Reclamation of Lands Disturbed by Mining

Proceedings of the Sixth Annual British Columbia Mine Reclamation Symposium

Vernon, B.C.
March 10-12, 1982

PAPER 1983–2

Province of British Columbia

Ministry of Energy, Mines and Petroleum Resources

INSPECTION AND ENGINEERING BRANCH

SPONSORED BY
TECHNICAL AND RESEARCH COMMITTEE ON RECLAMATION
BRITISH COLUMBIA MINISTRY OF ENERGY, MINES AND PETROLEUM RESOURCES
AND
THE MINING ASSOCIATION OF BRITISH COLUMBIA

RECLAMATION OF LANDS DISTURBED BY MINING

PROCEEDINGS

of the

SIXTH ANNUAL BRITISH COLUMBIA

MINE RECLAMATION SYMPOSIUM

Convened at

Vernon Lodge

Vernon, British Columbia

on

March 10, 11, and 12, 1982

Sponsored by

Technical and Research Committee on Reclamation

British Columbia Ministry of Energy, Mines and Petroleum Resources

and the

Mining Association of British Columbia

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EDITOR'S NOTE

These proceedings present the papers in chronological order. Papers have been briefly edited and retyped. Time constraints prohibited final text proofreading by individual authors, consequently, the editor accepts responsibility for any errors.

J.C. Errington

OPENING REMARKS

R.J. Berdusco
Chairman

Technical and Research Committee on Reclamation

OPENING REMARKS

Ladies and gentlemen, welcome to the Sixth Annual British Columbia Mine Reclamation Symposium.

As Chairman of the Technical and Research Committee on Reclamation, I would like to thank all of you for contributing to such a strong turnout. I am particularly pleased that in such lean economic times, enough corporations, institutions and individuals find this event of high enough priority. It is a good sign.

Thanks also to the many speakers who contributed technical papers and other information. Without you we would not have the opportunity to get together and compare notes on mine reclamation and renew old friendships.

Thanks are also extended to the committee members for their year-round work and in particular John Errington, Art O'Bryan, Ron Hillis, Jake McDonald and Bob Gardiner of the symposium committee.

We are grateful for the continuing support for committee work, including the annual symposium, which is provided by the Mining Association of British Columbia and the Ministry of Energy, Mines and Petroleum Resources.

KEYNOTE ADDRESS

BRITISH COLUMBIA'S ENERGY
REVIEW PROCESS

by

E.R. Macgregor
Energy Resources Division
Ministry of Energy, Mines and Petroleum Resources

Note: The text of Mr. Macgregor's address was not available for publication, however, an outline of his presentation notes are included.

THE ENERGY REVIEW PROCESS

CONTEXT

- Utilities Commission Act
- Regulated Projects

ENERGY REVIEW PROCESS

- Purpose
- Procedures
- "Disposition" Options
- Inter-Agency Framework

ENERGY PROJECT CERTIFICATE

- Requirements
- Application Process
- Pre-Application
- Application

ENERGY REMOVAL CERTIFICATE

- Purpose
- Requirements
- Handling

UTILITIES COMMISSION ACT

KEY FUNCTIONS

1. Approval of major, "regulated" energy projects

    - energy project certificate
    - energy operation certificate

2. Approval of energy removals from the province

    - energy removal certificate

3. Regulation of public utilities

    - B.C. Utilities Commission responsibilities and authority

        - gas utilities
        - electricity
        - B.C. Hydro

"REGULATED ENERGY PROJECTS UNDER
PART 2 (SECTION 16) OF THE ACT

"Regulated projects" are defined according to the amount of energy used or involved in production or transmission. This includes new projects and additions to existing projects falling within defined limits, as follows:

Transmission Lines	- 500 kV or higher
Pipelines	- capable of transporting 16 pj per year
Transshipment or Storage Facilities	- capable of storing 3 pj energy equivalent to 482,000 barrels of crude oil or 2.8 billion cubic feet of natural gas
Electricity	- a hydro or thermal power plant, or an addition to a plant, of 20 MW or higher
Energy Use	- any new project capable of using 3 pj per year, or the addition of 3 pj to an existing project
Other	- an undertaking of any kind that the Lieutenant Governor in Council designates to be significant in the matter of energy

ENERGY REVIEW PROCESS

- The "Energy Review Process" describes the process for review of applications under the Utilities Commission Act.

