
<td>ENVIRONMENTAL</td>
<td>PRODUCERS</td>
<td>CONSULTANTS</td>
<td>ENGINEERS</td>
</tr>
<tr>
<td>N = 100</td>
<td>N = 28</td>
<td>N = 21</td>
<td>N = 9</td>
<td>N = 23</td>
<td>N = 7</td>
</tr>
<tr>
<td>(%)</td>
<td>(%)</td>
<td>(%)</td>
<td>(%)</td>
<td>(%)</td>
<td>(%)</td>
</tr>
</tbody>
</table>

1. AGRICULTURE 8 9 67 21 - - 15
2. BIOLOGY (GENERAL) 20 26 11 35 - - 20
3. BOTANY 16 9 - 9 - - 8
4. ENGINEERING 4 4 - - 14 8 4
   4.1 CIVIL 4 4 - - - - 4
   4.2 GEOTECHNICAL - - - - - - 1
   4.3 MINING 4 - - - - 86 84 18
5. FORESTRY 16 17 11 9 - - 10
6. GEOGRAPHY 4 13 - 4 - - 5
7. LANDSCAPE 4 - - 4 - - 2
   ARCHITECTURE - - - - - - 2
8. SOIL SCIENCE 16 9 - 9 - - 8

TECHNICAL SCHOOL

1. ENVIRONMENTAL SCIENCE 8 13 - 9 - - 8
2. FORESTRY - - 11 - - - 1
from those with training in soil science or landscape architecture. The second function discriminated maximally individuals with soil science training from those with forestry training (Figure 4.4).

Using the loading matrix of correlations between predictor variables and discriminant functions, it was observed that the primary variable distinguishing between education groups (first function) was attitude towards self-perpetuating vegetation as the main criterion for satisfaction of reclamation success. Only one predictor, the attitudes toward variances for difficult to revegetate sites, had loadings in excess of 0.30 in the second discriminant function.

The education group classification was not stable ($X^2 = 18.21, \text{df}=5, p=0.006$) as indicated by the stability of the classification procedure using tabulation of actual group membership versus predicted. Furthermore, it was not possible to discriminate education categories (groups) based on attitudes toward both reclamation planning and techniques and plant materials (Table 4.6).

An informal survey was also conducted to determine the extent of formal reclamation training which graduating mining engineers receive. Telephone conversations were held with the chairpersons of the mining engineering departments at Canadian universities which grant mining-related engineering degrees. The information is presented in Table 4.7.

All seven of the universities provide reclamation instruction to students within existing mining courses. The instruction was provided as part of a course on Mining and the Environment (University of Alberta, University of British Columbia, University of
Figure 4.4 Canonical Variates Plots: Education Groupings of Attitudinal Responses Towards Reclamation Legislation, Regulations and Guidelines.

- Landscape Architecture
- Agriculture
- Engineering
- Botany
- Biology
- Soil Science
- Geography
- Environmental Technology
- Forestry
<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>TEST</th>
<th>TEST STATISTIC</th>
<th>F-STATISTIC</th>
<th>DEGREES OF FREEDOM</th>
<th>PROBABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEGISLATION</td>
<td>WILK'S LAMBDA</td>
<td>0.164</td>
<td>1.339</td>
<td>112, 509</td>
<td>0.019 *</td>
</tr>
<tr>
<td></td>
<td>PILLAI TRACE</td>
<td>1.527</td>
<td>1.314</td>
<td>112, 624</td>
<td>0.024 *</td>
</tr>
<tr>
<td></td>
<td>HOTELLING-LAWLEY TRACE</td>
<td>2.184</td>
<td>1.350</td>
<td>112, 554</td>
<td>0.016 *</td>
</tr>
<tr>
<td></td>
<td>THETA (S=8, M=2.5, N=34.5)</td>
<td>0.168</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>PLANNING/TECHNIQUES</td>
<td>WILK'S LAMBDA</td>
<td>0.088</td>
<td>1.125</td>
<td>176, 520</td>
<td>0.163</td>
</tr>
<tr>
<td></td>
<td>PILLAI TRACE</td>
<td>1.950</td>
<td>1.084</td>
<td>176, 592</td>
<td>0.245</td>
</tr>
<tr>
<td></td>
<td>HOTELLING-LAWLEY TRACE</td>
<td>3.150</td>
<td>1.168</td>
<td>176, 522</td>
<td>0.098</td>
</tr>
<tr>
<td></td>
<td>THETA (S=8, M=6.5, N=32.5)</td>
<td>0.534</td>
<td>-</td>
<td>-</td>
<td>0.045 *</td>
</tr>
<tr>
<td>SPECIES</td>
<td>WILK'S LAMBDA</td>
<td>0.194</td>
<td>0.989</td>
<td>128, 495</td>
<td>0.521</td>
</tr>
<tr>
<td>SELECTION</td>
<td>PILLAI TRACE</td>
<td>1.413</td>
<td>0.992</td>
<td>128, 592</td>
<td>0.512</td>
</tr>
<tr>
<td></td>
<td>HOTELLING-LAWLEY TRACE</td>
<td>1.930</td>
<td>0.984</td>
<td>128, 522</td>
<td>0.535</td>
</tr>
<tr>
<td></td>
<td>THETA (S=8, M=3.5, N=32.5)</td>
<td>0.386</td>
<td>-</td>
<td>-</td>
<td>0.479</td>
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</tbody>
</table>
TABLE 4.7 MINE RECLAMATION INSTRUCTION IN CANADIAN MINE ENGINEERING FACULTIES.

<table>
<thead>
<tr>
<th>SUBJECT AREAS OF INSTRUCTION</th>
<th>UNIVERSITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>LEGISLATIVE REQUIREMENTS</td>
<td></td>
</tr>
<tr>
<td>ENVIRONMENTAL IMPACT ASSESSMENTS</td>
<td>+ + + + +</td>
</tr>
<tr>
<td>GUIDELINES</td>
<td>+ + + + +</td>
</tr>
<tr>
<td>BONDS AND PERMITS</td>
<td>+ + + + +</td>
</tr>
<tr>
<td>RECLAMATION PLANNING</td>
<td></td>
</tr>
<tr>
<td>INTEGRATION OF MINE PLANNING AND RECLAMATION</td>
<td>+ + + + + +</td>
</tr>
<tr>
<td>LAND-USE PLANNING</td>
<td>+ + + + +</td>
</tr>
<tr>
<td>RECLAMATION ECONOMICS</td>
<td>+ + + + +</td>
</tr>
<tr>
<td>POST-MINING LANDSCAPE</td>
<td></td>
</tr>
<tr>
<td>CHEMICAL AND PHYSICAL PROPERTIES OF MINE WASTES</td>
<td>+ + + + + +</td>
</tr>
<tr>
<td>CHEMICAL AND PHYSICAL METHODS OF STABILIZATION</td>
<td>+ + + + + +</td>
</tr>
<tr>
<td>SITE AND SURFACE PREPARATION</td>
<td>+ + + + +</td>
</tr>
<tr>
<td>FERTILIZERS AND SOIL AMENDMENTS</td>
<td>+</td>
</tr>
<tr>
<td>REVEGETATION</td>
<td></td>
</tr>
<tr>
<td>GENERAL INFORMATION</td>
<td>+ + + + +</td>
</tr>
<tr>
<td>SPECIES SELECTION</td>
<td>+</td>
</tr>
<tr>
<td>SEED MIXTURES</td>
<td>+</td>
</tr>
<tr>
<td>SEEDING METHODS</td>
<td>+</td>
</tr>
<tr>
<td>ALTERNATE ESTABLISHMENT TECHNIQUES</td>
<td></td>
</tr>
<tr>
<td>EDUCATIONAL INSTITUTIONS:</td>
<td></td>
</tr>
<tr>
<td>1 - UNIVERSITY OF BRITISH COLUMBIA, 2 - UNIVERSITY OF ALBERTA, 3 - LAURENTIAN UNIVERSITY, 4 - UNIVERSITY OF TORONTO, 5 - QUEEN'S UNIVERSITY, 6 - MCGILL UNIVERSITY, 7 - UNIVERSITY OF LAVAL.</td>
<td></td>
</tr>
<tr>
<td>CODE: (+) - YES, ( ) - NO.</td>
<td></td>
</tr>
</tbody>
</table>
Laval, McGill University, University of Toronto), as part of a Mine Design course (Laurentian University) or as part of a Mine Waste Management course (Queen's University). However, the subject areas of instruction varied.

All components of the legislative requirements are provided within the courses at the University of British Columbia and the University of Toronto while two other universities provide partial instruction, and three do not provide any instruction. Integration of mine and reclamation planning was part of the course work at all the universities while instruction in land-use planning and reclamation economics was limited.

The chemical and physical properties and methods for stabilization of mine wastes were subject areas of instruction at all universities except McGill. Teaching of site and surface preparation was also provided at most universities whereas only the University of Laval offered instruction in fertilizers and soil amendments.

Revegetation instruction was limited to general information at most of the universities except Laurentian and McGill which did not have any form of instruction. Only the University of Toronto provides instruction in seeding methods while only the University of Laval provides instruction in plant species selection.

Experience: Most of the respondents have been involved in reclamation related activities for less than 30 years (Figure 4.5). A large majority (92%) of government environmental personnel had experience divided equally between the four categories that comprise the range of 0-20 years. All of the experience of industry environmental personnel surveyed was within the 0-25 range although most of this was in the 0-15
Figure 4.5 Experience Categories for Sub-Populations of Questionnaire.

A = Environmental - Government
B = Environmental - Industry
C = Nursery / Seed Suppliers
D = Environmental Consultants
E = Industry Engineers
F = Government Engineers

Years
- C8 = > 35
- C7 = 31 - 35
- C6 = 26 - 30
- C5 = 21 - 25
- C4 = 16 - 20
- C3 = 11 - 15
- C2 = 6 - 10
- C1 = 0 - 5
range. Nursery stock and seed producers had the lowest level of experience of the professional groups with the majority (75%) in the 0-10 year range. All of the experience (100%) of environmental consultants surveyed was within the range of 0-25 years although 60% of this was within the 11-15 year category. The majority of experience of industry engineers (76%) was in the 6-15 year range although this was primarily in the 6-10 year category. The industry engineer sub-population was the only group that had individuals with greater than 35 years of experience. The majority of government engineer experience (44%) was within the 21-25 year category.

Five discriminant functions were calculated for group membership based on attitudes toward reclamation planning and techniques. However, only the first root was statistically significant \(X^2=168.42, \text{ df}=132, p=0.01\). The first two discriminant functions accounted for 46% and 38%, respectively, of the between-group variability. The first discriminant function separated maximally the most experienced individuals (31-35 years) from the least experienced (1-5 years). The second function discriminated similarly. Little new information was contained within the second function (Figure 4.6).

Examination of the loading matrix of correlations between predictor variables and discriminant functions for planning and techniques indicated that the primary variable distinguishing experience (first function) was attitude towards the concept of complete reclamation for surface mine activities. Only one predictor had loadings in excess of 0.30 in the second discriminant function. The attitudes toward the re-establishment of target plant communities for surface mine disturbance was the important predictor
Figure 4.6 Canonical Variates Plots: Experience Groupings of Attitudinal Responses Towards Mine Reclamation and Planning.
variable in the second function. When group membership was examined, it was observed that experience was a stable and reliable discriminator of group membership ($X^2=5.47$, df, $p=0.486$).

Multivariate significance tests were used to predict experience category membership based on attitudes towards both legislation, regulations and guidelines and plant materials; it was not possible to discriminate group membership (Table 4.8).

**Information:** In addition to the demographic data, information was obtained on the sources of reclamation information used by sub-populations (Table 4.9). Environmental consultants (29%), industry environmental (26%) and government environmental personnel (22%) made the greatest use of information available on reclamation. The majority of this information (60%) was in written form. Internal corporate correspondence (18%), symposium proceedings (15%), government publications (12%) and journal articles (12%) were the most frequently used written forms while conference presentations (10%) and government personnel (10%) were the most important verbal forms of information exchange.

**General Reclamation Information Priorities**

General statements concerned with high elevation surface mine reclamation were provided to determine the priorities and concerns of respondents with respect to environmental limitations, legislation and planning (techniques and species selection). The non-parametric Kruskal-Wallis test was applied to compare sub-population
<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>TEST</th>
<th>TEST STATISTIC</th>
<th>F-STATISTIC</th>
<th>DEGREES OF FREEDOM</th>
<th>PROBABILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEGISLATION</td>
<td>WILK'S LAMBDA</td>
<td>0.282</td>
<td>1.256</td>
<td>84, 413</td>
<td>0.079</td>
</tr>
<tr>
<td>/REGULATION</td>
<td>PILLAI TRACE</td>
<td>1.108</td>
<td>1.262</td>
<td>84, 468</td>
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<td>HOTELLING-LAWLEY TRACE</td>
<td>1.467</td>
<td>1.246</td>
<td>84, 428</td>
<td>0.085</td>
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<tr>
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<td>THETA (S=6, M=3.5, N=35.5)</td>
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<td>-</td>
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<td>1.431</td>
<td>132, 408</td>
<td>0.004 **</td>
</tr>
<tr>
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<td>PILLAI TRACE</td>
<td>1.786</td>
<td>1.426</td>
<td>132, 444</td>
<td>0.004 **</td>
</tr>
<tr>
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<td>HOTELLING-LAWLEY TRACE</td>
<td>2.811</td>
<td>1.434</td>
<td>132, 404</td>
<td>0.004 **</td>
</tr>
<tr>
<td></td>
<td>THETA (S=6, M=7.5, N=33.5)</td>
<td>0.500</td>
<td>-</td>
<td>-</td>
<td>0.035 *</td>
</tr>
<tr>
<td>SPECIES SELECTION</td>
<td>WILK'S LAMBDA</td>
<td>0.464</td>
<td>0.737</td>
<td>80, 341</td>
<td>0.950</td>
</tr>
<tr>
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<td>PILLAI TRACE</td>
<td>0.700</td>
<td>0.754</td>
<td>80, 370</td>
<td>0.937</td>
</tr>
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<td>0.722</td>
<td>80, 342</td>
<td>0.960</td>
</tr>
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<td>THETA (S=5, M=5.0, N=34.0)</td>
<td>0.230</td>
<td>-</td>
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<td>0.513</td>
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</table>
### Table A.9 Percent Utilization for Identified Reclamation Information Sources.

<table>
<thead>
<tr>
<th>Source</th>
<th>Occupation</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GOVERNMENT</td>
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</tr>
<tr>
<td></td>
<td>ENVIRONMENTAL</td>
<td></td>
</tr>
<tr>
<td></td>
<td>INDUSTRY</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NURSERY/SEED PRODUCERS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ENVIRONMENTAL PRODUCERS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CONSULTANTS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ENGINEERS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>INDUSTRY ENGINEERS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N = 28</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N = 21</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N = 9</td>
<td></td>
</tr>
<tr>
<td></td>
<td>N = 23</td>
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<tr>
<td></td>
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<td></td>
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<td>N = 100</td>
<td></td>
</tr>
<tr>
<td><strong>Written</strong></td>
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</tr>
<tr>
<td>1. JOURNAL ARTICLES</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>2. MAGAZINE ARTICLES</td>
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</tr>
<tr>
<td>3. GOVERNMENT PUBLICATIONS</td>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>4. SYMPOSIUM PROCEEDINGS</td>
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<td>15</td>
</tr>
<tr>
<td>5. ANNUAL RECLAMATION REPORTS</td>
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<td>0</td>
</tr>
<tr>
<td>6. INTERNAL CORPORATE CORRESPONDENCE</td>
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<td>3</td>
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<tr>
<td></td>
<td></td>
<td>18</td>
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<td></td>
</tr>
<tr>
<td>1. CONFERENCES</td>
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</tr>
<tr>
<td>2. ACADEMIC RESEARCHERS</td>
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<td>9</td>
</tr>
<tr>
<td>3. GOVERNMENT PERSONNEL</td>
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<td>10</td>
</tr>
<tr>
<td>4. INDUSTRY CORRESPONDENCE</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>5. NURSERY SUPPLIERS</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>6. SEED COMPANIES</td>
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<td>7</td>
</tr>
<tr>
<td>7. CO-WORKERS</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>22</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>26</td>
<td>9</td>
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<td>8</td>
</tr>
<tr>
<td></td>
<td>100</td>
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</tr>
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rankings. The results of the priority ranking in Section A are provided in Tables 4.10 - 4.15.

**Environmental Limitations**: The most important limitations to high elevation revegetation were ranked by respondents, with short growing season (25%), infertility of plant growth material (18%), slow soil development (16%) and cool growing season temperatures (15%) considered most important (Table 4.10). Ranked responses by sub-population were not significantly different (Kruskal-Wallis $H=0.29$, $X^2=0.3$, $df=5$, $p=1.00$).

**Legislation**: The most important provisions of government legislation, regulations or guidelines were ranked by respondents, with environmental protection (22%), reclamation enforcement (20%), reclamation evaluation criteria (19%), reclamation planning objectives (17%) and long-term monitoring of reclamation success (15%) considered most important (Table 4.11). Ranked responses by sub-population were not significantly different (Kruskal-Wallis $H=0.66$, $X^2=0.7$, $df=5$, $p=0.99$).

**Planning**: Planning considerations for high elevation coal mine reclamation programs were ranked by respondents. Slope stability (19%), land-use objectives (17%), ecosystem restoration (16%), vegetation establishment (15%), and erosion control (12%) were considered to be the most important (Table 4.12). Ranked responses by sub-population were not significantly different (Kruskal-Wallis $H=1.00$, $X^2=1.0$, $df=5$, $p=0.96$).

**Plant Materials**: The use of commercially available plants (seeds or seedlings) for reclamation was ranked by respondents with vegetative cover for land-use objectives
The most important environmental limitations to high elevation revegetation are:

<table>
<thead>
<tr>
<th></th>
<th>Response</th>
<th>Occupation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ENVIRONMENTAL GOVERNMENT (%)</td>
<td>ENVIRONMENTAL INDUSTRY (%)</td>
</tr>
<tr>
<td>INFERTILITY OF PLANT GROWTH MATERIAL</td>
<td>17</td>
<td>19</td>
</tr>
<tr>
<td>SURFICIAL SLOPE INSTABILITY</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>SLOW SOIL DEVELOPMENT</td>
<td>13</td>
<td>16</td>
</tr>
<tr>
<td>SHORT GROWING SEASON</td>
<td>25</td>
<td>31</td>
</tr>
<tr>
<td>COOL GROWING SEASON TEMPERATURES</td>
<td>13</td>
<td>7</td>
</tr>
<tr>
<td>LOW WATER HOLDING CAPACITY OF Spoil</td>
<td>11</td>
<td>12</td>
</tr>
<tr>
<td>WIND</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>SOIL PHYSICAL PROPERTIES</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>LACK OF QUALITY TOPSOIL</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>LACK OF SUITABLE PLANT MATERIALS</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>EXPOSURE (ASPECT)</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>KNOWLEDGE OF APPROPRIATE TECHNIQUES AND PLANT MATERIALS CONDITIONING</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>DESTROYED SOIL STRUCTURE</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>LOW WATER PERMEABILITY IN REPLACED SOIL</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>COLD WINTER TEMPERATURES</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>FROST ACTION IN THE SOIL</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>SLOW ECOSYSTEM RESTORATION</td>
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TABLE 4.12 THE THREE MOST IMPORTANT PLANNING CONSIDERATIONS FOR HIGH ELEVATION COAL MINE RECLAMATION PROGRAMS SHOULD BE . . .

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<th>ENVIRONMENTAL INDUSTRY (%)</th>
<th>NURSERY/SEED SUPPLIERS (%)</th>
<th>ENVIRONMENTAL CONSULTANTS (%)</th>
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(23%), short-term erosion control (20%), soil development (17%) and long-term erosion control (15%) were considered to be the most important (Table 4.13). Response rankings by professional groups were not significantly different (Kruskal-Wallis $H=0.92$, $X^2=0.9$, df=5, $p=0.97$).

The perceived benefits of native species in high elevation reclamation programs were ranked by respondents, with ecosystem restoration (28%) and plant adaptation to local environment (29%) considered to be the most important (Table 4.14). The ranked responses of the professional groups were not significantly different (Kruskal-Wallis $H=1.48$, $X^2=1.5$, df=5, $p=0.92$). Only 94% of the respondents completed this portion of the questionnaire.

The major limitations to the use of native plants in reclamation programs were ranked with seed availability (30%), lack of information (18%), seed cost (17%), slow growth (10%), poor seedling establishment (8%) and inconsistent seed germination (8%) considered to be the most important determinants (Table 4.15). Ranked responses by sub-population were not significantly different (Kruskal-Wallis $H=0.08$, $X^2=0.1$, df=5, $p=1.00$). Again, only 94% of the respondents completed this portion of the questionnaire.

**Respondent Attitudes**

Survey participants were asked to respond to a series of statements related to surface mine reclamation. Attitudinal responses were first checked with a goodness-of-fit test to determine if the responses from both Alberta and British Columbia could be pooled.
TABLE 4.13 THE MOST IMPORTANT USES OF COMMERCIALLY AVAILABLE PLANTS (SEEDS OR SEEDLINGS) FOR RECLAMATION ARE . . .

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<th>RESPONSE</th>
<th>ENVIRONMENTAL GOVERNMENT (%)</th>
<th>ENVIRONMENTAL INDUSTRY (%)</th>
<th>NURSERY/SEED SUPPLIERS (%)</th>
<th>ENVIRONMENTAL CONSULTANTS (%)</th>
<th>ENGINEER GOVERNMENT (%)</th>
<th>ENGINEER INDUSTRY (%)</th>
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214
TABLE 4.15  THE MOST IMPORTANT LIMITATIONS TO THE USE OF NATIVE PLANTS IN RECLAMATION ARE . .

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</tr>
<tr>
<td>10. NATIVE PLANTS HAVE LIMITED APPLICATION OTHER THAN MINE RECLAMATION</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>&lt;1</td>
</tr>
<tr>
<td>11. LEGISLATION</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
</tbody>
</table>
Four of the statements in Section C (Reclamation Planning and Techniques) and two statements from Section D (Plant Materials Selection) could not be pooled.

**Attitude Response Dimensionality:** Respondent attitude scores for the legislation, reclamation planning and plant materials sections of the questionnaire were combined to form three separate matrices. The resultant matrices were analyzed separately using the nonmetric multidimensional scaling (NMDS). The euclidean model was selected for analysis with the data treated at the ordinal level. NMDS computes coordinates for a set of points such that the resultant 'map' of distances represents the spatial relationships between objects. NMDS analyses were conducted in five dimensions. Kruskal's (1964) stress formula was used to assist in interpreting the correct dimensionality. In addition, a hierarchical cluster analysis was applied to assist dimension interpretation (Wilkinson 1990). On the basis of these procedures and on the interpretability of the configurations, a three dimensional solution was chosen as the most appropriate method of representing the data for each of the three sections. The three-dimensional solution for the legislation, regulations and guidelines section showed a high goodness-of-fit with a 0.06542 stress of configuration and an $r^2$ of 0.96470. Goodness-of-fit for the other two sections was also high, with the NMDS solution for the planning and techniques section showing stress and $r^2$ values of 0.06519 and 0.97699, respectively, and the solution for the plant materials section showing stress and $r^2$ values of 0.05782 and 0.97899, respectively.

Examination of the NMDS configurations facilitated hypothesis development; a necessary step in understanding the dimensions participants used to discriminate within
each section of the questionnaire. Dimensionality of the legislation, regulations and guidelines matrix indicated an attitude orientation of short-term financial and regulatory monitoring concerns versus long-term monitoring of land-use objectives (Figure 4.7). Dimension two reflected an attitude orientation of reclamation (complete/partial disturbance reclamation) while the third dimension showed a holistic/ecological reclamation approach versus a segmented partial-systems approach.

The first dimension of the reclamation planning and techniques matrix reflected a continuum of attitudes from integrated mine operations/reclamation planning to the more conventional segmented techniques planning approach (Figure 4.8). Dimension one also showed a positive/negative trend or dissatisfaction with existing practices. Dimension two reflected an active/passive trend in reclamation management practices. The third dimension indicated an overall attitude trend of acceptance versus uncertainty with existing reclamation planning information, particularly with equipment modification techniques.

Examination of the first dimension of the plant materials matrix revealed a trend in species suitability with reference to establishment techniques (Figure 4.9). Dimension two showed a trend of long-term benefits (persistence) versus short-term costs (seed availability, establishment methods) with the use of native species in reclamation programs while dimension three represented a trend in the use of native species from abstract to practical.
Figure 4.7 Casement Plot of Dimensions Representing the Latent Structure of Attitudinal Responses Towards Reclamation Legislation, Regulations and Guidelines as Revealed by Non-Metric Multidimensional Scaling.

Dimension 1 Represents - short-term versus long-term concerns
Dimension 2 Represents - complete versus partial reclamation
Dimension 3 Represents - holistic versus partial systems approach
Figure 4.8 Casement Plot of Dimensions Representing the Latent Structure of Attitudinal Responses Towards Reclamation Planning and Techniques as Revealed by Non-Metric Multidimensional Scaling.

Dimension 1 Represents - conventional practices
Dimension 2 Represents - active/passive management
Dimension 3 Represents - equipment techniques
Figure 4.9 Casement Plot of Dimensions Representing the Latent Structure of Attitudinal Responses Towards Plant Materials as Revealed by Non-Metric Multidimensional Scaling.

Dimension 1 Represents - species suitability
Dimension 2 Represents - long-term benefits of native species
Dimension 3 Represents - conceptual basis for native species use
Reclamation Legislation, Regulations and Guidelines

Respondents were asked to provide their opinion on several statements pertaining to regulatory control of reclamation practices. The statements were divided into three categories: (1) reclamation legislation, (2) reclamation economics and (3) reclamation evaluation. The results of the cross-tabulations are provided in Tables 4.16 - 4.23.

Reclamation Legislation: Several statements were provided to determine the attitudes of respondents toward the existing regulatory process (Table 4.16).

A majority (66%) of the respondents disagreed with the statement that all forms of surface mine disturbances should be revegetated (Table 4.16). However, not all professional groups supported this opinion (Table 4.17). Sub-population differences were highly significant ($X^2=38.8, \text{ df}=20, p=0.009$), with 80% of nursery stock and seed suppliers in agreement with the statement.

Opinions on the granting of variances for difficult to revegetate mine disturbances were divided: 43% agreed and 36% disagreed (Table 4.16). A large number of neutral responses (21%) were recorded for this statement. However, significant differences in professional group response were recorded ($X^2=32.58, \text{ df}=20, p=0.042$). In general, the 'environmental' professions were split whereas the engineering professions were more polarized. Most industry engineers (79%) were in favor of variances whereas 60% of government engineers were not in favor (Table 4.18). Possibly, government engineers have a more balanced perspective on economics and land-use issues.

Several respondents (48%) considered increasing the demands of reclamation a viable method of improving high elevation coal mine reclamation. However, a number of
<table>
<thead>
<tr>
<th>STATEMENT</th>
<th>NUMBER OF RESPONSES</th>
<th>PROVINCE</th>
<th>STRONGLY DISAGREE (%)</th>
<th>DISAGREE (%)</th>
<th>NEUTRAL (%)</th>
<th>AGREE (%)</th>
<th>STRONGLY AGREE (%)</th>
<th>TOTAL (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- ALL FORMS OF SURFACE MINE DISTURBANCES (SPOIL DUMPS, Pit Floor, Head Walls, Foot Walls, Tailings Ponds) SHOULD BE REVEGETATED.</td>
<td>93</td>
<td>A + B</td>
<td>26</td>
<td>40</td>
<td>6</td>
<td>18</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>- VARIANCES (EXCEPTIONS TO REGULATIONS) SHOULD BE GRANTED FOR THOSE PORTIONS OF SURFACE MINE DISTURBANCES WHICH ARE DIFFICULT TO REVEGETATE.</td>
<td>93</td>
<td>A + B</td>
<td>9</td>
<td>27</td>
<td>21</td>
<td>40</td>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td>- MORE DEMANDING RECLAMATION LEGISLATION WILL IMPROVE THE PROCESS OF HIGH ELEVATION COAL MINE RECLAMATION.</td>
<td>93</td>
<td>A + B</td>
<td>7</td>
<td>25</td>
<td>20</td>
<td>41</td>
<td>7</td>
<td>100</td>
</tr>
<tr>
<td>- THE COAL RECLAMATION GUIDELINES PROVIDE ENOUGH GUIDANCE FOR THE DESIGN OF HIGH ELEVATION COAL MINE RECLAMATION.</td>
<td>93</td>
<td>A + B</td>
<td>9</td>
<td>41</td>
<td>18</td>
<td>32</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>- RECLAMATION LEGISLATION/GUIDELINES SHOULD EMPHASIZE THE RE-ESTABLISHMENT OF ECOSYSTEM PROCESSES RATHER THAN THE ESTABLISHMENT OF 'TARGET' PLANT COMMUNITIES</td>
<td>93</td>
<td>A + B</td>
<td>2</td>
<td>19</td>
<td>17</td>
<td>45</td>
<td>17</td>
<td>100</td>
</tr>
<tr>
<td>- THE INTERACTION BETWEEN GOVERNMENT AND INDUSTRY CONCERNING RECLAMATION IS PRESENTLY TOO ADVERSARIAL.</td>
<td>93</td>
<td>A + B</td>
<td>6</td>
<td>39</td>
<td>23</td>
<td>28</td>
<td>4</td>
<td>100</td>
</tr>
</tbody>
</table>

KEY: A - ALBERTA, B - BRITISH COLUMBIA
**TABLE 4.17 PERCENTAGE RESPONSE BY SUB-POPULATIONS TO THE STATEMENT "ALL FORMS OF SURFACE MINE DISTURBANCES SHOULD BE REVEGETATED."**

<table>
<thead>
<tr>
<th>OCCUPATIONAL GROUP</th>
<th>NUMBER OF RESPONSES</th>
<th>STRONGLY DISAGREE (%)</th>
<th>DISAGREE (%)</th>
<th>NEUTRAL (%)</th>
<th>AGREE (%)</th>
<th>STRONGLY AGREE (%)</th>
<th>TOTAL (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. GOVERNMENT ENVIRONMENTAL</td>
<td>28</td>
<td>10</td>
<td>55</td>
<td>7</td>
<td>17</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>2. INDUSTRY ENVIRONMENTAL</td>
<td>21</td>
<td>50</td>
<td>20</td>
<td>0</td>
<td>25</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>3. NURSERY / SEED PRODUCERS</td>
<td>5</td>
<td>0</td>
<td>20</td>
<td>0</td>
<td>80</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>4. ENVIRONMENTAL CONSULTANTS</td>
<td>20</td>
<td>15</td>
<td>50</td>
<td>10</td>
<td>5</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>5. GOVERNMENT ENGINEERS</td>
<td>7</td>
<td>20</td>
<td>40</td>
<td>20</td>
<td>20</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>6. INDUSTRY ENGINEERS</td>
<td>12</td>
<td>50</td>
<td>29</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>100</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>93</strong></td>
<td><strong>26</strong></td>
<td><strong>40</strong></td>
<td><strong>6</strong></td>
<td><strong>18</strong></td>
<td><strong>10</strong></td>
<td><strong>100</strong></td>
</tr>
<tr>
<td>OCCUPATIONAL GROUP</td>
<td>NUMBER OF RESPONSES</td>
<td>STRONGLY DISAGREE (%)</td>
<td>DISAGREE (%)</td>
<td>NEUTRAL (%)</td>
<td>AGREE (%)</td>
<td>STRONGLY AGREE (%)</td>
<td>TOTAL (%)</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------------------</td>
<td>-----------------------</td>
<td>--------------</td>
<td>-------------</td>
<td>-----------</td>
<td>-------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>1. GOVERNMENT ENVIRONMENTAL</td>
<td>28</td>
<td>7</td>
<td>24</td>
<td>21</td>
<td>48</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>2. INDUSTRY ENVIRONMENTAL</td>
<td>21</td>
<td>15</td>
<td>20</td>
<td>35</td>
<td>30</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>3. NURSERY / SEED PRODUCERS</td>
<td>5</td>
<td>0</td>
<td>40</td>
<td>20</td>
<td>40</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>4. ENVIRONMENTAL CONSULTANTS</td>
<td>20</td>
<td>15</td>
<td>40</td>
<td>15</td>
<td>30</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>5. GOVERNMENT ENGINEERS</td>
<td>7</td>
<td>0</td>
<td>60</td>
<td>20</td>
<td>20</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>6. INDUSTRY ENGINEERS</td>
<td>12</td>
<td>0</td>
<td>7</td>
<td>14</td>
<td>57</td>
<td>22</td>
<td>100</td>
</tr>
<tr>
<td>TOTAL</td>
<td>93</td>
<td>9</td>
<td>27</td>
<td>21</td>
<td>40</td>
<td>3</td>
<td>100</td>
</tr>
</tbody>
</table>
respondents (32%) were not in favor (Table 4.16). Significant differences in profession opinions were also recorded ($X^2=34.56$, df=20, $p=0.026$), with government environmental personnel (55%) and environmental consultants (70%) in favor, and industry engineers (79%) opposed (Table 4.19).

Half of the respondents (50%) did not consider existing reclamation guidelines to be adequate for the design of high elevation reclamation programs although a high percentage (32%) thought that existing guidelines were adequate. A majority of respondents (62%) were in favor of legislation/guidelines which emphasize re-establishment of ecosystem processes rather than ‘target’ plant communities (Table 4.16).

Industry/government interaction was not considered to be adversarial by 45% of the respondents while 32% categorized the relationship between industry and government as adversarial (Table 4.16).

**Reclamation Economics:** Attitudes of respondents toward reclamation economics were also examined (Table 4.20). Many respondents (72%) considered bonding to be an appropriate incentive for satisfactory completion of reclamation. Furthermore, 75% of the respondents believed that companies should set aside funds within separate accounts to finance reclamation activities (Table 4.20).

A majority of respondents (63%) were in favor of a time limit on corporate responsibility for management of revegetated landscapes. Respondents supportive of restrictions on corporate responsibility for reclamation were requested to indicate a time limit (Table 4.21). The number of respondents (32%) considered the range
Table 4.19 Percentage response by sub-populations to the statement "More demanding reclamation legislation will improve the process of high elevation coal mine reclamation."

<table>
<thead>
<tr>
<th>Occupational Group</th>
<th>Number of Responses</th>
<th>Attitude Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Strongly Disagree (%)</td>
</tr>
<tr>
<td>1. Government Environmental</td>
<td>28</td>
<td>7</td>
</tr>
<tr>
<td>2. Industry Environmental</td>
<td>21</td>
<td>0</td>
</tr>
<tr>
<td>3. Nursery / Seed Producers</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>4. Environmental Consultants</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>5. Government Engineers</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>6. Industry Engineers</td>
<td>12</td>
<td>29</td>
</tr>
<tr>
<td>Total</td>
<td>93</td>
<td>7</td>
</tr>
<tr>
<td>Statement</td>
<td>Number of Responses</td>
<td>Province</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------------------------------</td>
<td>---------------------</td>
<td>----------</td>
</tr>
<tr>
<td>- The posting of reclamation performance bonds is an appropriate incentive to ensure reclamation is completed satisfactorily.</td>
<td>93</td>
<td>A + B</td>
</tr>
<tr>
<td>- All companies should be required by law to set aside funds within separate accounts to cover the costs of reclamation.</td>
<td>93</td>
<td>A + B</td>
</tr>
<tr>
<td>- Corporate responsibility for the management of revegetated post-mining landscapes should be restricted to a specified time period.</td>
<td>93</td>
<td>A + B</td>
</tr>
<tr>
<td>- Post-mining land-use objectives should be dictated solely by the economic feasibility of such objectives.</td>
<td>93</td>
<td>A + B</td>
</tr>
</tbody>
</table>

Key: A - Alberta, B - British Columbia.
TABLE 4.21 RESPONSE BREAKDOWN (PERCENT) FOR THOSE RESPONDENTS WHO RESPONDED AFFIRMATIVELY TO THE STATEMENT THAT "CORPORATE RESPONSIBILITY SHOULD BE RESTRICTED TO A SPECIFIC TIME PERIOD."

<table>
<thead>
<tr>
<th>RESPONSE</th>
<th>OCCUPATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ENVIRONMENTAL GOVERNMENT</td>
</tr>
<tr>
<td></td>
<td>N = 17</td>
</tr>
<tr>
<td>1. SPECIFIED TIME INTERVAL</td>
<td></td>
</tr>
<tr>
<td>0 YEARS</td>
<td>0</td>
</tr>
<tr>
<td>1 - 5</td>
<td>12</td>
</tr>
<tr>
<td>6 - 10</td>
<td>40</td>
</tr>
<tr>
<td>11 - 15</td>
<td>12</td>
</tr>
<tr>
<td>16 - 20</td>
<td>0</td>
</tr>
<tr>
<td>21 - 25</td>
<td>0</td>
</tr>
<tr>
<td>&gt; 25</td>
<td>0</td>
</tr>
<tr>
<td>2. UNTIL VEGETATION IS SELF-SUSTAINING</td>
<td>12</td>
</tr>
<tr>
<td>3. UNTIL NATURAL SUCCESSIONAL PROCESSES ESTABLISHED</td>
<td>0</td>
</tr>
<tr>
<td>4. UNTIL LAND-USE OBJECTIVES ARE ACHIEVED</td>
<td>6</td>
</tr>
<tr>
<td>5. UNTIL BOND RELEASE OR GOVERNMENT CERTIFICATION</td>
<td>12</td>
</tr>
<tr>
<td>6. NOT POSSIBLE TO ESTABLISH TIME PERIOD (SITE-SPECIFIC)</td>
<td>6</td>
</tr>
<tr>
<td>7. TIME PERIOD NOT ESSENTIAL</td>
<td>0</td>
</tr>
</tbody>
</table>

|                      | 100 | 100 | 100 | 100 | 100 | 100 | 100 | 100 |
between six and ten years to be an appropriate time frame whereas only 12% considered one to five years as an appropriate time frame. A small percentage (16%) considered the time necessary to achieve self-sustaining vegetative cover to be the criterion for determining corporate responsibility. Ranked responses by profession were not significantly different (Kruskal-Wallis H=8.46, $X^2=8.5$, df=5, p=0.13). Only 57 of the 63 respondents specified a time period or provided a criterion for determining a time limit.

A majority of respondents (79%) did not favor economic feasibility (i.e., practicality in terms of cost) as the main determinant of post-mining land-use objectives. Furthermore, significant differences in profession response were recorded ($X^2=32.58$, df=20, p=0.042). In general, the 'environmental' professions were not in favor whereas the engineering professions were split in their responses (Table 4.22).

Reclamation Evaluation: Attitudes of respondents toward the evaluation process of reclamation success were also examined (Table 4.23). Current government procedures for monitoring revegetation success were not considered to be adequate by 60% of the respondents, but 28% did not express an opinion (Table 4.23).

Reference areas were considered to be essential for revegetation success and bond release by 47% of the respondents while 30% were not in favor, and 23% expressed no opinion (Table 4.23).

Establishment of self-perpetuating vegetative cover was considered to be the main determinant of reclamation success criteria by 70% of survey respondents while
TABLE 4.22 PERCENTAGE RESPONSE BY SUB-Populations TO THE STATEMENT "POST-MINING LAND-USE OBJECTIVES SHOULD BE DICTATED SOLELY BY THE ECONOMIC FEASIBILITY OF SUCH OBJECTIVES."

<table>
<thead>
<tr>
<th>OCCUPATIONAL GROUP</th>
<th>NUMBER OF RESPONSES</th>
<th>ATTITUDE SCALE</th>
<th>STRONGLY DISAGREE (%)</th>
<th>DISAGREE (%)</th>
<th>NEUTRAL (%)</th>
<th>AGREE (%)</th>
<th>STRONGLY AGREE (%)</th>
<th>TOTAL (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. GOVERNMENT ENVIRONMENTAL</td>
<td>28</td>
<td></td>
<td>38</td>
<td>59</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>2. INDUSTRY ENVIRONMENTAL</td>
<td>21</td>
<td></td>
<td>20</td>
<td>65</td>
<td>15</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>3. NURSERY / SEED PRODUCERS</td>
<td>5</td>
<td></td>
<td>0</td>
<td>80</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>4. ENVIRONMENTAL CONSULTANTS</td>
<td>20</td>
<td></td>
<td>25</td>
<td>55</td>
<td>10</td>
<td>10</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>5. GOVERNMENT ENGINEERS</td>
<td>7</td>
<td></td>
<td>14</td>
<td>29</td>
<td>36</td>
<td>14</td>
<td>7</td>
<td>100</td>
</tr>
<tr>
<td>6. INDUSTRY ENGINEERS</td>
<td>12</td>
<td></td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>TOTAL</td>
<td>93</td>
<td></td>
<td>25</td>
<td>54</td>
<td>13</td>
<td>6</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>STATEMENT</td>
<td>NUMBER OF RESPONSES</td>
<td>PROVINCE</td>
<td>STRONGLY DISAGREE (%)</td>
<td>DISAGREE (%)</td>
<td>NEUTRAL (%)</td>
<td>AGREE (%)</td>
<td>STRONGLY AGREE (%)</td>
<td>TOTAL (%)</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>---------------------</td>
<td>----------</td>
<td>-----------------------</td>
<td>-------------</td>
<td>-------------</td>
<td>-----------</td>
<td>-------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>CURRENT GOVERNMENT PROCEDURES FOR MONITORING REVEGETATION SUCCESS ARE ADEQUATE TO ENSURE THE SUCCESSFUL RECLAMATION OF HIGH ELEVATION MINE DISTURBANCES.</td>
<td>93</td>
<td>A + B</td>
<td>18</td>
<td>42</td>
<td>28</td>
<td>11</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>RECLAMATION REFERENCE AREAS (PERMANENTLY MARKED PLOTS IN UNDISTURBED HABITATS ADJACENT TO MINING OPERATIONS) ARE ESSENTIAL FOR THE EVALUATION OF REVEGETATION SUCCESS AND BOND RELEASE.</td>
<td>93</td>
<td>A + B</td>
<td>6</td>
<td>24</td>
<td>23</td>
<td>32</td>
<td>15</td>
<td>100</td>
</tr>
<tr>
<td>ESTABLISHMENT OF A SELF-PERPETUATING VEGETATIVE COVER SHOULD BE THE MAIN CRITERIA OF RECLAMATION SUCCESS.</td>
<td>93</td>
<td>A + B</td>
<td>2</td>
<td>18</td>
<td>10</td>
<td>46</td>
<td>24</td>
<td>100</td>
</tr>
<tr>
<td>EQUIVALENT PRODUCTIVITY IS AN APPROPRIATE CRITERIA FOR SATISFACTION OF RECLAMATION SUCCESS.</td>
<td>93</td>
<td>A + B</td>
<td>14</td>
<td>26</td>
<td>25</td>
<td>29</td>
<td>6</td>
<td>100</td>
</tr>
</tbody>
</table>

KEY: A - ALBERTA, B - BRITISH COLUMBIA.
opinions on equivalent productivity as a criterion were split; 35% in favor versus 40% opposed (Table 4.23).