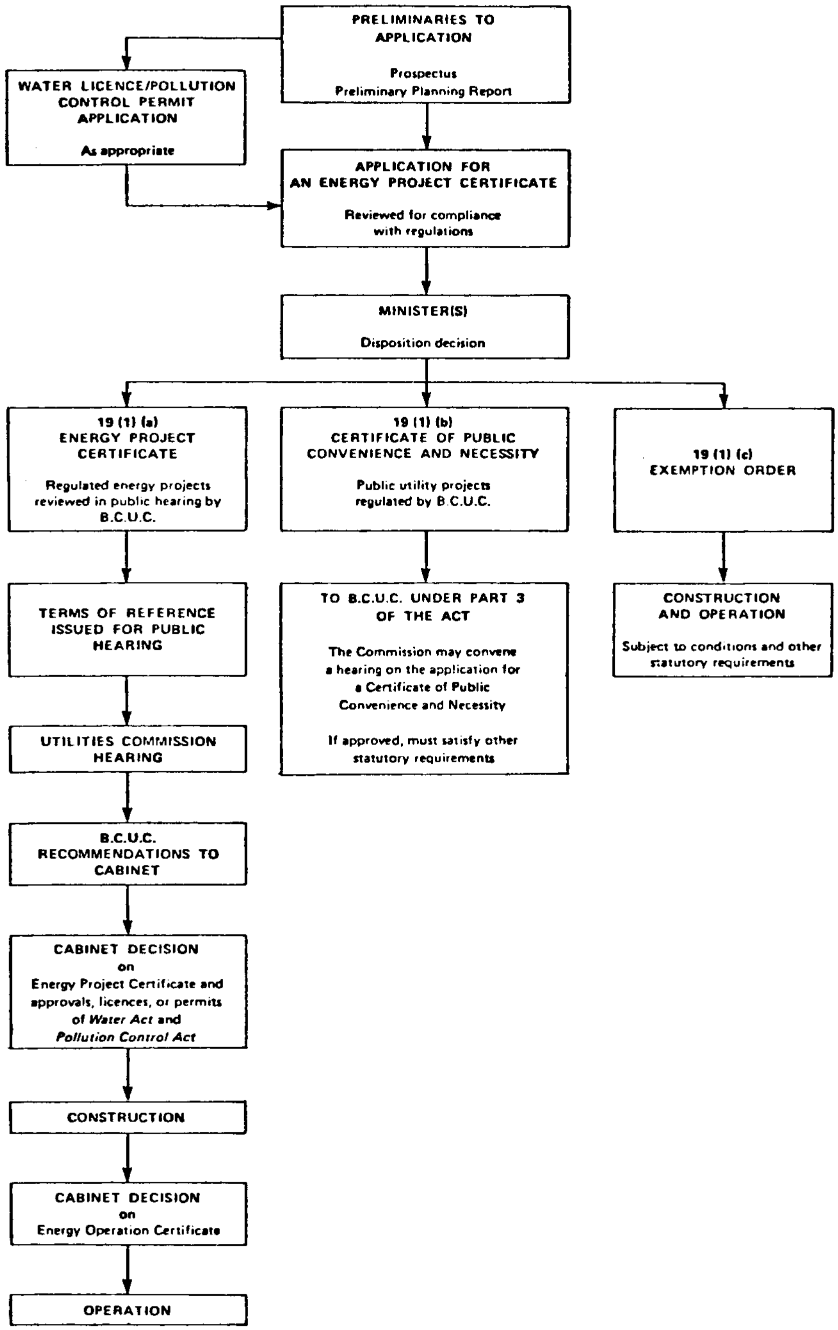
- Intended to evaluate proposals for development and use of B.C.'s energy resources, primarily in terms of energy and environment policies.

  Aim is toward integration and streamlining.

- The process is used to work with applicants and to assist Ministers in making "Disposition Decisions" under Section 19 of the above Act.

  Decisions set subsequent course.

ENERGY PROJECT REVIEW: CERTIFICATION PROCEDURES



DISPOSITION: OPTION 1

REVIEW BY COMMISSION/DECISION BY CABINET
SECTION 19 (1)(a)

- Minister of Energy, Mines and Petroleum Resources, with the concurrence of the Minister of Environment, may refer the application to BCUC for review according to Terms of Reference specified by the Ministers. The Terms of Reference may include a requirement that the Commission recommend whether or not a Pollution Control Permit and/or Water Licence be issued.

- Commission conducts a public hearing on the application according to its own procedures.

- Commission's report and recommendations are submitted to Cabinet.

- Cabinet decides upon issuance of an Energy Project Certificate and, where appropriate, a Pollution Control Permit and/or Water Licence. Terms and conditions may be specified.

- Upon completion of construction, and substantial compliance with the Energy Project Certificate, Cabinet issues an Energy Operation Certificate, with any necessary terms and conditions.

DISPOSITION: OPTION 2

REVIEW AND DECISION BY COMMISSION
SECTION 19 (1)(b)

- Where a public utility applies for an Energy Project Certificate, the Minister of Energy, Mines and Petroleum Resources may refer the application to the Commission to be considered under Part 3 of the Act.

- The Commission, at its discretion, may hold a public hearing on the application.

- If approved, the Commission issues a Certificate of Public Convenience and Necessity with terms and conditions required in the public interest.

- The Commission is responsible for ongoing regulation of any public utility operating in the province.

DISPOSITION: OPTION 3

EXEMPTION
SECTION 19 (1)(c)

- Minister of Energy, Mines and Petroleum Resources, with concurrence of the Minister of Environment, may order that the construction and operation of a project be exempt from some or all of the provisions of the Act.

- Terms and conditions may be specified by the Ministers.

Province of British Columbia

Ministry of
Energy, Mines and
Petroleum Resources

ENERGY PROJECT REVIEW: INTER–AGENCY FRAMEWORK

ENERGY PROJECT COORDINATING COMMITTEE

Ministry of Energy, Mines and Petroleum Resources
(Project Analysis Branch)
Ministry of Environment (Assessment Branch)
British Columbia Utilities Commission (Staff Member)

WORKING COMMITTEE	ENVIRONMENT/RESOURCE/ LAND USE	SOCIAL/ECONOMIC	ENERGY/ECONOMICS/FINANCE
AREA OF GENERAL INTEREST	Resource Management Land Use Planning	Regional and Community Development Planning Social Service Policies	Energy Policy Industrial Strategy Taxation/Financial Policy
FUNCTION REGARDING APPLICATION AND PROJECT	Environmental Impact Analysis Benefit/Cost Analysis Mitigation/Compensation Permitting	Impact Analysis Social/Services Mitigation/Compensation Permitting	Energy Policy Demand/Supply Forecasting Economic/Financial Feasibility Benefit/Cost Analysis
MEMBER AGENCIES	Environment* Forests Agriculture and Food Transportation and Highways Lands, Parks and Housing Energy, Mines and Petroleum Resources Provincial Secretary and Government Services	Coordinated by Socio/Economic Coordinating Committee (SECC); Review Agencies Include: Municipal Affairs* Health/Education Lands, Parks and Housing Attorney General/Labour Transportation and Highways Provincial Secretary and Government Services Industry and Small Business Development	Energy, Mines and Petroleum Resources* Finance Industry and Small Business Development

NOTE: Relationships between Working Committees will vary, depending on the project.

*Currently chairs Working Committee.

ENERGY PROJECT CERTIFICATE

REGULATION 388/80 REQUIREMENTS

1. Description of Applicant

2. Project Description

   a. Purpose, costs, and ancillary facilities.

   b. Timetable.

   c. Public works, undertakings, or infrastructure.

   d. Environmental and socio-economic impact assessment and proposals for minimizing negative impacts and maximizing positive impacts.

3. Project Justification

   a. Studies of technical, economic, and financial feasibility.

   b. A study estimating the value of all project costs and benefits and their distribution.

4. Ancillary Applications

   Approvals, permits, licences required under Pollution Control Act, Water Act, and other statutes.

5. Public Consultation Program

6. Other Information as Required

Province of British Columbia — Ministry of Energy, Mines and Petroleum Resources

ENERGY PROJECT REVIEW: ENERGY PROJECT APPLICATION PROCESS

PRE–APPLICATION PHASE

↓

PROSPECTUS

(1) General project description and schedule.
(2) Project rationale.
(3) Description of proposed preliminary studies.

↓

Review by Energy Project Coordinating Committee and Working Committees; consultation with proponent

↓

PRELIMINARY PLANNING REPORT

(1) Identification and assessment of feasible alternative locations.
(2) Analysis of alternative locations and identification of preferences.
(3) Preliminary Procurement Plan.
(4) Terms of reference for proposed environmental/socio-economic impact studies.
(5) Terms of reference for proposed project justification studies.
(6) Description of public consultation program.
(7) Preliminary list of approvals, licences, and permits required.

↓

Review by Energy Project Coordinating Committee and Working Committees; consultation with proponent in developing Application

↓

APPLICATION PHASE

↓

APPLICATION

(1) Description of applicant as per Regulation.
(2) Project description:
  (a) purpose, costs, and ancillary facilities.
  (b) timetable for construction, operation, abandonment, reclamation, with critical dates.
  (c) public works, undertakings, or infrastructure entailed with costs and schedule.
(3) Environmental and socio-economic impact assessment and proposals for minimizing negative impacts and maximizing positive impacts.
(4) Project justification: energy supply/demand, technical feasibility, financial feasibility, procurement, benefit-cost data.
(5) Ancillary applications: approvals, permits, licences required under *Pollution Control Act*, *Water Act*, and other pertinent statutes.
(6) Public consultation program description and summary of response.
(7) Other information as required.

↓

Review by Energy Project Coordinating Committee and Working Committees; consultation with applicant as necessary

↓

APPLICATION DISPOSITION BY MINISTER(S)

[Section 19(1) of *Utilities Commission Act*]

PRE-APPLICATION PHASE

PROSPECTUS

Concise resume of:

1. Project description
2. Project rationale
3. Proposed preliminary studies

PRELIMINARY PLANNING REPORT

1. Preliminary environmental and socio-economic impact assessment.

2. Preliminary procurement plan.

3. Terms of reference for detailed studies.

4. Description of public consultation program.

5. Preliminary list of approvals, licences, and permits required.

APPLICATION PHASE

1. Application Description

2. Project Description

   - description, purpose, costs, and timetable
   - ancillary facilities and infrastructure

3. Environmental and Socio-economic Impact Assessment

   - summarize results of preliminary impact assessment of alternative locations and selection of preferred location(s)

   - assess impacts associated with preferred location(s) and present proposals for reducing negative impacts and obtaining maximum benefits from positive impacts

   - outline plans and procedures for site-specific impact, mitigation and/or compensation

   - outline plans and procedures for clean-up, revegetation, reclamation, and abandonment (as appropriate)

4. Project Justification

   - energy supply and demand forecasts
   - technical feasibility information
   - financial feasibility information
   - procurement plan
   - benefits and costs information

5. Ancillary Applications

   - list of all approvals, permits or licences required

   - indication of simultaneous applications under the Pollution Control Act and Water Act

6. <u>Public Consultation</u>

- report on public information and consultation program

7. <u>Other Information</u>

- as requested by the Minister

ENERGY REMOVAL CERTIFICATE

- certificate required for removal of an energy resource produced, manufactured, or generated within the province, except for exemptions listed in Regulation 385/80

- energy resource is defined as natural gas or oil, all forms of liquid and gaseous hydrocarbons, and electricity

- application to Minister

EVALUATION CRITERIA

- efficient use of energy resources

- surplus to present and future requirements for British Columbia

REGULATION 389/80 - REQUIREMENTS

1. <u>Description of Applicant</u>

2. <u>Energy Removal</u>

- type, quantity, and source
- duration
- market, price, and means of delivery
- facilities and infrastructure
- rationale for surplus

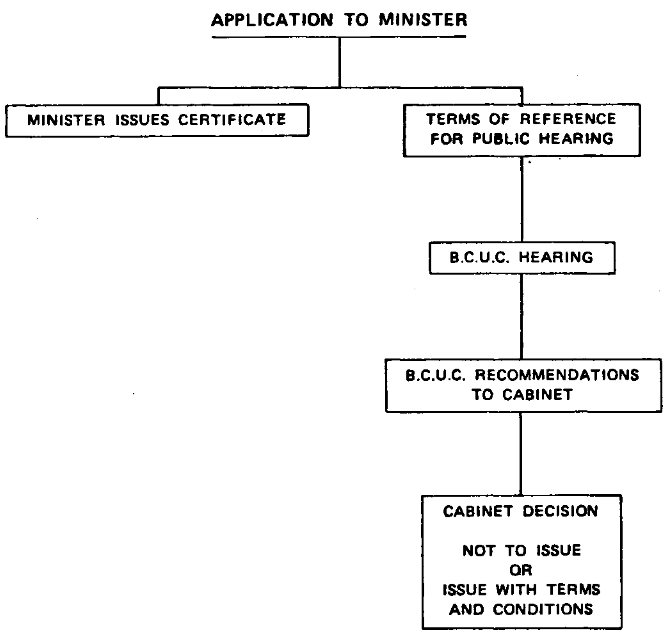
3. <u>Other Information</u>

- as requested by the Minister

Province of British Columbia

Ministry of Energy, Mines and Petroleum Resources

ENERGY PROJECT REVIEW: APPLICATION FOR ENERGY REMOVAL CERTIFICATE



CURRENT PROJECTS

Electrical Generation Projects
Electrical Transmission Projects
Gas Transmission Projects
Petrochemical Proposals
LNG Proposals
Removal Applications
Related "Applied Research" problem solving, and procedural projects

WEDNESDAY, MARCH 10TH SESSION

Chairman
J.D. McDonald, P.Eng.
Senior Reclamation Inspector
B.C. Ministry of Energy, Mines and Petroleum Resources