Reclamation Planning and Techniques

Respondents were asked to provide their opinion on several reclamation planning and techniques statements. The statements were grouped into five categories: (1) reclamation research and objectives, (2) landscape design and aesthetics, (3) biology, (4) revegetation techniques and (5) material management. The results of the cross-tabulations are provided in Tables 4.24 - 4.31.

Reclamation Research and Objectives: A small majority of respondents (52%) believed that the function of reclamation is to give ‘nature’ some initial assistance while 81% were opposed to restoration as an objective of reclamation activities. Respondents were divided almost equally (disagree - 32%, neutral - 31%, agree - 37%) on the establishment of ‘target’ plant communities as the focus of reclamation activities. The high number of neutral responses may be a reflection of a lack of understanding of the ‘target’ plant community concept although this was defined in the questionnaire (Table 4.24).

A large majority of respondents (95%) were in favor of coordinated government/industry reclamation research programs (Table 4.24).

Respondents were divided (agree - 40%, disagree - 36%, neutral - 24%) with respect to the utility of EIS data for reclamation planning (Table 4.25). The relatively high
### TABLE 4.24 ATTITUDES OF RESPONDENTS TOWARDS STATEMENTS CONCERNED WITH RECLAMATION OBJECTIVES AND RESEARCH PROGRAMS.

<table>
<thead>
<tr>
<th>STATEMENT</th>
<th>NUMBER OF RESPONSES</th>
<th>PROVINCE</th>
<th>STRONGLY DISAGREE (%)</th>
<th>DISAGREE (%)</th>
<th>NEUTRAL (%)</th>
<th>AGREE (%)</th>
<th>STRONGLY AGREE (%)</th>
<th>TOTAL (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- THE FUNCTION OF RECLAMATION ACTIVITIES IS TO GIVE NATURE SOME 'INITIAL' ASSISTANCE.</td>
<td>97</td>
<td>A + B</td>
<td>4</td>
<td>26</td>
<td>18</td>
<td>38</td>
<td>14</td>
<td>100</td>
</tr>
<tr>
<td>- THE OBJECTIVE OF ALL RECLAMATION PROGRAMS SHOULD BE THE COMPLETE RESTORATION OF THE DISTURBANCE TO PRE-DISTURBANCE CONDITIONS.</td>
<td>97</td>
<td>A + B</td>
<td>32</td>
<td>49</td>
<td>8</td>
<td>9</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>- THE OBJECTIVE OF HIGH ELEVATION RECLAMATION PROGRAMS SHOULD BE THE ESTABLISHMENT OF 'TARGET' PLANT COMMUNITIES.</td>
<td>97</td>
<td>A + B</td>
<td>2</td>
<td>30</td>
<td>31</td>
<td>34</td>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td>- COORDINATED GOVERNMENT AND INDUSTRY RECLAMATION RESEARCH PROGRAMS CAN BE USEFUL IN THE DEVELOPMENT OF RECLAMATION PROGRAMS.</td>
<td>97</td>
<td>A + B</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>60</td>
<td>35</td>
<td>100</td>
</tr>
</tbody>
</table>

KEY: A - ALBERTA, B - BRITISH COLUMBIA.
### TABLE 4.25 ATTITUDES OF RESPONDENTS TOWARDS STATEMENTS CONCERNED WITH RECLAMATION PLANNING.

<table>
<thead>
<tr>
<th>STATEMENT</th>
<th>NUMBER OF RESPONSES</th>
<th>PROVINCE</th>
<th>STRONGLY DISAGREE (%)</th>
<th>DISAGREE (%)</th>
<th>NEUTRAL (%)</th>
<th>AGREE (%)</th>
<th>STRONGLY AGREE (%)</th>
<th>TOTAL (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- ENVIRONMENTAL DATA COLLECTED DURING THE MINE DEVELOPMENT REVIEW PROCESS PROVIDES APPROPRIATE INFORMATION FOR THE COMPLETION RECLAMATION PLANNING.</td>
<td>97</td>
<td>A + B</td>
<td>8</td>
<td>28</td>
<td>24</td>
<td>35</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>- MINE PLANNERS AND RECLAMATION PLANNERS SHOULD BE 'JOINTLY' INVOLVED IN THE DESIGN OF BOTH MINE AND RECLAMATION PLANS.</td>
<td>97</td>
<td>A + B</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>30</td>
<td>66</td>
<td>100</td>
</tr>
<tr>
<td>- MINE PLANS SHOULD BE ALTERED WHERE NECESSARY TO ACCOMMODATE RECLAMATION CONCERNS.</td>
<td>97</td>
<td>A + B</td>
<td>1</td>
<td>2</td>
<td>10</td>
<td>45</td>
<td>42</td>
<td>100</td>
</tr>
<tr>
<td>- LANDSCAPE DESIGN AND AESTHETICS ARE GIVEN ENOUGH ATTENTION IN THE DESIGN OF HIGH ELEVATION MINE RECLAMATION PROGRAMS.</td>
<td>97</td>
<td>A + B</td>
<td>11</td>
<td>39</td>
<td>33</td>
<td>16</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>- THE ARCHITECTURE OR STRUCTURAL APPEARANCE OF 'TARGET' PLANT COMMUNITIES IS AN IMPORTANT CONSIDERATION IN THE DESIGN OF HIGH ELEVATION COAL MINE RECLAMATION PLANS.</td>
<td>97</td>
<td>A + B</td>
<td>1</td>
<td>17</td>
<td>42</td>
<td>35</td>
<td>5</td>
<td>100</td>
</tr>
</tbody>
</table>

**KEY:** A - ALBERTA, B - BRITISH COLUMBIA.
percentage of neutral responses may be due to participants' lack of familiarity with these documents.

Most participants (96%) were in favor of joint involvement of mine engineers and reclamation planners in the development of mine and reclamation plans although a significant difference ($X^2=28.87$, df=15, p=0.019) in profession response was recorded (Table 4.26). However, the professional group differences were related to the magnitude of agreement with joint engineer/planner involvement. Engineers and consultants were not as strongly in favor of joint involvement. Most respondents (87%) also believed that mine plans should be altered to accommodate reclamation concerns although the magnitude of acceptable change is unknown.

**Landscape Design and Aesthetics:** Half of the respondents did not believe that enough attention is given to landscape design and aesthetics in the development of high elevation reclamation programs (Table 4.25). Furthermore, 40% of the respondents indicated that the architecture or structural appearance of 'target' plant communities is an important concern for high elevation coal mine reclamation (Table 4.25). However, for both statements, a high number of responses were neutral indicating that many respondents did not have an opinion to express or may not have fully understood this statement.

**Material Management:** Data describing the attitudes of professional groups toward material management and mine reclamation are listed in Table 4.27. Half of the survey respondents considered slope instability an impediment to vegetation establishment at high elevations. The majority of respondents (74%) did not believe resloping should be
TABLE 4.26  PERCENTAGE RESPONSE BY SUB-P opulations TO THE STATEMENT "MINE PLANNERS AND RECLAMATION PLANNERS SHOULD BE JOINTLY INVOLVED IN THE DESIGN OF BOTH MINE AND RECLAMATION PLANS."

<table>
<thead>
<tr>
<th>OCCUPATIONAL GROUP</th>
<th>NUMBER OF RESPONSES</th>
<th>ATTITUDE SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>STRONGLY DISAGREE</td>
</tr>
<tr>
<td>1. GOVERNMENT ENVIRONMENTAL</td>
<td>28</td>
<td>0</td>
</tr>
<tr>
<td>2. INDUSTRY ENVIRONMENTAL</td>
<td>21</td>
<td>0</td>
</tr>
<tr>
<td>3. NURSERY / SEED PRODUCERS</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>4. ENVIRONMENTAL CONSULTANTS</td>
<td>23</td>
<td>0</td>
</tr>
<tr>
<td>5. GOVERNMENT ENGINEERS</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>6. INDUSTRY ENGINEERS</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>97</strong></td>
<td><strong>0</strong></td>
</tr>
</tbody>
</table>
TABLE 4.27 ATTITUDES OF RESPONDENTS TOWARDS STATEMENTS CONCERNED WITH MATERIAL MANAGEMENT AND MINE RECLAMATION.

<table>
<thead>
<tr>
<th>STATEMENT</th>
<th>NUMBER OF RESPONSES</th>
<th>PROVINCE</th>
<th>STRONGLY DISAGREE (%)</th>
<th>DISAGREE (%)</th>
<th>NEUTRAL (%)</th>
<th>AGREE (%)</th>
<th>STRONGLY AGREE (%)</th>
<th>TOTAL (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- SURFICIAL SLOPE STABILITY LIMITS VEGETATION ESTABLISHMENT AT HIGH ELEVATIONS.</td>
<td>97</td>
<td>A + B</td>
<td>4</td>
<td>25</td>
<td>18</td>
<td>42</td>
<td>11</td>
<td>100</td>
</tr>
<tr>
<td>- MINE SPOIL RESLOPING SHOULD ONLY BE CONSIDERED FOR GEOTECHNICAL OR SLOPE STABILITY REASONS.</td>
<td>97</td>
<td>A + B</td>
<td>24</td>
<td>50</td>
<td>11</td>
<td>12</td>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td>- TOPOGRAPHIC MODIFICATIONS ARE ESSENTIAL FOR SEEDLING ESTABLISHMENT AT HIGH ELEVATIONS.</td>
<td>97</td>
<td>A + B</td>
<td>1</td>
<td>13</td>
<td>26</td>
<td>47</td>
<td>13</td>
<td>100</td>
</tr>
<tr>
<td>- TOPSOIL STORAGE AND REPLACEMENT IS NECESSARY FOR SUCCESSFUL HIGH ELEVATION SURFACE MINE RECLAMATION.</td>
<td>43</td>
<td>A</td>
<td>2</td>
<td>7</td>
<td>14</td>
<td>37</td>
<td>40</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>54</td>
<td>B</td>
<td>11</td>
<td>21</td>
<td>26</td>
<td>33</td>
<td>9</td>
<td>100</td>
</tr>
<tr>
<td>- SUITABLE RECLAMATION EQUIPMENT IS LACKING FOR THE REVEGETATION OF HIGH ELEVATION MINE DISTURBANCES.</td>
<td>43</td>
<td>A</td>
<td>2</td>
<td>28</td>
<td>19</td>
<td>49</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>54</td>
<td>B</td>
<td>4</td>
<td>39</td>
<td>35</td>
<td>22</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

KEY: A - ALBERTA, B - BRITISH COLUMBIA.
restricted to engineering concerns. However, profession attitudes toward resloping were significantly different ($X^2=32.06$, df=20, $p=0.047$) with most environmental professionals in favor of resloping for non-engineering reasons (Table 4.28). Both the industry engineers and the nursery stock/seed supplier professions had a large number of neutral responses which may indicate a lack of knowledge or uncertainty on the part of these professionals. Three fifths of the respondents (60%) considered topographic modifications to be essential for seedling establishment at high elevations (Table 4.27).

A slight majority of Alberta respondents (51%) were of the opinion that suitable high elevation reclamation equipment is lacking whereas many British Columbia respondents (43%) had a differing opinion (Table 4.27). The difference between jurisdictions was significant ($X^2=9.60$, df=4, $p=0.049$). Several British Columbia respondents (35%) did not express an opinion which may be indicative of a lack of knowledge concerning available equipment.

Revegetation Techniques: A majority of respondents (58%) thought that contemporary techniques are satisfactory for high elevation surface mine reclamation although 23% did not express an opinion (Table 4.29). Opinions were mixed with respect to agricultural techniques and high elevation reclamation with a large number of respondents (44%) not expressing an opinion.

A majority of respondents (61%) were of the opinion that insufficient attention is paid to soil development in the planning of reclamation programs although differences between professions were highly significant ($X^2=33.22$, df=15, $p=0.005$) (Table 4.30).
TABLE 4.28 PERCENTAGE RESPONSE BY SUB-POPULATIONS TO THE STATEMENT "MINE SPOIL RESLOPING SHOULD ONLY BE CONSIDERED FOR GEOTECHNICAL OR SLOPE STABILITY REASONS."

<table>
<thead>
<tr>
<th>OCCATIONAL GROUP</th>
<th>NUMBER OF RESPONSES</th>
<th>STRONGLY DISAGREE (%)</th>
<th>DISAGREE (%)</th>
<th>NEUTRAL (%)</th>
<th>AGREE (%)</th>
<th>STRONGLY AGREE (%)</th>
<th>TOTAL (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOVERNMENT ENVIRONMENTAL</td>
<td>28</td>
<td>27</td>
<td>59</td>
<td>7</td>
<td>7</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>INDUSTRY ENVIRONMENTAL</td>
<td>21</td>
<td>20</td>
<td>70</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>NURSERY / SEED PRODUCERS</td>
<td>7</td>
<td>14</td>
<td>29</td>
<td>28</td>
<td>29</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>ENVIRONMENTAL CONSULTANTS</td>
<td>23</td>
<td>35</td>
<td>44</td>
<td>13</td>
<td>4</td>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>GOVERNMENT ENGINEERS</td>
<td>6</td>
<td>8</td>
<td>31</td>
<td>15</td>
<td>31</td>
<td>15</td>
<td>100</td>
</tr>
<tr>
<td>INDUSTRY ENGINEERS</td>
<td>12</td>
<td>20</td>
<td>20</td>
<td>40</td>
<td>20</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>TOTAL</td>
<td>97</td>
<td>24</td>
<td>50</td>
<td>11</td>
<td>12</td>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td>STMTMENT</td>
<td>NUMBER OF RESPONSES</td>
<td>PROVINE</td>
<td>STRONGLY DISAGREE (%)</td>
<td>DISAGREE (%)</td>
<td>NEUTRAL (%)</td>
<td>AGREE (%)</td>
<td>STRONGLY AGREE (%)</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>---------------------</td>
<td>---------</td>
<td>-----------------------</td>
<td>--------------</td>
<td>-------------</td>
<td>-----------</td>
<td>-------------------</td>
</tr>
<tr>
<td>CONTEMPORARY RECLAMATION TECHNIQUES ARE SATISFACTORY FOR HIGH ELEVATION</td>
<td>97</td>
<td>A + B</td>
<td>8</td>
<td>50</td>
<td>23</td>
<td>19</td>
<td>0</td>
</tr>
<tr>
<td>SURFACE MINE RECLAMATION PROGRAMS.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>THERE IS TOO MUCH EMPHASIS ON AGRICULTURAL TECHNIQUES IN HIGH ELEVATION</td>
<td>97</td>
<td>A + B</td>
<td>4</td>
<td>20</td>
<td>44</td>
<td>25</td>
<td>7</td>
</tr>
<tr>
<td>RECLAMATION PROGRAMS.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENOUGH ATTENTION IS GIVEN TO SOIL DEVELOPMENT IN THE PLANNING OF</td>
<td>97</td>
<td>A + B</td>
<td>7</td>
<td>54</td>
<td>31</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>RECLAMATION PROGRAMS.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MULCH APPLICATION IS NECESSARY FOR SEED GERMINATION ON HIGH ELEVATION</td>
<td>43</td>
<td>A</td>
<td>7</td>
<td>26</td>
<td>53</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>SURFACE MINE DISTURBANCES.</td>
<td>54</td>
<td>B</td>
<td>22</td>
<td>41</td>
<td>35</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>MAINTENANCE FERTILIZER APPLICATIONS ARE REQUIRED IN HIGH ELEVATION</td>
<td>43</td>
<td>A</td>
<td>5</td>
<td>14</td>
<td>32</td>
<td>49</td>
<td>0</td>
</tr>
<tr>
<td>RECLAMATION PROGRAMS.</td>
<td>54</td>
<td>B</td>
<td>6</td>
<td>31</td>
<td>39</td>
<td>20</td>
<td>4</td>
</tr>
</tbody>
</table>

Key: A - ALBERTA, B - BRITISH COLUMBIA.
<table>
<thead>
<tr>
<th>OCCUPATIONAL GROUP</th>
<th>NUMBER OF RESPONSES</th>
<th>ATTITUDE SCALE</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>STRONGLY DISAGREE</td>
<td>DISAGREE</td>
<td>NEUTRAL</td>
<td>AGREE</td>
<td>STRONGLY AGREE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. GOVERNMENT ENVIRONMENTAL</td>
<td>28</td>
<td>14</td>
<td>52</td>
<td>27</td>
<td>7</td>
<td>0</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>2. INDUSTRY ENVIRONMENTAL</td>
<td>21</td>
<td>5</td>
<td>65</td>
<td>25</td>
<td>5</td>
<td>0</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>3. NURSERY / SEED PRODUCERS</td>
<td>7</td>
<td>0</td>
<td>14</td>
<td>86</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>4. ENVIRONMENTAL CONSULTANTS</td>
<td>23</td>
<td>0</td>
<td>78</td>
<td>18</td>
<td>4</td>
<td>0</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>5. GOVERNMENT ENGINEERS</td>
<td>6</td>
<td>8</td>
<td>23</td>
<td>54</td>
<td>15</td>
<td>0</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>6. INDUSTRY ENGINEERS</td>
<td>12</td>
<td>25</td>
<td>50</td>
<td>0</td>
<td>25</td>
<td>0</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>97</strong></td>
<td><strong>7</strong></td>
<td><strong>54</strong></td>
<td><strong>31</strong></td>
<td><strong>8</strong></td>
<td><strong>0</strong></td>
<td><strong>100</strong></td>
<td></td>
</tr>
</tbody>
</table>
Most of the nursery stock/seed suppliers (86%) and industry engineers (54%) did not express an opinion.

Respondent attitudes toward topsoil storage varied by province (Table 4.29). Topsoil storage and replacement was favored by 77% of the respondents in Alberta versus 42% in British Columbia. The difference in response between provinces was highly significant ($X^2=16.98$, df=4, $p=0.002$).

Respondent attitudes toward mulch application and maintenance fertilization varied by province (Table 4.29). Only a small number of respondents in British Columbia (37%) considered mulch application to be necessary for high elevation seed germination. In contrast, 67% Alberta respondents believed mulch application is necessary. However, in both jurisdictions, there was a large number of respondents (Alberta - 53%, British Columbia - 35%) who did not express an opinion. The difference in response between provinces was highly significant ($X^2=11.92$, df=3, $p=0.008$).

Attitudes toward maintenance fertilization were also significantly different between provinces ($X^2=10.88$, df=4, $p=0.029$). Half of Alberta respondents (49%) were in favor of maintenance fertilization whereas only 24% were in favor in British Columbia (Table 4.29).

Biology: Plant successional theory was considered by a majority of respondents (85%) to be an important source of information for reclamation planning (Table 4.31). Overall, respondents were split (38% in favor versus 44% opposed) with respect to the facilitation of plant and animal colonization through human intervention although a
<table>
<thead>
<tr>
<th>STATEMENT</th>
<th>NUMBER OF RESPONSES</th>
<th>Province</th>
<th>STRONGLY DISAGREE (%)</th>
<th>DISAGREE (%)</th>
<th>NEUTRAL (%)</th>
<th>AGREE (%)</th>
<th>STRONGLY AGREE (%)</th>
<th>TOTAL (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- PLANT SUCCESSIONAL THEORY (THE SEQUENTIAL REPLACEMENT OF PLANT SPECIES ASSEMBLAGES OR COMMUNITIES THROUGH TIME) IS USEFUL IN PROVIDING INFORMATION FOR MINE RECLAMATION PLANNING.</td>
<td>97</td>
<td>A + B</td>
<td>0</td>
<td>3</td>
<td>12</td>
<td>65</td>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>- POPULATIONS OF NATIVE PLANTS AND ANIMALS WILL ESTABLISH ON MINE DISTURBANCES WITHOUT THE ASSISTANCE OF MAN.</td>
<td>97</td>
<td>A + B</td>
<td>9</td>
<td>35</td>
<td>18</td>
<td>36</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>- ADEQUATE ATTENTION IS GIVEN TO THE EVALUATION OF RE-ESTABLISHED WILDLIFE HABITAT IN HIGH ELEVATION RECLAMATION PROGRAMS.</td>
<td>97</td>
<td>A + B</td>
<td>6</td>
<td>48</td>
<td>29</td>
<td>17</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

KEY: A - ALBERTA, B - BRITISH COLUMBIA.
significant difference in profession response was recorded ($X^2=35.06$, $df=20$, $p=0.023$) (Table 4.32).

A small majority of respondents (54%) did not believe that adequate attention is given to the evaluation of re-established wildlife habitat in high elevation reclamation programs although a high number of respondents (29%) did not express an opinion (Table 4.31).

**Plant Materials Selection**

Respondents were asked to provide their opinion on several plant materials selection statements. The statements were grouped into four categories: (1) plant species selection, (2) native plant species, (3) aesthetics and native species, (4) commercial production of native species. The results of the cross-tabulations are provided in Tables 4.33 - 4.39.

**Plant Species Selection:** Species suitability was considered to be very important by a large majority (98%) of respondents, and 60% of these same respondents considered EISs to be an effective source for species suitability information (Table 4.33). Respondents were uncertain as to the utility of agronomic species in high elevation reclamation programs. Many respondents (40%) felt that agronomic species are suitable for purposes other than 'nurse' or 'companion' crops whereas 30% indicated that agronomics were suitable only as 'nurse' crops. The responses of professional groups (Table 4.34) were highly significant ($X^2=38.21$, $df=20$, $p=0.010$), but a large number (27%) expressed no opinion. The attitudes of industry environmental
TABLE 4.32 PERCENTAGE RESPONSE BY SUB-POPULATIONS TO THE STATEMENT "POPULATIONS OF NATIVE PLANTS AND ANIMALS WILL ESTABLISH ON MINE DISTURBANCES WITHOUT THE ASSISTANCE OF MAN."

<table>
<thead>
<tr>
<th>OCCUPATIONAL GROUP</th>
<th>NUMBER OF RESPONSES</th>
<th>ATTITUDE SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>STRONGLY DISAGREE (%)</td>
<td>DISAGREE (%)</td>
</tr>
<tr>
<td>1. GOVERNMENT ENVIRONMENTAL</td>
<td>28</td>
<td>21</td>
</tr>
<tr>
<td>2. INDUSTRY ENVIRONMENTAL</td>
<td>21</td>
<td>5</td>
</tr>
<tr>
<td>3. NURSERY / SEED PRODUCERS</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>4. ENVIRONMENTAL CONSULTANTS</td>
<td>23</td>
<td>9</td>
</tr>
<tr>
<td>5. GOVERNMENT ENGINEERS</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>6. INDUSTRY ENGINEERS</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>97</td>
<td>9</td>
</tr>
</tbody>
</table>
TABLE 4.33 ATTITUDES OF RESPONDENTS TOWARDS STATEMENTS CONCERNED WITH PLANT SPECIES SELECTION FOR MINE DISTURBANCE REVEGETATION.

<table>
<thead>
<tr>
<th>STATEMENT</th>
<th>NUMBER OF RESPONSES</th>
<th>PROVINCE</th>
<th>STRONGLY DISAGREE (%)</th>
<th>DISAGREE (%)</th>
<th>NEUTRAL (%)</th>
<th>AGREE (%)</th>
<th>STRONGLY AGREE (%)</th>
<th>TOTAL (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- SPECIES SUITABILITY IS VERY IMPORTANT AT HIGH ELEVATIONS.</td>
<td>91</td>
<td>A + B</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>42</td>
<td>56</td>
<td>100</td>
</tr>
<tr>
<td>- THE ENVIRONMENTAL DATA COLLECTION PHASE OF THE MINE DEVELOPMENT REVIEW PROCESS IS AN EFFECTIVE WAY OF SELECTING PLANT SPECIES FOR RECLAMATION.</td>
<td>91</td>
<td>A + B</td>
<td>4</td>
<td>21</td>
<td>15</td>
<td>53</td>
<td>7</td>
<td>100</td>
</tr>
<tr>
<td>- AGRONOMIC SPECIES ARE ONLY SUITABLE AS 'NURSE' CROPS IN RECLAMATION PROGRAMS.</td>
<td>91</td>
<td>A + B</td>
<td>10</td>
<td>30</td>
<td>27</td>
<td>29</td>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>- THE INCLUSION OF GRASS SPECIES IN HIGH ELEVATION SEED MIXES IS ESSENTIAL.</td>
<td>91</td>
<td>A + B</td>
<td>0</td>
<td>4</td>
<td>20</td>
<td>57</td>
<td>19</td>
<td>100</td>
</tr>
<tr>
<td>- THE INCLUSION OF LEGUME SPECIES IN HIGH ELEVATION SEED MIXES IS ESSENTIAL.</td>
<td>40</td>
<td>A</td>
<td>0</td>
<td>24</td>
<td>40</td>
<td>36</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>51</td>
<td>B</td>
<td>10</td>
<td>29</td>
<td>49</td>
<td>12</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>- SHRUB SPECIES ESTABLISHMENT IS ESSENTIAL FOR THE RECLAMATION OF HIGH ELEVATION DISTURBANCES.</td>
<td>91</td>
<td>A + B</td>
<td>0</td>
<td>12</td>
<td>26</td>
<td>49</td>
<td>13</td>
<td>100</td>
</tr>
</tbody>
</table>

KEY: A - ALBERTA, B - BRITISH COLUMBIA.
TABLE 4.34  PERCENTAGE RESPONSE BY SUB-POPULATIONS TO THE STATEMENT "AGRONOMIC SPECIES ARE ONLY SUITABLE AS 'NURSE' CROPS IN RECLAMATION PROGRAMS."

<table>
<thead>
<tr>
<th>OCCIDENTAL GROUP</th>
<th>NUMBER OF RESPONSES</th>
<th>STRONGLY DISAGREE (%)</th>
<th>DISAGREE (%)</th>
<th>NEUTRAL (%)</th>
<th>AGREE (%)</th>
<th>STRONGLY AGREE (%)</th>
<th>TOTAL (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. GOVERNMENT ENVIRONMENTAL</td>
<td>27</td>
<td>7</td>
<td>19</td>
<td>37</td>
<td>37</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>2. INDUSTRY ENVIRONMENTAL</td>
<td>20</td>
<td>30</td>
<td>40</td>
<td>15</td>
<td>15</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>3. NURSERY / SEED PRODUCERS</td>
<td>9</td>
<td>0</td>
<td>56</td>
<td>0</td>
<td>33</td>
<td>11</td>
<td>100</td>
</tr>
<tr>
<td>4. ENVIRONMENTAL CONSULTANTS</td>
<td>22</td>
<td>5</td>
<td>36</td>
<td>18</td>
<td>27</td>
<td>14</td>
<td>100</td>
</tr>
<tr>
<td>5. GOVERNMENT ENGINEERS</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>67</td>
<td>33</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>6. INDUSTRY ENGINEERS</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>67</td>
<td>33</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>TOTAL</td>
<td>91</td>
<td>10</td>
<td>30</td>
<td>27</td>
<td>29</td>
<td>4</td>
<td>100</td>
</tr>
</tbody>
</table>
professionals (70%) and nursery/seed producers (56%) were the most supportive of a less restrictive interpretation of agronomic species utility.

Most respondents (76%) indicated that the inclusion of grass species is necessary for successful reclamation of high elevation disturbances. However, respondents were uncertain as to the necessity of including legume species in high elevation seed mixes. Only a small percentage of respondents from Alberta (36%) and British Columbia (12%) considered legume species to be essential to high elevation reclamation (Table 4.33). The attitudes of professionals varied by jurisdiction ($X^2=8.90$, df=3, $p=0.032$). However, a large number of respondents (Alberta - 40%, British Columbia - 49%) expressed no opinion or were uncertain of the value of legume species in high elevation seed mixes.

Shrub species establishment was considered to be essential by 62% of the respondents although 26% expressed no opinion or were uncertain (Table 4.33).

Native Plant Species: Respondents were divided on the requirement of native species for long-term revegetation success at high elevations (Table 4.35). Many respondents (41%) believed that native species will be necessary for long-term success whereas 42% were opposed. The attitudes of professional groups were significantly different ($X^2=36.61$, df=20, $p=0.016$) with the industry environmental group least supportive (10%) and environmental consultants most supportive (64%) (Table 4.36). Attitudes of government environmental (41% agreed, 41% disagreed) and nursery/seed producers (44% agreed, 45% disagreed) were divided almost equally.
### TABLE 4.35 ATTITUDES OF RESPONDENTS TOWARDS STATEMENTS CONCERNED WITH NATIVE PLANT SPECIES USE IN MINE RECLAMATION.

<table>
<thead>
<tr>
<th>STATEMENT</th>
<th>NUMBER OF RESPONSES</th>
<th>PROVINCE</th>
<th>STRONGLY DISAGREE (%)</th>
<th>DISAGREE (%)</th>
<th>NEUTRAL (%)</th>
<th>AGREE (%)</th>
<th>STRONGLY AGREE (%)</th>
<th>TOTAL (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- LONG-TERM RE-ESTABLISHMENT OF VEGETATION ON HIGH ELEVATION COAL MINE DISTURBANCES WILL ONLY BE POSSIBLE WITH THE EXTENSIVE USE OF NATIVE SPECIES.</td>
<td>91</td>
<td>A + B</td>
<td>4</td>
<td>38</td>
<td>17</td>
<td>33</td>
<td>8</td>
<td>100</td>
</tr>
<tr>
<td>- NATIVE PLANT SPECIES USE IS SUITABLE ONLY IF VERY SITE-SPECIFIC SEEDING PRACTICES ARE USED.</td>
<td>91</td>
<td>A + B</td>
<td>3</td>
<td>45</td>
<td>34</td>
<td>16</td>
<td>2</td>
<td>100</td>
</tr>
<tr>
<td>- NATIVE SPECIES ESTABLISH TOO SLOWLY TO BE OF ANY VALUE IN MINE RECLAMATION SEEDING PROGRAMS.</td>
<td>91</td>
<td>A + B</td>
<td>26</td>
<td>52</td>
<td>15</td>
<td>6</td>
<td>1</td>
<td>100</td>
</tr>
<tr>
<td>- EMPHASIS ON PRODUCTIVITY RESTRICTS THE USE OF NATIVE SPECIES IN HIGH ELEVATION RECLAMATION PROGRAMS.</td>
<td>91</td>
<td>A + B</td>
<td>10</td>
<td>26</td>
<td>22</td>
<td>38</td>
<td>4</td>
<td>100</td>
</tr>
<tr>
<td>- THE USE OF NATIVE SPECIES SEEDLING TRANSPLANTS IS ECONOMICAL FOR LARGE SCALE PROJECTS.</td>
<td>91</td>
<td>A + B</td>
<td>8</td>
<td>24</td>
<td>46</td>
<td>19</td>
<td>3</td>
<td>100</td>
</tr>
<tr>
<td>- NATIVE SPECIES 'ISLANDS' ARE USEFUL AS SEED SOURCES FOR LATER PLANT SUCCESSIONAL DEVELOPMENT.</td>
<td>40 + 51</td>
<td>A + B</td>
<td>2</td>
<td>2</td>
<td>16</td>
<td>53</td>
<td>27</td>
<td>100</td>
</tr>
</tbody>
</table>

**KEY:** A - ALBERTA, B - BRITISH COLUMBIA.
TABLE 4.36 PERCENTAGE RESPONSE BY SUB-Populations TO THE STATEMENT "LONG-TERM RE-ESTABLISHMENT OF VEGETATION ON HIGH ELEVATION COAL MINE DISTURBANCES WILL ONLY BE POSSIBLE WITH THE EXTENSIVE USE OF NATIVE SPECIES."

<table>
<thead>
<tr>
<th>OCCUPATIONAL GROUP</th>
<th>NUMBER OF RESPONSES</th>
<th>ATTITUDE SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>STRONGLY DISAGREE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DISAGREE</td>
</tr>
<tr>
<td>1. GOVERNMENT ENVIRONMENTAL</td>
<td>27</td>
<td>0</td>
</tr>
<tr>
<td>2. INDUSTRY ENVIRONMENTAL</td>
<td>&quot;&quot;</td>
<td>20</td>
</tr>
<tr>
<td>3. NURSERY / SEED PRODUCERS</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>4. ENVIRONMENTAL CONSULTANTS</td>
<td>22</td>
<td>0</td>
</tr>
<tr>
<td>5. GOVERNMENT ENGINEERS</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>6. INDUSTRY ENGINEERS</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>91</td>
<td>4</td>
</tr>
</tbody>
</table>
Half of the respondents (48%) indicated that native species suitability is not restricted to specific seeding practices although a high number (34%) expressed no opinion or were uncertain (Table 4.35). A large majority (78%) agreed that native species establishment rates do not limit the value of native species in reclamation programs.

Professional group attitudes toward productivity as a restriction on native species use in high elevation reclamation programs was mixed, with 42% in agreement with productivity requirements being restrictive and 36% in disagreement (Table 4.35).

Professional group attitudes were also divided with respect to the use of native species transplant economics for large-scale projects (Table 4.35). A number of respondents (32%) considered seedling transplants uneconomical whereas 22% considered the use of transplants economically viable. However, the largest number of respondents (46%) expressed no opinion or were uncertain as to the economic viability of seedling transplants.

Native species 'islands' were considered useful as seed sources for plant successional development by most respondents (Alberta 75%, British Columbia 80%) although differences between jurisdictions were significant ($X^2=12.69$, df=4, p=0.014). The primary difference between jurisdictions relates to the magnitude of agreement with more British Columbia respondents strongly favoring 'islands' as seed sources (Table 4.35).

**Aesthetics and Native Species:** The attitudes of respondents toward the relationship between native species use and aesthetics was divided (Table 4.37). Many respondents (40%) agreed that the use of native species reduces the visual contrast between
### Table 4.37: Attitudes of Respondents Towards Statements Concerned with the Relationship Between Aesthetics and Native Species.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Number of Responses</th>
<th>Province</th>
<th>Strongly Disagree (%)</th>
<th>Disagree (%)</th>
<th>Neutral (%)</th>
<th>Agree (%)</th>
<th>Strongly Agree (%)</th>
<th>Total (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A reason that native species are preferable is because they reduce the visual contrast between the vegetation of reclaimed and adjacent natural areas.</td>
<td>91</td>
<td>A + B</td>
<td>11</td>
<td>28</td>
<td>21</td>
<td>35</td>
<td>5</td>
<td>100</td>
</tr>
<tr>
<td>More emphasis on aesthetics would increase the use of native species in mine reclamation.</td>
<td>91</td>
<td>A + B</td>
<td>2</td>
<td>32</td>
<td>29</td>
<td>30</td>
<td>7</td>
<td>100</td>
</tr>
</tbody>
</table>

Key: A - Alberta, B - British Columbia.
reclaimed and 'natural' areas whereas 39% disagreed. Attitudes toward greater emphasis on aesthetics as a driving force for increased use of native species in mine reclamation were also divided. Many respondents (37%) agreed that more emphasis on aesthetics would result in greater native species use whereas 34% disagreed. For both statements, a large number, 21% and 29% respectively, expressed no opinion or were uncertain.

Commercial Production of Native Species: Attitudes towards commercial production of native species favored both the expanded production of native species seed and native species seed or seedling development programs (Table 4.38). Most respondents (81%) agreed with the existence of a market for expanded native species seed production. However, significant differences ($X^2=33.43$, df=20, $p=0.034$) were recorded between government engineers and industry engineers and environmental professionals (Table 4.39). Government engineers expressed no opinion or were uncertain about expanded native species seed production. A majority (71%) felt that seed or seedling development plans are necessary for successful reclamation of high elevation mine disturbances.

6. Discussion

General Reclamation Information

The absence of significant differences in the ranked responses between professional groups for each of the general information statements suggests that the participants have a similar knowledge-base from which management decisions are made.
TABLE 4.38 ATTITUDES OF RESPONDENTS TOWARDS COMMERCIAL PRODUCTION OF NATIVE SPECIES SEED.

<table>
<thead>
<tr>
<th>STATEMENT</th>
<th>NUMBER OF RESPONSES</th>
<th>PROVINCE</th>
<th>STRONGLY DISAGREE (%)</th>
<th>NEUTRAL (%)</th>
<th>AGREE (%)</th>
<th>STRONGLY AGREE (%)</th>
<th>TOTAL (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- THERE IS A MARKET FOR EXPANDED NATIVE SPECIES SEED PRODUCTION IN ALBERTA AND BRITISH COLUMBIA.</td>
<td>91</td>
<td>A + B</td>
<td>1</td>
<td>1</td>
<td>17</td>
<td>53</td>
<td>28</td>
</tr>
<tr>
<td>- DEVELOPMENT PROGRAMS FOR THE COMMERCIAL PRODUCTION OF NATIVE PLANTS (SEEDS OR SEEDLINGS) ARE NECESSARY FOR THE SUCCESSFUL RECLAMATION OF HIGH ELEVATION MINE DISTURBANCES.</td>
<td>91</td>
<td>A + B</td>
<td>1</td>
<td>15</td>
<td>13</td>
<td>50</td>
<td>21</td>
</tr>
</tbody>
</table>

KEY: A - ALBERTA, B - BRITISH COLUMBIA.
TABLE 4.39 PERCENTAGE RESPONSE BY SUB-POPULATIONS TO THE STATEMENT "THERE IS A MARKET FOR EXPANDED NATIVE SPECIES SEED PRODUCTION IN ALBERTA AND BRITISH COLUMBIA."

<table>
<thead>
<tr>
<th>OCCUPATIONAL GROUP</th>
<th>NUMBER OF RESPONSES</th>
<th>ATTITUDE SCALE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>STRONGLY DISAGREE (%)</td>
<td>DISAGREE (%)</td>
</tr>
<tr>
<td>1. GOVERNMENT ENVIRONMENTAL</td>
<td>27</td>
<td>4</td>
</tr>
<tr>
<td>2. INDUSTRY ENVIRONMENTAL</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>3. NURSERY / SEED PRODUCERS</td>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>4. ENVIRONMENTAL CONSULTANTS</td>
<td>22</td>
<td>0</td>
</tr>
<tr>
<td>5. GOVERNMENT ENGINEERS</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>6. INDUSTRY ENGINEERS</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL</td>
<td>91</td>
<td>1</td>
</tr>
</tbody>
</table>
Respondents ranked short, cool growing seasons, infertility of growing media and slow soil development to be the main environmental limitations to high elevation revegetation. The opinions thus expressed were consistent with much of the research of Brown et al. (1978) and Chambers et al. (1984).

The amount of literature discussing the attitudes of reclamation participants toward the function of legislation and regulatory control is sparse. Respondent regulation rankings indicate that environmental protection, reclamation enforcement, reclamation evaluation criteria and planning objectives are the most important regulatory provisions.

The most important functions of reclamation planning as indicated by respondent rankings are land-use objectives, ecosystem restoration, vegetation establishment, erosion control and spoil slope stability. Although the order of ranking is slightly different, overall, the results are compatible with the information provided in mine reclamation textbooks, e.g., Law (1984), Chironis (1987) and Richards et al. (1993).

In general, based on response rankings, respondents were sufficiently informed to make decisions regarding plant species selection. The role of commercially available plant species (land-use objectives, short- and long-term erosion control and soil development) and perceived native species benefits (ecosystem restoration and natural adaptation) are consistent with the report published by Hardy BBT Limited (1990). Respondents considered lack of information, seed cost and slow growth or seedling establishment to be the major limitations to the use of native species in high elevation reclamation programs. The survey results describing the constraints on native species use are consistent with Brown and Chambers (1990).
Information

Information is important for all endeavors, but information leading to innovation is essential for the multidisciplinary problems encountered within high elevation mine reclamation.

Environmental consultants as well as industry and government environmental professionals were the most frequent users of reclamation information. These results are not surprising since this is the primary focus of their occupations. However, the narrow focus of the type of reports used with high frequency tends to limit conceptual understanding and constrain innovation by restricting access to information from subject areas such as successional theory or aesthetics. As suggested in Chapter 2, information acquisition for several reclamation related concepts is on a developmental hiatus within these jurisdictions.

Furthermore, most of the information (symposium proceedings, internal corporate reports and government reports) is of limited distribution, so it is unlikely that these reports have been professionally adjudicated. Ellis (1989) indicated that the uncertainty regarding professional appraisal is a problem for EIAs and Environmental Risk Assessments (ERAs) and, based on the research presented here, is a problem within the reclamation field.

In both jurisdictions, symposia are the ‘central places’ from which information is disseminated. Innovation adoption results through symposium participant interactions with primarily mining engineers at their respective mines. Bratton (1987) has stressed the importance of symposia, which tend to be practical, over more formal modes of
information acquisition (academia); however, without a conceptual foundation, it is unlikely that reclamation practitioners will be able to develop past the innovation adoption (practical) mode and will continue to operate as technical functionaries.

**Dimensionality**

The NMDS solutions revealed salient response dimensions that are important as a first step in understanding the attitudes and displaying the cognitive maps of reclamation practitioners. In general, financial concerns, the degree of management involvement, and practical equipment and plant establishment techniques explained most of the latent structure of the attitudinal response matrices. However, much of the variability in attitudinal response within each section (legislation, planning and techniques, plant materials) could be condensed to economic considerations. Concern with regulatory monitoring, disturbance variances or holistic/partial reclamation within the legislation/regulation section, active versus passive management in the planning/techniques section and establishment techniques in the plant materials section all indicated an underlying monetary focus by the respondents. This concern is understandable given the financial situation of the industry but must not be allowed to over-ride concerns for successful revegetation of high elevation mine disturbances. The preeminence of financial concerns within all aspects of the high elevation reclamation will, if allowed to continue, exacerbate existing problems and result in chronic environmental degradation at high elevations.

The preeminence of financial concerns may be indicative of the hegemony of the engineering profession within the mine reclamation field. This situation is problematic
particularly in British Columbia where the engineering profession has effective control, particularly within industry. In general, environmental personnel are subordinate to either production or planning engineers.

*Group Membership*

None of the discriminant functions accounted for complete between-group variability which indicates that group differences based upon education, experience or profession are slight. Only the planning and techniques group membership classification was reliable; all others described were unstable. The reliability of attitudes of reclamation planning and techniques for group membership may reflect the pragmatic nature and applications focus of reclamation practice in the jurisdictions studied.

Attitudes toward legislation, regulation and guideline statements as well as planning and techniques statements were both significant predictors of professional group membership. Maximum separation between industry and government engineers was based on attitudes towards performance criteria for reclamation success (particularly equivalent productivity) whereas 'environmental professions' and engineers were separated on the basis of attitudes toward the economic feasibility of end land-uses and the requirement of complete surface disturbance revegetation. While the classification was not stable, it is possible to suggest that along the continuum of economic concern, financial priorities (engineers) were replaced by ecological priorities ('environmental professions').
Professional group membership was predicted significantly by respondent attitudes toward reclamation planning and techniques, with the classification being a reliable predictor. Industry environmental professionals were separated maximally from all other groups on the basis of coordinated involvement of reclamation and mine planners in the development of reclamation plans and the acceptability of current reclamation techniques for high elevation. Wildlife habitat evaluation, spoil resloping and mine plan alteration comprised the second function. While much has been written in the literature regarding the interaction between environmental and mine planning personnel, the degree of interaction and the magnitude of mine plan alteration to accommodate reclamation considerations is difficult to determine since this is dependent upon site-specific economics.

Education group membership was predicted only with significance in the attitudes of respondents toward the regulatory statements of self-perpetuating vegetation cover and reclamation variances. The separation of education groupings may be due to biologists having a greater appreciation of the scope of difficult site rehabilitation than landscape architects, soil scientists and foresters.

Studies which have examined the effect of experience on the attitudes of natural resource management professionals have provided conflicting results (Brown and Harris 1992, Richards and Huntsinger 1994). The present study also provides conflicting data. Respondent attitudes toward reclamation planning and techniques were the only statistically significant predictors of experience. Specifically, complete restoration versus initial assistance in the establishment of ecosystem functioning was the
determinant in the first function while the use of 'target' plant communities was important in the second function. The attitude towards restoration and initial assistance again reflected the recurrent theme of economics within the attitudinal response matrix. Although complete restoration is considered to be prohibitive (Schwarzkopf 1993), the perception that initial assistance is inexpensive can only be measured in relative terms. Initial assistance in the establishment of ecosystem functioning would certainly be closer to complete restoration on the reclamation economics continuum at high elevations.

**Reclamation Legislation, Regulations and Guidelines**

**Legislation:** The lack of strong support for existing regulatory requirements in high elevation coal mine reclamation indicates that the current situation is unacceptable and suggests the need for systemic changes in the process, particularly in British Columbia. The attitudes of respondents toward disturbance variances, complete or partial disturbance reclamation, increased demands for reclamation or greater attention to ecosystem processes reflected a latent uncertainty and possible lack of knowledge about the regulatory requirements of high elevation reclamation.

**Reclamation Economics:** Corporate-driven economic expediency and inadequate incentives due to short regulatory planning horizons prevent optimized reclamation performance. Although, most respondents did not favor economic feasibility of reclamation as the main determinant of post-mining land-use selection, financial concerns were obviously the basis for variance provisions with the regulations of both jurisdictions.
Enforcement of regulation through economic means (bonding) was strongly favored, but the magnitude of bonding was not determined, and the duration of corporate responsibility was variable. With respect to the duration of corporate responsibility, it appears that most participants had expectations of high elevation reclamation that were incompatible with conventional wisdom regarding alpine or subalpine successional processes. A minimum of 50-100 years was considered appropriate for alpine disturbance succession by Churchill and Hanson (1958) and Matthews (1992) while Arno and Hammerly (1984) considered 50-75 years to be an appropriate time period for subalpine disturbances. If truncated corporate responsibility is permitted, government regulators as stewards of public interest are in a difficult position. Under current regulations, there would be no possibility for enforced corporate involvement after bond release or certification if a retrograde ecosystem were discovered.

Reclamation Evaluation: Reclamation evaluation has two components: performance criteria requirements and monitoring procedures, both of which are strongly influenced by opinions. The large majority of respondents opposed to 'restoration' indicates a preoccupation with economic concerns and pragmatism. However, the majority of respondents were in favor of self-perpetuating vegetation cover as a criteria for the evaluation of reclamation success even though this concept is ill-defined. Uncertainty was expressed with respect to the value of equivalent productivity as a performance criteria. The results are in contrast to the survey by NORECOL (1986) in which it was concluded that equivalent productivity should be a requirement of revegetation success. However, the attitudes toward equivalent productivity as a performance criterion may
reflect even more entrenched economic concerns by mining corporations, and possibly, a greater number of 'informed' opinions as to the ambiguity of this concept within the context of mine reclamation regulation. In Alberta, the concept of 'equivalent productivity' has been replaced with 'equivalent capability' (Powter and Chymko 1991) possibly because of the 'economic realities' and inherent difficulties of regulatory enforcement. Essentially, equivalent productivity is biocentric (biomass per unit area per unit time) whereas land capability is more anthropocentric and utilitarian, stressing the productive capacity of the landscape. Although often used interchangeably, equivalent productivity and land capability are really very different concepts.

Monitoring procedures were considered to be inadequate by most respondents. Since reclamation monitoring is determined by regulatory requirements and performance criteria, there should be a direct relationship between performance criteria and monitoring procedures. However, the initial development of reclamation standards occurred without adequate conceptual support; therefore, the relationships between practices, performance criteria and monitoring procedures are incomplete. Monitoring that transcends disciplinary boundaries is proposed in Chapter 2.

**Reclamation Planning and Techniques**

A large variation in respondent attitudes toward the preparation of reclamation planning was observed.

**Reclamation Objectives and Research**: Planning is often seen to be separate from research as well as from management, but actually these activities are interactive and
mutually reinforcing processes (Nelson 1991). Research and planning are linked cybernetically with monitoring, evaluation and feedback when considered as part of a holistic system. These observations can also be applied to reclamation planning with respect to research, post-mining land-use objectives and evaluation monitoring.

Joint industry/government involvement within reclamation research was highly favored by respondents. Joint involvement provides for cooperative and realistic solutions to regulatory problems. Cooperative industry/government research is common in Alberta and the United States but has been restricted to a few high profile issues in British Columbia. Furthermore, through joint industry/government research, it may be possible to reduce the cognitive differences between specific reclamation professional groups and to make the occupational boundaries between regulators, field personnel and researchers more diffuse.

Joint involvement was also considered important for the development of mine reclamation plans. A large majority of respondents were of the opinion that mine engineers and reclamation planners should work together to develop plans, but it was not possible to determine the magnitude of the changes that would be acceptable. The slight professional group differences were expected, with mining engineers and consultants least supportive. However, the opinions expressed in the present study do not indicate the extent to which respondents consider multidisciplinary involvement necessary in reclamation plan preparation. Based on a collation of the information presented in Chapter 2 and the results of this chapter, much greater involvement than is practiced currently is required.
A large majority of respondents were against complete restoration of surface mine disturbances while only a slight majority of respondents were in favor of the ‘initial assistance’ or minimalist approach to high elevation mine reclamation. The strong opposition to restoration is consistent with the observations of Miller (1991) in the United States while the support for the minimalist approach is anachronistic and may reflect the coal mining industry’s overriding financial concerns.

In general, respondents were ambivalent toward the utility of the project review and regulatory process as a reclamation planning document. The design and information content of this environmental document must be revised (Chapter 3). Considerable time and effort is invested in an EIS and in the EIA process, but the utility of this process with respect to mine reclamation is truncated frequently at the permitting stage.

Landscape Design and Research: Although utilitarian post-mining landscapes have a ‘repellent beauty’ which has historical significance in terms of past experience, emotional attachment and attitudes towards the landscape (Francaviglia 1991), such cultural landscapes are generally considered socially unacceptable (Box 1978).

The visual impacts of mining, i.e., surface excavations, waste disposal and process facilities, are obvious. Although the visual effects of surface coal mine pits (Plass 1979), spoil dumps (Calvin et al. 1972, Magill 1995) and infrastructures (Millward 1985) have been recognized, few attempts have been made to estimate or minimize their intrusiveness within the planning process. Too often, the mining engineer’s vision of what is visually acceptable is based more on economics than visual quality. Strictly engineered designs with even graded slopes and tops that maximize spoil dump volume
and stability or high relief pit highwalls are rarely convergent with the topography of the surrounding landscape. Nevertheless, mining operations can provide opportunities to create a variety of sloping surfaces organized for specific end land-uses.

In the present study, a majority of respondents were of the opinion that insufficient attention is directed towards landscape design and aesthetics within the planning of high elevation reclamation programs. The importance of landscape aesthetics is acknowledged tacitly but given little technical support in the planning and design of mountainous post-mining landscapes. A lack of attention to aesthetics results in inadequate integration of ecological and social concerns within the reclamation process. Based on the results of the questionnaire, there is a need for more accurate predictions of the post-mining landscape and for documentation of the public’s attitudes toward post-mining disturbances and aesthetics.

Several technical tools are available to facilitate integration of aesthetics within the reclamation process. Computer generated graphic analysis employed as perspective plots (Scott 1984) or 3D digital terrain models (DTM) (Paulson 1990) are valuable in landscape design (Higuchi 1989) and in developing scenarios for predicting post-mining landscapes in project approval process. As well, GIS as a data base can be used to develop DTMs of the desired landscape. The DTM can be used as a tool for public input into the project to create final ‘opportunity landscape’ designs (Baker and Jackson 1994). Moreover, landscape simulations would be useful in creating professional quality landscape images which could be used in public preference studies of design alternatives (Watzek and Ellsworth 1994).
Schulhof (1989) has recommended the **visitor-employed photography** (VEP) technique (Cherem and Driver 1983) as a method of incorporating public preferences in restoration projects. However, other methods such as **photo-inventory** (Hammitt et al. 1994), **participant photography** (Chenoweth 1984), or combined experience sampling and **participant photography** (Hull and Stewart 1995) may be more appropriate. Landscape modification and species selection could be modified then to incorporate aesthetic preferences.

Although there is no simple general relationship between **aesthetic response** and the presence of engineered structures in 'natural' landscapes, preference is influenced strongly by the compatibility or fittingness of man-made features and their surroundings (Wohwill and Harris 1980, Magill 1992).

Natural versus man-made features are important determinants of visual preference (Ulrich 1986). Compatibility or congruity of shape and absence of color contrast are important features of aesthetic preference and should be considered in the design or ‘re-design’ of man-made features (Wohlwill 1983). Curvilinear boundaries predominate in natural landscapes whereas humans tend to counteract natural forces by creating and maintaining straight lines (Coppin and Bradshaw 1982). People are more sensitive to vertical and horizontal lines than to oblique lines and are more responsive to right angles than to acute or obtuse angles and irregular shapes (Tuan 1976). Perception of landscapes is also influenced strongly by the effects of the openness and the depth of landforms (Litton 1968).
Methods of improving the 'naturalness' or reducing the visual obtrusiveness of the post-mining landscape in mountainous terrain should consider the aesthetic preferences of high relief and spacious canyons (Herzog 1987), rock outcrops and cliffs and the presence of water (Zube et al. 1975). The geometrization of the post-mining landscape, particularly the pits, could be reduced by inpit dumps or restoration blasting.

Furthermore, the greener hues of revegetated disturbances relative to 'natural' landscapes highlight simply the visual contrast of such landscape mosaics (Allen 1992). The spatial configuration of plant materials must be based on ecological aesthetics (sensu Parsons 1995). Gablick (1992) suggests that there is inter-dependence between biological integrity and stability, and aesthetics. Thus, there is a need to consciously recreate patterns, forms, colors, textures and spatial characteristics that occur in natural models. Omission of important plant lifeforms not only changes community function but also creates considerable visual contrast.

Further research should be undertaken to examine the practical implications of including such activities within government regulations and operational reclamation.

Material Management: The management of reclamation materials contained the most divergent opinions of the questionnaire, particularly between regulatory jurisdictions. A majority of respondents considered slope instability to be an impediment to revegetation. Resloping of steeply engineered structures as a method of improving slope stability and facilitating revegetation was considered necessary in the opinion of most respondents with strongest support found within the 'environmental professions'
and least support within the engineering profession. The results on resloping are consistent with the opinions of respondents surveyed in Alberta (Smith 1989). Engineering professionals are generally against resloping because of the considerable costs involved (Campbell 1992).

A divergence of opinions was noted also for the use of ‘topsoil’ as a growing medium. Alberta respondents were in favor of the use of topsoil whereas British Columbia respondents were not. Apparently, Alberta respondents are more knowledgeable about the long-term value of topsoil as their opinions are consistent with the international literature, e.g., Ziemkiewicz (1985), Ogle and Redente (1988).

Also, Alberta respondents believed that suitable equipment for high elevation reclamation is lacking whereas British Columbia respondents were not in agreement with this statement. The Alberta response once again is consistent with the international literature, e.g., Brammer (1978), Crofts and Carlson (1982). However, the large number of neutral responses from British Columbia may indicate a lack of knowledge.

**Biology:** The importance of successional theory to reclamation has been stressed by Polster (1991) and Chambers et al. (1992). Successional theory was considered to be an important source of information for mine reclamation planning by most respondents. However, the actual incorporation of successional theory into mine reclamation planning is unknown. Successional concepts are latent currently within both regulatory requirements and practices. At present, reclamation practices specify implementation techniques and desired outcomes in the form of performance standards, both of which
are based loosely on conceptual models of communities or ecosystems and their dynamics. Reclamationists who perceive the successional process as a convergence upon a single regional or local steady-state endpoint design initial site preparation and revegetation practices to 'accelerate' succession and consider any divergence from such a trajectory to require immediate intervention. In contrast, the reclamationists who view multiple pathway trajectories in a dynamic system as successful, define a range of acceptable outcomes and plan and implement reclamation programs anticipating alternative outcomes. The attitudes reflect the conventional reclamation research focus of initial 're-assembly.' At high elevations, different small habitats and communities will take different lengths of time for recovery, e.g., a wind-exposed ridgecrest would require longer time than a more sheltered leeward slope. Therefore, reclamation practitioners need to stimulate multiple successional pathways in order to re-establish appropriate habitats and vegetation patterns. Reclamation, as practiced currently, emphasizes end-product exclusively rather than the process of developing that end-product. Apparently, reclamationists do not understand the relationship between management activities (initial re-assembly) and the process involved in achieving end land-use objectives.

The opinions of respondents toward the degree of management involvement in the establishment of plant and animal populations was split between those in favor of significant intervention (interventionists) versus those against (minimalists). While economic concerns appear to be the basis for these opinions, lack of knowledge of the cost/benefits of intervention may be promoting the minimalist view. Luken (1990)
clearly demonstrates the benefits of interventionist practices. The occupational group differences noted were not unexpected and reflect an engineering predilection with short-term economic expediency.

Most respondents did not feel that wildlife habitat re-creation is evaluated properly. This is particularly important, since most high elevation mines have wildlife habitat re-creation as a land-use objective. The evaluation of reclamation practices, particularly the achievement of land-use objectives, is an area of considerable controversy.

Revegetation Techniques: Present revegetation techniques were considered to be satisfactory for the successful reclamation of high elevation mine disturbances by the majority, although Alberta respondents were less favorable. Respondents were also ambivalent toward the emphasis on agricultural techniques within high elevation mine reclamation practices. These attitudes contrast with the observations of MacMahon (1988) for high elevation reclamation, and Call and Roundy (1991) for reclamation of arid and semi-arid regions. However, a majority of respondents were concerned with the lack of attention to soil development within reclamation planning, an attitude consistent with the field research of Jackson (1989).

Management techniques to facilitate seedling establishment (mulching) and vegetation maintenance (fertilizing) appear to be contentious issues. Alberta respondents were in favor of both these practices whereas British Columbia respondents were not. Again, the Alberta responses are consistent with the international literature, e.g., Chambers et al. (1990), Chambers et al. (1994). British Columbia respondents appear to be
concerned with economics to the exclusion of practical biological applications (e.g., ecosystem development and self-sustaining vegetation cover).

**Plant Materials**

**Species Selection:** Species suitability was considered to be a very important aspect of mine reclamation by almost all respondents, with the information contained within EIS's considered to be useful for species selection. These results are consistent with the anecdotal observations of Ward (1974) and Lea (1983).

Attitudes toward restricted or 'nurse-crop' benefits of agronomic species as opposed to long-term benefits were inconclusive for the aggregate sample population, but industry environmental professionals and nursery/seed suppliers tended to be more supportive. The use of agronomic grasses and native shrubs was favored by a majority of respondents, but attitudes toward the use of agronomic legume species were inconclusive.

**Native Plant Species:** In general, results were inconclusive with respect to the use of native species within high elevation mine reclamation programs. The general attitude towards dependency on native species for long-term high elevation reclamation success was divided, although environmental consultants were in favor. Most respondents believed native species use is not limited by restrictive establishment practices, slow establishment and growth rates or regulatory productivity criteria. The results contrast with the anecdotal observations of Bengson (1986) and Smyth (1987).
Attitudes toward native species transplant economics were split although the large number of neutral responses may indicate of a lack of knowledge on the part of the respondents. However, the use of native species ‘islands’ was favored strongly and may be a perceived mechanism for circumventing uneconomical native species establishment.

**Aesthetics and Native Species:** Attitudes toward the aesthetic benefits of native species were inconclusive. The use of native species as a method of reducing the visual contrast between disturbed and undisturbed areas was not favored strongly. Moreover, attitudes toward increased emphasis on native species was divided. The aesthetics results are in contrast to the observations of Bell and Meidinger (1977) and Jones and McTavish (1986) who strongly favored the use of native species in reducing the visual contrast between reclaimed and undisturbed landscapes.

**Commercial Production of Native Species:** The majority of respondents were supportive of increased research development and expanded native species seed or transplant production for high elevation mine disturbances. The results on native species production are consistent with the Alberta reclamation research priority survey results of Smith (1989).

The general ambivalence of the respondents toward native species suggests that their widespread use is still, after several decades of polemics, far from resolution. The use of native species is still in need of both technical (e.g., seed collection and germination, establishment methods) and socio-political research (aesthetics, land-use values).
7. **Conclusion**

The principle findings of this chapter are that within the two models of reclamation regulation, there is a preoccupation with economics and disagreement on many technical and practical issues.

However, the attitudes of professional groups within the present survey are not as distinct as those described for forest land management, wildlife management, land conservation or engineering and pollution. This may be due to the diffuse structure of the reclamation field and to the methods of information acquisition and dissemination used. The environmental management field is broad with no well defined single set of core skills, and reclamation as a subset discipline is particularly ill-structured.

There is also a lack of consensus (as indicated by the large number of neutral responses) to statements for which definitive results have been published internationally. Although the stated objectives for reclamation are similar between the jurisdictions surveyed (Chapter 2), respondent attitudes in Alberta are more consistent with applicable international literature. Attitudes were most divergent, both between professions and jurisdictions, on contentious issues such as total disturbance reclamation, spoil resloping, topsoiling, mulch application, maintenance fertilization and the benefits of native species. These divergent attitudes are interpreted to represent differing opinions on short-term economics and long-term benefits with respect to the achievement of land-use objectives.

The lack of consensus may also reflect the relatively recent development of reclamation science and practice in the two jurisdictions or may indicate the quality of information
and the method of information dissemination within the jurisdictions. The fact that a large majority of respondents completed all sections of the questionnaire, regardless of education, profession or experience suggests that cognitive oversimplification may be a problem. If respondents are not aware that reclamation includes both well-structured (defined) and ill-structured (undefined) problems, they will not understand that technical rationality may not be satisfactory.

Environmental performance involves short- and long-term objectives, but many environmental managers fail to see the long-term implications, and focus on the 'bottom line.' This problem appears to be symptomatic of the reclamation practitioners of the present survey. Conspicuously, participants have only a rudimentary understanding of ecological concepts embedded within the legislation, particularly with regard to successional theory.

Knowledge of ecosystem structure and function will always be imperfect, so it is important to understand how reclamation professionals deal with the imperfections in the knowledge-base. Much of the reclamation process is inter-disciplinary, so reclamation professionals are often required to provide interpretations at or beyond the limits of their professional expertise.

Perceptions of reclamation problems and practice are a function of the interconnections of professional and educational background and previous experience. Reclamation professionals with a broader knowledge-base are more likely to have a holistic view of reclamation practice whereas those without this information are likely to have a more reductionistic or mechanistic approach. The reductionist approach of the engineer
conflicts with the systems perspective of the environmental paradigm. However, the exclusion of anthropogenic forces by ecologists in their studies also creates problems. Often, disarticulation of processes occurs when human actions are excluded from ecological models (Vayda 1993).

The separation of technological determinism from societal values is particularly problematic for high elevation reclamation since environmental and economic limitations impose considerable constraints on revegetation practices. Engineering and technological solutions to environmental management often display profound ignorance of the complex interactions within nature (Mosquin 1993). Portions of reclamation such as aesthetics are particularly susceptible because the attitudes of reclamation professionals and of the public are so strongly dependent on an individual’s collective life experiences.

Reclamation practice is inherently value-laden and controlled by the epistemological matrices of participants (Figure 4.10). Therefore, the challenge is to educate environmental professionals (engineers, botanists, horticulturists, agronomists, soil scientists, wildlife biologists and landscape architects) who are fully prepared to plan reclamation projects. However, the ‘hard architecture’ of knowledge imparted at post-secondary institutions creates impediments to integrated learning. Universities and/or colleges should develop a cross-disciplinary reclamation curriculum inclusive of the preceding disciplinary content plus ethics and philosophy. The current education system emphasizes theories, not values, with technical efficiency preeminent (Disinger 1992). Reclamation professionals, particularly engineers, must be given greater training
Figure 4.10 Relationship between attitudes/opinions and the reclamation process.

in the broader perspectives of societal and environmental value systems. Essentially, technological thinking needs to be supplemented by ecological thinking. The need for this kind of training is apparent in light of the limited and narrow focus of information provided to graduating engineers in Canada. The engineering profession is identified specifically here because this is the group which, for the most part, circumscribes reclamation economics and design. Mining engineers must have an increased appreciation of the effects of development upon the surrounding environment. Information thus acquired would allow engineers to apply their design skills in the creation of more imaginative structures from initial design conception.

For the 'cognitively myopic' engineer, a series of interrelated courses which give a non-technical breadth or 'contextual understanding' to engineering education is needed. Broad-based training is particularly important for applied science disciplines and would reduce the cognitive biases and cognitive oversimplifications that are apparent within the professional groups involved in reclamation as well as reduce group inabilities to perceive component interdependencies. In so doing, greater consensus would be possible on contentious issues such as topsoiling, resloping, mulch application, maintenance fertilization and native species use.

However, reclamationists as applied ecologists, can learn from the approaches and practices of engineers. In addition to basic and applied-basic information, the engineering profession develops 'in-house' knowledge, e.g., special descriptive, prescriptive and tacit (pictureless and wordless) knowledge (Vincenti 1990). In working together to design reclamation plans, reclamation professionals function as
'ecological' engineers and, therefore, would benefit from an understanding of the strategies and tactics of traditional engineering. Engineers incorporate safety factors which are the profession's admission that their knowledge is incomplete (a smaller safety factor for better understood systems). Therefore, reclamation personnel should incorporate the tacit knowledge of environmental safety factors (risk and uncertainty) and related strategies on decision-theory into their reclamation planning procedures. Given the limited knowledge-base on re-creating ecosystems, a standard of improved understanding as well as behavior commensurate with the best available knowledge should be applied.

The symposia approach to education (Figure 4.11) presupposes a requisite amount of knowledge. However, this supposed knowledge-base is apparently not present within the population of respondents sampled. The symposium process as a mechanism for information dissemination tends to foster disjointed incrementalism rather than synthesis and technical rather than scientific discussion. Often the information presented is anecdotal in nature or focused on retrospective ad hoc studies of 'successful' implementation which have limited value for conceptual or consensus development. The conceptual understanding of respondents appears to be lacking. In particular, participants in the mine reclamation process conceptualize revegetation of disturbed land as an instantaneous phenomenon where plants are introduced and rapidly establish to form a permanent, static plant community. However, this perception is inconsistent with ecological theory.
Figure 4.11 Information generation for regulatory policy and legislation formulation.

**Academia**
- Theses
- Dissertations
- Textbooks
- Journal Articles
- Symposia Proceedings

**Environmental Consultants**
- Client Reports $^a,b$
- Symposium Proceedings $^a,b$
- Magazine Articles
- Journal Articles $^a$

**Nursery Stock and Seed Suppliers**
- Verbal Communication $^a,b$
- Symposium Proceedings $^b$

**Mining Industry**
- Internal Reports $^a,b$
- Symposium Proceedings $a,b$
- Magazine Articles $^a$

**Government**
- Government Reports $^a$
- Symposium Proceedings $a,b$
- Journal Articles $^a$
- Verbal Communication $a,b$

Legend:
$^a$ - Alberta
$^b$ - British Columbia

Policy, Regulations, Legislation
In their written comments, several respondents from the industry environmental category stated that production engineers and foremen should receive formal instruction on reclamation practices. Information dissemination to the individuals directly supervising and performing site preparation and materials handling is ineffectual (Figure 4.12). Since much of the information dissemination would represent 'shallow' knowledge (Schön 1983), many of the recipients would be receiving incomplete or non-contextual information: the antithesis of the holistic or systems approach to reclamation practice.

Appropriate didactic materials are needed to address all information assimilation modalities (kinesthetic, auditory, visual) or learning styles. Learning modalities are important for opinion change as videotaped messages possibly have greater impact on opinion change than do written messages. However, the written modality may be superior to videotaped and audio cassettes when information is complex. Thus, a modular curriculum would be required due to the differing knowledge-bases of the respective participant groups (environmental personnel, engineers, foremen and operators). The informational content of curricula for each group specific module is presented in Figure 4.13. A modular, self-instructional training program to teach new mine reclamation inspectors about soils and revegetation, surface and ground water hydrology, engineering principles has been implemented in the United States at the University of Kentucky by the Department for Surface Mining Reclamation and Enforcement (DSMRE) (Cole and Sendlein 1992). The program proposed herein differs significantly from that in the United States in that the curriculum has three
Figure 4.12 Hierarchical flowchart of reclamation information and innovation exchange.

Legend:
- Written Reports, Seminars and Symposia
- Informal Verbal Communication
Figure 4.13 Instructional training module descriptions and targeted occupational groups.

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<thead>
<tr>
<th>Instructional Modules</th>
<th>Occupational Group</th>
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<tr>
<td><strong>Introductory Module</strong></td>
<td>• Mine Managers, Mine Engineers,</td>
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<td>Foremen and Equipment Operators</td>
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<td></td>
<td>• Industry Environmental Personnel</td>
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<td>• Consultants</td>
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<td>• Government Personnel</td>
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<tr>
<td><strong>Intermediate Module</strong></td>
<td>• Planning Engineers and Foremen</td>
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<td>• Industry Environmental Personnel</td>
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<td>• Consultants</td>
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<td>• Government Personnel</td>
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<td><strong>Advanced Module</strong></td>
<td>• Industry Environmental Personnel</td>
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<td>• Consultants</td>
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<td>• Government Personnel</td>
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<td><strong>Introductory Module</strong></td>
<td>• Regulatory Requirements</td>
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<td>• Overview of Concepts</td>
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<td>• Overview of Reclamation Practices</td>
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<td><strong>Intermediate Module</strong></td>
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<td>• Soils - Physical, Chemical and Biology</td>
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<td>• Vegetation / Environment Relationships</td>
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<td>• Site Preparation Techniques</td>
<td>• Revegetation Techniques</td>
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<tr>
<td><strong>Advanced Module</strong></td>
<td>• Regulatory Guideline Interpretation</td>
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<td>• Reclamation Economics</td>
<td>• Landscape Design and Aesthetics</td>
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<td>• Plant Species Selection and Establishment</td>
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<td>• Invertebrate and Vertebrate Fauna Biology</td>
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<td>• Ecosystem Processes</td>
<td>• Landscape Ecology</td>
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<tr>
<td>• Succession Management (Autotrophic and Heterotrophic)</td>
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<tr>
<td>• Research/Monitoring Design, Sampling and Analytical Techniques</td>
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[Note: Instructional modules include videotapes, manuals and workbooks.]
formats or levels directed toward different target groups (short- and long-range planning engineers, foremen and equipment operators) and contains significant additions, particularly in the areas of population biology, successional theory and aesthetics. The approach also suggests formal training of operational staff and not just regulators; therefore, greater standardization of practice and increased information diffusion would result.

To be consistent with adaptive environmental management, it is important to develop easily updated modules which contain conceptual and theoretical information as well as operational manuals for all participants. Dated and conceptually limited manuals exist currently in the United States (Chapter 2), in British Columbia and in Alberta. Most of these publications are in the form of field handbooks.

Curriculum modules and field handbooks would be updated regularly by academic researchers or consultants under contract to the responsible regulatory agencies. Information would be available from the monitoring network data (Chapter 2) as well as extensive bibliographic reference bulletins such as SEAMALERT or Laurentian University's on-line computer database and retrieval system (Kelly 1992). The theoretical or conceptual and practical information derived from various sources (Figure 4.11) would assure adaptive management. Such a process would facilitate the formal positional justification proposed for regulation development.

Finally, accreditation of reclamation professionals should become a requirement. The accreditation process would ensure an adequate knowledge-base on the part of
reclamation practitioners and researchers, thereby raising and standardizing the quality of reclamation practice. Accreditation is discussed further in Chapter 2.
CHAPTER V
SYNTHESIS

1. Introduction

Reclamation is a multidisciplinary environmental management problem for which a considerable amount of technical information has been accumulated. However, the information lacks depth and cohesion. Reclamation, both conceptually and practically, is a fragmented collection of 'traditional' disciplines which have coalesced around incoherent or disjointed theory. As a result, coordination between the various 'sub-disciplines' has been lacking and there is a need to re-evaluate the practices and roles of surface mine reclamation, particularly with reference to a unification of concepts from disciplines such as engineering, ecology and landscape aesthetics. The importance of a holistic interdisciplinary approach is essential for ecologically-based reclamation practice.

Three areas of concern were identified: (1) the sociopolitical regulatory milieu, (2) attitudes and opinions towards reclamation and (3) ecological concepts and management planning. Within each of the three areas, similar problems were identified: (a) inadequate integration of relevant basic ecological concepts (ecosystem and succession theory, population biology, landscape ecology) within applied reclamation science, (b) insufficient understanding of the inter-connectedness of attitudes and sociopolitical values upon reclamation objectives, research and practices, (c) inadequate disciplinary integration, (d) a lack of 'quality' information (simplistic, ad hoc, parochial)
for decision-making and planning, and (e) an absence of long-term vision and a lack of appropriate feedback mechanisms for practices.

A comprehensive approach to problem-solving requires the collation of 'borrowed' empirical analyses and theoretical constructs. The final chapter represents a synthesis of sociopolitical and ecological information.

2. Legislation, Regulations and Guidelines

Legislation, regulations and enforcement are the driving forces behind the protection of the environment and, therefore, provide much of the context for reclamation decisions and activities.

The systems for regulating surface coal mines in the jurisdictions reviewed are very complex. Comparatively, the United States system is more reliant on statute and regulation than either Alberta or British Columbia. As a result, 'technological forcing' is more prevalent in the United States. Little of the reclamation legislation reviewed contained specific references to mountainous or high elevation disturbances. Instead, a broad 'regulatory net' has been developed for reclamation activities.

The current command-penalty model of environmental regulation results in adversarial interactions between government and industry and should be replaced by a formal negotiated system based on continuing research and adaptive management. A negotiated system provides regulatory flexibility and would stimulate creative problem-solving. Continued research combined with required positional justification would eliminate potential discretionary abuse by 'sympathetic administrations' and ensure
corporate compliance. Where technological uncertainty is high, e.g., in high elevations, it may be necessary to convene a panel of 'experts' to adjudicate. Coordinated government/industry research is the most effective method of developing consensus for practices and regulations. Directly- or indirectly-affected members of the general public should have formal input into the development of regulations as well. Public involvement would reduce the potential of 'agency capture' and should result in a greater integration of aesthetic concerns.

The comparative analysis of regulatory requirements revealed that several jurisdictions are similar programmatically yet dissimilar substantively. Areas of dissimilarity include regulatory provisions such as topographic modifications and revegetation as well as performance standards, reclamation monitoring and enforcement. Also, there is a lack of ecological perspective in many reclamation practices and regulatory requirements. In general, the regulatory requirements focus primarily on the end-product rather than on the process of creating that end-product.

Landscape modification as a form of 'habitat template' preparation is well developed in most jurisdictions although regulatory requirements, or lack thereof, constrain innovation. Incorporation of landscape aesthetics within reclamation planning and implementation is poor within all jurisdictions reviewed and represents an area for future research. Amendments should be made to the regulatory process to include a formalized process for incorporating landscape aesthetics in both the planning and monitoring phases of reclamation regulation.
Ecosystem-based reclamation performance monitoring, a crucial part of regulatory enforcement and adaptive environmental management, is lacking or poorly implemented in most jurisdictions. Evaluation of reclamation success is important to the regulatory process, and three approaches have been described: (1) productivity, (2) capability and (3) functional analysis. Each of these approaches has associated problems of measurement and prediction, so an evaluation program which combines capability and functional analysis is proposed. This evaluation process focuses on the trajectory or process of successional development rather than on the end-product.

In general, ecosystem response to management practices is not well understood. At present, chronosequences or SFTs provide the best information on ecosystem succession. Limitations in the knowledge-base can be viewed only from the perspective of long-term ecosystem-based monitoring programs. Particular attention must be directed toward population- and landscape-level processes. Well-designed monitoring programs are essential to the improvement of management practices on high elevation surface mine disturbances.

A hierarchical (population, community, ecosystem, landscape) monitoring program is proposed as part of the performance evaluation program. GIS technology is considered to be an essential tool in the monitoring process, particularly with respect to temporal changes in spatial processes and patterns. Detailed sampling parameters, research design, analysis and presentation format should be outlined in guidelines and a field handbook. Comprehensive ecological monitoring and analytical procedures, included as part of an improved reclamation guidelines program, would empower reclamation
practitioners, require ‘environmental due diligence’ by the mining companies and lead to higher professionalism and greater standardization of practices.

3. Environmental Impact Statements and Reclamation Planning

Adequate pre-disturbance or baseline information upon which to base decisions is crucial to impact assessment and environmental management of surface mines. The information collected during the EIA process or feasibility phase is essential for reclamation planning. Several important conclusions regarding environmental management in general and reclamation specifically can be drawn from the examination of mine development EIS documents.

The technical basis of the EIS document needs to be improved with specific reference to reclamation planning, implementation and monitoring. Although variable, most EISs did not contain sufficient information (content and quality) upon which to base project approval with respect to reclamation. Frequently, important information describing diversity, rare and endangered species, succession and spatial relationships of wildlife habitat was lacking. Generally, the approaches used reflect a static perspective of ecosystems, and the information collected is ritualized. Standardization of data collection parameters and methodology and the development of appropriate data analysis and presentation protocols are necessary. Sensitivity mapping techniques and GIS technology should be used in the preparation of EISs. In addition, accreditation of professionals would improve the data gathering and synthesis stages of the process and assure environmental ‘due diligence.’
4. **Attitudes of Reclamation Participants**

Fundamental to significant improvements in the overall high elevation reclamation process is an understanding of the reclamation 'ethos.' A study of the influences of the opinions and attitudes of the participants toward reclamation research, planning and program implementation provides important knowledge for understanding current problems and directing future research.

The attitudes expressed by participants demonstrates a preoccupation with short-term economics and a lack of consensus on many technical issues. Overall, attitudes of professional groups within the survey are not divergent. However, attitudes are divergent (both between professions and jurisdictions) on contentious issues such as total disturbance reclamation, spoil resloping, topsoiling, mulch application, maintenance fertilization and the benefits of native species. There is also a lack of consensus (as indicated by the large number of neutral responses) to statements for which definitive results have been published internationally. The lack of consensus may be indicative of the quality of information and the method of information dissemination within the jurisdictions. Cognitive oversimplification appears to be a problem in some jurisdictions. Conspicuously, participants have only a rudimentary understanding of ecological concepts embedded within the legislation, particularly with regard to successional theory.

Reclamation practice is inherently value-laden and controlled by the collective life experiences of the participants. Perceptions of reclamation problems and practices are a function of the inter-connections of education, professional training and *experiential*
knowledge. Much of the reclamation process is new and multidisciplinary, so reclamation professionals are often required to provide interpretations at or beyond the limits of their professional expertise. Components of reclamation practice, e.g., aesthetics, are susceptible in particular, as the attitudes of reclamation professionals and the public depend strongly on an individual's viewpoint. Thus, environmental professionals should be exposed to a cross-disciplinary reclamation curriculum inclusive of the broader perspectives of societal and environmental value systems.

The symposia approach to education supported in British Columbia and, to a lesser extent in Alberta, presupposes a requisite knowledge-base on the part of participants. However, the symposium mechanism of information dissemination tends to foster disjointed incrementalism rather than synthesis and technical rather than scientific discussion, resulting in a lack of conceptual understanding. Developmental hysteresis will persist until the existing regulatory and information acquisition/dissemination paradigm is changed. Information dissemination to the individuals supervising and performing site preparation and materials handling is particularly ineffectual. Thus, a modular self-instructional educational program with appropriate didactic materials addressing the three learning modalitites (kinesthetic, auditory, visual) is proposed. The program would have three formats or levels containing practical and conceptual information 'customized' for the different groups of participants. Curriculum modules and field handbooks would be updated regularly by academic researchers or consultants under contract to the responsible regulatory agencies. This approach also requires
formal training of operational staff which would result in greater standardization of practice and information dissemination.

Finally, accreditation of reclamation professionals should become a requirement. The accreditation process would ensure an adequate knowledge-base on the part of reclamation practitioners and researchers thereby raising and standardizing the quality of reclamation practice.

5. Summary

Within the domain of academic and resource management specialists, an increasingly important objective is the integration of concepts from various disciplines. Significant improvements in resource management activities such as high altitude mine reclamation can be made only through a broader, more integrative (geographical) research approach in which technical information is understood and synthesized with sufficient consideration by each participating discipline. Human motivation and responses within the environment must be considered as part of the system being managed or manipulated. This approach is lacking in all current reclamation literature, and any attempt to frame technical and ecological information within the existing societal value-system represents a significant contribution to the existing knowledge-base.

The inter-connectedness of reclamation-related scientific/technical research and societal values, reflected by regulatory requirements is recognized in this dissertation. In the future, there must be a shift away from the current pragmatic focus on technology towards a more holistic view of philosophy, objectives and practices. The ‘discipline’
of mine reclamation must progress also from simplistic attempts at ecosystem 're-
assembly' to a science which involves ultimately the long-term management of entire
ecosystems over extended periods of time. Reclamation must be viewed as a process
and not as an artificial product or end-point determined by regulatory requirements and
monitoring protocols.

Reclamation is an experimental management science that requires imagination and
science. To progress, reclamation practice must develop a 'balanced' synthesis of
theory and practice.
LITERATURE CITED


**Tuan, Yi-Fu (1976).** Space and place: humanistic perspective. *Progress in Geography*, 6, 211-252.


Appendix 3.0 List of Environmental Impact Statements Reviewed.


Appendix 4.1 Survey questionnaire respondent participation request letter.

October 15, 1990
Mr. J. Doe
Department of Environment,
100 Government Road,
Unknown, Province,
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Dear Sir or Madame:

I am a Doctoral student in the Geography Department at the University of Victoria studying under Dr. Philip Dearden. Through my dissertation, I am attempting to address some of the problems and needs faced when reclaiming high elevation coal mine disturbances in the Canadian Rockies. The research is divided into four components: (1) attitudes and perceptions of all individuals involved in the reclamation process, (2) reclamation legislation and policies, (3) reclamation planning and techniques, and (4) plant materials selection.

The first component of the research involves a survey of the various individuals who are involved in the design and implementation of high elevation reclamation programs. The population includes government personnel, industry environmental planners and technicians, plant and seed suppliers, and mine engineers. I have written to you to ask
you to participate in my survey. A mail questionnaire will be used as the survey instrument. Completion of the questionnaire will take approximately 30 minutes, and confidentiality is guaranteed. The survey will be distributed in late October, 1990. Please indicate your willingness to participate by checking ( √ ) the appropriate space below:

( ) I am willing to participate in your study.

( ) I am not willing to participate in your study.

Return this letter to me in the enclosed envelope by Saturday, October 31. If you have any questions or comments, call me at (604) 242-3160. Your assistance with this research project is appreciated very much. Thank you for your time.

Sincerely,

Clint R. Smyth, B.Sc., M.Sc.
Appendix 4.2 List of questionnaire respondents.

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<tr>
<td>Mr. Brian Saul, P.Eng.</td>
<td>Fording Coal Limited</td>
<td>(604) 865-2271</td>
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<td>P.O. Box 100</td>
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<td>Mr. Rob Scott, P.Eng.</td>
<td>P.O. Box 506</td>
<td>(604) 242-3587</td>
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<td></td>
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<td>Mr. Paul Thomas</td>
<td>Gregg River Resources Limited</td>
<td>(403) 692-3967</td>
</tr>
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<td>Bag Service 5000</td>
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**Government Engineering**

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<tr>
<th>Name</th>
<th>Address</th>
<th>Phone Number</th>
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<tr>
<td>Mr. Richard Booth</td>
<td>Inspection and Engineering Branch</td>
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<td></td>
<td>Ministry of Energy, Mines and Petroleum Resources</td>
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<tr>
<td>Mr. Murray Galbraith</td>
<td>Inspection and Engineering Branch</td>
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<td></td>
<td>105 - 525 Superior Street</td>
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</tbody>
</table>
Fernie, B.C.  
V0B 1M0  
Telephone: (604) 423-6884  

Victoria, B.C.  
V8V 1X4  
Telephone: (604) 356-2210  

Mr. Khalid Jamil  
Energy Resources Conservation Board  
Coal Department  
640 - 5th Avenue SW.  
Calgary, Alberta  
T2P 3G4  
Telephone: (403) 261-8311  

Mr. Ralph McGinn  
Inspection and Engineering Branch  
Ministry of Energy Mines and Petroleum Resources  
105 - 525 Superior Street  
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V8V 1X4  
Telephone: (604) 356-2200  

Mr. Dave Turner  
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Ministry of Energy, Mines and Petroleum Resources  
1652 Quinn Street  
Prince George, B.C.  
V2N 1X3  
Telephone: (604) 565-6125  

Mr. Andrew Whale  
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Ministry of Energy, Mines and Petroleum Resources  
Bag 1000  
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V0B 1M0  
Telephone: (604) 423-6884  

Mr. Steve Wuschke  
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Prince George, B.C.  
V2N 1X3  
Telephone: (604) 565-6125
Appendix 4.3 Survey questionnaire covering letter.