MINE LAND REFORESTATION IN THE ST. REGIS FOREST MANAGEMENT AREA HINTON, ALBERTA

Papers presented by:

NEIL DUNCAN
ENERGY RESOURCES CONSERVATION BOARD

(Paper not available)

ERIC BERESFORD
UNION OIL

- Planning for post-mining reclamation within a forest management area, Obed-Marsh Project, Hinton, Alberta

AL KENNEDY
ESSO MINERALS CANADA

- Reclamation Monitoring at the Judy Creek test pit site

RICK FERSTER
LUSCAR LIMITED

(Paper not available)

PLANNING FOR POST-MINING RECLAMATION WITHIN A FOREST MANAGEMENT AREA

OBED-MARSH PROJECT, HINTON, ALBERTA

by Eric Beresford

INTRODUCTION

Neil Duncan has just outlined the overall picture of the various mine developments planned within the St. Regis Forest Management Area.

The total area under forest management is some two million acres with logging for the pulp mill commencing in 1956 in the Obed project area.

The Alberta government has leased this same piece of Crown real estate to a variety of commercial interests, taking royalties, lease rentals and revenues from all parties.

In the project area I am concerned with, the land has been leased for oil and gas exploration, seismic lines, pipelines, power lines, roads, coal development, sand and gravel pits, and superimposed over all of this, is the forest industry. And that's on only 15,000 acres!

Each user has been given either approval to construct a well site, road, or conduct numerous exploration right-of-ways, or a licence of occupation, so it is little wonder that the St. Regis company feels threatened from all sides.

The Obed project is the first coal project approved under the Alberta Coal Policy of 1976 which is entirely within the Forest Management Area and therefore must be returned to a commercial forest after mining. Cooperation with St. Regis and the preplanning necessary to ensure successful tree growth are therefore of prime importance.

PROJECT DESCRIPTION

The project area comprises some 15,000 acres in two coal blocks, the Obed and Marsh Blocks, located approximately 17 miles from the town of Hinton. The town of Hinton has a population of 8,000 people which currently work at the St. Regis pulp mill and two existing coal mines.

The development is planned for the extraction of 4.5 million tonnes of raw coal or three million clean tonnes per year, from the two lease areas for some 35 years, all by surface mining methods. The mine will employ 450 people, has long term overseas contracts for this thermal coal, and will contribute substantial revenue to Canada, the Province and the local economy.

The coal seams are flat, lying under a ridge approximately 5,700' in elevation.

The overburden will be mined by large draglines, with assist equipment as necessary, and the coal extracted by shovels. The coal requires washing to remove the shale and clay partings in the seams so a preparation plant, with workshops and office facilities is required.

The clean coal will be conveyed from the plant by a seven mile long overland conveyor to a loadout on the main CN line. The project requires a new access road to the mine, separate from the existing logging road.

The land required for the mine operation will be taken out of the Forest Management Area for 35 to 40 years and amount to some 350 acres of forest land. The mine will be successively reclaimed at a rate of 150 to 200 acres per year after the initial start-up period.

The Development Reclamation Permit states that the land must be returned to commercial timber production equal to or better than before disturbance.

PLANNING - INITIAL EXPLORATION

In the early exploration phases of a coal property the disturbance is relatively minimal with a series of access roads being built to drill sites.

During the exploration program it is routine to take some bulk samples for coal testing. These samples are taken from either small open pits or adits into the seam.

After completion of a year's program, the sample pits, drill sites and often also access roads are reclaimed, seeded and put to bed. It is in everyones best interest to reclaim these early disturbances quickly and to a high standard.

In addition, the reclamation of these early sites gives a good indication of any problems that may develop in the mining phase, and varying techniques can be used and monitored very early on in mine planning.

PLANNING - MINE DEVELOPMENT

The project area has been extensively logged since 1956 and is at various stages of reforestation. The commercial species area white spruce and lodgepole pine.

Early in the mine planning stage it is mandatory to produce an Environmental Impact Assessment and identify areas of concern. This study obtains information on vegetation, wildlife, water resources, soils and climatic conditions. In our case, the study was concentrated on forest productivity, soils and water resource management, although all other impacts were recognized.

It is fundamental to any mine plan and subsequent reclamation plan to determine the soil type and quantities and nature of sub-soil and overburden rock present in the area.

Field work necessary to obtain this information included digging pits by backhoe and auger drilling. Laboratory work included determining the chemical composition of each material and noting any high sodium areas.

The resulting soil map at a scale of 1:5 000 formed the basic planning map used by the project mining engineers.

Soils in this area have developed on glacial till which lie in a mantle of 15' to 30' over bedrock strata.

With this basic information available a reclamation plan was developed to meet the objective of restoring an "equal to or better than" soil profile. The plan included selecting those soil and subsoil materials which were required for the reclamation program and developing a mining system which will satisfy the reclamation objectives.

The mining system which was developed, included grubbing and clearing forest slash and debris by windrowing into piles by a bulldozer. This is followed by removing the A and B soil horizons and by selectively removing the C horizon and a subsoil layer of till to a predetermined depth.

Because the rainy season at Hinton is in the spring and summer months, the removal of the soil/subsoil material can only be carried out with scrapers in a fall and winter operation of approximately six months each year.

In order to restore the site to productive forest land the soil/subsoil material will be placed to an average depth of 1.3 m over the levelled dragline spoil piles; and the forest trash debris will be spread over this area.

The introduction of this forest debris restricts erosion and forms micro-sites in which small container trees can flourish.

It has been found through experience on the site since 1973/74 that tree growth success is guaranteed when this procedure is followed.

However, this reclamation method is expensive. In an attempt to find a less expensive way of growing trees on a post-mining area, replicated design field trials have been set up at Obed.

These test plots were set up in 1980 and simulate various reclamation techniques that can be statistically and scientifically measured. The results from these plots will likely produce modifications to the previously outlined approach.

Experiments have been designed to determine if the forest debris can be removed at the same time as the soil/subsoil material instead of separating the two materials as described.