Geography Department  
University of Victoria  
P.O. Box 3050  
Victoria, B.C.  
V8W 3P5

Dear Sir or Madame:

We are doing a research study on high elevation coal mine reclamation. Our specific interests involve the role of legislation (policies/guidelines), environmental impact statements, conventional reclamation techniques and plant materials in high elevation mine reclamation programs within Alberta and British Columbia. In order to understand these issues, we need to know the opinions of people involved in reclamation related activities.

Completion of this questionnaire is voluntary. However, we believe that you have an important contribution to make, so by completing this questionnaire you will help us gain a better insight into these issues.

The research (Project Number 123-90) is being conducted by Clint Smyth and Dr. Philip Dearden of the Geography Department at the University of Victoria. All of the information from this study will be used for the purpose of research and will be kept strictly confidential. You are asked to sign the consent form prior to completion of the
questionnaire. After completion of the questionnaire, the consent form and questionnaire should be returned separately, one in each of the two self addressed and stamped envelopes. Completion of the questionnaire should take about 30 minutes. Should you decide not to complete the questionnaire, please return the entire package. Those individuals who do decide to participate will receive a synopsis of the results following the completion of the study.

Your time and effort are greatly appreciated.

Sincerely,

Clint R. Smyth
Appendix 4.4 Survey questionnaire consent form.

Consent Form for Questionnaire Participants

I am fully aware of the purpose and nature of the questionnaire study and do hereby indicate my willingness to complete the attached questionnaire by signing below.

To ensure my anonymity, I will return the consent form in a separate mailing envelope. The completed questionnaire will be returned in another envelope.

__________________________________________
Signature

__________________________________________
Position

__________________________________________
Organization

__________________________________________
Date
Appendix 4.5  High Elevation Coal Mine Reclamation Questionnaire

Section A  General Reclamation Questions

The following are a series of general statements concerned with mine reclamation. Please rank order according to importance three of the responses provided for each statement. One represents the highest importance and three the lowest.

1. The three most important environmental limitations to high elevation revegetation are ..
   - infertility of plant growth material (spoil)
   - surficial slope instability
   - slow soil development
   - short growing season
   - cool growing season temperatures
   - low water holding capacity of spoil
   - other (please specify)

2. The three most important provisions that government legislation, regulations or guidelines should provide are . . .
   - environmental protection
   - reclamation evaluation criteria
   - reclamation enforcement
   - long-term monitoring of reclamation success
   - reclamation research goals
   - reclamation cost savings
   - reclamation planning objectives
   - other (please specify)

3. The three most important planning considerations for high elevation coal mine reclamation programs should be . . .
   - slope stability
   - vegetation establishment
   - soil development
   - landscape aesthetics
   - land-use objectives
   - acid mine drainage
   - spoil dump configuration
   - erosion control
   - landscape design
   - ecosystem restoration
   - spoil re-handling
   - species selection
   - economics
   - other (please specify)

4. The three most important uses of commercially available plants (seeds or seedlings) for reclamation are . . .
   - soil development
   - short-term erosion control
   - aesthetic appeal
   - vegetative cover
   - long-term erosion control
   - reduced fertilizer costs
   - forage for wildlife
   - wildlife habitat creation
   - other (please specify)
5.1 Do you believe there are benefits to using native species in high elevation mine reclamation programs?

1 Yes 2 No

- If yes, please rank order three of the responses provided in the second part of number five (5.2) and then complete number six.
- If no, please proceed to Section B.

5.2 The three most important benefits of native species in high elevation reclamation programs are . .

- adapted to the local environment
- lower nutrient requirements
- visual appeal
- long-term erosion control
- wildlife habitat creation
- ecosystem restoration potential
- reduced fertilizer costs
- forage for wildlife
- short-term erosion control
- vegetative cover
- soil development
- other (please specify)

6. Three major limitations to the use of native plants in reclamation programs are . .

- seed cost
- slow growth
- lower competitive ability
- lack of information
- inconsistent seed germination
- seed availability
- poor seedling establishment
- seed pre-treatment requirements
- other (please specify)

Section B - Coal Mine Reclamation Legislation, Regulations Guidelines.

The following are some statements which deal with coal mine development and reclamation regulations or guidelines. Please circle the level of agreement which most closely corresponds to your opinion about the statement. There are no right or wrong answers - we are only interested in your opinion.

Do you have an opinion about coal mine reclamation legislation, regulations or guidelines within your respective geopolitical region?

1 Yes 2 No

- If your answer is yes, please complete this Section.
- If your answer is no, please go on to Section C.

Strongly Disagree Neutral Agree Strongly Disagree

1. The coal reclamation guidelines provide enough guidance for the design of high elevation coal mine reclamation.

1 2 3 4 5
2. Reclamation reference areas (permanently marked plots in undisturbed habitats adjacent to mining operations) are essential for the evaluation of revegetation success and bond release.
1 2 3 4 5

3. Establishment of a self-perpetuating vegetative cover should be the main criteria of reclamation success.
1 2 3 4 5

4. Reclamation legislation/guidelines should emphasize the re-establishment of ecosystem processes rather than the establishment of 'target' plant communities ('target' plant communities are groupings of plants identified as being essential for end land-use objectives).
1 2 3 4 5

5. The interaction between government and industry concerning reclamation is presently too adversarial.
1 2 3 4 5

6. All forms of surface mine disturbances (spoil dumps, pit floor, head walls, foot walls, tailings ponds) should be revegetated.
1 2 3 4 5

7. Current government procedures for monitoring revegetation success are adequate to ensure the successful reclamation of high elevation mine disturbances.
1 2 3 4 5

8. Equivalent productivity is an appropriate criteria for satisfaction of reclamation success.
1 2 3 4 5

9. More demanding reclamation legislation will improve the process of high elevation coal mine reclamation.
1 2 3 4 5

10. The posting of reclamation performance bonds is an appropriate incentive to ensure reclamation is completed satisfactorily.
1 2 3 4 5

11. All companies should be required by law to set aside funds within separate accounts to cover the costs of reclamation.
1 2 3 4 5

12. Corporate responsibility for the management of revegetated post-mining landscapes should be restricted to a specified time period.
1 2 3 4 5

- If you agree or strongly agree with this statement, please indicate in the space provided how long this time period should be.
13. Post-mining land-use objectives should be dictated solely by the economic feasibility of such objectives.  

14. Variances (exceptions to regulations) should be granted for those portions of surface mine disturbances which are difficult to revegetate.

**Section C - Mine Reclamation Planning and Techniques**

The following are some statements which deal with mine reclamation planning and reclamation techniques at high elevations. Please circle the level of agreement which most closely corresponds to your opinion about the statement. There are no right or wrong answers - we are only interested in your opinion.

Do you have an opinion about mine reclamation planning and reclamation techniques?

1 Yes  
2 No

- If your answer is yes, please complete this Section.  
- If your answer is no, please go on to Section D.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The function of reclamation activities is to give nature some initial assistance.</td>
<td>1 2 3 4 5</td>
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<tr>
<td>2. Contemporary reclamation techniques are satisfactory for high elevation surface mine reclamation programs.</td>
<td>1 2 3 4 5</td>
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<td></td>
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<tr>
<td>3. Coordinated government and industry reclamation research programs are useful in the development of reclamation programs.</td>
<td>1 2 3 4 5</td>
<td></td>
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<tr>
<td>4. Mine plans should be altered where necessary to accommodate reclamation concerns.</td>
<td>1 2 3 4 5</td>
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<tr>
<td>5. Mine planners and reclamation planners should be jointly involved in the design of both mine and reclamation plans.</td>
<td>1 2 3 4 5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Environmental data collected during the mine development review process provides appropriate information for the completion of reclamation planning.</td>
<td>1 2 3 4 5</td>
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</tbody>
</table>
7. The objective of high elevation reclamation programs should be the establishment of ‘target’ plant communities.

8. Landscape design and aesthetics are given enough attention in the design of high elevation mine reclamation programs.

9. The architecture or structural appearance of ‘target’ plant communities is an important consideration in the design of high elevation coal mine reclamation plans.

10. Surficial slope stability limits vegetation establishment at high elevations.

11. Mine spoil resloping should only be considered for geotechnical or slope stability reasons.

12. Populations of native plants and animals will establish on mine disturbances without the assistance of man.

13. Adequate attention is given to the evaluation of re-established wildlife habitat in high elevation reclamation programs.

14. Plant successional theory (the sequential replacement of plant species assemblages or communities through time) is useful in providing information for mine reclamation planning.

15. Topsoil storage and replacement is necessary for successful high elevation surface mine reclamation.

16. There is too much emphasis on agricultural techniques in high elevation reclamation programs.

17. Suitable reclamation equipment is lacking for the revegetation of high elevation mine disturbances.

18. Topographic modifications are essential for seedling establishment at high elevations.

19. Mulch application is necessary for seed germination on high elevation surface mine disturbances.

20. Maintenance fertilizer applications are required in high elevation reclamation programs.
<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>21. Enough attention is given to soil development in the planning of reclamation programs.</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>22. The objective of all reclamation programs should be the complete restoration of the disturbance to pre-disturbance conditions.</td>
<td>1</td>
<td>2</td>
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**Section D - Plant Materials**

The following are some statements which deal with species selection in high elevation coal mine reclamation programs. Please circle the level of agreement which most closely corresponds to your opinion about the statement. There are no right or wrong answers - we are only interested in your opinion.

Do you have an opinion about the plant species or species selection process used in mine reclamation planning and reclamation techniques?

1. Yes 2. No

- If your answer is yes, please complete this Section.
- If your answer is no, please proceed to Section E.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
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<tbody>
<tr>
<td>1. Species suitability is very important at high elevations.</td>
<td>1</td>
<td>2</td>
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<tr>
<td>2. The environmental data collection phase of the mine development review process is an effective way of selecting plant species for reclamation.</td>
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<td>2</td>
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<tr>
<td>3. Development programs for the commercial production of native plants (seeds or seedlings) are necessary for the successful reclamation of high elevation mine disturbances.</td>
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<tr>
<td>4. The inclusion of grass species in high elevation seed mixes is essential.</td>
<td>1</td>
<td>2</td>
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</tr>
<tr>
<td>5. The inclusion of legume species in high elevation seed mixes is essential.</td>
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<tr>
<td>6. Shrub species establishment is essential for the reclamation of high elevation disturbances.</td>
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<tr>
<td></td>
<td>Strongly Disagree</td>
<td>Disagree</td>
<td>Neutral</td>
<td>Agree</td>
<td>Strongly Agree</td>
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<tr>
<td>7. Agronomic species are only suitable as 'nurse' crops in reclamation programs.</td>
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<td>2</td>
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<tr>
<td>8. More emphasis on aesthetics would increase the use of native species in mine reclamation.</td>
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<td>2</td>
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<tr>
<td>9. Native plant species use is suitable only if very site specific seeding practices are used.</td>
<td>1</td>
<td>2</td>
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<tr>
<td>10. Native species establish too slowly to be of any value in mine reclamation seeding programs.</td>
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<tr>
<td>11. Emphasis on productivity restricts the use of native species in high elevation reclamation programs.</td>
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<td>5</td>
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<tr>
<td>12. Long-term re-establishment of vegetation on high elevation coal mine disturbances will only be possible with the extensive use of native species.</td>
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<td>2</td>
<td>3</td>
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<td>13. A reason that native species are preferable is because they reduce the visual contrast between the vegetation of reclaimed and adjacent natural areas.</td>
<td>1</td>
<td>2</td>
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<td>5</td>
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<tr>
<td>14. The use of native species seedling transplants is economical for large scale projects.</td>
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<td>2</td>
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<tr>
<td>15. Native species 'islands' are useful as seed sources for later plant successional development.</td>
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<td>16. There is a market for expanded native species seed production in Alberta and British Columbia.</td>
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**Section E - Demographic Information**

The following general questions are to help us interpret our findings. The replies are strictly confidential. Please fill in the blanks or circle the appropriate number(s).

1. Please indicate the type of work that is performed by your company or organization.

   1 Coal Mining  
   2 Environmental Consulting  
   3 Engineering Consulting  
   4 Government (Research, Regulatory)  
   5 Nursery Stock Supplier  
   6 Seed Supplier  
   7 Other (Please specify)

2. In what city or town and province are you located?

   City: ____________________________ Province: ____________________________
3. How many years have you been involved with mining or mine reclamation related activities?

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<td>over 35</td>
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4. Please circle the category that best represents your present involvement in high elevation reclamation programs? (You may circle more than one category).

- government technician (inspector)
- government wildlife biologist
- government agrologist
- government forester
- government biologist
- mine environmental/reclamation supervisor
- mine environmental/reclamation planner
- mine environmental/reclamation technician
- seed supplier
- nurseryman
- environmental consultant
- geologist
- engineering consultant (please specify)
- engineer (please specify)

5. What is your educational background?

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<td>environmental technology</td>
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<tr>
<td>school or college</td>
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<tr>
<td>geography</td>
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<tr>
<td>geology</td>
<td>5</td>
</tr>
<tr>
<td>soil science</td>
<td>6</td>
</tr>
<tr>
<td>biology</td>
<td>7</td>
</tr>
<tr>
<td>botany (plant science)</td>
<td>8</td>
</tr>
<tr>
<td>mine engineering</td>
<td>9</td>
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<td>civil engineering</td>
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</tr>
<tr>
<td>agriculture</td>
<td>11</td>
</tr>
<tr>
<td>other (please specify)</td>
<td>12</td>
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</table>

6. What is your most frequent source of information on plant species selection and reclamation techniques? (You may circle more than one category).

- government personnel
- symposia proceedings
- journal articles
- company (internal) research
- nursery stock producers
- magazine articles
- government publications
- conferences
- academic researchers
- seed companies
- other (please specify)

7. Are there any comments you wish to make?

_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
_____________________________________________________________________
APPENDIX 5.0

Glossary of Mining and Environment Related Terminology.

Like the science of ecology, the content area for environmental management and more specifically reclamation, is very broad and requires the use of terminology or ‘jargon’ from a number of disciplines. Terminology is important insofar as a lack of uniformity detracts from effective communication (United States National Research Council 1974) and theory development (Wali 1992). Therefore, a glossary has been provided to facilitate text comprehension. Most of the definitions are direct quotations, but some are paraphrased. Direct transferrances *ipsissima verba* are provided in quotation marks. In all cases, authorship of the definitions is provided.

**Abandoned Mine**: “A mining operation where coal is no longer being produced and it is the intent of the operator not to continue production from the mine” (Bituminous Coal Research Incorporated 1974).

**Abatement**: “The reduction of the pollution effects of mine drainage” (Bituminous Coal research Incorporated 1974).

**Abiotic**: “The non-living components of the environment, such as air, rocks, soil, water, coal, peat, plant and litter” (Burrows 1990).

**Abrupt Edge**: “An edge between stands of communities that is regular (i.e., straight lines or gently sweeping curves) leading to relatively low amounts of edge per unit area” (Forman and Godron 1986).
**Abundance:** “The number of organisms in a population, combining ‘intensity’ (density within inhabited areas) and ‘prevalence’ (number and size of inhabited areas)” (Begon et al. 1990).

**Abutment:** “The point of contact between the ends of an embankment and the natural ground material” (Bituminous Coal Research Incorporated 1974).

**Acari:** “Members of the Acarina order (mites)” (Guralnik 1984).

**Access Road:** “Any haul road or other road constructed, improved, maintained, or used by the operator which ends at the pit or bench, and is located within the area of land affected by disturbances such as mining” (Bituminous Coal Research Incorporated 1974).

**Accreditation:** Recognition or conformation with a standard. Maintenance with standards that qualify for professional practice (Guralnik 1982). Accreditation implies attainment of a specified training standard whereas certification implies a guarantee. Accreditation is a more accurate term for professional proficiency since the process ensures competency of participants but does not guarantee their work.

**Acid:** “A compound which yields hydrogen ions when it dissociates in solution, e.g., $\text{H}_2\text{SO}_4 = \text{H}_2^+ + \text{SO}_4^{\text{-}}$” (Trudgill 1988).

**Acid Mine Drainage (AMD):** “The seepage of sulfuric acid solutions from mines and their removed wastes (rock and tailings) dumped at the surface. Sulfuric acid is produced through natural reactions between exposed sulfide minerals, air and water (groundwater and/or percolating precipitation). This is a special case of the more widespread phenomenon of acid rock drainage (ARD) which occurs wherever sulfide-bearing rocks are exposed to water and air (e.g., highway and railroad rock cuts or naturally exposed rock surfaces)” (Province of British Columbia Ministry of Environment, Lands and Parks and Environment Canada 1993). “Acid rock drainage (ARD) is the result of natural oxidative weathering of sulfide minerals, primarily pyrite, by water to produce an acidic iron sulfate solution” (Brown and Williamson 1995).

**Acid Spoil:** “Spoil material which contains sufficient pyrite so that weathering produces acidic water with a pH between 4.0 and 6.9. The chemical process involves the oxidation of iron sulfide minerals in the presence of moisture with the subsequent hydrolysis and oxidation of ferrous ions to form acidic, high sulfate and heavy metal content leachates.”
\[4\text{FeS}_2 + 15\text{O}_2 + 2\text{H}_2\text{O} \Rightarrow 4\text{Fe}^{3+} + 8\text{SO}_4^{2-} + 4\text{H}^+\]

The degree of acidity in spoils and drainages is a function of the balance between acid generation and the buffering capacity of spoils at pH 7" (Bituminous Coal Research Incorporated 1974).

**Act**: “A document formally stating what has been and made into law” (Guralnik 1984).

**Active Surface Mine Operation**: “A mining operation where land is being disturbed in preparation for and during the removal of a mineral or minerals” (Bituminous Coal Research Incorporated 1974).

**Adapted Species**: “Species that can complete their entire life-cycles and replace themselves in succeeding generations. Both introduced and native species can be adapted species” (United States Department of Agriculture Forest Service 1979a).

**Adaptive Environmental Management (AEAM)**: Ecosystems are complex and cannot be understood with complete certainty. Since ecosystems are adaptive or operate as fuzzy constructs, environmental management should be adaptive or incorporate fuzzy logic (Ludwig 1993). To ensure sound management decisions are made, a continuing process of action based on planning, monitoring, evaluation and adjustment is required. AEAM involves resource planning and policy formulation conducted through the interaction of resource specialists and policy makers in a workshop setting. The process provides an approach in which ecological and socio-political aspects of resource management, planning and policy formulation and implementation can be assessed (Holling 1978).

**Additional Information**: “Refers to one or more contacts within a relevant agency as well as publications which may be of use” (Energy Resources Conservation Board 1978).

**ad hoc**: “For a special case and without general application” (Guralnik 1984).

**Adit**: “A mine entrance tunnel, driven at shallow angle, often in a hillside, and sometimes conveying drainage water from the mine” (Richards et al. 1993).
Administration: "Refers to the operating bodies within a process, such as manager, coordinator or committee, and their interrelationships" (Energy Resources Conservation Board 1978).

Administration Area: The administration and ancillary services complex at a mine site.

Aerial Photograph: "A vertical or oblique photograph of the surface of the earth taken from the air. The scale of the photograph depends on the height of the aircraft or space vehicle and on the focal length of the camera. Photographs are taken in runs or strips, termed sorties, of overlapping prints and these are later assembled into mosaics. The majority of aerial photographs are verticals, taken when the optical axis of the camera is approximately perpendicular to the earth's surface. A distinction is made between high-oblique and low-oblique photographs, both taken when the optical axis of the camera is directed between the horizontal and the vertical. The high-oblique photograph includes the apparent horizon, the low-oblique does not show the apparent horizon" (Whittow 1984).

Aesthetics: "The study of beauty and attendant psychological responses" (Bell et al. 1990).

Aesthetics (Ecological): Planning and management of environments for both aesthetics and ecological sustainability. In some cases, there may be conflict in the simultaneous achievement of ecological sustainability (wildlife habitat) and visual quality (Parsons 1995).

Aesthetic Preference: Broad agreement in aesthetic preferences for natural settings that usually holds across individuals, groups and cultures (Wellman and Buhyoff 1980). Preference for unspectacular natural scenes are comparatively high if they are comparatively ordered. Low preference natural scenes are marked by either featureless low complexity or disordered high complexity with no focal point (Ulrich 1986). Complexity is best structured to establish a focal point with moderate depth (Hull and Buhyoff 1983), with easily traversed ground (Daniel and Boster 1976) and a deflected or curvilinear sightline (Appleton 1975).

Aesthetic Response: Defined as a preference of like-dislike affect (emotion) in association with pleasurable feelings and neurophysiological activity elicited by visual encounter with an environment (Berlyne 1971). "Aesthetic response is adaptive in terms of total behavior of the individual and is closely linked to the preceding affective cognitive state as well as to neurophysiological activity and behavior" (Ulrich 1983).
Affect: “Feelings or emotional states (Bell et al. 1990). Affects are considered to be innate, cross cultural phenomena, each having characteristic experiential and facial components. Many feelings are essentially pre-cognitive and constitute the initial level of response to the environment (Izard 1977). The initial affective response may then sustain and shape subsequent cognition, which in turn can refine the general initial feeling reaction and may generate other emotions (Ulrich 1983).

Aftercare: “The addition of fertilizer, seeds, plants, grazing, harvesting, mowing or rotational crops that may be required to maintain and develop site potential after landscaping and initial revegetation (Coppin and Bradshaw 1982).

After Use: “Designated post-mining land-use” (Coppin and Bradshaw 1982).

Agency: “Refers to any organizational unit of government such as department, ministry or branch” (Energy Resources Conservation Board 1978).

Agency Capture: See Agency-Client Theory.

Agency-Client Theory: Three theories of agency-client relationships in natural resource management have been proposed. Each focuses on agency-client relations as factors affecting bureaucratic action and/or success. (1) Capture theory - Capture theory posits that an agency’s clientele may come to control the agency, thereby deflecting it from its mandate. Effectively, the organizational environment controls the agency (e.g., Bureau of Land Management controlled by ranchers). (2) Co-optation Theory - Co-optation is a process by which an agency manipulates the organizational environment to its advantage. Organizations can establish necessary legislation or regulations by developing and satisfying clientele (e.g., Tennessee Valley Authority). (3) Agency Resource Theory - This theory considers agency power to be based on two sets of ‘resources’: (a) the availability of expertise, knowledge and information and (b) the ability of the agency to mobilize support either from clientele or the general public. Agency actions and policy reflect the relative strengths of these two resources (Fortmann 1990).

Aggrading: “In a system undergoing plant succession, there is generally a concomitant increase in biomass and/or structure. Net primary production must exceed decomposition for a system to be aggrading” (Forman and Godron 1986).
**Aggregate Surface Mine:** A surface mine which extracts construction aggregates or gravel.

**Agriculture:** The science and art of farming; work of cultivating the soil, producing crops, and raising livestock” (Guralnik 1984).

**Agroecosystem:** “An agricultural ecosystem usually driven to some degree by external subsidies of energy, water and nutrients. Systems purposefully modified by chemical or mechanical technology and by selected genetic input” (Risser 1985).

**Agrologist:** “A professional agriculturist involved with animal, soil and plant production relationships.” (Dorney 1989).

**Agrology:** “The branch of agriculture dealing with the study of soils” (Lincoln et al. 1982).

**Agronomic (Cultivar, Cultigen):** “A cultivated plant genotype. Cultivated varieties of grasses or herbs, bred and selected for particular characteristics (i.e., shape, form, site preferences)” (Coppin and Bradshaw 1982).

**Agronomy:** “The theory and practice of agricultural management of crop production and husbandry” (Lincoln et al. 1982).

**Agrophytocoenoses:** “Spatially homogenous species assemblages or monospecific stands” (Archer and Pyke 1991).

**A Horizon:** “The soil horizon formed at or near the surface. It is characterized by the accumulation of organic material and/or the removal of organic or mineral material in solution or suspension” (Foth 1978).

**Allogenic:** “Allogenic succession is vegetation change due to environmental conditions and environmental change or ‘external’ forces” (Glenn-Lewin and van der Maarel 1992). Abrupt and disruptive allogenic change (disturbance) has increasingly been recognized as interacting with biological processes during succession (Sousa 1984, Walker et al. 1986, Zasada and Chapin 1986, Walker and Chapin 1987, Whittaker 1989) and possessing endogenous as well as exogenous aspects (White 1979, Pickett and White 1985).
Alpine: “Pertains to those portions of mountains above the upper limit of tree growth and to the organisms inhabiting this region” (Daubenmire 1978).

Alternatives: “In EIA, an examination of alternative locations, methods and techniques for a particular project, including the alternative of not proceeding. It may be demonstrated that a project is not actually needed if demand-management approaches are adopted or strengthened. At regional and national levels, a choice of policies, plans, and programs, may be presented with a range of environmental impacts and mitigation measures” (Gilpin 1995).

Alternative Endpoints: Land-use objectives that are different than the pre-disturbance land-uses (Bradshaw 1988).

Ambient Air or Water Quality: “Refers to the overall or general condition of air or water in a region outside the zone of influence of discharges in contrast to the local condition which may be related to a specific source of contamination” (Province of British Columbia Ministry of Environment, Lands and Parks and Environment Canada 1993).

Amelioration: “Improvement of soil conditions for plant growth by addition of fertilizers, amendments, etc., and/or cultivations” (Coppin and Bradshaw 1982).

Amendment: “Any material, such as lime, gypsum, sawdust, or synthetic conditioners, that is worked into the soil to make it more productive. Technically, a fertilizer is also an amendment but the term, ‘amendment’ is used most commonly for added materials other than fertilizer” (Bituminous Coal Research Incorporated 1974).

Amphibian: “Any of the class Amphibia of vertebrates, including frogs, toads, newts, and salamanders, that usually begin life as tadpoles with gills, and later develop lungs: they are cold-blooded and scaleless” (Guralnik 1984).

Anadromous: “Those species of fish which mature in the sea and migrate into streams to spawn (salmon, steelhead)” (United States Department of Agriculture Forest Service 1982).
Angle of Repose: “The greatest angle to the horizontal that any loose or fragmented solid material will stand without sliding or coming to rest when poured or dumped in a pile or on a slope” (Bituminous Coal Research Incorporated 1974).

Angling: “The act or skill of fishing with hook and line” (Guralnik 1984).

Animal Tracks: See Signs.

Annual Variability: The variation and turnover rates of populations from year to year (Woolhouse and Harmsen 1987).

Anthropocentric: “Any human-oriented perspective of the environment, but usually used to emphasize a distinction between humans and non-humans” (Meffe and Carroll 1994).

Anthropogenic Impact: “Damage or alteration of any sort to a natural system resulting directly or indirectly from human activities” (United States Department of Agriculture Forest Service 1979b).

Apologist: “One who speaks or writes in defense of a faith, cause or institution” (Woolf 1981).

a posteriori: “Inductive: relating to or derived by reasoning from observed facts” (Woolf 1981).

Applicant: “The proponent or developer seeking approval or consent for a proposed project, or seeking the issue of a permit or license” (Gilpin 1995).

Applied Ecologist (Professional Consulting Ecologist): “An ecologist generally trained in biology in an academic, consulting or management role using his or her expertise to solve problems in economics, politics and logistics” (Dorney 1989).

Appeal: “Refers to a formal opportunity to request a reconsideration of a decision by a higher authority with the power to cancel or modify that decision” (Energy Resources Conservation Board 1978).
Approval: “Is a positive decision by an individual or agency whose acceptance of a proposal is required by law before the proposal may proceed. It could be the only approval required or could be one of many. It may be with or without conditions. May be granted by senior or junior official, or minister or cabinet minister following recommendation from government official” (Energy Resources Conservation Board 1978).

Approval-In-Principle: "Means that a proposal is generally acceptable but that further examination is required. Conditions may be included, which if not met, may result in project rejection" (Andrews and Higham 1986).

a priori: “From a cause to an effect; deductive. Based on hypothesis or theory rather than on experience” (Sykes 1982).

Approximate Original Contour (AOC): A requirement of the Surface Mine Control and Reclamation Act (SMCRA Public Law 95-87) of 1977 for the return of original topographic contours following cessation of surface mining activities. Approximate original contour (AOC) is defined as "... that surface configuration achieved ... so that it closely resembles the surface configuration of the land prior to mining and blends into and complements the drainage pattern of the surrounding terrain ..." [701(23)]. Approximate original contour requirements are achieved by a combination of backfilling, grading and compaction (Imes and Wali 1978, Zipper et al. 1989).

Arachnid: “Any member of the large Arachnida class of arthropods that have four pairs of legs and that breath by means of lung-like sacs or breathing tubes. Some arachnids such as mites (Acarina) and ticks (Ixodoidea) have bodies without exterior segmentation, others such as spiders (Araneida) have bodies divided into two segments, and still others such as scorpions (Mecoptera) have bodies of several segments” (Guralnik 1984).

Archaeology: “The scientific study of the life and culture of ancient peoples, as by excavation of ancient cities, relics or artifacts” (Guralnik 1984).

Area of Habitat: “The area within a project or management area which an evaluation species (HEP) can be expected to inhabit” (Hays 1985).

Area Mining: “Strip mining that is carried out, usually using dragline equipment, in level to gently rolling topography on relatively large tracts” (Bituminous Coal Research Incorporated 1974).
Arthropod: “Any invertebrate organism of the phylum Arthropoda, which includes the insects, crustaceans, arachnids, and myriapods, having a hard, segmented, external covering and jointed limbs” (Guralnik 1984).

Aspect: “The direction in which a slope faces, especially in the context of exposure or different degrees of insolation” (Whittow 1984).

Assembly Rules: “Assembly rules are hypothetical restrictions on the ways in which species can assemble into communities” (Wilson and Roxburgh 1994).

Attitude: Although there is no universally agreed-upon definition (Olson and Zanna 1993), an attitude is considered to be a multidimensional construct (Bagozzi and Burnkrant 1979) involving a learned pre-disposition to respond in a consistently favorable or unfavorable manner with respect to a given object or subject (Schiff 1971, Swan 1971, Ajzen and Fishbein 1980, Miller 1983a). An individual’s attitude toward any object or subject is a function of their beliefs and the evaluative aspect of those beliefs (Fishbein and Ajzen 1975). Attitude is a mental or neural state of readiness organized through experience and exerts a direct influence on dynamics of behavior (Rajecki 1990).

Attitudes can be broken down into affective, cognitive and behavioral components (Ostrom 1969, O’Riordan 1973). Attitudes and beliefs can influence every step of the information-processing sequence including attention, encoding comprehension, interpretation, elaboration and memory (Kunda 1990). Frequently, people develop positive attitudes toward those objects in their environments that promote attainment of personal goals and negative attitudes towards objects that thwart them (Katz 1967).

Attitude-Scaling: Attitude scale construction is designed to provide unidimensional measures of attitude interpretable as interval scores. Scaling assumes an underlying continuum of favorability-unfavorability on which any given item and therefore any given respondent can in principle be located. Judgments are relative and depend on context, therefore there can be no absolutes, only comparative differences (Eiser and van der Pligt 1984).

Respondent answers to attitude and opinion items in surveys are influenced by a variety of methodological factors: (1) statement or question wording, (2) item sequencing (preceding statements affect subsequent statement responses) (Olson and Zanna 1993) and response scales (Himmelfarb 1992). Several scales (Guttman, Likert, Thurstone, Guildford) have been developed to measure attitudes in social psychology (Ostrom
1969). Measurement of attitudes necessitates construction of items (statements) that require thoughtful consideration rather than superficial reaction by respondents (Schuman and Johnson 1976).

**Attitude (Group):** Different attitudes are often correlated with professional groupings and years in profession (Sewell 1971). The opinions and judgments expressed by group consensus will often be adopted by the individuals as their personal opinions (Moscovici and Zavalloni 1969). Group discussion often has the effect of inducing shifts in both individual and group opinions (Kaplan and Miller 1987).

**Augering:** Removal of coal from coal seams using an auger.

**Autecology:** “The branch of biology which deals with the inter-relationships between the individual organism or species and its environment” (Daubenmire 1978).

**Autotrophic:** “Capable of utilizing carbon dioxide and/or carbonates as a sole or major source of carbon and of obtaining energy for carbon reduction and biosynthetic processes from radiant energy (photoautotroph) or oxidation of inorganic substances (chemoautotroph)” (Foth 1978).

**Available Nutrients:** “The nutrients in the soil available for plant growth; generally the sum of those absorbed on the exchange complex plus the soluble nutrients (exchange capacity, nutrients), and measured as the amount extracted by chosen chemical extractants (usually weak acids)” (Coppin and Bradshaw 1982).

**Available Water:** “The part of the water in the soil that can be taken up by plants at rates significant to their growth” (Bituminous Coal Research Incorporated 1974).

**Average Property Basis:** In British Columbia, this phrase is used for the post-mining land-use productivity requirement and “includes all areas where the land surface is disturbed, including (but not restricted to) pit, waste dumps, tailings impoundments, plant site, roads, and pipelines” (Province of British Columbia 1992a).

**Avifauna:** “The bird fauna of an area or period” (Lincoln et al. 1982).
**Back Blade:** “In regrading, to drag the blade of a bulldozer or grader as the machine moves backward, as opposed to pushing the blade forward” (Bituminous Coal Research Incorporated 1974).

**Backfill:** “Placing discard material back into an excavation or pit and returning the area to a predetermined configuration” (Energy Resources Conservation Board 1978).

**Background Concentration:** “The natural or normal concentration of a substance in the environment” (Richards et al. 1993).

**Background Level (Water Quality):** “The natural or normal concentration of a chemical or other constituents in water” (Bituminous Coal Research Incorporated 1974).

**B Horizon:** “A soil horizon, usually beneath an A horizon, or surface soil, in which (1) clay, iron, or aluminum, with accessory organic matter, have accumulated by receiving suspended material from the A horizon above it or by clay development in place; (2) the soil has a blocky or prismatic structure; or (3) the soil has some combination of these features. In soils with distinct profiles, the B horizon is roughly equivalent to the term “subsoil” (Foth 1978).

**Bank:** “A mound of mine refuse. Synonyms include tip, culm, gob, refuse pile, slate dump, stack, and heap” (Bituminous Coal Research Incorporated 1974).

**Bank Cubic Meter (BCM):** “A cubic meter of rock in place before it is drilled and blasted; a volumetric term commonly used in coal mining in place of the weight measure (tonnes) used in metal mining” (Teck Corporation 1995).

**Bare-Root Stock:** “Nursery stock grown 1-2 years in beds, after which the individual plants are lifted (dug up) while dormant and transplanted” (United States Department of Agriculture Forest Service 1979c).

**Baseline Data:** “Data gathered prior to mining for the purpose of outlining conditions existing on the undisturbed site. In the United States, reclamation success is often measured against baseline data” (United States Department of Agriculture Forest Service 1982).
Baseline Thematic Mapping (BTM): “A digital tool that provides data on land-use, ground cover and topography” (Province of British Columbia Ministry of Environment, Lands and Parks, and Environment Canada 1993).

Base of Highwall: “The point of intersection between the highwall and the plane formed at the base of the excavated material” (Thrush 1968).

Basin: “A natural depression of strata containing a coal bed or other stratified deposit” (Bituminous Coal Research Incorporated 1974).

Bed: “A stratum of coal or other sedimentary deposit” (Bituminous Coal Research Incorporated 1974).

Bedding Area: “A specific site selected by big game animals to lie down and rest” (Lyon and Christensen 1992).

Bedrock: “The surface of an excavated area at some point between the material being mined and the original surface of the ground which equipment can set, move or operate. A working road or base below a highwall as in contour stripping for coal” (Bituminous Coal Research Incorporated 1974).

Bench: “The surface of an excavated area at some point between the material being mined and the original surface of the ground on which equipment can set, move or operate. A working road or base below a highwall as in contour stripping for coal” (Bituminous Coal Research Incorporated 1974).

Bench Mining: “A type of strip mining used to recover coal lying in beds parallel to the surface on moderate to steeply sloping ground. The overburden is removed in a series of benches constructed parallel to the strike of the seam” (Thrush 1968).

Beneficial Use: “In the context of environmental planning, a use of the environment or any element or segment of the environment that is conducive to public benefit, welfare, safety, or health, and which requires protection from the effects of waste discharges, emissions, deposits and despoliation” (Gilpin 1995).

Benthic Organisms: “Animals which live on the bed of a river, lake or sea at the solid-liquid interface” (Richards et al. 1993).
**Berm**: “A strip of coal left in place temporarily for use in hauling or stripping. A pile of coarse material placed along the bottom of a spoil dump or a waste bank either to control runoff or to stabilize the material (toe wall)” (Bituminous Coal Research Incorporated 1974).

**Berm (Spill-Containment)**: “An earthen structure built to contain possible spills and effluent discharge” (Teck Corporation 1995).

**Best Practicable Means (BPM)**: “A commonly used approach to pollution control requirements from industrial and other premises; the word ‘practicable’ is taken to mean ‘reasonably practicable’ having regard to the state of technology, to local conditions and circumstances, and to the financial implications. The concept is much easier to administer than the ambient quality approach. Other approaches include ‘best available control technology’, ‘good control practice’, and ‘maximum available control technology’ (Gilpin 1995).

**Big Game**: Large animals hunted, or potentially hunted, for sport such as elk, mule and white tail deer, mountain goat, bighorn sheep, moose, black bear (Westar Mining Limited 1983).

**Bioaccumulation (Bioconcentration)**: “The increase in levels of toxic substances in an organism over time due to continued exposure. This can only happen if the substances do not break down quickly and are essentially stored in some part of the organism” (Province of British Columbia Ministry of Environment, Lands and Parks and Environment Canada 1993).

**Biocoenose**: “A community or natural assemblage of organisms; often used as an alternative to ecosystem but strictly it is the fauna/flora associations per se excluding physical aspects of the environment” (Lincoln et al. 1982).

**Biodegradation**: “Microbially-mediated process by which enzymes sequentially degrade larger molecules to smaller ones, thereby altering both the chemistry and physical structure of a given substrate” (Richards et al. 1993).

**Biodiversity**: “The variability among living organisms from all sources including inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of
which they are part; this includes diversity within species, between species and of ecosystems” (Federal-Provincial-Territorial Biodiversity Working Group 1994).

**Bioengineer:** A person familiar with engineering practices incorporating biological surfaces in the design for cost saving or aesthetic purposes (Schiechtl 1980).

**Bioengineering:** “The use of vegetation to perform an engineering function such as erosion control or slope stabilization” (Richards et al. 1993).

**Biogeochemical Cycling:** Ecosystems are open systems in which biogeochemical functions consist of inputs from various source outputs to various sinks (Vitousek and Reiners 1975). Biogeochemical cycles or nutrient cycles are biological exchanges of nutrients interacting with physical and chemical exchanges. All nutrients reside in compartments which represent a defined space in nature. Compartments contain a certain quantity or pool of nutrients, with the rate of movement or flux rate between compartments measured as the quantity of nutrient passing from one pool to another per unit time. Ecosystems are not isolated from one another, and nutrients enter an ecosystem through meteorological, geological or biological transport mechanisms and leave an ecosystem via the same routes.

**Biogeoclimatic Classification:** “Biogeoclimatic classification is a hierarchical system of ecosystem classification developed by Krajina (1965). The biogeoclimatic classification approach subdivides a region into climatic classes according to Köppen, and further subdivides these into biogeoclimatic zones according to the climatic climax dominant vegetation on mesic sites with zonal soils. Zones are subdivided into subzones according to floristic and structural differences in the plant community and differences in soils. Within subzones, patterns of ecosystem types are identified along topographic sequences of ecosystem types which are associated with gradients of soil moisture and fertility are summarized in the form of edaphic grids, which then form the ecological basis for the development of guidelines for a variety of silvicultural decisions. The vegetation component of the ecosystem is analyzed according to the Braun-Blanquet system, and standard descriptions of soil and landform are prepared. Because the system is hierarchical and follows the basic principles of systematic taxonomy, it is said to be an ecosystematic classification” (Kimmins 1987).

**Biogeocoenose:** See Ecosystem.

**Biogeographer:** “A geographically trained scientist oriented toward spatial description of biotic features; usually, but not restricted to botanical studies” (Dorney 1989).
Biological Angle of Repose: “The minimum angle at which creep and raveling on the surface of a rock waste dump prevents the extensive growth of vegetation or ceases to prevent plants from colonizing the surface (approximately 27°) (Harrison 1977, Dick 1979, Errington 1984, Jackson 1989).

Biomagnification: “The increase in the concentration of contaminants as they move up the food chain. A predator unknowingly ‘collects’ whatever toxic substances happen to be in the food that it consumes” (Province of British Columbia Ministry of Environment, Lands and Parks and Environment Canada 1993).

Biomass: “The total weight or mass of living material (expressed as dry matter) of an individual organism, population, community or region” (Burrows 1990).

Biome: “A large-scale ecosystem comprising vegetation and associated animals. (e.g., arctic tundra, savannah)” (Burrows 1990).

Biophysical Classification (Biophysical Mapping): “Biophysical classification is an approach that has been developed for broad classification of large areas. The approach is a series of inventories of climate, soils, landforms and vegetation which are synthesized into a series of environmental categories, rather than a true taxonomic ecological classification. The biophysical approach generally involves a team of specialists (e.g., geologists, pedologists, plant ecologists). Mapping has largely been done from aerial photographs with limited ground-truthing because of access problems and the vast extent of area being mapped. The method has been developed and applied particularly in large-scale reconnaissance inventories for such purposes as hydroelectric schemes and pipeline projects in Canada and the United States (Kimmins 1987).

Bioremediation: “The use of microbial treatment methods to decontaminate soil and groundwater in a field situation” (Richards et al. 1993).

Biosphere: “The total area of planet earth where life can survive - such as the soil, water and lower atmosphere” (Province of British Columbia Ministry of Environment, Lands and Parks and Environment Canada 1993).

Biota: “The plants and animals of an area taken collectively” (United States Department of Agriculture Forest Service 1982).
Biplanar Slip: “Slope failure involving shearing along two planes of differing orientation” (Richards et al. 1993).

Blind Drain: “A trench filled with stones selected so as to fill a trench, yet to allow water flow” (Bituminous Coal Research Incorporated 1974).

Bond Release: See Performance Bonding.

Bonding: See Performance Bonding.

Bonding Instruments: See Performance Bonding.


Borrow Pit: “An excavation from which material such as sand or gravel is removed to assist an industrial development” (Gilpin 1995).

Botany: “The science of biology that deals with plants, their life, structure, growth, and classification” (Guralnik 1984).

Breaker Refuse: “Slate, bone, or rock as removed by hand or mechanical cleaners in all classes of reakers” (Bituminous Coal Research Incorporated 1974).

Broadcast Seeding: “Random scattering seed on the surface of the soil. Aerial seeding and hydroseeding are types of broadcast seeding. In contrast with drill seeding which places the seed in rows in the soil. All are forms of direct seeding” (Bituminous Coal Research Incorporated 1974).

Broad Scale: “In spatial proportion, referring to a large area where the ratio of map length to true length is small” (Forman and Godron 1986).

Browse: “Shrubby forage consumed especially by large animals” (Cooper et al. 1991).
**Bucket-Wheel Excavator:** An excavator with a rotating wheel containing several buckets. The material is removed by the rotating buckets and placed on a conveyor system.

**Buffer:** “Substances in soil or water that act chemically to resist changes in reaction or pH” (Burrows 1990).

**Buffer Strip:** “A strip of erosion-resistant vegetation, adjacent to a disturbed area, that retards the flow of run-off water; causes deposition of transported material, thereby reducing sedimentation of receiving streams” (Bituminous Coal Research Incorporated 1974).

**Bulk Sampling:** A larger scale coal sampling program used for testing coal quality and process technology.

**Bunchgrass:** “A perennial herbaceous grass lacking rhizomes. A caespitose or tussock grass” (Daubenmire 1978).

**Bund:** “An earthwork or wall surrounding a tank or tanks to retain the contents in the event of the fracture of the tank” (Gilpin 1995).

**Bund (Screening):** “An embankment to reduce or eliminate public visibility of an undesirable industrial development” (Coppin and Bradshaw 1982).

**C Horizon:** “A mineral soil horizon or layer, excluding bedrock, that is either like or unlike the material from which the solum is presumed to have formed, relatively little affected by pedogenic processes” (Foth 1978).

**Calving Area:** “The areas, usually on spring fall range, where cows give birth to calves and maintain them during their first few days or weeks” (Westar Mining Limited 1983).

**Canada Land Inventory System:** The Canada Land Inventory is a computer based data and mapping system which includes information about present land-use, resource capability, socio-economic and agroclimate (McClellan 1965, McCormack 1971, Hoffman 1976). A numerical classification system of 1 (highest capability) to 7 (lowest
capability) was developed to aid land use planning and decision-making (Mitchell 1979).

Canonical Loadings: See Discriminant Function Analysis.

Canonical Variates: See Discriminant Function Analysis.

Canopy: “The uppermost layer of leafy stems in vegetation” (Burrows 1990).

Capability: “Focuses on the nature and degree of limitations imposed by the physical characteristics of a land unit for a certain use” (Leskiw 1993).

Capability Class (Soil): “The class indicates the general suitability of the soils for a specified land-use. It is a grouping of subclasses that have the same relative degree of limitation of hazard. The limitation or hazard becomes progressively greater from Class 1 to Class 7” (Leskiw 1993).

Capability (Land): “An evaluation of land performance that focuses on the degree and nature of limitation imposed by the physical characteristics of a land unit on a certain use, assuming a specific management system” (Fedkenheuer et al. 1987). Capability or potential use of land based on criteria, which are dependent on the following factors: (1) slope, (2) texture and stoniness, (3) climate and (4) moisture. Factors such as fertility are not included because they can easily be modified. The specific management system which influences criteria is determined by socio-political interests (Coppin and Bradshaw 1982).

Carbon:Nitrogen Ratio (C/N): “The ratio of % total carbon to % total nitrogen in the soil. The ratio is obtained by dividing the percent organic matter by percent nitrogen. The C/N ratio is a good indicator of N availability in soils. Substrates with a C/N ratio of 30 or more would require N fertilization and substrates with a C/N more than about 10 could benefit from added N” (Barber 1984).

Carnivore: “An animal (or plant) which ingests animals” (Burrows 1990).

Carrying Capacity ($K$): “The ability of a given area to support a particular biomass or population-size of organisms in a steady state” (Lincoln et al. 1982). “The number of animals of a given species that a habitat supports measured at the low stage of any
animal population cycle" (United States Department of Agriculture Forest Service 1982). “The maximum number of people that a given land area will maintain in perpetuity under a given system of usage without land degradation” (Street 1969). “Maximum rate of animal stocking without damaging vegetation or related resources (Lyon and Christensen 1992).

**Cartography:** “The science and practice of representing the features of the Earth’s surface graphically” (Star and Estes 1990).

**Cast Blasting:** “Cast blasting is defined as the horizontal displacement of waste material onto a previously mined out section of pit floor through the use of explosives. This technique effectively reduces the volume of waste that would normally be removed by truck/shovel operation (Nadiu and Singhal 1987).

**Cation:** “An ion carrying a positive charge of electricity. Common cations are calcium, magnesium, sodium, potassium and hydrogen” (Soil Improvement Committee of the California Fertilizer Association 1985).

**Cation Exchange Capacity (CEC):** “The capacity of a sediment to absorb and exchange cations (positively charged ions) such as Na\(^+\), K\(^+\), Mg\(^{2+}\), Ca\(^{2+}\), NH\(_4\)^+ or H\(^+\). CEC is commonly measured in mols/kilogram (formerly milliequivalents per 100g of sediment). Cations in lesser amounts are Fe, Mn, Zn and Cu (Rowell 1981).

**Census:** “In ecology, an attempt to count exactly every member of a population” (Begon et al. 1990).

**Central Place:** “A principal centre with long-term activities and control over surrounding secondary centres” (Johnston et al. 1986).

**CERCLA:** “CERCLA is the Comprehensive Environmental Response, Compensation and Liability Act or Superfund legislation of the United States. CERCLA extends liability for cleanup costs and damages to current and former owners and operators, regardless of who caused the contamination. Most metals and many products used at mine facilities are defined as hazardous” (Sengupta 1993). “CERCLA was originally drafted to deal with industrial dump sites such as the Love Canal or the Valley of Drums in Kentucky. The scheme under CERCLA is designed around fairly well defined process of study, evaluation, selection of remedial options and execution of these options. Liability for the costs associated with the process is placed with the owner of
the site, the operator of the site and those that arranged for hazardous substances to be placed at the site (Gablehouse 1995).

**Certification:** The act of certification or the satisfactory achievement of a standard (Guralnik 1984).

**Check Dam:** “A barrier constructed across a drainway to retard stream flow and form a small sediment basin in order to assist in sediment control” (Energy Resources Conservation Board 1978).

**Chi-Square Goodness of Fit Test:** “The chi-square goodness of fit test is used to compare the observed sample distribution with some theoretical probability distribution. This is a special case of the chi-square one-sample test. This test requires nominal data for a single sample” (Brent et al. 1991).

**Chi-Squared Test:** “A statistical method using the chi-squared statistic, for testing the degree to which observed frequencies or values differ from the frequencies or values expected from the specific hypothesis being tested; used as a goodness-of-fit test when data are arranged in a classification table having a single variable, or as a test of independence or association in a classification having two or more variables” (Lincoln et al. 1982).

**Chronosequence (Space-for-Time Substitution):** “Also referred to as the static approach to studying vegetation succession (van der Maarel and Werger 1978), chronosequences are spatial sequences in which environmental factors other than time are assumed to be unimportant, either because they are invariant or relatively ineffectual” (Matthews 1992).

Chronosequence methodology represents a functional factorial approach where surfaces and vegetation of different age are assumed to represent a developmental sequence (Major 1951). Ideal vegetation and soil chronosequences do not exist (Matthews 1997), but actual chronosequence approximations can be represented by quasi-mathematical formulae: \( V = f(t, cl, o, r, p) \), where \( t \) = time, \( cl \) = climate, \( o \) = organisms, \( r \) = relief, and \( p \) = parent material (Major 1951); or \( V = f(t, So, I) \), where \( t \) = terrain age, \( So \) = initial site conditions and \( I \) = influx variables (Jenny 1980), and \( S = f(t, cl, o, r, p) \), where \( t \) = time, \( cl \) = climate, \( o \) = organisms, \( r \) = relief, and \( p \) = parent material (Jenny 1980).
Chronoseries: “The various developmental phases in a chronosequence, as expressed on the ground at one time” (Burrows 1990).

Clast: “A term referring to particles of rock of any size from clay to boulders” (Whittow 1984).

Clean Coal: “Coal which has been processed by a processing plant” (Thrush 1968).

Climate: “The prevailing or average weather conditions of a place as determined by the temperature and meteorological changes over a period of years” (Guralnik 1984).

Climax (Climax Community): The climax state is defined as a steady-state equilibrium of plant species populations in relation to habitat factors, without dependence on the attainment of soil maturity or long-term geomorphological evolution. Two models of climax have been proposed. The monoclimax model states that all successions (seres) in a given area eventually converge on the same climax community. Given sufficient time, community reactions modify the environment to such an extent that habitat differences are nullified and the characteristics of the climax are determined by regional climate. The monoclimax model was strongly influenced by the organismic analogy of Clements (1916). In contrast, the polyclimax model of Tansley (1935) considers only partial convergence of seres leading to more than one climax community. In the landscape, these form a vegetation mosaic, which is determined by a mosaic of habitats. The polyclimax model recognizes factors other than climate as effective influences. Phases of the mosaic may be controlled by climate (climatic climax), parent material (edaphic climax) topography (topoclimax), or pyroclimax (fire) (Mueller Dombois and Ellenberg 1974). The term ‘climax’ is controversial and Niering (1987) has suggested the replacement of ‘climax’ with ‘steady state’ or ‘relative stability’; terminology which would permit a more flexible approach to examining physiognomic and historically conditioned mosaics of relatively stable cover types on a diversity of sites within a given vegetation zone or biotic system.

Cluster Analysis: “A group of multivariate methods for analyzing a single data set to find groups of cases that display various degrees of similarity. A distinction is usually made between algorithms that are divisive and partition multivariate space into regions and those that are ‘agglomerative’ and form larger and larger groups hierarchically. Cluster analysis is based on Euclidean distance, which is used as a measure of the similarity or dissimilarity between two data points (cases). Euclidean distance is simply an extension to a space of n dimensions of the Pythagoras distance theorem. Data is generally represented graphically with a dendrogram” (Morrison et al. 1992).
Coal: “A black or brownish black solid combustible substance formed by the partial decomposition of vegetable matter without free access of air, and under the influence of moisture, and often increased pressure and temperature that is widely used as a natural fuel” (Woolf 1981).

Coal Measures: “Geological strata, consisting of beds of coal interstratified with shales, sandstones, limestones and conglomerates” (Richards et al. 1993).

Coal Preparation: “Process by which coal is separated from non-coal materials present in the run-of-mine” (Richards et al. 1993).

Coal Seam: “A layer, vein, or deposit of coal. A stratigraphic part of the earth’s surface containing coal” (Bituminous Coal Research Incorporated 1974).

Coarse Fragments: “Rock or mineral particles greater than 2 mm in diameter” (Bituminous Coal Research Incorporated 1974).

Coarse Refuse or Rejects: “Coarse fragment overburden and coal fragments rejected by the processing plant (Bituminous Coal Research Incorporated 1974).

Code: “A systematic collection, compendium or revision of laws, rules or regulations. A private or official compilation of all permanent laws in force consolidated and classified according to subject matter. Many jurisdictions have published official codes of all laws in force, including the common law and statutes as judicially interpreted, which have been compiled by code commissions and enacted by the legislatures” (Black et al. 1990).

Coding: “Changing the scale of measurement a posteriori” (Orlóci and Kenkel 1985). Thematic coding involves the use of keywords or phrases that are context dependent and exclusive.

Coenose: “A major ecological unit (ecosystem, biome) comprising plants, animals, microbes and inorganic components of their environment” (Goldsmith et al. 1986).

Cognitive: “Process of knowing in the broadest sense including perception, memory and judgment” (Guralnik 1984).
Cognitive Consistency Theory: Individuals often have beliefs that are inconsistent (cognitive dissonance). A basic premise of cognitive consistency theory is that individuals will feel pressure to reduce these inconsistencies if they are made aware of them. However, individuals are not always aware of their inconsistent beliefs and the extent to which inconsistencies exist reflects a lack of integration. Cognitive integration serves as a moderator of the relationships between different attitudes (Van Liere and Dunlap 1983).

Cognitive Dissonance: "A term to describe a perceived inconsistency between one's attitudes and one's behavior producing a conflict which needs to be resolved" (Harris and Hodges 1981). "Dissonance produces an unpleasant motivational state and that a person changes his or her cognitions in order to reduce dissonance and thus relieve or alleviate the concomitant stress" (Rajecki 1990).

Cognitive Integration: "Cognitive integration refers to the extent to which beliefs that are intrinsically related are held in isolation" (Van Liere and Dunlap 1983).

Cognitive Oversimplification: The tendency of a group or groups to simplify or underestimate the complexity of the content area or a problem analysis of another group or discipline (Miller 1982).

Cognitive Style: The method of learning used by an individual and/or group (Fischhoff 1979).

Coking: "The process by which the gases of coal are removed by heating in a coke oven. Coke burns with intense heat and little smoke and is used as an industrial fuel" (Guralnik 1984).

Colliery: "A coal mine and its building and equipment. This term is mainly used in Britain" (Guralnik 1984).

Colonization: "The act or process of establishing a colony or colonies. The process of plant establishment on open unvegetated sites" (Burrows 1990).

Command-penalty Model: A model of regulatory enforcement in which requirements are stated and a penalty is imposed if the requirements are not met by an individual or organization. Often the penalty is in the form of a fine.
Comment: “A comment by an agency is its response to a proposal based on the potential impacts of the proposal within the agency’s mandate” (Energy Resources Conservation Board 1978).

Commission on Resources and Environment (CORE): “CORE is an independent commission established by the provincial government of British Columbia in January 1992 to help resolve ‘valley-by-valley’ conflicts over land-use. CORE’s mandate is to develop and implement a process that will create a comprehensive land-use plan for British Columbia. The commission is also charged with initiating a regional process to resolve resource disputes. CORE’s key goals are to sustain our environment, economy and communities; to inform and involve the public; and to replace confrontation with consensus in making resource management decisions” (Province of British Columbia Ministry of Environment, Lands and Parks and Environment Canada 1993).

Commons: “Originally referred to lands in medieval Europe that were owned by townships rather than by private individuals. Now used to include any exploitable resource that is not privately owned” (Meffe and Carroll 1994).

Community: “A group of one or more populations of plants and animals in a common spatial arrangement; an ecological term used in a broad sense to include groups of various sizes and degrees of integration” (Burrows 1990).

Compaction: “The closing of the pore spaces among the particles of soil and rock, resulting in a higher density. Generally caused by running heavy equipment over the area, as in the process of leveling the overburden material of surface mine banks or dumps” (Bituminous Coal Research Incorporated 1974).

Companion Crop (Nurse Crop, Cover Crop): “An annual crop that is seeded with perennial species to modify microenvironmental conditions during initial establishment” (United States Department of Agriculture Forest Service 1979b).

Compensation: “Refers to money, land or other valuable consideration paid to a person or government in exchange for damage suffered as a result of the implementation of a proposal” (Energy Resources Conservation Board 1978).

Configuration: The shape or outline of forest stands or plant communities; the degree of irregularity in the edge between stands or communities; varying from simple to mosaic. “The location and juxtaposition of landscape elements” (Forman and Godron 1986).
Congruence (Congruity): The degree of ‘fit’ between the physical features of a setting or landscape (Forman and Godron 1986). The degree of congruity in space among different (landscape) units is important in landscape management (McHarg 1971).

Conservation Biology: “An integrative approach to the protection and management of biodiversity that uses appropriate principles and experiences from basic biological fields such as genetics and ecology, from natural resource management fields such as fisheries and wildlife, and from social sciences such as anthropology, sociology, philosophy and economics” (Meffe and Carroll 1994). Conservation biology has two objectives: (1) the investigation of human impacts on biological diversity and (2) the development of practical approaches to prevent the extinction of species (Primack 1993).

Conservation: “The act or practice of conserving, protection from loss or waste; preservation” (Guralnik 1984).

Consultant: “An expert who is called on for professional or technical advice or opinions” (Guralnik 1984).

Contaminated Land: “Land which contains substances (contaminants) which, when present in sufficient quantities or concentrations, are likely to cause harm, directly or indirectly, for example to humans, the environment or building materials” (Richards et al. 1993).

Content Analysis: “Analysis of the manifest and latent content of a body of communicated material through a classification, tabulation and evaluation of its key symbols and themes in order to ascertain its meaning and probable effect” (Woolf 1981). “Content analysis involves four steps: (1) selection of response categories, (2) sampling, (3) measurement and (4) analysis (Stankey 1972). Measurement involves the assignment of numerical values to the various elements one wishes to code in the communication (Budd et al. 1967). Content analysis has been used extensively in political science and journalism.

Content Area: “An organized body of knowledge or discipline that is reflected in its technical vocabulary” (Harris and Hodges 1981).
Context: “A review of related literature, including a justification for the research investigation” (Sowell and Casey 1982).

Contingency Table: A classification table with different categories on each of the two axes, forming cells into which numbers may be entered to show frequency of occurrence. “A table consisting of two or more rows and columns of data in which observations or individuals are classified according to two variables; tests of independence such as the \(X^2\) test can be used to measure the relationship between the two variables” (Elliott and Stoesz 1992).

Contour Stripping or Surface Mining: “The removal of overburden and mining from a coal seam that outcrops or approaches the surface at approximately the same elevation in steep or mountainous areas” (Bituminous Coal Research Incorporated 1974).

Contouring: See Landshaping

Contrast: “The degree of difference and the abruptness of transition between adjacent areas” (Forman and Godron 1986).

Corridor: “A narrow strip of land that differs from the matrix on either side” (Forman and Godron 1986).

Cost-Benefit Analysis: “An analytical approach to solving problems of choice which identifies for each objective, that alternative yielding the greatest benefit for a given cost or that alternative producing the required level of benefits at the lowest cost. This same analytical process has also been referred to as cost-effectiveness analysis when the benefits of the alternatives cannot be quantified in terms of dollars (United States Department of Agriculture Forest Service 1979b).

Cover: “Vegetation used by wildlife for protection from predators, or to ameliorate conditions of weather, or in which to reproduce; also a shortened version of crown cover” (Westar Mining Limited 1983).

Cover (Crown): “The amount of canopy provided by branches and foliage of trees, shrubs, and herbs in a plant community. May be specified by species, kind of plant, or collectively” (Daubenmire 1978).
Cover (Escape): “Vegetation dense enough to aid animals in escaping from potential enemies” (Lyon and Christensen 1992).

Cover (Forage Ratio): “The percentage of a habitat analysis unit in cover condition, and the percentage in forage condition, expressed as a ratio totaling 100” (Lyon and Christensen 1992).

Coverage: “Refers to the types of proposals to which a process applies” (Energy Resources Conservation Board 1978).

Coversoil: “Unconsolidated materials including salvaged surface soil, salvaged regolith, or selected bedrock spoil used to top-dress spoils to build a better quality minesoil” (Energy Resources Conservation Board 1978).

Creep: “Slow, continuous or discontinuous downslope movement of sediment in a rock waste (spoil) or overburden dump, or natural slope” (Thrush 1968).

Crest: “The top of a dam or spillway to which water must rise before passing over the structure. It is frequently restricted to the overflow portion” (Bituminous Coal Research Incorporated 1974).

Crest (Slope): “Top edge of a slope” (Richards et al. 1993).

Criterion: “A standard or rule by which something can be judged” (Sykes 1982).

Critical Area: “An area that should not be disturbed (mined) because it is deemed extremely difficult or impossible to reclaim” (United States Department of Agriculture Forest Service 1979c).

Critical Habitat: “According to United States Federal law, the ecosystems upon which endangered and threatened species depend” (Meffe and Carroll 1994).

Cross-Tabulation: Analysis of categorical data. Cross-tabulations can be used to perform a chi-square test for independence or a chi-square test for homogeneity.
Culvert: “A pipe or other covered passage under a road or railway which carries a stream or drainage ditch” (Jones et al. 1990).

Cumulative Effects: “Progressive environmental degradation over time arising from a range of activities throughout an area or region, each activity considered in isolation being possibly not a significant contributor” (Gilpin 1995).

Cumulative Effects Analysis: “A class of tools for predicting effects on distribution and abundance of plant and animal species and communities from activities both on-site and off-site” (Morrison et al. 1992).

Curriculum: “A fixed series of studies required, as in college, for graduation, qualification in a major field of study” (Guralnik 1984).

Cuttings: “Sections of stems or branches usually from woody plants, that are either cut from a plant and replanted at the site being revegetated or cut from the plant, rooted in a nursery and planted as a transplant (United States Department of Agriculture Forest Service 1979a).

Dayligating: “A term to define the surface mining procedure for exposing an entire underground mined area to remove all of the remaining mineral underlying the surface” (Bituminous Coal Research Incorporated 1974).

Deciduous: “Pertaining to any plant organ or group of organs that is shed naturally; perennial plants that are leafless for some time during the year” (Westar Mining Limited 1983).

Decision Criteria: “Goals and objectives that will resolve the issues, management concerns and program requirements identified by a planning team. These criteria also provide guidance for evaluation and selection of alternatives during the planning process” (United States Department of Agriculture Forest Service 1979b).

Decision-Maker: “The body or person responsible for deciding whether a project shall proceed or not, or proceed subject to conditions or constraints. The decision-maker is usually an elected body or responsible agency or minister, the decision-making being essentially a function of government” (Gilpin 1995).
Decomposer: An organism which promotes the decomposition of organic matter through its metabolic processes.

Decomposition: “Break down of plant or animal tissue, organic matter by microbial action” (Coppin and Bradshaw 1982).

Deductive Method: “A scientific method involving the formulation of theories or hypotheses from which singular statements (predictions) are deduced that can be tested” (Lincoln et al. 1982).

Degradative Succession: “A temporal succession of species that occurs on a degradable resource” (Begon et al. 1990).

Degradation: “Gradually decreasing in biomass or structure” (Forman and Godron 1986).

Demand: “The aggregate desire for economic goods and services. The quantity of a good or service that consumers are willing to purchase at different prices. Demand involves the relationship between quantity and price” (Meffe and Carroll 1994).

Demography: “The study of populations, especially their structure and growth rates” (Harper 1977).

Denning Site: “A place of shelter for an animal; also where an animal gives birth and raises young” (Westar Mining Limited 1983).

Density (Forage): “The percent of ground surface which appears to be completely covered by vegetation when viewed directly from above” (Westar Mining Limited 1983).

Density (Stand): “Density of stocking expressed in number of trees (stems) per hectare” (Westar Mining Limited 1983).

Depauperate: “Impoverished, moribund” (Lincoln et al. 1982).
**Depth Effect:** "The number of surfaces visible at different horizontal distances" (Forman and Godron 1986).

**Derelict Land:** "Land so damaged by industry and other development that it is incapable of beneficial use without treatment" (Richards et al. 1993).

**Detection Limit:** "The lowest concentration of a compound which can be analyzed by a given analytical technique" (Richards et al. 1993).

**Detritivore:** "An animal which obtains its nutrients and energy by consuming detritus" (Burrows 1990).

**Detritus:** "Dead organic matter" (Burrows 1990).

**Developer:** "The initiator of a project; also called the proponent, or applicant for development consent" (Gilpin 1995).

**Development:** "The work of preparing a proven ore body or reserve for extraction and transportation (United States Department of Agriculture Forest Service 1982).

**Diffusion:** "The spread of a phenomenon over space and through time" (Johnson et al. 1986).

**Digital Elevation Model (DEM) or Digital Terrain Model (DTM):** "A raster array of elevation values" (Star and Estes 1990).

**Digitizing:** "Refers to the process by which spatial information is captured into digital mapping format. Usually, this involves manual tracing of linework and point locations from source maps using a digitizing tablet" (Westland Resources Group 1993).

**Dip:** "The slope angle of geological strata relative to the horizontal" (Richards et al. 1993).
Direct Gradient Analysis: "Method employing extensive sampling on natural gradients to analyze distributions of plant species with respect to the distribution patterns of the main environmental variables" (Burrows 1990).

Discard: "The overburden or non-coal material removed in gaining access to the coal or mineral material in surface mining" (Energy Resources Conservation Board 1978).

Discard Piles (Free-Dump Piles): "Piles created by the deposited discard or overburden material prior to backfilling" (Energy Resources Conservation Board 1978).

Discharge: "The volume of water flowing past a point per unit time commonly expressed as cubic meters per second" (United States Department of Agriculture Forest Service 1979c).

Discipline: "Branch of instruction or learning, mental or moral training" (Sykes 1982).

Discounting: "The practice of placing a lesser value (economic or other) on future events than on present events for the purpose of comparison. An item received today is worth more than an identical item received next year" (United States Department of Agriculture Forest Service 1979b).

Discriminant Function Analysis (Canonical Variates Analysis): "Discriminant function analysis (DFA) is a technique for finding the linear additive combination of interval-level independent variables which best classifies cases into separate categories of some nominal-level categorical dependent variable, unlike logistic regression which requires dichotomous dependent variables" (Brent et al. 1991).

Disjointed Incrementalism: A fragmented and incremental approach to problem resolution which provides results that lack an understanding of component interdependencies (Hollick 1981a).

Dispersal (Fauna): Movement of animals from one geographic location to another. Proximal causal factors of dispersal include: (1) intrinsic (genetic) and (2) extrinsic (habitat loss), (3) carrying capacity and (4) density-dependent regulation (Lidicker and Stenseth 1992).
Dispersal or Dissemination (Plant): “The scattering of detached structures capable of reproducing a plant” (Daubenmire 1978).

Disperser: An organism that disperses propagules.

Dissolved Solids: “The total amount of dissolved material (organic or inorganic) contained in water” (United States Department of Agriculture Forest Service 1982).

Disturbance: An event that causes a significant change from the normal pattern in an ecological system. Any factor that removes plant biomass (Grime 1979). Disturbance is a perturbation or a deviation from the basic reference condition which is characterized by direction, magnitude and persistence (Rykiel 1985).

Disturbance Patch: “An area that has been disturbed within a matrix” (Forman and Godron 1986).

Disturbed Land: “Land on which excavation has occurred or upon which overburden has been deposited, or both” (Leskiw 1993).

Diversion: “A channel constructed across a slope to intercept surface runoff, changing the course of all or part of a stream or the runoff, thereby reducing sediment problems” (Energy Resources Conservation Board 1978).

Diversion Ditch: “A man-made waterway used for collecting surface runoff on the uphill side of a mine in order to keep it out of the workings; a ditch designed to change the normal or actual course of water (Halverson and Sidle 1992).

Dominance: “The degree to which one or a few species predominate in a community in terms of numbers, biomass, or dynamics” (Forman and Godron 1986).

Dozer or Bulldozer: “Tractor with a steel plate or blade mounted on the front end in such a manner that it can be used to cut into earth or other material and move said material primarily forward by pushing” (Bituminous Coal Research Incorporated 1974).

Dragline: “An excavating machine that utilizes a bucket operated and suspended by means of lines or cables, one of which hoists or lowers the bucket from a boom; the other, from which the name is derived, allows the bucket to swing out from the machine
or to be dragged toward the machine for loading. Mobility of draglines is by crawler mounting or by a walking device for propelling, featuring pontoon like feet and a circular base or tub. The swing of the machine is based on rollers and rail. The machine usually operates from the highwall” (Bituminous Coal Research Incorporated 1974).

**Drainage System (Basin):** “The region or area drained by a river or river system” (Guralnik 1984).

**Due Diligence:** “The application of appropriate environmental management practices (management system, technology, monitoring protocols) to ensure corporate compliance with regulatory practices and standards. The standards, customs, norms and guidelines established by the governing body of a particular industry or the industry itself, have no legal force. They represent a minimum standard of care, thereby providing an indication of the standard by which others in the industry will be judged” (Stammer 1994).

**Dynamic Equilibrium:** “A state of equilibrium reached within a system subject to two opposing forces. A state of relative stability in a biological system” (Burrows 1990).

**Ecocentric:** An attitude toward the environment that is ecologically-based or biologically-based (biocentric) and values the intrinsic rights of all organisms (Noss 1991).

**Eco-engineering:** Eco-engineering is engineering in which ecological diversity, equilibrium and integrity are considered and planned in all engineered developments (Vaníček 1977).

**Ecological Amplitude:** “For a species, the range of ecological tolerance, in relation to all environmental gradients which influence it” (Burrows 1990).

**Ecological Audit:** An audit of the ecological information content and knowledge of an environmental management process.

**Ecological Approach to Management:** “The application of ecological principles to the management of resources to ensure the long-term maintenance of ecosystem structure, function and composition at appropriate temporal and spatial scales” (Federal-Provincial-Territorial Biodiversity Working Group 1994).
**Ecological Diversity:** Diversity is difficult to define but has been described as the relative degree of abundance of wildlife species, plant species, communities, habitats, or habitat features per unit of area (Wayne and Bazzaz 1991). Species diversity is the result of the biological mechanisms of niche separation, habitat diversity, mass effects (the establishment of species in sites where they cannot persist) and ecological equivalency (coexistence of species with effectively identical niche and habitat requirements) (Shmida and Wilson 1985, Auerbach and Shmida 1987).

**Ecological Guild:** “A group of species, the individuals of which exploit the same kind of resources in a similar way” (Burrows 1990).

**Ecological Life History:** Ecological theories often include concepts of strategies and optimization of resource use such that homologous ecological life histories are expected in similar environments because these characteristics optimize specific vital functions (Miller 1983, Halloy 1990). Three classification schemes have been proposed to describe ecological life histories: (1) $r$-$K$ Spectrum (Pianka 1970), (2) $C$-$S$-$R$ Triangle (Grime 1979) and, (3) $MAF$ Ecological Strategy (Okansen and Ranta 1992).

**Ecological Response Units:** Ecological response units are subdivisions of habitat types defined according to physical and biotic factors of the environment exclusive of vegetation. Ecological response units are usually subdivided on the basis of topographic criteria such as slope and orientation (Bonham et al. 1980) and thus are particularly well suited to surface mine reclamation inventories (Fischer 1986).

**Ecological Rehabilitation:** “Rehabilitation with site-indigenous species. This process falls short of restoration because it does not attempt to replace all ecological functions” (Newton 1993).

**Ecological Restoration:** “The process of intentionally altering a site to establish a defined, indigenous and historic ecosystem. The goal of this process is to emulate the structure, function, diversity and dynamics of the specified ecosystem (Society for Ecological Restoration 1990).

**Ecological Risk Assessment:** Ecological risk assessment is a tool used in environmental management. The objective in ecological risk assessment is to use available toxicological and ecological information to estimate the probability that some undesired ecological event will occur. Risk assessment differs from simple assessment, by its quantitative consideration of uncertainty and expression of the estimated effect as
a probability. Ecological risk analyses include model sensitivity analyses and field experimental validation. While acute toxicity data are widely available for a few species and chemicals, there is a paucity of data on response to chronic exposure, particularly for the sublethal responses such as feeding, growth and reproduction that can be critical to ecological function. Therefore, at present, risk estimation methods are useful only for screening purposes or comparison of risks among chemicals (Bartell et al. 1992).

**Ecological Stability:** See Stability.

**Ecologist:** "A natural scientist by training who studies ecology from either a synecological or autecological point of view without particular concern for its application" (Dorney 1989).

**Ecology:** "The scientific study of the interrelationships of organisms (plant and animals) and their environment. The word comes from the Greek term meaning the study of the home" (Province of British Columbia Ministry of Environment, Lands and Parks and Environment Canada 1993).

**Economic Impact Assessment:** "An assessment of the economic impacts of change on a community; it consists of budget and fiscal impacts, economic activity impacts and economic and social structural changes" (United States Department of Agriculture Forest Service 1979b).

**Ecoprovince:** "An area of the earth’s surface characterized by very broad ecological interactions between the four major environmental components of the ecosystem - air, water, land and biota" (Province of British Columbia Ministry of Environment, Lands and Parks and Environment Canada 1993).

**Ecoregion:** "A part of an ecoprovince characterized by regional ecological interactions between the four major environmental components of the ecosystem - air, water, land and biota" (Province of British Columbia Ministry of Environment, Lands and Parks and Environment Canada 1993).

**Ecosection:** "A part of an ecoregion characterized by sub-regional interactions between the four major environmental components of the ecosystem - air, water, land and biota" (Province of British Columbia Ministry of Environment, Lands and Parks and Environment Canada 1993).
Ecosystem (Biogeocenose): "An interacting ‘natural’ system including all the component biotic organisms together with the abiotic environment. An ecosystem is an open system having trans-boundary flows of energy and matter" (Dorney 1989).

Ecosystem Engineers: "Ecosystem engineers are organisms that directly or indirectly modulate the availability of resources to other species, by causing physical state changes in biotic or abiotic materials. In so doing they modify, maintain and create habitats. Autogenic engineers (e.g., corals or trees) change the environment via their physical structure (i.e., their living and dead tissues). Allogenic engineers (e.g., beavers) change the environment by transforming living or non-living materials from one physical state to another via mechanical means. The direct provision of resources to other species, in the form of resources is not engineering. Organisms act as engineers when they modulate the supply of a resource or resources other than themselves. Many (perhaps most) impacts of keystone species include not only trophic effects, but also engineers and engineering" (Jones et al. 1994).

Ecosystem Fragmentation: "Ecosystem fragmentation causes large changes in the physical environment as well as biogeographic changes. Fragmentation generally results in a landscape that consists of remnant areas of native vegetation surrounded by a matrix of agricultural or other developed land. As a result, fluxes of radiation, momentum (i.e., wind), water, and nutrients across the landscape are altered significantly. These in turn can have important influences on the biota within remnant areas, especially at or near the edge between the remnant and the surrounding matrix" (Saunders et al. 1991).

Ecosystem (Habitat) Management: "A management focus that de-emphasizes individual species, focusing instead on maintaining habitat or ecosystem quality, including ecological processes important in maintaining the characteristic biodiversity of an area" (Meffe and Carroll 1994). "Ecosystem management integrates scientific knowledge of ecological relationships within a complex sociopolitical and values framework toward the general goal of protecting native ecosystem integrity over the long-term" (Grumbine 1994).

Ecosystem Re-Assembly: See Assembly Rules.

Ecosystem Response: The aggregate or emergent response of an ecosystem to management intervention.
Ecotesserae (Landscape Element): “The basic, relatively homogeneous ecological unit whether of natural or human origin an the land at the scale of a landscape” (Forman and Godron 1986).

Ecotone: “The relatively narrow zone influenced by the transition between plant communities or between successional stages or vegetative conditions within a plant community” (Burrows 1990).

Ecovar: Native species used for revegetation that have a broad genetic base in comparison to the narrow genetic base of cultivars (Jackson and Roundy 1992).

Edaphic: “Pertaining to the soil, particularly the influence of soil on organisms” (Daubenmire 1978).

Edge: “The place where plant communities meet or where successional stages or vegetative conditions within plant communities have a common interface. An outer band of a patch that has an environment significantly different from the interior of the patch” (Forman and Godron 1986).

Edge Effect: “A distinctive species composition or relative abundance in the outer band of a patch relative to the patch interior” (Forman and Godron 1986).

Effluent Discharge: “Excess water from a mining or milling operation that is discharged to the receiving environment” (Teck Corporation 1995).

Electrical Conductivity: “The electrical conductivity of a saturated soil extract, normally expressed in units of millimhos (mmhos) at 25°C that is used to assess soluble salt content” (Rowell 1981).

Electrofishing: A fish censusing technique which uses electrical current to shock fish so they can be caught.

Emergency Spillway: “A spillway designed to convey water in excess of design standards during peak runoff periods” (Thrush 1968).
End Tipping: “Placing of material by tipping from lorries or dump trucks” (Richards et al. 1993).

Endangered Species: “Species which are threatened with immediate extinction or extirpation if the factors which are threatening them continue to operate. Included are species whose numbers have been reduced to a critical level or whose habitats have been so drastically reduced that they are deemed to be in immediate danger of extinction” (Federal-Provincial-Territorial Biodiversity Working Group 1994).

Energy Flow: “The passage of energy into and out of an organism, population or system; the passage of energy through different trophic levels in a food chain” (Lincoln et al. 1982).

Engineer: “One trained or engaged in a branch of engineering” (Sykes 1982).

Engineering: “The application of scientific principles to practical ends” (Sykes 1982). Engineering is a social enterprise. The knowledge that engineers depend upon arises from a social process. The credibility of this knowledge depends upon the integrity of this social process (Bella 1987).

Environment: “All external conditions that may act upon an organism or soil to influence its development, including sunlight, temperature, moisture and other organisms” (Daubenmire 1978).

Environmental Administrator: “An individual who deals with environments holistically by examining policies, methods and processes by which humans shape their environment as well as the control of human action regarding environmental quality maintenance” (Dorney 1989).

Environmental Assessment (Strategic) SEA: “Strategic environmental assessment (SEA) is the term used to describe the environmental assessment process for policies, plans and programs which are approved earlier than the authorization of individual projects. SEA and EIA share the same objectives, and should be closely related to each other within the same policy and planning process” (Lee and Walsh 1992).

Environmental Audit: “In general terms, an environmental audit is a systematic, periodic review of management systems, policies, and practices of corporations, institutions, and governments with respect to how they affect the environment and
consumption of resources, followed by adjustments and corrections where appropriate” (Thompson and Wilson 1994).

**Environmental Auditor:** “A group of professionals approving legal environmental compliance for a corporation, often for its directors and share holders” (Dorney 1989).

**Environmental Checklist:** “A list of environmental parameters which may be affected by any proposed development” (Energy Resources Conservation Board 1978).

**Environmental Compliance:** Meeting environmental standards.

**Environmental Designer:** “A person primarily with design training (architecture, landscape architecture or planning) who for design purposes utilizes scientific information on physical and natural environmental features and their dynamics” (Dorney 1989).

**Environmental Engineer:** “A person with technical engineering training skills who utilizes systems or ecosystems concepts and guidelines for construction or design purposes” (Dorney 1989).

**Environmental Gradients (High Elevation):** “Three main environmental gradients interact to govern biological and physical systems on the earth’s mountain ranges: latitudinal, elevational, and topographic. Each of these large gradients consists of many interacting factors that vary quantitatively along the gradient. At any latitude, the interacting factors create a unique mountain environment. This, in turn, is further complicated by the effects of the elevational topographic gradient and the continually changing altitudinal atmospheric gradients. Superimposed on these complications are the effects of topography as they affect wind and the drifting of snow” (Billings 1995).

**Environmental Impact Assessment (EIA):** “The critical appraisal of the likely effects of a policy, plan, program, project, or activity, on the environment. To assist the decision-making authority, assessments are carried out independently of the proponent, who may have prepared an EIS. The decision-making authority might be a level of government (local, state, or federal) or a government agency (at local, state [provincial] or federal level). Assessments take account of any adverse environmental effects on the community; any environmental impact on the ecosystems of the locality; any diminution of the aesthetic, recreational, scientific or other environmental values of a locality; the endangering of any species of fauna or flora; and adverse effects on any place or building having aesthetic, anthropological, archaeological, cultural, historical, scientific,
or social significance; any long-term or cumulative effects on the environment; any curtailing of the range of beneficial uses; any environmental problems associated with the disposal of wastes; any implications for natural resources; and the implications for the concept of sustainable development. EIA extends to the entire process from the inception of a proposal to environmental auditing and PPA” (Gilpin 1995).

The impact review mechanism is variable. Shopley and Fuggle (1984) identified five mechanisms as the basis of project review and assessment: (1) the ad hoc impact assessment (relatively unstructured and often intuitive), (2) the checklist assessment (potentially affected environmental components are listed and then used to categorize and incorporate cause and effect within the development process), (4) network analysis (assessment involves speculation of second- and third-order effects with an environmental attribute matrix), and (5) ecological modeling (physical or mathematical models are used to simulate environmental dynamics).

Environmental Impact Statement (EIS): “A document, prepared by a proponent, describing a proposed activity or development and identifying the possible, probable or certain effects of the proposal on the environment; examining the alternatives to the proposal; setting out the mitigation measures to be adopted; proposing a program of environmental management; provisions for monitoring, PPA or auditing; and plans for decommissioning and rehabilitation. An EIS should be prepared following scoping exercises to identify the key issues. It should be objective, thorough and comprehensive, but without superfluous material. EISs are usually prepared by consultants working for the proponent presenting what has become an ethical dilemma; however, the ultimate test is not pleasing the proponent in the short-term, but in achieving development consent after rigorous examination by a government agency and the public. This has ensured an increasing degree of integrity in the preparation of EISs. An EIS is often a key document in the EIA process” (Gilpin 1995).

Environmentalist: “A person of unspecified training concerned about issues of pollution, land policy, land management, or land-use planning, often perceived as an environmental advocate. The term may be used in a pejorative way by lawyers, industrialists and news reporters.” (Dorney 1989).

Environmental Lawyer: “A trained legal professional who emphasizes environmental quality issues in his or her practice” (Dorney 1989).

Environmental Management: “A concept of care applied to individual premises, corporate enterprises, localities, regions, catchments, natural resources, areas of high conservation value, lifetime cycles, waste handling and disposal, cleaner processing and recycling systems, with the purpose of protecting the environment in the broadest sense.
It involves the identification of objectives, the adoption of appropriate mitigation measures, the protection of ecosystems, the enhancement of the quality of life for those affected, and the minimization of environmental costs” (Gilpin 1995).

**Environmental Manager:** “A generic description of a systems-oriented professional with a natural science, social science or, less commonly an engineering, law or design background tackling problems of the human-altered environment on an interdisciplinary basis and from a quantitative and/or futuristic viewpoint (Petak 1981).

**Environmental Mediator:** “A professional attempting to reconcile conflicting points of view on a particular environmental issue” (Dorney 1989).

**Environmental Planner (Environmental Systems Analyst):** “An environmental planner putting his or her knowledge of the ecosystem into a planning process or predictive frame of reference to effect a better fit between the works of humans and nature” (Dorney 1989).

**Environmental Planning (Ecoplanning):** “An attempt to balance and harmonize the various enterprises, which man for his own benefit, has superimposed on natural environments” (Edington and Edington 1977). “In a generalized way, the system’s objective is to provide the best framework for making planning decisions based on economic, social, and environmental aims, providing for public involvement, promoting the guiding rather than the restrictive aspects of planning. Decisions need to be made at a policy, plan, program and project level, providing for the involvement of all tiers of government” (Gilpin 1995). Steps in environmental planning include: (1) planning, (2) goal setting, (3) ecological inventory, (4) and suitability analyses (Steiner and Brooks 1981).

**Environmental Protection Plan:** “An approach to the avoidance, mitigation and monitoring of potential environmental disturbances” (Buckley 1991).

**Environmental Resource Patch:** An area where environmental resources, such as soil moisture or rock type, differ from the surrounding matrix (Winterhalder 1988).