Other test plots have been set up to determine tree growth differences on North- and South-facing slopes with varying depths of soil.

Soil temperature and moisture cells were also set in the plots and this information will be correlated with tree growth measurements. An automatic-recording weather station has also been set up at the plant site.

These test plots have been constructed in an area not scheduled for mining for 20 years, and it is hoped that foresters will have become convinced that successful reforestation can be accomplished on mined-out land well before these plots are taken out.

In conclusion, I would like to say that a good spirit of cooperation has been built up between St. Regis and Union Oil, and each industry can benefit from a non-renewable resource activity such as coal mining followed by restoration of healthy tree growth on mined-out lands.

As we say, we are only borrowing the land for a short while and giving it back for future years of productive timber growth.

RECLAMATION MONITORING AT THE JUDY CREEK TEST PIT SITE

by Al Kennedy

INTRODUCTION

This paper presents an overview of Esso Minerals Canada's reclamation monitoring program in progress at our Judy Creek test pit site. Details and data on reclamation at Judy Creek are available upon request from Esso Minerals Canada.

The Judy Creek test pit is located approximately 5 km southeast of Swan Hills, Alberta. The site can be termed a "boreal forest" with the typical complement of vegetation communities common to northern boreal ecosystems.

During December 1978, operations began at the pit site with construction of the access road and clearing of timber and vegetation.

In January 1979, the pit was constructed and approximately 10,000 tonnes of bulk coal samples were taken to Wabamum, Alberta for a test burn in the Transalta Utilities thermal power plant. Following these operations the pit site was backfilled and recontoured to reclamation specifications using previously stockpiled surface material, and shale and till overburden. A total area of 19.3 ha was disturbed of which 1.5 ha was required for the pit itself.

Reclamation activities such as fertilizing, seeding and the planting of conifer seedlings as well as the gathering and planting of deciduous stem cuttings were carried out on the site between May and June 1979. Within the area of clearing, five separate studies were established for ongoing evaluation.

RECLAMATION STUDIES

I would now like to describe the five reclamation studies being carried out at the test pit and highlight some observations from these studies which have been monitored for three growing seasons.

The first study is designed to examine the effects of 70 cm, 30 cm, and 0 cm of surface soil over till on the establishment and growth of a grass/legume seed mixture and reforestation species. Surface soils at

Judy Creek are generally orthic grey luvisols over a loose sorted glacial till. The three treatments were replicated three times making a total of nine study plots. Plots 1, 2 and 3 have 70 cm of soil, Plots 4, 5 and 6 have no surface soil and Plots 7, 8 and 9 have 30 cm of surface soil.

Each plot was seeded in a similar manner, that is, with a 15 kg grass/ legume mix. However, on Study No. 1 plots, 99 lodgepole pine and 44 deciduous stems (willow and balson poplar) were planted on one half of each plot. Plots were examined for growth in August 1979 and June and August 1980 and 1981. Monitoring results indicate that 70 cm of soil appears to be least suitable for establishment of seeded cover, 30 cm of soil is moderately suitable, and 0 cm appears to provide the best growing media. Establishment of pine seedlings is similar on all plots but survival is slightly poorer on 70 cm of soil. Deciduous cuttings have done poorly on all sites.

The objective of the second study is to analyze the effect of different grass and legume seeding mixtures and application rates on establishment and growth of pine and spruce seedlings. Twenty-four plots were established and seeded with 15 kg/ha and 30 kg/ha of bunch forming grass/legume mixes and grass-only mixes. Fertilization rates were identical throughout the plots.

Monitoring results to date indicate that the seed mixture or application rate has little effect on the survival of outplanted pine and spruce seedlings. Variation in moisture regime seems to be a more important limiting factor to tree establishment on these plots. I do have the details of the various seed mixes and would be pleased to discuss them with interested persons after the presentation.

The third study was established to determine the potential for natural revegetation to occur on the test pit site. Three study plots were topped with 70 cm of soil and left without fertilization or seeding treatments. After three growing seasons, there has been little or no natural plant establishment on these plots. This is thought to be due to sheet erosion caused by heavy rainfalls each spring.

The fourth study consists of six plots which were established to compare the growth and survival of coniferous trees on undisturbed soil with those growing on disturbed soil (for example, those in Study Plot 1).

On average, tree seedling survival was greater on the undisturbed plots than on the disturbed sites in Study No. 1.

The fifth reclamation study consists of three plots, with 70 cm, 30 cm and 0 cm of surface soil placed over 1 m of shale overburden. Plots were revegetated with the same seed mix and reforestation rate used for the general site reclamation. The depth of surface soil over shale does not appear to have a marked effect on plant establishment and growth. However, revegetation species appear to grow at a lower rate when no surface soil is provided.

Two plots were established during May 1980 to compare the survival and growth of one year old versus two year old outplanted lodgepole pine. Monitoring results indicate that one year old seedlings have a higher survival rate. However, survival rate appears to be more related to planting techniques than environmental factors such as soil condition or vegetative cover.

In addition to the soils and vegetation studies that I have just described for Judy Creek, a program of wildlife monitoring is also been carried out. The objectives of the wildlife studies are to clarify the rate of recolonization of the test pits by various wildlife species.

Results to date indicate that a small mammal population is established on the pit site and some damage to new outplanted seedlings can be attributed to these animals. During 1981 the population level of mice, particularly meadow voles increased substantially. Correspondingly, the mortality of conifer seedlings was observed to increase from 14.8% to 34%. Moose and deer are beginning to use the test pit and are browsing on outplanted deciduous shrubs. However, damage to these shrubs from browsing is not presently observable.

CONCLUSIONS

Monitoring studies are planned to continue at Judy Creek annually for two more years and once every three years thereafter to 15 years. We believe the information gained from the Judy Creek test pit monitoring will be beneficial to our reclamation planning for the proposed Judy Creek mine and hopefully can be used in reclamation planning for other Esso Minerals coal properties in Alberta such as the Hinton east property.

MANAGING ENVIRONMENTAL REQUIREMENTS FOR NEW MINE DEVELOPMENTS IN BRITISH COLUMBIA

Paper Presented
by

R.A. Hawes
Norecol Environmental Consultants Ltd.