**Environmental Scientist:** “A science trained person of many possible subdisciplines oriented toward field studies, but not necessarily involving human dominated ecosystems” (Dorney 1989).
Environmental Sensitivity: “Environmental sensitivity (ES) is a measure of ease with which damage can be inflicted on a particular area from limited actions. Sensitivity is a derived parameter an cannot be measured directly because it represents the relationship between an applied stress and the resultant strain or response. Environmental stress-response relations have several forms: (1) reversibility, (2) thresholds, (3) response rates, (4) inter-dependence and (5) primary, secondary and higher-order responses. Estimating environmental sensitivity involves predicting the consequences of environmental stresses and then combining these into aggregate indices which can be mapped” (Buckley 1991).

Environmental Sensitivity Maps (ESM): “Environmental sensitivity maps show the probable environmental impacts of different types of land-use or development in a geographical context. An ESM must identify likely stresses and responses, estimate sensitivities and map them in a useable form. Thus, it combines the techniques of environmental impact assessment (EIA) with those of regional planning and mapping. In general, ESM is particularly efficient and cost effective for environmental planning at a regional scale, in mosaic terrain and in pristine areas.” There are four main stages: (1) preliminary map preparation from remote sensed images, (2) ground survey, (3) final map preparation of physical and biological parameters and (4) construction of environmental sensitivity map (Buckley 1991).

Equilibrium: “A state reached when the population birth rate and immigration is equal to mortality and emigration. Also applied to species changes in a community or to any other ecological process in which rate of increase equals rate of decrease, resulting in a steady-state” (Meffe and Carroll 1994).

Equivalent Capability: A term used to define post-mining land capability in which the ability of the reclaimed landscape to support various land-uses is similar to that which existed prior anthropogenic disturbance, but not necessarily equal in terms of individual land-uses (Powter and Chymko 1991).

Erosion: “The group of physical and chemical processes whereby earth or rock material is worn away loosened or dissolved and removed from any part of the earth’s surface. Erosion includes the processes of weathering, solution, corrosion and transportation. Erosion is often classified by the eroding agent (wind, water wave or raindrop erosion) and/or by the appearance of the erosion (sheet, rill or gully erosion) and/or by the location of the erosional activity (surface or shoreline) or by the material being eroded (soil or beach erosion)” (United States Department of Agriculture Forest Service 1979c).
**Essential Element (Plant Nutrition):** "A chemical element required for the normal growth of plants" (Bituminous Coal Research Incorporated 1974).

**Excavation:** "The act of removing overburden material" (Thrush 1968).

**Experience Sampling Method:** The experience sampling method involves using pagers to interrupt subjects at random times during the day. At each interrupt, participants complete a short questionnaire designed to assess current activities, thoughts, moods, [attitudes] *et cetera* (Hormuth 1986). When combined with the participant photography method, this technique can be used to measure landscape experience (Hull and Stewart 1995).

**Experiential Knowledge:** See Knowledge (Experiential).

**Ex-pit Dumps:** "Spoil dumps located outside of the pit" (Thrush 1968).

**Exploration:** "The process of identifying and investigating mineral prospects in order to discover if a viable mineral deposit or reservoir exists" (Thrush 1968).

**Exploration Road:** Roads used as access for exploration drilling and adit construction (Thrush 1968).

**Externality:** "A cost, usually in terms of environmental degradation, that results from an economic transaction but is not included as a debit against economic returns" (Meffe and Carroll 1994).

**Fauna:** "The entire animal life of a given region, habitat or geological stratum" (Lincoln et al. 1982).

**Feasibility Study:** "As applied to mineral activity, the feasibility study follows discovery of the mineral and is done by the operator. Its purpose is to analyze the rate of return that can be expected from the mineral development at a certain rate of production. Based on this study, the decision to develop an ore body may be made" (United States Department of Agriculture Forest Service 1982).
Feedback: “A loop in which one component affects a second component that in turn affects the first component” (Forman and Godron 1986).

Fellfield: “A type of tundra ecosystem characterized by rather flat relief, very stony soil and low widely spaced vascular plants” (Daubenmire 1978).

Fertilizer: “Any natural or manufactured material added to the soil in order to supply one or more plant nutrients. The term is generally applied to largely inorganic materials other than lime or gypsum sold in the trade” (Soil Improvement Committee, California Fertilizer Association 1985).

Fill: “Depth to which material is to be placed (filled) to bring the surface to a predetermined grade. Also, the material itself” (Bituminous Coal Research Institute 1974).

Fittingness: “Fittingness refers to the perceived harmony or integration between a feature and its natural background. Low fittingness or obtrusiveness is produced by properties such as large element size, low congruity of shape and high color contrast” (Wohwill and Harris 1980).

Flood (Probable): “The maximum flood for which there is reasonable chance that it will occur on a given stream at a selected site” (Bituminous Coal Research Incorporated 1974).

Flora: “The plant population of a particular area; a list of plant species (with descriptions) of a particular area arranged in families and genera, together with a key to aid identification” (Daubenmire 1978).

Fly Ash: “Ash with a fine particle size produced from pulverized coal burned in power stations, or other residues in incinerations” (Richards et al. 1993).

Foliar Diagnosis: “An estimation of mineral nutrient deficiencies (excesses) of plants based on examination of the chemical composition of selected plant parts, and the color and growth characteristics of the foliage of the plants” (Foth 1978).

**Food Web:** “The series of organisms through which food energy is transferred. All the food chains in an ecosystem form a food web, an interlocking system of food relationships” (Simmons 1979).

**Footwall:** “The surface left after the removal of the coal, and formed by the rock stratum which lays directly beneath the coal seam” (Thrush 1968).

**Forage:** “Vegetation used for food by wildlife, particularly ungulates and domestic livestock” (Westar Mining Limited 1983).

**Forb:** “Any herbaceous plant species other than those in the Gramineae, Cyperaceae, and Juncaceae families, fleshy leaved plants” (Burrows 1990).

**Forest:** “Vegetation in which the dominant cover plants are trees” (Burrows 1990).

**Forester:** “A professional trained in the planning and management of timber crops” (Dorney 1989).

**Forestry:** “Systematic forest management for timber production, amenities and conservation” (Guralnik 1984).

**Free Face:** “The steep sides of a dump down which rock waste is tipped from a platform” (Thrush 1968).

**French Drain:** “A covered ditch containing a layer of filled or loose stone or other pervious material. The largest stones are at the bottom with stone size decreasing toward the surface of the trench. The spaces between the stones serve as a passageway for water” (United States Department of Agriculture Forest Service 1979c).

**Frequency:** “The number of items belonging to a category or class; the number of occasions that a given species occurs in a series of samples” (Lincoln et al. 1982).

**Fungi:** “Any of a large group of thallophytes, including molds, mildews, mushrooms, rusts and smuts which are parasites on living organisms or feed upon dead organic material, lack chlorophyll, true roots, stems and leaves and reproduce by means of spores” (Guralnik 1984).
Furbearer: “An animal with fur (e.g., fox, mink) that is harvested (shot or trapped) for human use (e.g., coats, hats or gloves) (Guralnik 1984).

Game Species: “Species of vertebrate wildlife hunted by man for sport” (Westar Mining Limited 1983).

Geographical Information Systems (GIS): “The complete sequence of components for acquiring, processing, storing and managing spatial data” (Star and Estes 1990). GIS can be considered to have five component subsystems: (1) data encoding and input processing, (2) data management, (3) data retrieval, (4) data manipulation and analysis and (5) data display (Smith et al. 1987). GIS technology is an important tool for storing, evaluating, depicting updating and processing spatial data (Goodchild 1992, Haines-Young et al. 1993).

Geography: The study of the earth’s surface as the space within which the human population lives. The word comes from the Greek geo, the earth, and graphein, to write. As defined above, geography occupies a puzzling position within the traditional organizations of knowledge. It is neither a purely natural science nor a purely social science. In consequence, there have been rather powerful external forces (as well as internal logic) which have split geography into two parts: a geography of the natural world termed ‘physical geography’ and a geography of the human-created world termed ‘human-geography’ (Johnston et al. 1986).

Geology: “The study of the origin, structure, composition, and history of the Earth, together with the processes which have led to its present state” (Whittow 1984).

Geometrization: “The formation of predominantly linear or polygonal features” (Forman and Godron 1986).

Geomorphology: “Study of the forms of the land surface and the processes producing them. Also, study of the underlying rocks or parent materials and the landforms present, which were formed in geological time” (Whittow 1984).

Georeferencing: “Georeferencing refers to the location of a layer or coverage in space as defined by a known coordinate referencing system” (Eastman 1992).
**Geostatistics:** Geostatistics are statistical tools used to identify and quantify spatial relationships in georeferenced data found in point or block samples. Geostatistical techniques are extensions of classical statistics, but with the assumption of sample independence removed (Upchurch et al. 1988).

**Geotechnical:** "The structure, distribution, shape, etc. of rock formations and their structural disturbances and alterations" (Keller 1979).

**Glacier Foreland:** "The area of newly-formed landscape in front of a glacier which was recently ice-covered, but has since been exposed by glacier retreat. The pattern of ecosystems on the glacier foreland is commonly interpreted as a spatial representation of temporal change" (Matthews 1992).

**Goal:** "A concise statement of an organization's central strategy in addressing a problem expressed in terms of a desired state or process that operating programs are desired to achieve. A goal is usually expressed as a broad general statement, is generally not quantifiable, and is timeless in that it usually has no specific data by which it is to be completed. A goal is the principle statement by which objectives must be developed" (United States Department of Agriculture 1979b).

**Goodness-of-fit:** The closeness of agreement between a set of observed frequencies and a set of expected frequencies, usually measured by the chi-squared test (Norcliffe 1982).

**Graminoid:** "All grasses (Gramineae) and grasslike plants including sedges (Carex spp.) and rushes (Juncus and Luzula spp.)" (Daubenmire 1978).

**Granivore:** "An organism that feeds on seeds (Lincoln et al. 1982).

**Grass:** "Any plant species that is a member of the family Gramineae" (Burrows 1990).

**Grassland:** "Vegetation type where the dominant cover plants are grasses" (Burrows 1990).

**Grazing:** "In the strict sense, the consumption of grass by animals" (Burrows 1990).
Gravel Pit: See Aggregate Surface Mine.

Griding: The establishment of grid points.

Gross Primary Production (GPP): “The total fixation of energy by photosynthesis in a region” (Begon et al. 1990).

Ground Cover: “Any living or dead vegetative material producing a protecting mat on or just above the soil surface” (Bituminous Coal Research Incorporated 1974).

Ground Truth: “Information obtained on the ground, at the same time a remote sensing system is acquiring data from the same location. Ground truth is normally considered the most accurate data available, and is used to interpret and calibrate remotely sensed observations” (Star and Estes 1990).

Ground Water: “Subsurface water occupying the saturation zone, from which wells and springs are drawn. In a strict sense the term applies only to water below the water table. Also called plerotic or phreatic water” (Bituminous Coal Research Incorporated 1974).

Growing Media: The material in which plants are rooted and grow (e.g., soil, potting mixes, spoil, overburden).

Growing Season: “The period of the year when climatic conditions are suitable for plant growth; this period can be determined by temperature (too cold or too hot), or rainfall (too little) limitations” (United States Department of Agriculture Forest Service 1979a).

Growth Form: “A type of plant distinguished by size, morphology and duration of the vegetative body irrespective of taxonomic or ecological relations” (Daubenmire 1978).

Guidelines: “Directing principles” (Sykes 1982).

Guild: “A group of species that exploit the same class of environmental resources in a similar way” (Begon et al. 1990).
Habit (Growth Habit): “General appearance of a plant” (Hultén 1968).

Habitat: “The sum total of environmental conditions of a specific place occupied by a species or a population of such species” (Begon et al. 1990).

Habitat Analysis Unit: “An area of land selected as the unit for evaluating the quality of elk habitat” (Lyon and Christensen 1992).

Habitat Capability: “The capacity of a given area to meet the needs of ungulates, either seasonally or year-round” (Lyon and Christensen 1992).

Habitat Capability (HC) Models: “Similar to the HSI model, HC models perform essentially the same function as HSI models but may vary slightly in structure. Two limitations exist for both HSI and HC models: (1) it is difficult to interpret whether the resulting index value is intended to represent environmental conditions or population response, and (2) sensitivity of the resulting habitat index values to any one environmental variable is diminished as more variables are added to the model” (Morrison et al. 1992).

Habitat Creation: “The establishment of a historical ecosystem on lands that did not previously support that ecosystem or on severely altered sites” (Newton 1993).

Habitat Evaluation Procedures (HEP): “A method developed by the United States Fish and Wildlife Service for evaluating the quality of wildlife habitat” (Meffe and Carroll 1994). Habitat evaluation procedures were established to provide a standardized process for modeling wildlife habitats. The models incorporate basic species seasonal life cycle requirements (e.g., food, shelter, escape, reproductive habitat). The procedure is based on the habitat unit, defined as the product of habitat quality and habitat quantity. Using this technique, habitats are assigned relative values depending on how well they provide the required habitat components. HEP quantifies habitat suitability as a dimensionless value and determines species or guild specific habitat units for the site (Rhodes et al. 1983).

Habitat Templet: The stage upon which ecosystem structure and functioning is developed. The habitat templet concept is derived from Taylor et al. (1990), and is a modification of the concept developed by from Southwood (1988). One axis is denoted by density-dependent selection (r-K continuum) and the other axis by an impoverishment selection (I- selection) which is equal to the adversity [A-] selection of Southwood (1988).
**Habitat Type:** “A collective term for all parts of the land surface supporting or capable of supporting the same kind of climax plant (community) association” (Daubenmire 1978). Habitat type phase is a subdivision of habitat type representing minor differences in climax or mature vegetation that may reflect environmental differences or floristic and/or historic peculiarities within the habitat type. Habitat type series is a group of habitat types having the potential climax species” (Cooper et al. 1991).

**Habitat Unit:** “A value calculated by multiplying the Habitat Suitability index for an Evaluation Species by its Area of Habitat. The Habitat Unit provides a standardized basis for comparing habitat changes over time and space” (Hays 1985).

**Hardiness:** “A general term for the relative condition of tolerance by plants of severe conditions” (Burrows 1990).

**Harrow:** “A heavy frame with spikes or sharp edged disks drawn by a tractor or heavy equipment and used for breaking up and leveling ploughed ground or burying seeds” (Guralnik 1984).

**Haulage Units:** “Trucks or other mobile equipment used to transport ore and waste” (Teck Corporation 1995).

**Haul Road:** “Road from the pit to a tipple, overburden dump or the preparation plant used for transporting mined material by truck” (Bituminous Coal Research Incorporated 1974).

**Herb:** “Any plant that dies back to the ground surface each year (Daubenmire 1978).

**Herbivory (Herbivore, Herbaceous):** “Feeding on plants; phytophagous” (Lincoln et al. 1982).

**Heterotroph:** “An organism that consumes or absorbs chemical energy stored in large organic molecules” (Lincoln et al. 1982).

**Hierarchy:** “A sequence of sets composed of smaller subsets” (Forman and Godron 1986).
High Elevation: The area which includes alpine, subalpine and high montane.

Highwall: “The unexcavated face of exposed overburden and coal in a surface mine or the face or bank on the uphill side of a contour strip mine excavation” (Bituminous Coal Research Incorporated 1974).

Histogram: “A diagrammatic representation of data to show their frequency distribution, usually constructed in the form of a multiple-bar graph, with the frequencies plotted as ordinates and the magnitudes as the abscissae” (Whittow 1984).

Holism (Holistic): “A philosophical viewpoint which considers structure and function of biological systems as wholes when attempting to explain biological phenomena (cf. reductionism) (Burrows 1990). Holism results in greater appreciation of the interconnectedness between abiotic and biotic components of ecosystems (Risser 1985).

Holocoenotic: “A synonym for ecosystematic. The holocoenotic concept states that it is impossible to isolate the importance of single environmental factors to the distribution or abundance of species, because the factors are interdependent and synergistic” (Barbour et al. 1987).

Home Range: “The area around an animal’s home that is used for feeding and other daily activities” (Forman and Godron 1986).

Homogeneity of Variance (Homoscedasticity of Variance): The data points are uniformly scattered (Wilkinson 1990).

Horticulture: “The science or study of nursery or garden culture” (Sykes 1982). The term ‘horticulture’ means the art of garden cultivation, and comes from the Latin word ‘hortus’, meaning garden.

Horticulturist: “An individual who practices the art or science of growing flowers, fruits, vegetables and shrubs in gardens, nurseries or orchards” (Guralnik 1984). With respect to revegetation, horticulturists assist in the early stages of plant selection, propagation methods, nursery production and scheduling as well as in the later stages of supervising planting and establishment and monitoring diagnosis (Burkhart 1988).
Humus: Humus is the more or less stable dark colored, amorphous and colloidal fraction of the soil organic matter formed during the decomposition or organic residues and containing humic and fulvic acids and other poorly defined or unknown substances relatively resistant to decomposition (Paul and Clark 1989).

Hunting: "The act of a person or animal that hunts" (Guralnik 1984).

Hydraulic Conductivity: "The rate of water flow through a porous medium. Also referred to as the coefficient of permeability" (United States Department of Agriculture Forest Service 1979c).

Hydrologic Budget: "An important concept in surface-mined reclamation is the 'hydrologic budget' which refers to the amount of water entering an area by precipitation, streamflow, aquifer flow, runoff in relation to the amount leaving the area by stream flow aquifer flow, evaporation and transpiration (United States Department of Agriculture Forest Service 1979c).

Hydrogeology: "The study of surface and subsurface water" (Keller 1979).

Hydrology: "The science that relates to the water systems of the earth" (Bituminous Coal Research Incorporated 1974).

Hydromulching: "Spraying mulch on a site with a stream of water" (United States Department of Agriculture, Forest Service 1979c).

Hydroseeding: "A method of applying seeds and fertilizers to areas inaccessible to normal cultivation machinery, such as steep slopes. The materials are mixed into a water slurry and sprayed on with a high pressure pump, hoses and a jet" (Coppin and Bradshaw 1982).

Hysteresis: "Lag effect or delay in a process due to a change in inputs from a preceding process" (Lincoln et al. 1982).

Idiom: "The language or dialect of a people, region or class" (Guralnik 1984).

Immature Soil: "A soil with indistinct or slightly developed horizons" (Leskiw 1993).
Immigration: “The movement of an individual or group into a population or geographical region” (Burrows 1990).

Impact: “The force of impression or operation of one thing on another” (United States Department of Agriculture Forest Service 1979b).

Impact Scoping: “Impact scoping is the process of identifying important issues of a proposal and focusing the environmental impact assessment (EIA) on the high priority issues (Kennedy and Ross 1992). “Scoping involves meetings between the proponent and planning or environmental agencies, members of the public, and other interests likely to be affected. The result should determine the scope and depth of the significant issues to be examined in the forthcoming EIS” (Gilpin 1995).

Impoundment: “A reservoir for collection of water. Collection of water by damming a stream or the like. Used in connection with the storage of tailings from a mine” (Bituminous Coal Research Incorporated 1974).

in situ Treatment: “Decontamination or other treatment process applied within undisturbed soil or groundwater to alleviate a contamination or pollution problem” (Richards et al. 1993).

Incongruity: “In Berlyne’s theory of aesthetics, the extent to which there is a mismatch between a component of the environment and its context” (Bell et al. 1990).

Index of Biological Integrity: A aggregate measurement of ecosystem health (Karr 1991).

‘Indicator Areas’ (‘Key Areas’ or ‘Ecological Response Units’): Areas selected for monitoring studies. These areas of vegetation respond the quickest to perturbation (Bonham 1989).

Indicator Plants: “Plants characteristic of a specific soil or site condition” (Leskiw 1993).

Indicator Species (Ecosystem Health): “A species used as a gauge for the condition of a particular habitat, community, or ecosystem. A characteristic, or surrogate species for a community or ecosystem” (Meffe and Carroll 1994).
Indeces of Biological Activity: Measurements of soil organic matter, potential dehydrogenase and phosphatase enzymatic activity and mycorrhizal infection potential (MIP) (Klein et al. 1982, Reeves et al. 1982).

Indigenous: “Referring to organisms which have developed naturally in a given area and not as a consequence of artificial introduction” (Richards et al. 1993).

Inductive Method: “A scientific method involving the formulation of universal statements, such as hypotheses or theories from singular statements such as empirical observations or experimental results” (Lincoln et al. 1982).

Inertia: “The ability of a biological system to resist or recover from external disturbances” (Burrows 1990).

Infiltration: “Movement of water into the soil from the surface by percolation” (Coppin and Bradshaw 1982).

Infiltration Capacity: “The maximum rate at which water can enter soil or rock waste without causing surface flow” (Naeth et al. 1991).

Influx Variables: In the context of vegetation, environmental factors are influx variables when they actively affect the direction, or rate of progress along successional pathways. Influx variables therefore include the environmental causes of allogenic successional change (Tansley 1935).

Information: “Knowledge obtained from investigation, study or instruction” (Sykes 1982). “Modern society depends upon organizational systems for much of its information, particularly with respect to the assessment of large-scale technological projects. However, these organizations tend to distort information to meet organizational needs. Such distortions do not depend upon dishonest behavior on the part of individuals. Rather, tendencies to distort information are systemic properties of the organizational systems themselves” (Bella 1987a).

Innovation: “A new technique or idea that causes a significant effect” (Forman and Godron 1986).
**Inoculation:** Introduction of an organism into a new environment. The artificial introduction of micro-organisms (bacteria or fungi) into a habitat or their introduction into a culture medium.

**Inorganic:** “Involving neither organic life nor the products of organic life; not composed of organic matter; mineral” (Guralnik 1984).

**In-pit Dumps:** “Spoil dumps which are located within permanently inactive pits” (Thrush 1968).

**Insect:** “A member of a large class (Insecta) of small arthropods characterized in the adult state by the division of their body into a head, thorax and abdomen, three pairs of legs on the thorax and usually 2 pairs of membranous wings. The class Insecta includes beetles (Coleoptera), bees (Apoidea), beetles (Syrphidae), wasps (Hymenoptera, Vespiformes, Vespa) and mosquitoes (Anopheles or Culex)” (Guralnik 1984).

**Instability:** “A state in which a small environmental change is sufficient to divert a system out of equilibrium, its regime of oscillation around a central position” (Forman and Godron 1986).

**Instrumental (Utilitarian) Value:** “The worth of an entity as judged by its utility or usefulness to humans” (Meffe and Carroll 1994).

**Integrated Resource Management:** “Land management that considers all resource values and allows for the operation of more than one resource use in the same land area. Integrated resource management considers both competing and complementary resource values in a comprehensive manner. The goal is to maximize social, environmental and economic benefits with no undue harm to any one resource sector” (Province of British Columbia Ministry of Environment, Lands and Parks and Environment Canada 1993).

**Interdisciplinary:** “The interaction between two or more different disciplines which may range from simple communication of ideas to mutual integration of organizing concepts, methodology, procedures, epistemology, terminology, data, organization of research and education in a large field” (Dorney 1989). Paradoxically, scientific problems demand both increased specialization and interdisciplinary research (Roederer 1985).
Interdisciplinary Group or Team: “An interdisciplinary group or team which consists of persons trained indifferent fields of knowledge with different concepts, methods and data in terms organized by a common problem with continuous intercommunication among participants from different disciplines” (Dorney 1989).

Intrinsic Value (Inherent Value): “The worth of an entity independent from external circumstances or its value to humans; value judged on inherent qualities of an entity rather than value to other entities” (Meffe and Carroll 1994).

Introduced Species: “A species that may be adapted to an area but not native to it” (Daubenmire 1978).

Invasion: “The entrance of an organism into an area where it was not formerly represented” (Daubenmire 1978).

Inventory: “A geographically based assessment of entire taxa” (Pavlick and Barbour 1988).

Invertebrate: “An animal lacking a spinal column” (Sykes 1982).

Island Biogeographic Theory: A theory explaining the number of species on islands as related to an island’s area, isolation, and age, as caused by the balance between colonization and extinction. The number of species on an island results from a dynamic equilibrium between extinction and colonization. Extinction rate is inversely proportional to island size (area effect), and colonization rate is inversely proportional to distance from a source of propagules (distance effect). The theory predicts that when distance from the mainland is equal for all islands, larger islands should have greater diversity, larger and more stable populations and more colonizers per unit time than smaller islands. Theory can be applied to insular islands (MacArthur and Wilson 1967).

Jargon: “The specialized vocabulary and idioms of those in the same work place or profession” (Guralnik 1984).

Jurisdiction: “The geographic area in which a government (local, provincial, state, or national) exercises authority; or a sphere in which a government agency operates. Conflicts relating to jurisdiction might arise between levels of government and between government agencies” (Gilpin 1995).
Juvenile: “A young plant, either a seedling or an adolescent, not yet sexually reproducing” (Burrows 1990).

Juxtaposition (Juxtapose): “The act of arranging stands in space. To situate side by side or to place together” (Forman and Godron 1986).

Key Species Management: “Management directed toward maintaining keystone species or other ecologically or politically important species as a surrogate for managing all species in a system” (Meffe and Carroll 1994).

Key-factor Analysis: “A statistical treatment of population data designed to identify factors most responsible for change in population size (Begon et al. 1990).

Keystone Process: “An ecosystem analog of a keystone species; a critical ecosystem function that controls broad ecosystem characteristics. Nitrogen or phosphorous cycling, for example, may be key processes in given ecosystems” (Meffe and Carroll 1994).

Keystone Species: Keystone species are those species whose activity and abundance determine the integrity of the community and its stability (Paine 1969). “Keystone species have a disproportionately large effect on other species in a community” (Meffe and Carroll 1994).

Knowledge: “An accumulation of information including facts and principles” (Guralnik 1984). Knowledge can be dichotomized as either ‘shallow’ or ‘deep.’ ‘Shallow’ knowledge is a simplified version of knowledge and consists of ‘rules of thumb’ about how to do certain things but not why. Knowledge which includes why certain things are done is referred to as ‘deep’ knowledge. In some cases, ‘shallow’ knowledge may represent ‘tacit knowledge’ while in others it may represent ‘forgotten reasoning’ (Schön 1983). Engineers develop ‘in house’ knowledge in addition to basic and applied-basic information which includes special descriptive knowledge, prescriptive knowledge and tacit knowledge (pictureless and wordless) (Vincenti 1990).

Knowledge (Experiential): Knowledge gained through practical experience rather than formal training.
Kriging: “Kriging is the method of interpolation derived from regionalized variable theory. Kriging depends on expressing spatial variation of the property in terms of the variogram and it minimizes the prediction errors which are themselves estimated (Oliver and Webster 1990).

Kruskal-Wallis Test: “The Kruskal-Wallis test is sometimes called Kruskal-Wallis one-way analysis of variance by ranks. It evaluates the null hypothesis that k independent groups have equal centers or medians. It assumes an underlying distribution is continuous. When there are only two groups, it is equivalent to the Mann-Whitney U test” (Brent et al. 1991).

Land Capability: “The suitability of land for use without permanent damage and is an expression of the effect of physical land conditions including climate, on the total suitability without damage for crops that require regular tillage, for grazing, for woodland and for wildlife” (Energy Resources Conservation Board 1978). “Land capability involves consideration of the risks of land damage from erosion and other causes and the difficulties in land evaluation owing to physical land characteristics, including climate” (Naeth et al. 1991).

Land Classification: Classification of specific bodies of land according to their characteristics or to their capabilities for use. A use capability classification may be defined as one based on both physical and economic considerations according to their capabilities for man’s use, with sufficient detail of categorical definition and cartographic (mapping) expression to indicate those differences significant to men. Frequently in resource management and planning, the terms capability and suitability are used interchangeably. However, there is enough variation in these terms to warrant careful distinction. In general, capability suggests the land may be qualified for a specific use, while suitability implies that a specific use is most appropriate, given the conditions of the site. Thus, focusing on the concept of suitability, an effective assessment framework depends on the techniques that make systematic use of information about the environment and its condition in relation to the proposed activity (Erickson 1979, Lein 1990).

Landform: “A geomorphic feature of the earth’s surface. The definition of landform includes features such as plain, plateau and mountain as well as hill, valley, canyon, and alluvial fan that make up the surface of the earth” (Holland 1976).

Land Reclamation Ethic: A land reclamation ethic is developing as part of environmental decision-making. Developers are often required to develop restoration of previously damaged lands as part of obtaining permission to disturb new areas. The land reclamation ethic is developed around two optimistic beliefs: (1) the notion that
humanity is morally responsible for reconstructing the natural areas and environments it has damaged, and (2) the notion that humanity is capable of reconstructing those parts of nature that have been damaged (Haigh 1993). Implicit in the ‘restoration thesis’ is the refusal to accept the sharp distinction between ‘human’ and ‘natural’. Published philosophical defenses of the restoration thesis by strip miners are lacking, but environmental engineers and mining company personnel appear to see the difference between the activities of humans and other species as only matters of degree (Gunn 1991). Destruction must not be irresponsible.

**Landscape:** A heterogeneous land area composed of a cluster of interacting ecosystems that are repeated in similar form throughout. Landscapes vary in size, down to a few kilometers in diameter. A landscape is defined as a distinct measurable unit with several interesting ecological characteristics (Forman and Godron 1981).

**Landscape Aesthetics:** Humans selectively perceive what they are accustomed to seeing; feature and patterns in the landscape make sense to us because we share a history with them. Humans see things simultaneously as they are and as they viewed them before; previous experience suffuses all present perception (Lowenthal 1975). Appreciation of landscape elements depends on an evaluation of their function as well as their appearance. Aesthetician training promotes comparative analysis. A landscape may or may not be ecologically fit or be economically valuable to be appreciated; appreciation involves other interests (Lowenthal 1978).

**Landscape Architecture:** “The design and management of the use of the outdoor environment. Landscapes are created by human activities in a natural habitat and the objectives of landscape architecture are to plan the creation of such landscapes as functional and aesthetically satisfying units. The landscape architect operates both by direct modification of the habitat, e.g., through the creation of new vegetation belts, and by attempting to control human use of existing environments” (Johnston et al. 1986).

**Landscape Assessment:** Several approaches have been developed for landscape assessment: (1) “Descriptive Landscape Assessment - landscape assessment based upon the judgments of professionals trained to detect patterns, primarily based upon artistic judgment” (Bell et al. 1990). In this approach, patterns of the dominance elements (line, form, color and texture) and contrasts created by these patterns are thought to be organized by the observer’s perceptual system, causing a focus of attention on a particular component of the landscape vista (Bell et al. 1990). (2) “Physical-Perceptual Approach to landscape assessment involves strategies that emphasize the characteristics of the physical environment which can be statistically related to judgments of aesthetic quality” (Bell et al. 1990). The physical-perceptual (psycho-physical, or physicalist) approach is empirically based and generates a multiple regression equation which produces a ‘good fit’ between preference ratings and particular landscape features that
can be objectively measured (Daniel and Boster 1976, Wellman and Buhyoff 1980, Ulrich 1986). Although the physical-perceptual approach does a respectable job of predicting assessments of scenes, the physicalist approach has problems because there are no theoretical statements to explain the causal relationship between environmental variables and aesthetic response (Ulrich 1986). (3) "Psychological Approach to landscape assessment is theoretical and examines the psychological or cognitive processes that underlie aesthetic judgments" (Bell et al. 1990). The psychological approach (Daniel and Vining 1983) attempts to relate preference and other emotions to psychologically relevant visual properties (complexity) that are present in widely different landscapes. The psychological approach focuses on the psychological or cognitive processes that influence aesthetic judgments rather than the physical features of the environment. The informational-processing focus of Kaplan (1987) is a variant of the psychological approach. The assessment approach asserts that evolving humans found spatial information-processing crucial for survival and therefore analysis of environmental preference should focus on the kinds of landscapes and cognitive processes that are important. Informational approach stresses content and process. Content can be general and specific and is based on the concept of affordances. Affordances are features or configurations that determine what one can do in an environment such as locomotion, refuge, prospect. Specific contents are landscape components such as trees, water and mountains. The cognitive processes proposed involve making sense (environment structuring) and involvement (information on environment complexity or coherence).

The trend in the literature is towards the development of preference models based on the responses of recreationists and public interest groups as opposed to professional judgment or expert approaches (Ulrich 1986). Professional or expert approaches based on aesthetic design principles such as Litton (1968) or the United States Department of Agriculture (1974) have been criticized and are also incompatible with public inputs decisions affecting landscape development.

**Landscape (Background):** “The distant part of a landscape; surroundings, especially those behind something and providing harmony or contrast with the surrounding area or surface. An area located from 3-5 kilometers to infinity from the viewer” (Province of British Columbia 1981).

**Landscape Complexity:** “With regard to landscape or architectural aesthetics, the variety and salience of elements in a scene” (Bell et al. 1990).

**Landscape (Cultural):** “A concrete and characteristic product of the complicated interplay between a given human community, embodying certain cultural preferences and potentials, and a particular set of natural circumstances. It is a heritage of many areas of natural evolution and of many generations of human effort” (Wagner and
Mikesell 1962). Post-mining landscapes may be viewed as important parts of the cultural landscape (Francaviglia 1991, Williams 1993).

**Landscape (Dominance Elements):** "Dominance elements of a landscape are form, line, color and texture" (American Society of Landscape Architects 1978).

**Landscape Ecology (Geoecology):** "The study of the structure, function and change in a heterogeneous land area composed of interacting ecosystems" (Forman and Godron 1986). Landscape ecology considers the spatial patterning of ecosystem functions at a landscape scale (Klopatek et al. 1983, Golley 1987, O’Neill et al. 1988, Turner 1990). Landscape ecology is an integrative science, linking human society and the biophysical environment holistically (Risser 1985).

**Landscape Evaluation:** "The assessment of landscape or scenic quality. Landscape evaluation is a very recent development in environmental work and has developed very quickly through the creation and experimental use of a wide range of assessment techniques. The initial impetus was provided by K.D. Fines (1968) and D.L. Linton (1968). Fine’s work involved the use of photographs assessed by a set of respondents as controls for assigning values to specific sites investigated in the field. Linton’s work was based on the assumption of the importance of relief in scenic beauty; the investigative work was factual rather than evaluative and could be largely accomplished by trained map readers.

More recently, much research has been concerned with the individual components of the landscape, e.g., relief, buildings, land-use, water, sometimes within the context of a landscape inventory. Evaluation in the components approach depends basically on the weightings put on the presence or absence of each component in any one areal unit, although more complex multivariate techniques of analysis have also been employed to deal with associations between landscape components. Components approaches are generally based on data collected for grid squares, whilst field evaluation methods developed from Fine’s work are more often based on irregular ‘tracts’. It is generally accepted that despite the apparent objectivity of measurement of the components of landscape, all evaluation of attractiveness, either via the components approach or via some expression of consumer preferences, is inevitably subjective" (Johnston et al. 1986).

**Landscape (Experienced):** Ittelson et al. (1976) defined five theoretical modes of environmental experience: (1) environment as an external place (an individual’s attention is focused outward), (2) environment as emotional territory (awareness of the emotional impact of the setting), (3) environment as self (the objects and setting have special meaning), (4) environment as a social system (awareness of the physical
environment can be affected by social interaction, and (5) environment as a setting for action. Hull and Stewart (1995) have provided an operational definition of experienced landscape: (1) the encountered landscape (the views people or objects encountered), (2) sequence (the sequence in which scenes or objects are encountered), and (3) the feelings and thoughts experienced with the views encountered.

**Landscape Foreground:** “The detailed landscape found within 0 - 0.8 kilometers (0 - 0.5 miles) from the observer” (Province of British Columbia 1981).

**Landscape Function:** “The flows of energy, materials and species among component ecosystems” (Forman and Godron 1986).

**Landscape ‘Harmony’:** Harmony results from the inclusion of neither too few or too many ideas, qualities or materials (Ekbo 1950). Harmony is a blend of unity and variety. Unity may be created by the repetition or dominance of the basic elements of form, line, color and texture (American Society of Landscape Architecture 1978). Human activity generally causes deviations of incongruities from characteristic landscapes (Mittman 1974).

**Landscape (Middle Ground):** “The space between the foreground and the background in a picture or landscape. The area located from 1/4-1/2 to 3-5 miles from the viewer” (Province of British Columbia 1981).

**Landscape (Natural):** “An area where human effects, if present, are not ecologically significant to the landscape as a whole” (Province of British Columbia 1981).

**Landscape Perception:** “The awareness and interpretation of what is seen and experienced is influenced by physical factors and by human factors such as emotion and intellect. There are as many perceptions of landscapes as there are viewers. No two persons see a landscape in exactly the same way. Man’s impression of an object or space is based on past and/or anticipated experience” (Province of British Columbia 1981).

**Landscaping:** “Manipulation of ecosystems or disturbed lands for social values such as aesthetics and recreational access” (Newton 1993).

**Land-Shaping (Pit Landforms):** Reclamation of pits creates considerable land-use-capability problems and require creative management practices. Where highwalls are
highly visible, screening with berms or vegetation has been proposed (Plass 1979), but this practice is considered unacceptable in most situations (Box 1978). Several options exist for pit shaping and contouring: (1) restoration blasting (sculpturing of rock faces through blasting), (2) blasting highwalls to form benches and reduce face angle, (3) placement of suitable growth media on bench surfaces or (4) partial or complete pit backfilling with suitable material (Coppin and Bradshaw 1982, Acott 1987).

**Land-Shaping (Spoil Dumps):** “Returning spoil banks to even sloped terrain features” (Bituminous Coal Research Incorporated 1974). Land-shaping is also referred to as contouring, grading, resloping, shaping and site preparation. Modification of post-mining geomorphology in the form of backfilling, contouring (resloping) and shaping by mining equipment represents one of the most challenging and costly aspects of reclamation (Schafer 1984, Reith 1986, Gardiner et al. 1992).

**Landslide:** “Rapid movement of soil, rock or debris down a slope as a result of gravity or gravity and water when the material is saturated” (Whittow 1984).

**Land-Use:** “Human-imposed functions of a land area” (Star and Estes 1990).

**Land-Use Planning:** “Any land-use planning model designed to be fully operational must balance the duality of physical restrictions and socioeconomic demands” (DeMers 1989). The inclusion of ecological information is important in land-use planning decisions (Dearden 1978). Land-use planning must take into account of human perceptions and historical uses of the land (Dorney 1989). “Landscape planning must reflect the way in which people think and feel about the landscape if it is to be successful” (Dearden 1984).

**Land-Use Planner:** “A person with academic training in planning, geography, biological sciences, forestry or environmental studies who conducts, analyses and proposes solutions to land use issues, though not necessarily with an ecosystem focus” (Dorney 1989).

**Leaching:** “The removal of materials in solution by the passage of water through the soil” (Leskiw 1993).

**Lead Agency:** “Refers to an agency with authority to coordinate a project review, to approve or reject proposals, or to make recommendations” (Energy Resources Conservation Board 1978).
Learning Style: “The particular sense organs or combination of sense organs one employs in the mental assimilation processes designed for or at least effective in cognition and behavior modification. Learning modalities can be auditory, visual or kinesthetic” (Bower and Hilgard 1981).

Lease: “A contract by which one party (landlord or lessor) gives to another (tenant or lessee) the use and possession of lands, buildings or property for a specified period of time and for fixed payments” (Guralnik 1984).

Legislation: “Laws made by a legislative body” (Sykes 1982).

Legume: A member of one of the families of Angiosperms: Papilionaceae, Mimosaceae or Caesalpinaceae. Some species such as the clovers, vetches and trefoils are important for reclamation through their association with *Rhizobium*. Bacteria in their roots fix atmospheric nitrogen (Burrows 1990).

Level Terrace: “A broad surface channel or embankment constructed across sloping soil on the contour, as contrasted to a graded terrace which is built at a slight angle to the contour” (Bituminous Coal Research Incorporated 1974).

License: “A document or permit indicating that formal permission has been granted” (Guralnik 1984).

Lichen: “A mutualistic association between a fungus and either a green alga or cyanobacterium. Lichen form distinctive thalli” (Burrows 1990).

Life History: “The significant features of the life cycle through which an organism passes with particular reference to strategies influencing survival and reproduction” (Lincoln et al. 1982).

Lift: “Removal of topsoil and subsoil prior to overburden removal or pipeline installation. Lifts can be made in a series of stages (one-lift or two-lift operations)” (Naeth et al. 1991).

Lime: “Lime, from the strictly chemical standpoint, refers to only one compound, calcium oxide (CaO); however, the term lime is commonly used in agriculture to include a great variety of materials which are usually composed of the oxide, hydroxide, or
carbonate of calcium or of calcium and magnesium. Liming helps to bring pH to tolerable limits, but must be incorporated at least to the depth of root development” (Coppin and Bradshaw 1982).

**Lithosol:** “A very stony and unusually shallow soil, often without evident development of horizons” (Lincoln et al. 1982).

**Litter:** “Freshly fallen or slightly decomposed organic debris” (Bituminous Coal Research Incorporated 1974).

**Loess:** “Material transported and deposited by wind and consisting of predominantly silt-sized particles” (Foth 1978).

**Long-Term Studies:** Many important ecological changes and processes occur over long time scales and these are often those with significant human relevance (Likens 1983, 1989). Time lags longer than a year can exist between cause and effect and increasingly long records of ecosystem structure and process expose new phenomena (Pimm 1991). In the absence of long-term research, serious misjudgments can occur in attempts to manage the environment (Magnuson 1990). Short-term studies which are not supplemented by long-term research, may cause serious misjudgments or misinterpretations and result in the mismanagement of the environment (Tilman 1989). Long-term research is particularly important for studying stressed ecosystems (Risser 1985).

“The best definition of long-term is ‘for as long as the regeneration time of the dominant organism or long enough to include examples of the important processes that structure the ecosystem under study.’ Due to difficulties inherent with long-term studies (money, practicality), four short-term methods are currently favored: (1) chronosequences, (2) long-term behavior inference (human historical records, dendrochronology, paleolimnology), (3) mathematical modeling and (4) surrogate systems with rapid dynamics.

**Longwall Mining:** “A method of mining involving total extraction of a coal seam along an advancing coal face usually several hundred meters in length” (Richards et al. 1993).

**Low Wall:** “The vertical wall, on the downslope side of the mining operation, consisting of the deposit being mined and some overlying rock and soil strata” (Bituminous Coal Research Incorporated 1974).
Macrofauna: “Large animals in a community within an arbitrary size range, e.g., between 2 mm and 20 mm body width, in soil vertebrates” (Begon et al. 1990).

Macronutrients: “A chemical element necessary in relatively large amounts (usually 500 parts per million in the plant). These elements consist of C, H, O, N, P, K, S, Ca and Mg” (Foth 1978).