J.W. Gadsby
Thurber Consultants Ltd.

MANAGING ENVIRONMENTAL REQUIREMENTS FOR NEW MINE DEVELOPMENTS IN BRITISH COLUMBIA

INTRODUCTION

To develop new mines in British Columbia, or to undertake major mine expansions, environmental impact assessment reports and permit applications are required for government approvals.

Mining projects are probably the largest multi-disciplinary undertakings in B.C. Unlike many civil engineering projects, such as the construction of highways and bridges, mine developments require a wide range of multi-disciplinary expertise from the exploration, construction and operational stages through to mine abandonment. Mine projects, because they tend to require large financial and human resources, and because they can impose potentially significant effects on the environment over a relatively long period of time, have developed special environmental requirements in B.C. Often these requirements are more stringent than those found in other industries.

It is generally recognized in the mining industry that environmental approvals can impose significant hurdles. The process of obtaining approvals can lead to long and costly delays or even abandonment of some potential mining ventures. The manager responsible for mine development must be concerned about how to design and schedule the environmental studies to meet regulatory requirements. This is often not an easy task.

The present guidelines process for B.C. mine developments has been designed to ensure that projects are technically acceptable and can be supported by the government and the general public. However, to the mine manager the guidelines process often is confusing, time consuming, and costly. It does not provide for effective integration of the engineering, environmental and project decision-making processes that are ongoing to bring the mine into production. Furthermore, bureaucratic confusion and lack of concensus by the review agencies often make it difficult and time-consuming to determine the project study parameters necessary to meet government requirements.

Another major problem with the guidelines is that they don't incorporate the political component into the decision-making process. The guidelines are primarily technical in nature and tend to underplay the political issues. This creates a major unpredictable element in the approval process. Although public support or opposition to the project is not explicitly addressed, it may be a significant or even major component in obtaining project approval at the political level. As a result, a project may attempt to meet all the technical requirements even if there is very little political support and chance of approval for the project.

To deal effectively with the British Columbia guidelines process, a properly designed strategy for managing the environmental studies is required. This strategy, which must incorporate elements of the environmental, engineering, corporate and government study and review processes, will help to minimize the time and study costs, and will greatly enhance the chance of achieving mining approvals.

In this paper we outline the present stages and key steps in the environmental approval process. An outline of key management objectives are suggested to integrate the engineering, environmental and government guidelines processes. A summary of the key components in planning a successful environmental study program is provided.

STAGES IN THE ENVIRONMENTAL REVIEW PROCESS

The mining environmental review process is formalized around the Guidelines for Coal Development (1976) and the Procedures for Obtaining Approval of Metal Mine Development (1979). These two guidelines are among the first attempts to officially coordinate an environmental review process for industrial development in British Columbia.

An outline of the present environmental guidelines review process is shown in Figure 1. While Figure 1 is specific to coal mines, the process is similar for metal mines. This figure updates present environmental and engineering data requirements, which go from a broad general overview, based largely on available information, to detailed site specific engineering and ecological information for the impact assessment and permit components.

Figure 1 shows that even with a well-designed study program, and assuming that no significant environmental issues develop, it will take a

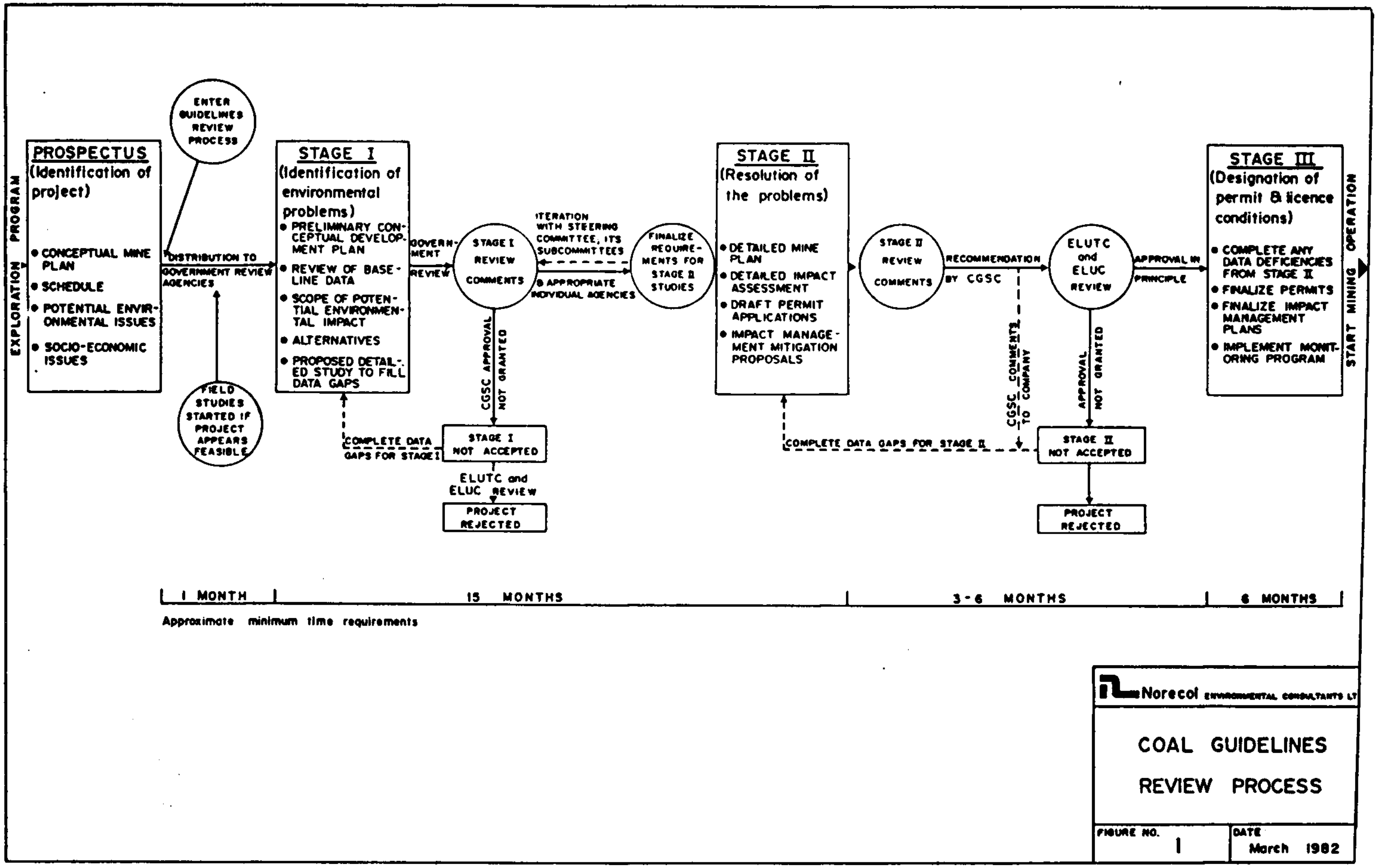


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Figure 1. Coal Guidelines Review Process

minimum of approximately 24 months from the submission of the Prospectus to the time of obtaining mining approvals.

The submission of the Prospectus initiates identification of the project and formally enters the proposed development into the guidelines process. The Prospectus is sent to review agencies for their information, but no formal review process occurs. As this is not an official review stage, identification of environmental problems is not a major concern to government agencies. The Prospectus outlines the conceptual mine plan, size and type of deposits, project schedule and potential biophysical and socio-economic concerns.

Stage I is the identification of the environmental and engineering problems stage. Stage I outlines baseline data, the preliminary mine development plan and alternatives, potential sources of environmental impacts and recommends detailed Stage II studies. The key to a good Stage I report is a conceptual mine layout and mining system which is conceptually, and from an engineering viewpoint, reliable. Based on the conceptual mine plan, major environmental concerns should be realistically identified, both for the government (for their recommendations of relevant Stage II requirements) and for the company so that they can design appropriate study programs to meet Stage II requirements. The Stage I report goes to review agencies for comment and detailing of specific Stage II concerns and data requirements.

The Stage I report is formally reviewed by the Coal Guidelines Steering Committee (CGSC) and review agencies. The Committee will coordinate the review agencies comments into recommended study programs and issues that should be addressed in the Stage II report. Alternatively, the Steering Committee could recommend rejection of the report due to insufficient project detail. It could also recommend project rejection to the Environment and Land Use Technical Committee (ELUTC) which makes representations to the Environment and Land Use Committee (ELUC) due to potentially serious environmental concerns.

Stage II is the resolution of the environmental problems stage. Stage II is the critical step in obtaining project approval-in-principle. A detailed environmental impact assessment report is required which: details environmental parameters as specified in the Stage I review; details the mine plan, including transportation routes and mine infrastructure requirements; identifies environmental impacts and proposed mitigation and impact management procedures; and outlines the proposed operational environmental studies and monitoring programs. Draft permit applications should also be submitted concurrently with the Stage II report.

Stage II review can result in CGSC recommendations for: (1) government approval-in-principle, subject to permit acceptance; (2) rejection of the report and thus the project due to the need for additional work; or (3) rejection of the project. The CGSC could also comment directly to the company that there are significant data gaps and that they should be completed for Stage II approval. The Guidelines process ends with completion of the Stage II requirements. Normally some Stage II level deficiencies, identified in the Stage II review, will be required to be completed for the CGSC during Stage III.

Stage III is the designation of the permit licences and conditions stage. Final engineering design and any Stage II data deficiencies must be completed and final determination of licence conditions made. Following approval of the licences the project can proceed.

Major expansions of existing coal and metal mines are now reviewed in the guidelines review process. Required are: a modified identification of the problems level Phase 1 report, and a detailed Phase 2 impact assessment and management report. The Phase 2 report is expected to provide Stage II level information to address environmental concerns specific to the mine expansion that can not be covered by the normal issuing of permits.

The guidelines process is currently undergoing formal review. The metal mines guidelines are expected to be revised in 1982, but the guidelines for coal mines may not be revised until early 1983. The revisions are not expected to result in major changes to the guidelines; rather they likely will formalize the presontly accepted practices, such as project approval-in-principle at Stage II.

TAILORING ENVIRONMENTAL AND ENGINEERING STUDIES TO OBTAIN AGENCY APPROVALS

The most common problems mine managers have in using the guidelines are:

- to fully understand the review process - the complexity of the process, identifying critical decision points, identifying key agencies and committees;

- understanding the scope and detail of engineering and environmental data requirements at each stage;

- understanding the time requirements for data collection and government review;

- designing proper sequencing and integration of studies; and

- understanding what approvals at each stage mean and the limitations of these approvals.

To deal with this complex environmental review process, produce a reliable mine design, and schedule and integrate the required multi-disciplinary components, a properly designed strategy for managing the studies is required. Developing the environmental management strategy requires the integration of key elements of the environmental, engineering, and the corporate study processes with the guidelines review process.

Figure 2 shows a flow chart for the exploration, engineering and financing of typical major mining projects.[1]

This figure shows the complexity of coordinating the multi-disciplinary team to bring a mine into operation.

Critical points in the mine management decision process occur at the Order of Magnitude Study, Budget Estimate Study, and the Final Feasibility Study.

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[1]This flow chart is provided by kind permission of T.S. Hughes, Mining Consultant, Bank of Montreal, Vancouver, B.C.