Mammal: “Any of a large class (Mammalia) of warm-blooded, usually hairy vertebrates whose offspring are fed with milk secreted by the female mammary glands” (Guralnik 1984).

Management Concern: “An issue or problem requiring resolution, or a condition constraining management practices identified by an interdisciplinary team (United States Department of Agriculture Forest Service 1979b).

Mandate: “Refers to the legal authority for a particular process. Sometimes details of a process are specified in legislation, regulations or orders-in-council” (Energy Resources Conservation Board 1978).

Map: “Usually a two-dimensional representation of all or part of the Earth’s surface, showing selected natural or man-made features or data, preferably constructed on a definite projection with a specified scale” (Star and Estes 1990).

Mass Movement: “Movements of large portions of the land surface caused by either water saturation and/or frost action. Mass movements include landslides, mud slides, creep, congeliturbation and solifluction” (Whittow 1984).

Material Management: The management practices involved in site preparation. The practices includes the segregation, storage and placement of topsoil, overburden, coversoil, spoil, tailings, coarse rejects and blended material for the purpose of providing suitable growing material for plants on the post-mining landscape (Hustrulid and Kuchta 1995).

Matrix: “The most extensive and most connected landscape element type present, which plays the dominant role in landscape functioning. Also, a landscape element surrounding a patch” (Forman and Godron 1986).
Maturation: "The process of development of mature features. In vegetation the accomplishment of a relatively steady state" (Burrows 1990).

Mesic: "An implication that microclimatic conditions are relatively mild, and soils well supplied with water" (Burrows 1990).

Metabolic Quotient ($q_{CO_2}$): An integrating parameter used to measure reclamation success. The parameter is calculated with the formula $q_{CO_2} = \frac{\text{microbial respiration } r}{\text{microbial biomass } B}$. The metabolic quotient is based on the work of Odum (1971), who showed that as long as production is greater than respiration, organic matter and biomass will accumulate in the system and $R/B$ will decrease with time (Insam and Haselwandter 1989). "The metabolic quotient $q_{CO_2}$ may be the easiest functional parameter with which to measure system stability and potential reclamation success. "Like the $C_{\text{micro/org}}$, the $q_{CO_2}$ value will decrease with time as systems accumulate carbon" (Zak et al. 1992).

Metabolic Rate: The rate of expenditure of energy compared to basal metabolism (Begon et al. 1990).

Metacommunity: A group of interacting populations of different species. Two or more species confined to the same set of habitat patches form a metacommunity or community of metapopulations (Hanski and Gilpin 1991).

Metal: "A metal dissociates in water to yield positive cations, $Ca^{2+}$, $Mg^{2+}$, $Al^{3+}$, $Fe^{3+}$, $Na^{+}$" (Trudgill 1988).

Metal Toxicity (Elements): Plants vary widely in their uptake and requirements for various macro- and micronutrients. Some toxic elements or compounds can be taken up by plants even though they are not required for growth. Often uptake of toxic elements are in proportion to their availability in the immediate of the plant. In other cases, plants may concentrate certain toxic substances to levels far in excess of the their availability (Trlica and Brown 1992).

Metal Toxicity (Mining): Mine wastes often contain excessive concentrations of metals that are toxic to plants, and hence these wastes are often devoid of vegetation (Wong 1986). For example, copper mine waste may contain elevated levels of zinc and lead (Smith and Bradshaw 1972). Toxic levels of copper, zinc, nickel, molybdenum and selenium are known to occur in colliery shales (Kabata-Pendias and Pendias 1984). Metals such as iron, aluminum, manganese, zinc, and heavy metals cadmium, lead and
copper are known to occur in mine spoils (Gentcheva-Kostadinova and Zheleva 1994) and tailings (Berg and Vogel 1973).

**Metapopulation:** "A network of semi-isolated populations with some level of regular or intermittent migration and gene flow among them, in which individual populations may go extinct but then be recolonized from other populations" (Meffe and Carroll 1994).

**Metastability:** "A state of being in equilibrium (oscillating around a central position), but susceptible to being diverted to another equilibrium. The relationship between stability and instability in ecological systems is essentially dialectic, since instability progressively gives way to instability and is always ephemeral" (Forman and Godron 1986). In modeling natural communities, concepts of equilibrium and non-equilibrium structure are often presented as conflicting hypotheses though they may represent differently scaled models of the same system (Allen and Starr 1982).

**Microarthropod:** "An arthropod that is microscopic" (Kenneth 1975).

**Microbe:** "One of the microscopic organisms" (Burrows 1990).

**Microbial Biomass:** "Microbial biomass in soil is a relatively large and labile component of organic matter containing important plant nutrients, particularly nitrogen and phosphorous" (Paul and Clark 1989). Microbial biomass is best determined by substrate-induced respiration procedure of Anderson and Domsch (1978). Respiration is expressed as CO₂/hr/g dry soil and converted into microbial biomass (micro gC micro/g dry soil) by applying the formula \[ Y = 40.04X + 0.37, \] where \( X \) is the glucose induced respiration (Insam and Haselwandter 1989).

**Microbial Ratio:** Insam and Domsch (1988) argued that potential problems with single microbial parameters [enzyme activity (Fresquez et al. 1987), microbial respiration, microbial biomass (Candell 1977)] as descriptors of reclamation success or system development is that while the level at which they are measured may achieve some stability, they cannot assess the stability and development of the linkages between levels that are important for total system stability. For measuring system stability, descriptors should link carbon and nutrient flow through the microbial component and organic matter accumulation. Insam and Domsch (1988) proposed that for a steady state to be achieved, there should be an equilibrium level for the ratio of microbial biomass carbon (\( C_{micro} \) / total soil organic carbon \( C_{org} \)). "If the equilibrium constant is known, then deviations from this value can provide a measure of system stability and whether the soil is gaining or loosing carbon. The ratio of \( C_{micro} / C_{org} \) is predicted to
increase over time to some equilibrium level for the system. The direction and rate of change will provide an indication as to the stability of the system" (Zak et al. 1992).

**Microbial Respiration:** A measure of the metabolic activity of soil microbes. Measurement is assessed by either placing soil in mason jars with beakers of 1.0N NaOH solution to trap CO₂ and titration of the alkali solution to obtain amounts of CO₂, or utilizing automatic measuring devices such as infrared gas analyzers (Anderson 1982).

**Microenvironment:** “Small-scale site such as that ‘perceived’ by a germinating seed” (Young 1992).

**Microfauna:** “The smallest arbitrary size categorization of animals in a community” (Begon et al. 1990).

**Microflora:** “Plants that are too small to be distinguishable without the aide of a microscope (algae, bacteria, fungi)” (Begon et al. 1990).

**Microheterogeneity:** “A pattern where the assemblage of landscape element types around a point is similar wherever the point is located in the landscape” (Forman and Godron 1986).

**Micronutrients:** “A chemical nutrient necessary only in extremely small amounts (usually <50 parts per million in the plant) for the growth of the plant. These elements consist of B, Cl, Cu, Fe, Mn, Mo and Zn” (Foth 1978).

**Microrganism:** “Any organism that can be seen only with the aid of a microscope” (Federal-Provincial-Territorial Biodiversity Working Group 1994).

**Microsere (Gap Replacement):** “A time sequence of communities of small aerial extent that may be observed in climax stands” (Daubenmire 1978).

**Microsite:** “A small-scale site such as that perceived, e.g., by a germinating seed” (Burrows 1990).
Microtopography: “Small scale variations in topography at the soil surface” (Coppin and Bradshaw 1982).

Microtopography Modification (Ripping, Pitting, Deep Chiseling, Furrowing): Modification of microrelief allows seeds to collect in hollows and provides shade and moisture to germinating seedling (Nicholson and Bell 1981). The optimum topographic relief appears to be 20-30 cm high in furrows 80-100 cm apart. Ripping or deep chiseling to depths ranging between 20-50 cm is generally performed following regrading to reduce bulk density and improve minesoil porosity (Ferguson and Frischknecht 1985). The depth of ripping is dependent upon material type and plant species selected to achieve land-use objectives. In general ripping shank spacing and penetration depth should be equidistant (Fedkenheuer et al. 1987).

Migration: “A cyclic movement of animals between separated areas that are used during different seasons” (Forman and Godron 1986).

Mine Drainage: “Any water forming on or discharging from a mining operation. May be alkaline or acidic” (Bituminous Coal Research Incorporated 1974).

Mine Dumps: “Surface area used for disposal of mine and/or preparation plant waste” (Bituminous Coal Research Incorporated 1974).

Mined-Land: “Land with new surface characteristics due to the removal of mineable commodity by surface mining methods and subsequent surface reclamation” (Bituminous Coal Research Incorporated 1974).

Mineral Developments: “This term is used in a broad sense and includes energy-related developments for such commodities as oil and gas, coal and uranium as well as commodities such as gold, silver and molybdenum” (United States Department of Agriculture Forest Service 1982).

Mineralization: “Conversion of mineral nutrients in organic matter and humus to inorganic forms by microbial activity. The inorganic forms are then available to plants” (Coppin and Bradshaw 1982).

Mineral Exploration: The process of exploring for minerals. Exploration involves conventional and geobotanical prospecting, seismic activity, core drilling, analysis and mapping.
**Mineral Resource:** “A mineral deposit or portion thereof, the tonnage and grade of which is not presently considered economic to mine and is not included in mineable reserves” (Teck Corporation 1995).

**Mine Road:** “A road constructed for a mining operator” (United States Department of Agriculture Forest Service 1979c).

**Minesoil:** Soil produced by mining and reclamation activities that is capable of supporting plant growth (Thrush 1968).

**Minimal Area:** A phytosociological term used to describe the smallest area in which a plant community can develop its characteristic composition and structure (Mueller-Dombois and Ellenberg 1974).

**Minimum Dynamic Area (MDA):** “The smallest area necessary for a reserve to have a complete, natural disturbance regime in which discrete habitat patches may be colonized from other patches within the reserve” (Meffe and Carroll 1994).

**Minimum Structure:** Pickett et al. (1989) stated that an understanding of disturbance effects on ecosystems can only be understood by examining the minimum structure of the system: (1) organization of entities into observed units (individuals, populations, communities), (2) coordination of the interactions between units, (3) unit regulating functions, (4) information flow between units (nutrients, energy), and (5) interactions between levels. Disturbance is viewed as a change in minimal structure.

**Minimum Viable Population (MVP):** “The smallest isolated population size that has a specified percent chance of remaining extant for a specified period of time in the face of foreseeable demographic, genetic, and environmental stochasticities, plus natural catastrophes” (Meffe and Carroll 1994).

**Mining:** “The act, process or work of removing ores, coal, gravel from a mine” (Guralnik 1984).

**Mining Plan:** “A plan submitted by the mine operator which outlines the steps the mining company will take to mine and reclaim the site. The mining plan is generally submitted prior to the startup of mining operations” (United States Department of Agriculture Forest Service 1979b).
Mite(s): “A large number of tiny, sometimes microscopic arachnids (Order Acarina), often parasitic or upon animals, insects or plants” (Guralnik 1984).

Mitigation: “Refers to efforts to alter a proposal to lessen any potentially adverse environmental impacts. An action to correct or lessen the severity of an adverse effect” (United States Department of Agriculture Forest Service 1982).

Mitigation Measures: “Action taken to prevent, avoid or minimize the actual or potential adverse effects of a policy, plan, program, or project. Measures might include abandoning or modifying a proposal, or relocating it, substitution of techniques, cleaner methods, recycling, pollution control methods, closure of older plant, landscaping and rehabilitation, acquisition of properties and better programming” (Gilpin 1995).

Molybdenum Toxicity: See Metal Toxicity.

Monitoring (Compliance): “A combination of observation and measurement for the performance of a project and its compliance with development consent conditions. Instrumentation might be required in relation to air, water and land pollutants, noise and blasting, radiation, transport movements, and land subsidence. Records might be required for materials movements, raw materials, products, wastes, complaints and investigations, instrument and analysis results” (Gilpin 1995).

Monitoring (Effects): Monitoring the impacts of a development on the environment. The monitoring involves comparisons with baseline data rather than to compliance standards.

Monitoring (General): Repeated inventory (regular or irregular) or surveillance carried out in order to describe trends, ascertain the extent of compliance with a predetermined standard, determine the degree of deviation from an expected norm (Morrison 1994). Monitoring is undertaken to ascertain whether the prevailing conditions (physiological, behavioral, ecological or environmental) match the previously defined standards or norms. Monitoring programs are implemented for several reasons: (1) assessing the effectiveness of policy or legislation, (2) assessing regulatory or audit functions and (3) detecting incipient change (early warning)” (Hellawell 1991).

Monoculture: “A large area covered by a single species (or, for crops, a single variety) of plant; or, in experiments, plants of the same species grown alone without any other species” (Begon et al. 1990).
Monotypic: “Vegetation stands consisting of only one plant species” (Burrows 1990).

Montane: “Pertaining to mountain slopes below the alpine belt” (Daubenmire 1978).

Moraine: “A deposit of rocks and debris carried and dropped by a glacier. A ridge of bouldery debris formed around the margin of a glacier” (Holland 1976).

Mosaic: “The intermingling of plant communities and their successional stages in such a manner as to give the impression of an interwoven design” (Forman and Godron 1986).

Moss: “One of a group of Bryophyte plants having a leafy gametophyte” (Burrows 1990).

Mountain Top Removal: “In this mining method, 100 percent of the overburden covering a coal seam is removed in order to recover 100 percent of the mineral. Excess spoil material is hauled to a nearby hollow to create a valley fill” (Bituminous Coal Research Incorporated 1974).

MFRRP: An acronym for Mountains and Foothills Reclamation Research Program, a joint industry/government program consisting of representatives of the Coal Association of Canada, Alberta Environment and Alberta Forestry, Lands and Wildlife. Initiated in 1984, the primary objectives of MFRRP were to summarize current information on reclamation methods for forestry, wildlife habitat and soil re-establishment and to develop an appropriate method(s) for measuring reclamation success in the mountains and foothills biomes of Alberta (Eccles et al. 1988).

Mulch: “Any material such as straw, sawdust, leaves, plastic film or loose soil that is spread on the surface of the soil to protect the soil and plant roots from the effects of raindrops, soil crusting, freezing evaporation. To apply mulch to the soil surface” (Foth 1978).

Multicollinearity: “Any independent variable is correlated with another independent variable or with a linear combination of other independent variables. Correlation among independent variables causes increased standard errors of regression coefficients, computational difficulties and the omission of variables may result in biased estimators for the regression parameters of the remaining variables if the missing variables are correlated with those remaining” (Tabachnick and Fidell 1983).
Multi-disciplinary: “Combining the subject matter of many different branches of learning or research” (Guralnik 1984). Multidisciplinary approaches are important in environmental studies (EIA) (Bastedo and Theberge 1983), but these ‘teams’ often suffer from debilitating internal problems associated with personality styles, stylistic differences (hard versus soft science) and group structure (organization and size) (Miller 1984). Although generally not formally structured in a similar manner to the EIA ‘team’, reclamation ‘specialists’ are part of a team which over a period of years must develop an operational reclamation plan.

Multiple Seam Mining: “Surface mining in areas where several seams are recovered from the same hillside” (Bituminous Coal Research Incorporated 1974).

Multiple Use Concept: “Refers to the simultaneous and compatible use of public land and water resources by different interest groups. For example, U.S. public law requires that national forests be open to recreational use, timber extraction, mining or other concessions, and biodiversity protection. In reality, the activities of the various interest groups are often incompatible with biodiversity protection” (Meffe and Carroll 1994).

Multiplication Facility (Wild Garden): A facility which uses agronomic and/or horticultural practices to increase seed supplies from breeder stock (Hartmann et al. 1990) (agronomics) or from ‘wild’ populations (ecovars).

Multivariate Normality: “Multivariate normal distribution. Although univariate normality does not guarantee multivariate normality, the probability of multivariate normality for most real variables in social science is increased if all the variables have normal distributions” (Tabachnick and Fidell 1983).

Mycorrhizae: “Mycorrhizae (‘fungus root’) are symbiotic relationships between plant roots and specialized soil fungi” (St. John 1984). “Mycorrhizal fungi are key components of soil microbiota and certain soil microorganisms are known to regulate mycorrhizal formation and function. Conversely, mycorrhizae affect the establishment of rhizosphere populations through nutrient cycling, which in turn affects plant growth and nutrition” (Azcón-Aquilar and Barea 1992).

Native Ecosystem: “The network of organisms coupled with their physical and chemical environment defines the term ecosystem. A definition of ‘native ecosystem’ must consider not only the native species, but also interactions and roles within the ecosystem” (Wilson et al. 1992).
Native Landscapes: “Adjacent sites differ in plant species composition, the types of animals they support and in the nitrogen and oxygen levels in their soils. The collection of these and adjacent ecosystems constitute the landscape” (Wilson et al. 1992).

Native Species: “An indigenous plant or animal, not exotic” (Sykes 1982). Different aspects of nativeness can be described in regard to geography, habitat, and genetics; all of which are interrelated facets of an ecological definition of native (Alverson 1993). “Three issues complicate the application of this definition to native species: (1) the changes in geographical distribution of species through time, and genetic variability among individuals of the same species, (2) many plant and most animal species possess considerable intraspecific genetic variability and (3) individuals from one part of a species’ range are often genetically distinct in some traits from individuals elsewhere in its range” (Wilson et al. 1992).

Non-equilibrium: “A condition in which rate of increase does not equal rate of decrease. In non-equilibrial population growth, environmental stochasticity disrupts the equilibrium” (Meffe and Carroll 1994).

Non-Game Species: All wild terrestrial and aquatic vertebrates not subject to sport fishing or hunting (Westar Mining Limited 1983).

Non-Metric Multidimensional Scaling (NMDS): NMDS is a non-parametric method (Kruskal 1964) for ordination (Minchin 1987) and data reduction which can use categorical or continuous data (Herzog 1987) in direct similarity or dissimilarity matrices (Wilkinson et al. 1992). No assumptions of linear relationship between distances and dissimilarities. NMDS produces a goodness-of-fit statistic to minimize which consists of the square root of the normalized squared discrepancies between interpoint distances in the NMDS plot and the smoothed distances predicted from the dissimilarities. Stress varies between 0 and 1 with values near 0 indicating a better fit (Wilkinson et al. 1992). The basic objective is to use only rank order information to identify a space of minimum dimensionality where a large number of the interpoint distances (corresponding to the dissimilarities) between every object is best represented geometrically according to the order of entries in the raw data matrix. As the algorithm of NMDS is operated upon (non-metric) information, different types of data proximities and resemblances can be used (Tong 1992). A two or three dimensional solution is preferred because solutions of higher dimensions become increasingly difficult to interpret. NMDS is recommended as a robust technique for indirect gradient analysis which deserves more widespread use by community ecologists (Minchin 1987).

Normal Distribution: “A symmetrical frequency distribution in which most of the measures fall near the mean and fewer scores are found near the extremes of the
distribution. The normal distribution forms a bell-shaped curve, with the mean, median, and mode at the same point on the curve” (Sowell and Casey 1982).

**Nurse Crop:** See Companion Crop.

**Nutrient Cycling:** The circulation of elements, such as nitrogen and carbon, via specific pathways from abiotic to biotic portions of the environment and back again; all mineral and nutrient cycles involving man, animals and plants such as the carbon cycle, phosphorous cycle, and nitrogen cycle (Rapp 1983).

**Nutrient-Use Efficiency:** Nutrient-use efficiency considers production efficiency based on investment of nutrients into photosynthesis (Berendse 1985).

**Objective:** “A clear and specific statement of planned results to be achieved within a stated time period. The results indicated in the statement of objectives are those which are designed to achieve the desired state or process represented by the goal. An objective is measurable and implies precise time-phased steps to be taken and resources to be used which together represent the basis for defining and controlling the work to be done” (United States Department of Agriculture Forest Service 1979b).

**Oil Sands:** See Tar Sands.

**Open Pit Mining (Opencast Mining):** “Surface mining, a type of mining in which the overburden is removed from the product being mined and is dumped back after mining; or may specifically refer to an area from which the overburden has been removed and has not been filled” (Bituminous Coal Research Incorporated 1974).

**Operation:** “All of the premises, facilities, railroad loops, roads, and equipment used in the process of extracting and removing a mineral commodity from a designated surface mine or in the determination of the location, quality and quantity of a natural deposit” (Bituminous Coal Research Incorporated 1974).

**Opinion:** “A belief not based on absolute certainty or positive knowledge but on what seems true, valid or probable in one’s own mind or judgment” (Guralnik 1984).
Opportunistic Species: “A species adapted for utilizing variable, unpredictable or transient environments, typically with a high dispersal ability and a rapid rate of population growth, i.e., $r$-selected species” (Gray 1993).

Opportunity Cost: “The value of the benefits foregone or given up due to the effect of choosing another management alternative that either impacts existing outputs or shifts resources away from activities so that they are no longer produced and their benefits lost” (United States Department of Agriculture Forest Service 1979b).

Opportunity Landscapes: Opportunity landscapes represent creative landscape changes that can overcome perceived land-use incompatibilities in a development. The concept of opportunity landscapes provides the first step in a decision-making process which integrates public values resulting in landscapes more compatible with community uses and re-creation of wildlife habitat (McLellan and Baker 1994). Often large developments are considered to be incompatible land-uses by the community and media. However, an interest-based approach for developing a project integrates community needs, yielding substantial benefits (Baker and Jackson 1994).

Orebody: “A mineral deposit with sufficient tonnage and grade from which a commodity may be mined, processed and sold economically” (Teck Corporation 1995).

Organic Matter: “Material which is living or was living” (Burrows 1990).

Orthophoto: “A photograph that has been manipulated in such a way as to eliminate image displacement due to photographic tilt and relief” (Star and Estes 1990).

Outcrop: “Coal which appears at or near the surface; the intersection of a coal seam with the surface” (Bituminous Coal Research Incorporated 1974).

Outcrop Mining (Contour Mining): “The surface mining of a coal seam that outcrops or approaches the surface at approximately the same elevation in steep or mountainous country (Thrush 1968).

Overburden: “Non-processable material overlying mineral deposits that must be stripped off before extraction can proceed” (Coppin and Bradshaw 1982).
Overlay: “A map or graphic display of data depicted on a transparent medium (e.g., plastic), which may be superimposed on another map, photograph or graphic display” (Whittow 1984).

Overview: “A preliminary environmental report which includes a description of the existing environment, a description of all phases of the proposed development and an initial identification of possible environmental impacts” (Energy Resources Conservation Board 1978).

Panoramic: “An unobstructed or complete view of a region in every direction; hence a complete and comprehensive view” (Province of British Columbia 1981).

Paradigm: “An established pattern of thinking. Often applied to a dominant ecological or evolutionary viewpoint (e.g., during earlier decades the dominant paradigm held that communities were shaped by equilibrial processes” (Meffe and Carroll 1994).

Parameter: “A constant in a mathematical expression or a typical element” (Sykes 1982).

Parasite: “An organism that obtains its nutrients from one or a very few host individuals causing harm but not causing death immediately” (Begon et al. 1990).

Parent Material (Genetic Material): “The unconsolidated mass of rock material (or peat) from which the soil profile develops” (Burrows 1990).

Participant Photography Method: A method of determining scenic preference. In this method, subjects are instructed to take pictures of views that they like. The number of people who photograph a view is used as a measure of the importance of that view (Chenoweth 1984). The approach may be useful in identifying salient views but is inappropriate in representing the dynamics of the landscape experience (Hull and Stewart 1992).

Particle Size Analysis: “The determination of the various amounts of separates in a soil sample usually by sedimentation, sieving, micrometer or a combination of these methods. A textural triangle is then used to determine soil texture” (Naeth et al. 1991).
Passerine: "Birds of the order Passeriformes. Perching birds, especially song birds" (Sykes 1982).

Passive Dispersal: "Movement of seeds, spores or dispersive stages of animals caused by external agents such as wind current" (Begon et al. 1990).

Patch: "The area of space within which a local population lives" (Hanski and Gilpin 1991). Also, a nonlinear surface area differing in appearance from its surroundings. Within any community, a patch can be defined as a locally distinct assemblage of species, potentially repeatable spatially and temporally (Forman and Godron 1986).

Pathogen: "A virus, bacterium or fungus which attacks plants (Burrows 1990).

Ped: "A unit of soil structure such as prism, block or granule which is formed by natural processes in contrast to a clod which is formed artificially" (Naeth et al. 1991).

Pedon: "A three-dimensional body of soil with lateral dimensions large enough to permit the study of horizon shapes and relations" (Foth 1978).

Pedogenesis: "The mode or origin of the soil with special reference to the processes or soil-forming factors responsible for the development of the solum, or true soil, from the unconsolidated parent material" (Foth 1978). Four groups of pedogenic processes sensu stricto have been identified for horizon differentiation: (1) additions, (2) losses, (3) transfers and (4) translocations. Pedogenesis can be considered to consist of two overlapping steps: (1) the accumulation of parent material and (2) horizon differentiation (Simonson 1978).

Pellet-Group Transects: A field sampling procedure used to identify faecal or scat material as indirect evidence of wildlife habitat use. "Pellet groups indicate the presence of ungulate species and provide a measure of abundance that is complementary to browse utilization data" (Luttmerding et al. 1990).

Perception: Perception is the process of extracting meaning from the complex stimuli which individuals encounter in everyday life. An individual’s perception is governed by past experiences as well as present outlook and is conditioned by values, moods, social circumstances and expectations (Mitchell 1979). Perceptions, like attitudes, are learned and develop through experience (Schiff 1971). Furthermore, attitudes affect
perceptions and perceptions affect attitudes with cognition a determinant in both (Bell et al. 1990).

**Perennial:** “A long-lived plant that survives over winter by some dormancy mechanism” (Burrows 1990).

**Performance Bond:** “A bond of liability placed on a mining company. The bond specifies regulations for determining the acceptability of certain mining and reclamation activities” (United States Department of Agriculture Forest Service 1979d). “The deposit is intended to guarantee the reclamation and rehabilitation of the area to be mined. If a mine goes bankrupt or fails to comply with the conditions imposed, the mining company forfeits the bond to the consent authority which then becomes responsible for the rehabilitation of the mine site” (Gilpin 1995).

**Performance Criteria:** Selected variables used for performance monitoring.

**Performance Standards:** Standards against which performance criteria are compared.

**Permanence:** “A qualitative condition for the coexistence of species that does not depend on quantitative properties of their dynamics. The term permanence encompasses the ecological notion of species being able to live together, without requiring that they should tend to equilibrium” (Law and Morton 1993).

**Permit:** “A document giving permission; license” (Sykes 1982).

**Persistence:** “A measure of stability, referring to the time period during which a certain characteristic continues to be present at a given level” (Burrows 1990).

**Perspective Plots:** Hand (sketch) or computer-based (plot) simulations of a landscape. Perspective plots are used in the visual assessment of a proposed plan or design (Oh 1994).

**Perturbation:** A disturbance (Sykes 1982). Many components of the landscape are perturbation dependent due to steep slopes and aspect (Turner et al. 1991).

**Perturbation Response Indices:** See Recovery Index or Rehabilitation Potential.
Phenology: “Phenology is the study of the timing of recurring biological events, the causes of their timing with regard to biotic and abiotic forces and the interrelation among phases of the same or different species” (Leith and Schultz 1976).

Phenophase: “Successive stages in a phenological series” (Ram et al. 1988).

Photogrammetry: “The process of creating topographical maps from stereo aerial photographs. The techniques of obtaining precise measurements from images” (Star and Estes 1990).

Photo-inventory: A method of identifying and predicting visual preference that is similar to the Scenic Beauty Estimation Method (SBE) of Daniel and Boster (1976). The method involves the use of photo-questionnaires. The questionnaires have eight 2x3 inch photos per page and 32 per questionnaire. A five point ordinal scale for rating preference (dislike - like) is printed below each photograph so the respondent can rate each individually. Frequency distributions and cumulative probability distributions are calculated on the transformed data (Hammitt et al. 1994). Comparison of field observations and photographs have shown that the photo-questionnaire approach is a valid measurement instrument of scenic preference (Kellomaki and Savolainen 1984).

Photomosaic: “A grouping of overlapping vertical aerial photographs or parts of aerial photographs jointed together to leave minimal scale alterations” (Whittow 1984).

Physical Geographer: “A geographically trained scientist oriented toward spatial description of physical features and natural resources. Generally, the emphasis is toward physiography, geomorphology or climatology” (Dorney 1989).

Physical Milieu: “In Barker’s ecological psychology, the physical component of the behavior setting” (Bell et al. 1990).

Physical-System Stability: “The most stable state of a system, with a negligible amount of photosynthetic surface or energy store in biomass” (Forman and Godron 1986).

Physiognomy: “The general appearance of vegetation arising from its stature, texture or color” (Burrows 1990).
Phytocoenose: “The total plant life of a given habitat or community” (Lincoln et al. 1982).

Phytomass: “Plant biomass; any quantitative estimate of the total mass of plants in a stand, population, or within a given area at a given point in time” (Lincoln et al. 1982).

Phytosociology (Plant Sociology, Phytocoenology): “The study of vegetation, including the organization, interdependence, development, geographical distribution and classification of plant communities” (Lincoln et al. 1982).


Pit: “Used in reference to a specifically describable area of open cut mining. May be used to refer to only that part of the open cut mining area from which coal is being actively removed or may refer to the entire contiguous mined area” (Bituminous Coal Research Incorporated 1974).

Pit (Borrow): “A bank or pit from which earth is taken for use in filling or embanking” (Bituminous Coal Research Incorporated 1974).

Pixel: “Of a surface, the smallest unit whose characteristics may be uniquely determined. From picture element” (Star and Estes 1990).

Plan: “Is a document with maps attached. It sets out desired uses of particular land or water areas and specifies established processes for approving proposed uses” (Energy Resources Conservation Board 1978).

Plant Association: “A kind of plant community represented by stands occurring in places where environments are so closely similar that there is a high degree of floristic uniformity in all layers” (Daubenmire 1978).

Plant Community: “A vegetative complex unique in its combination of plants which occurs in particular locations under particular influences and is a reflection or integration of the environmental influences on the site such as soils, temperature, elevation, solar radiation, slope, aspect, and rainfall” (Daubenmire 1978).
Plant Dispersal: "A process of plant propagule movement that results in establishment of the species at a new site" (Forman and Godron 1986).

Plant Feed Coal: "The amount of coal conveyed to the plant after separation of waste material at the breaker" (Bituminous Coal Research Incorporated 1974).

Platform: "The flat summit of a rock waste (spoil) or overburden dump" (Thrush 1968).

Policy: "A principle or course of action chosen to guide decision-making" (Sykes 1982).

Pollinators: Organisms which transfer pollen from the anther to the stigma of flowers (Hartmann et al. 1990).

Pollution: "The contamination of a natural ecosystem, especially with reference to the activity of man" (Lincoln et al. 1982).

Polygon: "An area of space delineated by a boundary composed of straight line segments. Since the straight line segments are delineated by pairs of points, a polygon is ultimately stored in a vector system as a list of points (each with X and Y coordinate values), and the last point identical to the first" (Eastman 1992).

Pooling: Aggregating data into groups for the purpose of statistical analysis (Orlóci and Kenkel 1985).


Potential Natural Vegetation: The vegetation expected to develop under specific habitat conditions (Ide and Takeuchi 1984).

Pot Trials: Plant growth trials in a nursery or greenhouse that are used to assess plant species performance with different growth media or fertilizers.
**Predator:** “Any animal that kills and feeds on other animals” (Westar Mining Limited 1983).

**Preparation Plant:** “A plant complex in which the raw coal is cleaned to the required grade (usually by the removal of impurities such as rock, carbonaceous shales and high-ash coals) and dried to a specified moisture content” (Bituminous Coal Research Incorporated 1974).

**Preplanning:** “Process of foreseeing reclamation problems and determining measures to minimize off-site damages during the mining operation and to provide for quick stabilization of the mining” (United States Department of Agriculture Forest Service 1979c).

**Present Optimum Vegetation:** Present optimum vegetation is defined as the vegetation structure that will manifest itself based on anthropogenic alteration of topoedaphic conditions due to various land-uses. Optimum vegetation can function as a special or alternative standard for land-use planning (Rijmenams et al. 1985).

**Primacy:** “The state of being first in time, order or rank” (Guralnik 1984).

**Problem Compartmentalization:** The division of a problem into components without understanding component interdependencies (Miller 1985c).

**Problem-Solving:** The resolution of a problem.

**Procedures:** “Refers to the steps which may be followed from initiation of a process through to completion” (Guralnik 1984).


**Production (Ecosystem):** “The accumulation of organic matter by organisms” (Burrows 1990).

**Productivity (Biological):** “The rate at which growth processes occur in an organism or ecosystem. Usually expressed as the quantity of dry matter per unit time (e.g.,
kg/ha/yr); or less frequently as grams of carbon per unit area per unit time (e.g., gC/m²/day). A rough conversion from weight C to dry weight is $\times 2.2$” (Simmons 1979).

**Productivity (Land):** “The physical yield expected from a land unit assuming specified management practices and input. Productivity (land) the physical yield expected from a land unit assuming specified management practices and input levels” (Fedkenheuer et al. 1987).

**Productivity (Soil):** “The capacity of a soil, in its normal environment, for producing a specified plant or sequence of plants under a specified system of management” (Pierce et al. 1983). “The ‘specified management’ limitation is needed because no soil can produce all crops with equal success and a single system of management cannot produce the same effect on all soils. Productivity emphasizes the capacity of the soil to produce crops and is expressed in terms of yield” (Naeth et al. 1991). “In most reclamation operations, the productivity of the reclaimed land is controlled by the soil material in the topmost portion of the mined profile (Rogowski 1994).

**Productivity (Vegetation):** “The rate of change in biomass per unit area per unit time (usually growing season or year) (Barbour et al. 1987).

**Profession:** “Vocation or calling, especially one that involves some branch of advanced learning or science” (Sykes 1982). Any field of human endeavor is a reflection of its practitioner’s attitudes and actions (Douglas 1987). A profession can be defined as having the following structural components: systematic theory, community sanctions, ethical code and culture (Kerr et al. 1977). Unique expertise and neutrality, professional honesty, attention to detail, clarity of exposition and familiarity with technical literature (Clark 1986) are all attributes of a profession or group of experts. Structural requirements such as formal education and process requirements such as values, norms and assumptions are the critical attributes that bind professions together and identify their uniqueness (Vollmer and Mills 1966, Kennedy 1985). Professional norms (generalized rules governing behavior) may be in the form of a code of ethics (Luegenbiehl 1983) or emerge during the course of professional practice (Fortmann 1990). Group norms and beliefs are an important determinant of professional action.

**Professional Consulting Ecologist:** “A natural scientist by training who provides advice on ecosystem structure, function and management for a consulting fee” (Dorney 1989).
**Professional Ecologist:** “A broad generic description that can be subdivided into three groups: (1) professional consulting ecologist, (2) ecologist and (3) biological manager - wildlife, fisheries and (some) foresters” (Dorney 1989).

**Professional:** “Belonging to or connected with a profession” (Sykes 1982).

**Professional Recognition:** “Processes by which individuals are recognized as members of professional organization. Three general forms of professional accreditation are recognized: (1) professional certification - a procedure through which an individual’s credentials (education and experience) are reviewed and found to meet a standard adopted by an organization, (2) professional licensing - an effort on the part of the state [province] to protect the public (Drummond 1992), and (3) professional registration - a non-discriminatory listing of all individuals who have provided documentation of their background and experience to a central organization (Society for Restoration Ecology 1990).

**Professionalism:** “The qualities or typical features of a profession or professionals” (Sykes 1982). Professional integrity (sound principles, honesty, sincerity, objectivity) is important (Clark 1986). “The essence of professionalism is representing collective values that surmount special interests and temporary concerns. Professionalism in resource policy is the capacity to represent effectively these values in the midst of conflict, to guide resolution and to formulate its instruments, and to implement the consequences in a manner that is effective, publicly informative and accountable” (Romm 1984).

**Profile:** “A diagram representing a vertical section of soils and overburden and showing the ‘natural’ horizons in that material” (United States Department of Agriculture Forest Service 1979d).

**Program:** “An array of projects which might proceed concurrently or sequentially such as an energy program or transportation program” (Gilpin 1995).

**Project:** “A proposed installation, factory, works, mine, highway, airport, or scheme and all activities with possible impacts on the environment” (Gilpin 1995).

**Project Review:** An assessment of the socioeconomic and environmental impacts and benefits of a proposed development.
Promulgate: “To publish or make known officially” (Guralnik 1984).

Propagule: “A reproductive structure, or diaspor, produced by a plant for dispersal” (Forman and Godron 1986).

Progressive Working: “Method of extracting shallow mineral deposits by placing overburden, spoil or fill in worked out sections (‘over the shoulder’), allowing progressive restoration to the soil and vegetation” (Coppin and Bradshaw 1982).

Proponent: “The proposer (or applicant) of an activity, policy, plan, program or project in the private or public sectors. A proposal usually requires official approval or consent and during the process of obtaining this, the public have increased opportunities to voice opinions of support and objection” (Gilpin 1995).

Proponent Role: “Refers to the tasks of the individual, company or government department making a proposal” (Energy Resources Conservation Board 1978).

Proposal: “Refers to the project or activity contemplated by a proponent. The proponent may change and develop the proposal throughout the environmental assessment process” (Energy Resources Conservation Board 1978).

Prospecting: “The removal of overburden, core drilling, construction of roads, or any other disturbance of the surface for the purpose of determining the location, quantity, or quality of the natural mineral deposit” (United States Department of Agriculture Forest Service 1979c).

Protected Area: “Geographically defined areas which are designated or regulated and managed to achieve specific conservation objectives” (Federal-Provincial-Territorial Biodiversity Working Group 1994).

Protocol: “A set of rules governing communication and the transfer of data” (Guralnik 1984).

Provenance: “Region of origin of seeds obtained from forest trees; but also applied to grasses and herbs; important because of ecotypes adapted to local conditions” (Coppin and Bradshaw 1982).
Public (Environmental Issues): "Research indicates that it is important to distinguish between the 'general public' and the attentive public in seeking to understand how public input into natural resource policy-making process is likely to influence the direction of governmental affairs. The phrase general public refers to the public-at-large whereas the phrase attentive public refers to a subset of the general public which is interested and involved in a particular issue (Lovrich and Pierce 1986).

Public Inquiry or Hearing: "An opportunity for members of the public, voluntary bodies, and government agencies to express opinions before an independent and impartial commissioner of inquiry to enable issues about a controversial proposal to be fully discussed. The usual outcome is the submission of a report by the commissioner with recommendations to a decision-making body or minister, the report becoming immediately a public document. The success of the public inquiry hinges upon the choice, integrity and independence of the commissioner, and upon a political and social context which encourages full participation by all citizens, without fear of reprisal or discrimination. The public inquiry often stands at the apex of EIA processes" (Gilpin 1995).

Public Issue: "A subject or question of widespread interest related to management of a development [project] and identified through public participation" (United States Department of Agriculture Forest Service 1982).

Public Participation: Public participation in the planning process. The involvement of individual citizens and public interest groups concerned with maintaining the aesthetic and functional integrity of their environment as well as representatives of public agencies charged with responsibility of environmental planning and regulation is essential for environmental management. Public participation mechanisms are now in the project-planning schemes of many Western nations (Rubin and Carbajal-Quintas 1995).

Public Role: "Refers to opportunities for members of the public to participate in a process" (Energy Resources Conservation Board 1978).

Quality Assurance/Ouality Control (QA/QC): A program and protocol to ensure quality control in environmental compliance monitoring of air, water, solid liquid and soil sampling parameters. Special requirements for sampling devices, containers and preservatives are outlined for sampling plans and protocols. Requirements for method detection levels, reliable detection levels and levels of quantification are described in conjunction with laboratory reports and user presentation of data near analytical detection limits (Keith 1991).
Qualitative: “Descriptive; non-numerical” (Lincoln et al. 1982).

Quality of Life: “In current usage, a concept embracing a miscellany of desirable things not always recognized or adequately recognized in the marketplace. It embraces such highly relevant matters as real income, housing, and working conditions, health and educational services, and recreational opportunities which might be regarded as the general standard of living. Other highly relevant matters include community relationships, race relationships, civil liberties, compassion, justice, freedom, fair play, safety and security, law and order and environmental conditions” (Gilpin 1995).

Quantitative: “Numerical; based on counts, measurements, ratios or other values” (Lincoln et al. 1982).

Quarrying (Quarry): “The open surface excavation of mineral resources such as slate, granite, sand and gravel” (Jones et al. 1990).

Questionnaire Survey: “A survey is the scientific study of people - their personal characteristics and aspects of their knowledge, attitudes and behavior. The purpose of surveys may be to test hypotheses of theoretical behavior or provide practical information (Backstrom Hursh-Cesar 1981). “A survey consists of eight steps: (1) selection of the survey mechanism, (2) selection of sample, (3) development of procedures, (4) organization of logistical issues, (5) development of procedures for computerizing the results, (6) pilot study, (7) main survey, and (8) data analysis and reporting” (Sheskin 1985).

Questionnaire (Total Design Method): The total design method (TDM) relies on the theoretical view of the reasons why people do and do not respond to questionnaires. The basic tenet is that every small administrative detail that might affect the quality and quantity of response must receive attention. Each respondent is made to feel that their a personal effort is important (Dillman 1978). The TDM method was used by Lovrich and Pierce (1986) in a survey that examined general and attentive public’s attitudes towards water resource issues.

Radio Telemetry: The use of radio frequencies and electronic equipment to monitor movements of tagged or collared animals for the purpose of describing and analyzing habitat use and home range.

Range: Areas in which animals such as large mammals use on an annual basis (Lyon and Christensen 1992).
Raptor: “Any predatory bird such as a falcon, hawk, eagle, or owl that has feet with sharp talons or claws adapted for seizing prey and a hooked beak for tearing flesh” (Westar Mining Limited 1983).

Rare or Endangered Species: “Small populations of species that are not currently endangered or vulnerable, but are at risk. These species are usually localized within restricted geographical areas or habitats or are thinly scattered over a more extensive range” (Federal-Provincial-Territorial Biodiversity Working Group 1994). The following specific definitions for plants have been provided. “(1) A rare plant is one that has a small population within the province or territory. It may be restricted to a small geographical area or it may occur sparsely over a wider area. (2) A threatened plant is one that is likely to become endangered within the foreseeable future over all or a significant portion of its range in the province or territory. (3) An endangered plant is one which is in danger of extirpation throughout all or a significant portion of its range in the province or territory” (Straley et al. 1985).

Reach: “A portion of a river, used especially to describe a section between bends or locks” (Whittow 1984).

Reallocation: A general term used to describe what happens when a part of a landscape in any state is assigned a new use that does not necessarily bear an intrinsic relationship with the pre-disturbance ecosystems structure or functioning (Aronson et al. 1993).

Re-assembly Rules: See Assembly Rules.

Receiving Environment: An environmental protection term describing the environment external to the development or project site. The term is used as a general description for the air, water courses and landforms to which effluent discharges might be made.

Reclamation: “Returning the land to a condition and productivity conforming to a prior land-use plan that moves toward a balanced ecological state, that does not contribute substantially to environmental deterioration, and that is consistent with aesthetic values” (Box 1978).

Reclamationist: An individual practicing the reclamation or rehabilitation of anthropogenic disturbances. “Reclamationists are often engineers, agronomists or
foresters, although the number of ecologists entering the field is increasing” (Winterhalder 1993).

Reconstruction Soil: “A soil profile formed by selected placement of suitable overburden materials on reshaped spoils” (Leskiw 1993).

Recovery: “Ability of a system to return to an earlier state after being changed” (Forman and Godron 1986).

Recovery Index (Inertia Index): An index of rehabilitation recovery. The index is calculated as the product of six parameters, each estimated on a three-point scale: (1) proximity of recolonization sources, (2) mobility of propagules, (3) physical suitability of habitat for recolonization, (4) chemical suitability of habitat for recolonization, (5) toxicity of disturbed habitat, and (6) effectiveness of human management structures to facilitate rehabilitation procedures (Cairns and Dickson 1977).

Recovery Stability: “A state of low metastability, with relatively low biomass and many short-lived, rapidly reproducing species” (Forman and Godron 1986).

Recovery Time: A measure of how long it would take to replace a characteristic with a comparable one if it were disturbed or destroyed (Forman and Godron 1986).

Recreation: “Leisure-time activity undertaken away from home. Some degree of movement is inherent in all recreational activity, although a time scale to such movement is usually imposed such that recreation involves trips of less than day length whilst tourism involves overnight stays away from home” (Johnston et al. 1986).

Recreation Land: Land and water used, or usable primarily as sites for outdoor recreation facilities and activities (Energy Resources Conservation Board 1978).

Recruitment: “The influx of new members into a population by reproduction or immigration” (Ferson 1991).

Refer: “To refer a document means to send a document to someone to obtain comments or recommendations” (Energy Resources Conservation Board 1978).
Reference Areas: “Reference areas are unmined land units maintained under appropriate management to measure vegetation ground cover, productivity and other parameters such as species diversity. Reference areas represent the climate, geology, soil, slope and vegetation in a mining permit area. The selection of reference areas depends on the approved land-use for the revegetation area” (Vogel 1987). Several baseline data and regional technical standards have been developed. (1) Reference Areas - areas 2-5 acres identified by vegetation type that are not to be disturbed by mining to which performance of revegetated area is compared in terms of quantitative measurements of productivity, cover and diversity. Larger areas are called Extended Reference areas. (2) Control Area - is similar to a reference area except quantitative conditions of cover and production are determined during a test year. (3) Historical Record - in some cases, a cumulative record of cover, production and species diversity may be developed during the 5-7 year period prior to mining and used to estimate the reasonable expectation for each vegetation parameter. (4) Technical Standards - in some areas where circumstances prevent gathering of data on pre-disturbance conditions (extenuating circumstances such as overgrazing or wildfire) it is permissible to seek literature-based estimates of cover, production woody plant density or species diversity that can be used as performance standards for a particular site” (Buckner 1989).

Reforestation: “The natural or artificial restocking of an area with forest trees to yield commercial products” (Newton 1993).

Refuse: “The solid waste generated from a preparation plant. Usually composed of a coarse fraction disposed of by trucks and dumped in banks, and a fine fraction (tailings) disposed of hydraulically into settling lagoons” Bituminous Coal Research Incorporated 1974). “All the solid waste from a coal mine, including tailings and slurry. Other synonyms are: dirt, gob, shale and slate” (Thrush 1968).

Regenerated Patch: “An area that becomes free of disturbance within a chronically disturbed matrix” (Forman and Godron 1986).

Regeneration: “Replacement of old individual plants by younger members of the same species. Also, the normal growth of individuals through youth to maturity” (Burrows 1990).

Region: “An area, usually containing a number of landscapes, that is determined by a complex of climatic, physiographic, biological, economic, social, and cultural characteristics” (Forman and Godron 1986).
Regrading (Engineering): “The movement of surface soil and mineral deposits to change the shape of the land surface” (Richards et al. 1993).

Regulation: “(verb) The act of regulating; a rule or order prescribed for management or government; a regulating principle; a precept; rule of order prescribed by superior or competent authority relating to action of those under its control; regulation is rule or order having force of law issued by executive authority of government. (noun) Such are issued by various governmental departments to carry out the intent of the law. Agencies issue regulations to guide the activity of those regulated by the agency and of their own employees and to ensure uniform application of the law. Regulations are not the work of the legislature and do not have the effect of law in theory. In practice, however, because of the intricacies of judicial review of administrative action, regulations can have an important effect in determining the outcome of cases involving regulatory activity” (Black et al. 1990).

Regulatory Agency: The government organization responsible for regulation.

Regulatory Functionary: An individual that performs a regulatory function but does not understand fully the goal(s), objective(s) or process(es) involved in that function. The term is derogatory and can be ascribed to individuals in both government and industry.

Regulatory Inertia: The resistance of a regulatory agency to change practices or redirect their focus of attention.

Rehabilitation: Implies that the land will be returned to a form and productivity in conformity with a prior land-use plan, including a stable ecological state that does not contribute substantially to environmental deterioration and is consistent with surrounding aesthetic values (United States National Research Council 1974, Box 1978).

Rehabilitation Potential: “Pseudo-mathematical equation for evaluating the rehabilitation potential of a site. Rehabilitation potential is described by the formula: \[ RP=(C,A,LS,E,P,D,I,M) \], where \( C = \) climate (precipitation, amount and duration of solar radiation, temperature), \( A = \) aspect, \( LS = \) slope (stability of slope, surficial and/or deep seated slope failure), \( E = \) ecology (combination of the resiliency and the successional stage of indigenous ecosystem that is to be rehabilitated), \( P = \) degree of pedogenic development, \( D = \) degree or magnitude of disturbance, \( I = \) competition from introduced exotics and herbivory and \( M = \) soil management technique” (Newton 1993).
Reject: “The material extracted from the feed coal during cleaning for retreatment or discard. The stone or dirt discarded from a coal preparation plant, washery or other process, as of no value” (Thrush 1968).

Relief: “The elevations or inequalities of the land surface when considered collectively. Minor configuration is referred to as microrelief” (Holland 1976).

Remnant Patch: “An area remaining from a former large landscape element and now surrounded by a disturbed area” (Forman and Godron 1986).

Remote Sensing: Any technique for analyzing landscape patterns and trends using low altitude aerial photography or satellite imagery (Meffe and Carroll 1994).

Reproduction (Vegetative): “Reproduction by asexual processes such as budding or fragmentation; vegetative division; vegetative propagation” (Lincoln et al. 1982).

Reptile: “Any of a Class (Reptilia) of cold-blooded vertebrates having lungs, an entirely bony skeleton, a body covered with scales or thorny plates, and a heart with two atria and, usually, a single ventricle, including snakes, lizards, turtles and crocodiles” (Guralnik 1984).

Research: “Scientific or scholarly investigation” (Sykes 1982). There are two routes to scientific explanation: induction and deduction. Induction proceeds from particular cases to universal statements and deduction proceeds from some general a priori premise to statements about particular events (Sheskin 1985). Usually formulated around a ‘research problem’ (a question raised or to be considered for enquiry, consideration, decision or solution), research can be classified as (1) descriptive (collection of facts and figures), (2) problem-solving (observations of many phenomena for which adequate scientific explanation is lacking), (3) methodological (generally theoretical with the primary objective of developing a methodology or technique) and (4) law giving (providing a new concept, theory or law) (Chakravarti and Tiwari 1990). Many scientific hypotheses, theories and models are shaped by economic, cultural and political forces outside of the ‘laboratory’ (Prigogine and Stengers 1984). The most important influence of research may be through its effect on policy makers (Berry 1972).

Reserves (Geologic): “The tonnage and grade of a mineral deposit based upon geological interpretation, but on which more data are needed before mineable reserves may be established” (Teck Corporation 1995).
Reserves (Mineable): “The tonnage and grade of that part of a mineral deposit expected to be mineable economically under present and anticipated conditions” (Teck Corporation 1995).

Reservoir: “A pond, lake, tank, basin, or other space, either natural in its origin, or created in whole or in part by the building of engineering structures, which is used for storage, regulation, and control of water” (Thrush 1968).

Resilience: “The speed with which a system returns to its former state after a disturbance” (Forman and Godron 1986). “The ability to recover rapidly from disturbance (decreases during succession)” (Grime 1979). Resilience is an important indicator of ecosystem health or integrity.

Resistance: The ability of a system, when subjected to an environmental change or potential disturbance, to withstand or resist variation. Resistance is an ecosystem’s inertia in the face of change (Margalef 1969).

Resloping: See Landshaping.

Resource Development: The development and utilization of a renewable or non-renewable resource.

Resource Management: “A broad multi-disciplinary area or program of study concerned with the management of all natural resources, renewable or non-renewable, whether managed by private enterprise or public-sector agencies. Effective inquiry in the resources field cannot be confined to one discipline but must address the complex interrelationships that exist between the physical, social, economic and political systems” (Johnston et al. 1986).

Restoration: “Process of bringing back a derelict or disused industrial site to a properly functioning state; often used to imply the original or similar land-use” (Coppin and Bradshaw 1982).

Restoration Ecology: “The process of using ecological principles and experience to return a degraded ecological system to its former or original state” (Meffe and Carroll 1994).
**Restoration Blasting:** Restoration blasting is a technique used in sculpturing quarried rock faces to give them a natural appearance. When quarrying ceases, rock faces continue to evolve under the influence of weathering and erosion processes produce a predictable series of landforms. Under these situations, landform development has been shown to be influenced not only by natural geological discontinuities, such as joints, faults or bedding planes, but also by patterns of rock fractures resulting from the drilling and blasting methods used during excavation. The pattern of restoration drilling and blasting is therefore designed to construct a sequence of skeletal landforms, including rock buttresses, highwalls and screes, which would replicate natural landforms (Gunn and Bailey 1993).

**Retrograde System:** “A retrogressive or degrading system. A system is degrading if net plant production is decreasing, decomposition exceeds plant production and biomass decreases over time” (Forman and Godron 1986).

**Revegetation:** “Re-establishment of plant or ground cover following land disturbance” (Newton 1993).

**Review:** “An appraisal of a proposal on the basis of a relevant policy, plan or statutory mandate” (Energy Resources Conservation Board 1978).

**Reviewing Agency:** “A government agency that reviews a document and provides comments to the referring agency and/or proponent” (Energy Resources Conservation Board 1978).

**Review Process:** “Is a method of reviewing an application or proposal through an organized sequence of procedures” (Energy Resources Conservation Board 1978).

**Rhizobium:** Bacteria associated symbiotically with legumes in root nodules, which have the ability to fix atmospheric nitrogen (di-nitrogen fixation) (Vincent 1970).

**Rhizome:** “Underground stem of grasses, sedges and forbs by which many plant species spread and colonize new areas” (Burrows 1990).

**Rhizosphere:** The soil immediately surrounding plant roots that is influenced structurally or biologically by the presence of such roots, root zone (Phyllosphere) (Kluepfel 1993).
Richness (Index $d$): “A measure of species diversity calculated as $d = (S-I)/\log N$ where $S$ is the number of species in the habitat or community and $N$ is the total number of individuals of all species” (Lincoln et al. 1982).

Riparian Zone: “An area identified by the presence of vegetation that requires free or unbound water or conditions more moist than normally found in the area” (Daubenmire 1978).

Ripping (Deep Chiseling): “Deep cultivation of compacted soil using a shanked ripping tool attached to a dozer or grader” (Bituminous Coal Research Incorporated 1974).

Riprap: “Broken rock, cobbles, or boulders placed on earth surfaces, such as the face of a dam, bank of a stream or lining drainage channels, for protection against the action of water” (Bituminous Coal Research Incorporated 1974).

Risk: “The probability or chance that some undesirable event will occur” (Ferson 1991).

Risk Assessment: “Refers to population modeling that emphasizes stochastic factors and probabilistic outcomes with the focus on the construction of case-specific simulations to estimate risks of quasi-extinction or falling below a specified population size” (Burgman et al. 1993).

Risk Management: The management and control of environmental risk. “Risk management practices under the current environmental regulations is a long, complex process that considers scientific, technologic, and management factors to develop various regulatory standards and pollution control measures” (Venkateswara 1995).

Rock Drains: An engineered structure used for conveyance of streamflow beneath spoil dumps in valley fill situations (Nichols 1987). The most economical technique is to dump select, durable coarse waste rock from a minimum of about 20m so that natural segregation places large clasts in the valley bottom. Water is then allowed to pass through, although some sedimentation occurs (Lighthall 1989).

Rock-Fill Dam: “A dam composed of loose rock usually dumped in place, often with the upstream part constructed of handpacked or derrick-placed rock and faced with rolled earth or with an impervious surface of concrete, timber or steel” (Thrush 1968).

Ruderal: “A plant of waste places, usually associated with human disturbance. The world distinguishes this group of plants from ‘weeds’ which are plants that are a nuisance to human activities—the ruderal is not necessarily a nuisance” (Begon et al. 1990).

Ruggedness: “The sum of the slopes, valleys, peaks, exposures and elevations present” (Forman and Godron 1986).

Ruminant: “Herbivorous mammals such as cows that chew the cud and have complex stomachs containing microorganisms that break down the cellulose in plant material” (Begon et al. 1990).

Run-of-mine: “The material transported to the processing plant from an underground or surface mine prior to separation into coal and discard” (Richards et al. 1993).

Runoff: “The proportion of the precipitation on an area that is discharged from the area through stream channels. That which is lost without entering the soil is called surface runoff and that which enters the soil before reaching the stream is called ground water runoff or seepage flow from the ground water” (Foth 1978).

Sampling: “Procedures for selecting subjects from a population. They may be either scientific or nonscientific” (Sowell and Casey 1982). In order that every member of the population will have an equal chance of being selected, bias must be excluded from the procedure.

Scarification: Light cultivation of soil surface to improve the seed beds, prevent lamination between successive soil layers and increase water infiltration (Hodder 1975).

Science: “Systematic and formulated knowledge; a branch of knowledge, especially one that can be conducted on scientific principles” (Sykes 1982). Romesburg (1991) has provided three categories to explain how management benefits from science. (1) Applied Science - The main purpose of applied science is to provide knowledge to manage the natural environment for commercial or transcendental value. (2) Basic Science - The primary function of basic science is to understand nature simply for intrinsic understanding. (3) Applied-Basic - Applied-basic science is basic science conducted within an applied area. Knowledge can be described at the level of constructs.
or isolates. Constructs are well defined and directly measurable concepts developed to serve science. In contrast, isolates are special constructs isolated from direct observation.

Scope: “Refers to the range of issues pertinent to a particular process” (Energy Resources Conservation Board 1978).

 Seam: “A stratum or bed of coal” (Bituminous Coal Research Incorporated 1974).

 Sediment Dam: “A barrier or dam constructed across a waterway or other suitable location to form a sediment basin for the deposition and storage of silt, sand, gravel, stone, and other detritus” (United States Department of Agriculture Forest Service 1982).

 Sediment Structure (Pond): “A barrier or dam constructed across a waterway or in other suitable locations to form a silt or sediment basin” (Bituminous Coal Research Incorporated 1974). A water impoundment made by excavating a pit or dugout to provide a basin for the deposition and storage of sediment.

 Seed: “A matured ovule which contains an embryo and nutritive tissue and is enclosed in protective layers of tissue (seed coat)” (Young and Young 1986).

 Seedbed: “The soil prepared by natural or artificial means to promote the germination of seed and the growth of seedlings” (Young 1992).

 Seeding Rates: The rate at which seeds are broadcast during seeding. Application of appropriate seeding rates is important for successful revegetation (Richardson 1980).

 Seedling: “A juvenile plant which continues to mobilize any of its seed reserves regardless of whether or not it is necessary. Translocation of seed reserves may continue long after the plant has real dependence on them” (Fenner 1987).

 Seining: “Fishing with a net that has floats along the top edge and weights along the bottom” (Guralnik 1984).
Self-perpetuating: “Of a kind that causes or promotes indefinite continuation or renewal of itself or oneself” (Guralnik 1984).

Self-sustaining: “Supporting or able to support oneself or itself” (Guralnik 1984).


Shovel: “Excavating or coal-loading machine that utilizes a bucket mounted on and operated by means of a handle or dipper stick that moves longitudinally on gears and which is lifted or lowered by cable. The entire machine is mounted on crawlers for mobility and the upper structure is mounted on rollers and rail for swing or turn” (Bituminous Coal Research Incorporated 1974).

Sign: “Sign represents indirect evidence of an animal’s presence or use of a habitat (e.g., artifacts, bodies, cast antlers, excrement [droppings, scats and pellet groupings], feeding sign, territorial markings, path, sound, track)” (Luttmerding et al. 1990).

Site-Specific: Environmental conditions or management practices of characteristic of a particular location or habitat.

Slope Angle: “Ground that forms an incline; upward or downward slant or degree of slant” (Bituminous Coal Research Incorporated 1974).

Slope (Aspect): The orientation or aspect of a slope. Slope aspect influences the rate and mode of slope development which is fundamentally due to differential insolation (Haigh 1978).

Slope Stability: “The resistance of any inclined surface, as the wall of an open pit or cut, to failure by sliding or collapsing” (Bituminous Coal Research Incorporated 1974). Geomorphic stability of waste rock dumps and mine tailings containment structures is a crucial issue in rehabilitation planning and design (Riley 1995).

Snow: “Precipitation in the form of small tabular and columnar white ice crystals formed directly from the water vapor of the air at a temperature less than 0°C.” (Sykes 1982).
Society: “A community, nation or broad grouping of people having common traditions, institutions and collective activities and interests” (Woolf 1981).

Socioeconomic: “Involving both social and economic factors.” (Guralnik 1984).

Sociopolitical: “Of or involving both social and political factors” (Guralnik 1984).

Soil: The top layer of the earth’s surface where rocks have been broken down into relatively small particles through biological, chemical, and physical processes. Any mineral or organic material used as a plant growth medium, whether fertile or sterile (subsoil, topsoil) (Harpstead et al. 1988).

Soil Analysis: A number of parameters sampled to characterize physical and chemical properties for description and management. A complete set of soil analyses should be performed well before seeding and planting so that low levels of available plant nutrients and potentially limiting physical and chemical properties can be identified (Ames 1980).

Soil Bulk Density ($D_b$): “The dry weight of a unit volume of soil in its field state. Bulk density is often expressed in grams per cubic meter or centimeter” (Coppin and Bradshaw 1982).

Soil Chemistry: The chemistry of the soil liquid phase. The chemical reactions which occur in soil affect the stability of structural units and the activities of macro- and micro-organisms. Soil chemical properties regulate the availability of essential major elements (nitrogen, phosphorous, potassium, sulfur, calcium and magnesium) and trace elements (boron, copper, iron, manganese, molybdenum and zinc) (Cresser et al. 1993).

Soil Consistence and Surface Resistance: “The attributes of soil material as expressed in its degree of cohesion and adhesion or in its resistance to deformation or rupture” (Naeth et al. 1991).

Soil Coarse Fragment Content: “Rock or mineral particles greater than 2 mm in diameter” Bituminous Coal Research Institute 1974).

Soil Drainage: “The frequency and duration of the periods when soil is free of saturation or partial saturation” (Naeth et al. 1991).
**Soil Fauna (Size Categories):** “Soil fauna have been divided into four size categories. (1) Microfauna (<200 µm), (2) Mesofauna (200 µm - 2 mm), (3) Macrofauna (2 - 20 mm), and (4) Megafauna (>20 mm) (Majer 1989).

**Soil Fertility:** “The status of a soil with respect to its ability to supply the nutrients essential to plant growth” (Foth 1978).

**Soil Fungi:** Fungi found inhabiting or completing portions of their life cycle within the soil ecosystem (St. John 1984).

**Soil Horizon:** “A layer of soil material approximately parallel to the land surface and differing from genetically related layers in physical, chemical and biological properties or characteristics such as color, structure, texture, consistence, kinds and numbers of organisms present, degree of acidity or alkalinity” (Naeth et al. 1991).

**Soil Moisture:** The water content of soils (Naeth et al. 1991).

**Soil Reaction (pH):** “A notation designating acidity and alkalinity, and standing for the negative logarithm to base 10 of the hydrogen ion concentration in a solution; a pH of 7 indicates neutrality; higher values indicate alkalinity and lower values indicate acidity” (Bituminous Coal Research Incorporated 1974). Soil pH serves as an indicator of conditions that influence nutrient availability, soil organism activity, physical properties of soils and toxicity of substances (Bradshaw and Chadwick 1980).

**Soil Science:** “The science dealing with soils as a natural resource on the surface of the earth, including soil formation, classification and mapping, and the physical, chemical, biological and fertility properties of soils per se, and these properties in relation to their management for crop production” (Foth 1978).

**Soil Texture:** “The relative proportions of the three soil separates (sand, silt and clay)” (Harpstead et al. 1988).

**Soil Water-holding Capacity:** “The ability of a soil to retain water” (Harpstead et al. 1988).

**Soluble Salts:** Soluble salts present in the soil solution. “The concentration of soluble salts in the soil influences moisture availability, since salts retain moisture osmotically.
Saline soils have concentrations of salts which are sufficiently high to 'compete' osmotically with vegetation, thus causing plants to wilt even when considerable water is present” (Scholl 1986).

**Space-for-time-substitution:** See Chronosequence.

**Spawning:** “The act of producing and disseminating eggs or egg masses in aquatic organisms” (Lincoln et al. 1982).

**Species Diversity (Phylogenetic Diversity):** See Ecological Diversity.

**Species Performance Trials:** Experimental trials (e.g., field, nursery and greenhouse) designed to assess plant species performance.

**Spoil:** “Bulk waste geological material produced alongside the marketable mineral; production waste, substandard and unmarketable material, or overburden that has to be discarded” (Thrush 1968).

**Spoil Dump (Spoil Bank, Spoil Pile, Tip, Pile, Overburden Dump, Waste Dump):** “An area on which overburden and other excavated spoil is deposited, usually by downhill dumping in surface mines on mountainous terrain. Also called cast overburden” (Thrush 1968).

**Stability (Ecological):** “The condition of a system characterized by a variation curve with a level general tendency and a large or small regular oscillation” (Ferson 1991). Ecosystem stability can be described by the terms constancy, persistence, resistance or resilience (elasticity, amplitude, hysteresis and malleability) (Hill 1987).

**Stage I:** “In British Columbia, the initial stage of the mine development review process during which the proponent of a mine development submits a prospectus or letter of intent. Terms of reference are established and the proponent must then prepare and submit a Stage I assessment to the regulatory agency for screening” (Andrews and Higham 1986).

**Stage II:** “In British Columbia, the regulatory agency (steering committee) sets the terms of reference for a more detailed project description based on review of Stage I.
The proponent then prepares and submits a detailed assessment of the proposed mine development for government review" (Andrews and Higham 1986).

**Stage III:** "In British Columbia, following approval-in-principle, the proponent makes direct application to regulatory agencies for the necessary permits and licenses" (Andrews and Higham 1986).

**Stakeholder:** A person or group with a share or interest in an enterprise, issue or project (Woolf 1981).

**Standing Crop:** “The biomass of living organisms within a unit area” (Begon et al. 1990).

**Static Factor of Safety:** “A safety factor is a ratio of resisting forces to driving forces. Several common methods can be used to calculate a safety factor and thus obtain some numerical index of stability. If the safety factor is greater than one, the resisting forces are larger than the driving forces and the slope or slide is stable. If the safety factor is just equal to one, equilibrium exists. If the safety factor is less than one, the resisting forces are smaller than the driving forces and the slope or slide is unstable and will probably move” (United States Department of Agriculture Forest Service 1979e). Engineers incorporate safety factors, which are the profession’s admission that their knowledge is incomplete. A smaller safety factor is used for better understood systems and a larger one for less well understood systems (Romesburg 1991).

**Statute:** “(1) An established rule; formal regulation. (2) A law passed by a legislative body and set forth in a formal document” (Guralnik 1984).

**Sterilization-of-the-resource:** Extraction and waste disposal of a portion of the resource which eliminates further extraction in the future.

**Stewardship:** “Management of natural resources that conserves them for future generations. Usually used to distinguish from short-term, utilitarian management objectives” (Meffe and Carroll 1994).

**Stocking (Stocking Density):** “A general term for the number of trees or basal area per acre [hectare] relative to some desirable number or basal area for best growth and management” (Cooper et al. 1991).
Stock Pile: “Storage of soils materials (growing media) for later use” (United States Department of Agriculture Forest Service 1979d).

Strip Mine: “Refers to a procedure of mining which entails the complete removal of all material from over the product to be mined in a series of rows or strips; also referred to as an open pit, or surface mine” (Bituminous Coal Research Incorporated 1974).

Subalpine: An area located altitudinally between the treeless alpine zone and the closed montane forest of lower elevations and characterized by discontinuous tree growth (Billings 19t).

Subpopulation: “An identifiable fraction or subdivision of a population” (Woolf 1981).

Succession (Autotrophic or Plant): Succession has been defined as the temporally dependent sequential change in the relative abundances of species (Grubb 1987, Huston and Smith 1987) which is a consequence of their differential dispersal, germination, growth, survival, life span and competitive abilities in response to disturbance (Drury and Nisbet 1973, Rebele 1992). As the number of individuals increases on the area, interspecific interactions begin to occur and certain species are replaced. Clements (1916) categorized the major successional processes into phases: (1) nudation (disturbance initiation), (2) migration (in situ and ex situ propagule arrival), (3) ecesis (species establishment and growth), (4) reaction (alteration of abiotic environment and feed-back effects on plants), (5) competition and (6) stabilization (control of habitat conditions by vegetation). The general approach of Clements is considered to be important in understanding how succession can be manipulated through reclamation practices on surface mine disturbances (MacMahon 1987, Redente and DePuit 1988).

Succession (Heterotrophic): “A temporal succession of species at a location, principally involving animals” (Begon et al. 1990).

Succession (Managed): Manipulating the succession process for desired management objectives. Succession management includes three components: (1) designed disturbance, (2) controlled colonization, (3) controlled species performance (Rosenberg and Freedman 1984, Luken 1990). In contrast to ‘natural succession’, managed succession artificially attempts to compress the process of plant establishment into a single period, regardless of an inability to predict environmental episodes necessary for seedling establishment. Revegetation of disturbed lands is often initiated using a hybrid of agricultural (Parmenter and MacMahon 1992) and horticultural (Burkhart 1988) practices, so many individuals conceptualize reclamation as an instantaneous
phenomena where plants are introduced and rapidly establish to form a permanent, static community (DePuit 1986). This perception may be valid on sites where aftercare is maintained (Polster 1989), but is invalid on those sites with long-term dynamic processes and low intensity management regimes (Call and Roundy 1991).

**Suitability Analyses:** Suitability can be defined as the ‘fitness’ of a particular area for a defined use (Steiner 1983). Within this process, matrices of degrees of suitability of several variables (land-use, aesthetics, landforms, soils, hydrology, vegetation) are used to determine alternative land uses (Rowe 1977, Erickson 1979). Suitability analyses are very important in landscape planning (Steiner and Brooks 1981).

**Surety:** “Something that makes sure or gives assurance, as against loss, damage, or default; security; guarantee” (Guralnik 1984).

**Surface Mine Control and Reclamation Act (SMCRA):** “Under terms of this act which became effective in 1977, mining companies must restore a strip-mined area to its original condition within the limits of available technology” (Owen 1985). The SMCRA originates in Washington DC and is administered by the Office of Surface Mine Reclamation and Enforcement (OSMRE), Department of Interior.

**Surface Mining:** “A broad term that refers to any process of removing earth, rock and any other material in order to extract the underlying mineral deposit” (United States Department of Agriculture Forest Service 1982). “Strip and contour mines are two specific types of surface mines” (Thrush 1968).

**Surficial Geology:** The geology of surficial or parent materials (e.g., morainal, lacustrine), excluding bedrock geology.

**Surveillance:** “An extended program of surveys undertaken in order to provide a time series; to ascertain the variability and/or range of states or values which might be encountered over time; without preconceptions of what these might be” (Hellawell 1991).

**Survey (Ecological):** “An exercise in which a set of qualitative or quantitative observations are made, usually by means of a standardized procedure and within a restricted period of time” (Usher 1991).
Suspended Solids: “Sediment which is in suspension in water but which will physically settle out under quiescent conditions (as differentiated from dissolved material)” (Bituminous Coal Research Incorporated 1974).

Sustainable Development: “Sustainable development is development which meets the needs of the present without compromising the ability of future generations to meet their own needs. To attain sustainable development, the following must be achieved: (1) meeting essential needs for jobs, food, energy, water and sanitation, (2) ensuring a sustainable level of population, (3) conserving and enhancing the natural resource base; (4) re-orienting technology and managing risk, (5) merging environmental issues and economics in decision-making, and (6) changing the quality and rate of growth” (World Commission on Environment and Development 1987). “Sustainable development in mining can only be achieved through continuous exploration, technological innovation and environmental rehabilitation” (von Below 1993).

‘Sympathetic Administration Syndrome:’ A situation in which discretionary abuse within the regulatory process results from the presence of a benevolent bureaucrat.


Tackifier: “A chemical emulsion which binds mulch fibers together during the hydroseeding or hydromulching process” (Richards et al. 1993).

Tailings: “Fine refuse from a milling operation that is usually deposited from a water medium” (Thrush 1968).

Tailings Dam or Pond: “Impoundment to which slurry is transported, and in which the solids will settle and the liquid may be withdrawn” (Energy Resources Conservation Board 1978).

Talus (Scree): The accumulation of broken rocks that occurs at the base of cliffs or other steep slopes. Sheets of fine to coarse colluvial rock debris on slopes (Whittow 1984).

Target Species: “A species being managed for a specific purpose (Hays 1985).
**Tar Sands**: “Tar sands are rocks that are impregnated with tar oil, asphalt, or other petroleum materials and from which recovery of petroleum products by usual methods such as oil wells is not commercially possible” (Keller 1979).

**Taxon (Taxa)**: “A taxonomic group of any rank, such as subspecies, species or genus” (Daubenmire 1978).

**Technical**: “Having to do with the practical, industrial, or mechanical arts or the applied sciences” (Guralnik 1984).

**Technological Forcing**: “The process of enacting regulations that require industry to develop new technology in order to comply with performance standards. ‘Technological forcing’ has often resulted in tension between industry and regulatory agencies” (Dickson 1988). Examples of technological forcing are the Approximate Original Contour requirement and native plant species procurement requirements of the SMCRA in the United States, and the topsoil requirement of the reclamation guidelines in Alberta.

**Technocentrism (Technological Determinism)**: Technological determinism - environmental problems have technical solutions (Carpenter and Kennedy 1980, Miller 1985d). A deep schism exists between biotechnologists (man can improve nature) and bioconservatives (preservation of the biological and ecological status quo). In other words, the deleterious side effects of technology are difficult to reconcile with environmental policies (Sagoff 1986).

**Terraced Slope**: “A slope that is intersected by one or more terraces. “Sloping ground cut into a succession of benches for purposes of controlling surface run-off, minimizing soil erosion, and assisting re-vegetation; also called a berm” (Bituminous Coal Research Incorporated 1974).

**Terrain**: “The physical characteristics of the natural features of an area, i.e.: its landforms, vegetation and soils” (Whittow 1984).

**Terrestrial Wildlife**: “Wildlife species that dwell primarily on land” (Westar Mining Limited 1983).

**Terricolous**: “Living on or in soil” (Lincoln et al. 1982).
**Tessera:** “The smallest homogeneous unit visible at the spatial scale of a landscape” (Forman and Godron 1986).

**Tessellation:** “A careful juxtaposition of elements into a coherent pattern” (Sykes 1982).

**Till:** “The debris deposited by a glacier” (Burrows 1990).

**Timberline:** The boundary between subalpine forest and alpine meadow which may imply the upper altitudinal edge of continuous forest, the altitude of the highest tree, or the midpoint between this range. Several components to timberline: (1) forest line - edge of continuous forest, (2) lower kampf-zone - above forest-line forest with openings which increase in area with elevation until the forest occurs in discrete islands surrounded by alpine heath and meadow vegetation, (3) middle kampf-zone - increasing elevation trees become multi-stemmed, stunted and form low sprawling twisted dense colonies termed krummholz, (4) sprawling colonies are snow covered during winter and have been referred to as the infra-cushion growth form (Ogilvie 1978).

**Time Series Analysis:** “A time series is a collection of observations made sequentially in time. Representative time series are economic (profits, costs, prices over time), physical (meteorological processes) and process control (performance of manufacturing process). Time series may involve continuously sampled observations (continuous) or involve observations recorded only at specific, usually equally spaced times (discrete). Time series can be predicted exactly (deterministic) or the future may only be partly determined by past events (probabilistic). The objectives of times series analyses are description, explanation, prediction and control. Types of variation are seasonal, cyclic, trends, irregular fluctuations (moving average or autoregressive models). The major diagnostic tool is the autocorrelation function which helps to describe the evolution of a process through time” (Chatfield 1989).

**Tip (Mining):** “A deposit of discard” (Richards et al. 1993).

**Toe:** “The point of contact between the base of an embankment or spoil bank and the foundation surface. Usually the outer portion of the spoil bank where it contacts the original ground surface” (Bituminous Coal Research Incorporated 1974).

**Topography:** “The shape of the ground surface, such as hills, mountains or plains. Steep topography indicates steep slopes or hilly land; flat topography indicates flat land with minor undulations and gentle slopes (Whittow 1984).
Topographic Modification: See Landshaping.

Topophilia: “The human being’s affective ties with his or her material environment, and particularly with specific places or settings: according to Yi-Fu Tuan (1974) it ‘couples sentiment with place’ (Johnston et al. 1986).

Toposequence: “A distinct spatial pattern present on a topographic gradient” (Burrows 1990).

Topsoil: “(1) Presumed fertile soil material used as a top dressing. Distinction has been made among synthetic, weathered, and geologic topsoil. Synthetic topsoil can include sand and stone chips as well as fly ash, sawdust, or manure not usually a part of geological soil and rock. Weathered topsoil is the natural top-dressing material that has been subjected to weathering throughout geologic time (Bituminous Coal Research Incorporated 1974). (2) “Surface soil material enriched with organic matter and humus (A horizon)” (Foth 1978).

Topsoiling (Reclamation): Application of topsoil to mining waste material to improve minesoil productivity. Although the absence of well-developed soils at high elevations limits cost effectiveness and practicality (Brown and Johnston 1980), topsoil application as opposed to direct treatment of overburden or regosol (Bradshaw 1984) may be a useful alternative for soil reconstruction on very difficult sites (Redente et al. 1982). If placed at sufficient depth, topsoil is usually a better growth medium because of greater moisture (Johnson 1987) and nutrient retention capacities (Schuman et al. 1985).

Toxicity: “Presence of chemicals in a concentration antagonistic to the growth or survival of plants or animals” (Coppin and Bradshaw 1982).

Trace Element: “Any of various chemical elements that occur in very small amounts in organisms and are essential for many physiological and biochemical processes” (Jones et al. 1990).

Transplant Establishment: The establishment or outplanting of containerized seedlings. Plant survival rates are generally high when transplanting is accomplished in the fall with dormant containerized stock, and when rigorous planting procedures are followed (Brown and Johnston 1980).
Trophic Level: “The classification of organisms according to their mode of feeding: primary or autotrophic; secondary or heterotrophic (herbivorous); tertiary or heterotrophic (carnivorous); saprophytic (detrivorous)” (Burrows 1990).

Truck (Haul Truck): A large ore or coal haulage unit.

Underground Mining (Deep-Mining): “The extraction of deep-lying mineral resources from subsurface workings. Deep mining usually involves the driving of a vertical shaft from the surface down to the level of the mineral deposits which are then accessed by means of horizontal tunnels. Many different mineral resources are exploited by deep-mining techniques including metalliferous ores, building stone, coal, precious stones, sulfur, potash and rock salt” (Jones et al. 1990).

Understory: “In a forest stand, that portion of the trees below the overstory, including seedlings, saplings and suppressed trees” (Cooper et al. 1991).


Utilitarian: “Stressing usefulness over beauty or other considerations” (Guralnik 1984).

Value Judgment: “An estimate made of the worth, goodness et cetera of a person, action event or the like” (Guralnik 1984).

Values: “The social principles, goals, or standards held or accepted by an individual, class or society” (Guralnik 1984).

Variance: “Official permission to bypass regulations” (Guralnik 1984).

Vascular Plant: “A plant with a specialized conducting tissue or tubes (i.e., phloem and xylem) for internal vertical movement of liquids” (Forman and Godron 1986).

Vegetation: “General term including grasses, legumes, shrubs, trees occurring naturally and/or planted intentionally” (Bituminous Coal Research Incorporated 1974).
Vertebrate: Any of a large subphylum (Vertebrata) of chordate animals, including all mammals, fishes, birds, reptiles, and amphibians, characterized by a segmented spinal column and a brain enclosed in a brainpan or cranium" (Guralnik 1984).

View: "Something, especially a broad landscape or panorama that is looked toward or kept in sight; the act of looking toward this object or scene" (Province of British Columbia 1981).

Visitor Employed Photography (VEP): VEP is a perceptual inventory or landscape assessment technique which involves the distribution of inexpensive and easily operated cameras to a sample of the users of a particular corridor or linear route of travel. The route of travel is only suggested, not regimented. Visitors frequently photograph similar scenes and this commonality of response is measured by consensus photographs. A consensus photograph (CP) represents a particular scene photographed by a percentage equal to or greater than a specified number of sampled users (Cherem and Driver 1983).


Visual Quality (Landscape): Three major tasks in determining a landscape's visual quality: (1) views must be sampled, (2) visual quality must be assessed, (3) assessments must be summarized. Experts or aestheticians can be employed (Hull and Revell 1989). Landscape features that enhance scenic beauty include water, distance and depth of view, parklands, low vegetation, ephemeral features (e.g., snow and flowers), natural and verdant vegetation and rugged terrain (Buhyoff and Wellman 1980, Zube et al. 1982, Ulrich 1983, Herzog 1987, Smardon 1988).

'Vital Attribute': Any attribute of a species which is vital in determining its role or position in the vegetation replacement process. Vital attributes considered to be important include: (1) methods of recovery from disturbance (vegetation spread, seedling pulse from seedbank, seedling pulse from surrounding vegetation), (2) the ability to establish in the presence of competition and (3) the time required to reach critical life-history stages (Noble and Slatyer 1980).

'Vital Ecosystem Attribute': "Those characteristics or attributes that are correlated with and can serve as indicators of ecosystem structure and function" (Aronson et al. 1993). 'Vital ecosystem attributes' as related to structure include: (1) species richness, (2) total plant cover, (3) beta diversity (the extent of species replacement or biotic change along environmental gradients) (Whittaker 1972), (4) alpha diversity (number of

**Void Ratio:** “The ratio of the bulk density to the particle density of a soil, a measure of the amount of air space (Porosity)” (Coppin and Bradshaw 1982).

**Volunteer:** “Springing up spontaneously or without being planted; a volunteer plant” (Bituminous Coal Research Incorporated 1974).

**Vulnerable Species:** “Any indigenous species of flora or fauna which is not classified as a threatened species, but is particularly at risk because of low or declining numbers; occurrence at the fringe of its range or in restricted area or some other reason” (Province of British Columbia Ministry of Environment, Lands and Parks and Environment Canada 1993)

**Waste (Hazardous):** “A term which refers to all substances, including toxic wastes, that present an immediate or long-term human health risk or which pose a health risk to the environment” (Jones et al. 1990).

**Waste (Toxic):** “Any discarded material, commonly from industrial or commercial processes, capable of causing injury or deaths to living organisms” (Jones et al. 1990).

**Water Bar (Cross Ditch):** “Any device, structure, or excavation upon a haul or access road for the purpose of channeling or diverting the flow of water off the road” (Bituminous Coal Research Incorporated 1974).

**Water Control Structures:** Engineered structures designed to control water flow (e.g., dams, interceptor ditches, sediment ponds, tailings impoundments).

**Waterfowl:** “A water bird; especially one that swims, swimming game birds” (Guralnik 1984).
**Water Quality:** See Ambient Air or Water Quality.

**Watershed:** “The area drained by a river or stream and its tributaries” (Forman and Godron 1986).

**Water (Subsurface):** “Water that occurs beneath the surface of the earth. It may be liquid, solid or gaseous state. It comprises suspended water and ground water” (Bituminous Coal Research Incorporated 1974).

**Water Table (Phreatic Surface):** “The upper surface of the ground water or that depth below which the soil is saturated with water” (United States Department of Agriculture Forest Service 1979c).

**Weathering:** “The group of processes, such as chemical action of air and rainwater and of plants and bacteria and the mechanical action of changes in temperature, whereby rocks, on exposure to the weather, change in character, decay, and finally crumble” (Bituminous Coal Research Incorporated 1974).

**Weed:** “A plant growing where man does not want it to grow” (Daubenmire 1978).

**Weighted Slope Averages:** “Quantified comparisons between pre-mining and reclaimed landscapes are required in several regulatory jurisdictions. However, comparisons are difficult and more often than not subjective because landforms do not lend themselves to normal randomized sampling techniques and statistical comparisons of sampled parameters” (Friedlander 1994).

**Weir:** “A notch over which liquids flow and which is used to measure the rate of flow. A dam across a stream for diverting or measuring the flow” (Bituminous Coal Research Incorporated 1974).

**Wilderness:** “With regard to recreation, refers to an environment that is dominated by nature and is relatively unmodified by humans” (Bell et al. 1990).

**Wild Flora and Fauna:** “Any wild species including mammals, birds, fishes, reptiles, amphibians, invertebrates, plants, fungi, algae, bacteria, viruses and other wild organisms” (Federal-Provincial-Territorial Biodiversity Working Group 1994).
Wildlife: "Undomesticated vertebrate animals, except fish, considered collectively" (Bituminous Coal Research Incorporated 1974).

Wildlife or Fisheries Ecologist (Biologist): "A natural scientist by training interested in faunistic studies and management based on ecological principles, especially on studies of population and sustained yield" (Dorney 1989).

Zoology: "The science, a branch of biology, that deals with animals, their life, structure, growth and classification" (Guralnik 1984).
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