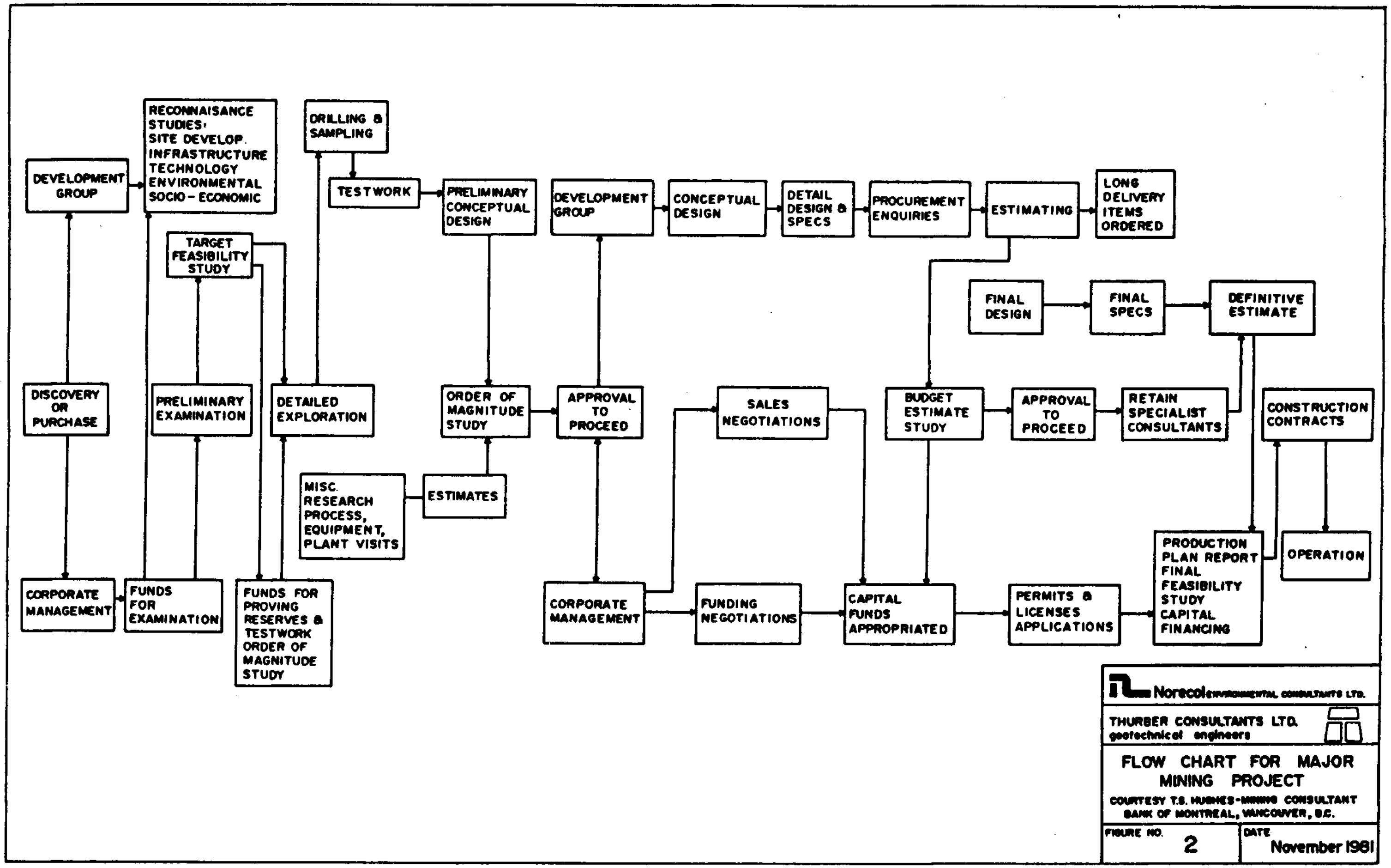

Figure 2. Flow Chart for Major Mining Projects

To develop the management objectives and strategy in order to effectively deal with the hurdles of environmental approvals, it is necesary to combine together the steps of the guidelines review process (Figure 1) with those of the mining flow chart (Figure 2).

Figure 3 has been prepared to illustrate the integration of the key elements in the environmental, engineering and the guidelines process to assist in developing the management strategy.

For submission of the Prospectus, mine management should have:

- completed the detailed exploration stage studies which delineate the proposed site development, infrastructure requirements and the project schedule,

- identified major environmental issues to be considered in engineering and financing feasibility studies,

- selected key persennel for the management, engineering and environmental study teams, and

- initiated liaison with the government review agencies.

During preparation of the Prospectus it may be prudent to initiate baseline studies which can be carried into the Stage I program. Such planning often saves valuable time, especially when seasonal data must be collected.

The prime purpose of the Stage I studies is to identify potential environmental problems for the project. In order that a realistic Stage I report may be submitted mine management should:

- provide a realistic conceptual mine plan which is reliable in engineering aspects. Although the mine plan will be modified during the more detailed design stages, it should be reasonably similar to the final design,

- identify major technical issues that could affect permits or be of concern to non-permitting agencies,

	PROSPECTUS	STAGE I	STAGE II	STAGE III
Environmental	- POTENTIAL ENVIRONMENTAL SENSITIVITIES AND ISSUES - SOCIO-ECONOMIC ISSUES	- REVIEW AVAILABLE BASELINE DATA - IDENTIFY POTENTIAL SOURCES AND MAGNITUDE OF ENVIRONMENTAL IMPACTS - PROPOSED STUDY PROGRAM TO FILL DATA GAPS	- DETAILED ENVIRONMENTAL IMPACT ASSESSMENT - IMPACT MANAGEMENT AND MITIGATING PROPOSALS - DRAFT PERMIT APPLICATIONS	- COMPLETE STAGE II DEFICIENCIES - FINALIZE PERMIT REQUIREMENTS
Engineering	- DETAILED EXPLORATION STAGE ORDER OF MAGNITUDE STUDY, SITE DEVELOPMENT SCHEDULE, INFRASTRUCTURE	- RELIABLE CONCEPTUAL MINE DESIGN, MINE PLAN AND SYSTEM - FEASIBLE FROM ENGINEERING ASPECTS - DETAILED EXPLORATION NEAR COMPLETION - ENGINEERING ALTERNATIVES CONSIDERED	- DETAILED ENGINEERING STUDIES SUITABLE FOR PERMIT APPLICATIONS	- FINAL ENGINEERING DESIGN
Guidelines	**PROSPECTUS** Identification of the Project →	**STAGE I** Identification of Environmental problems →	**STAGE II** Resolution of Environmental problems →	**STAGE III** Designation of Permit and Licence Conditions
Management Objectives & Strategy	- FEASIBLE, FINANCIALLY AND TECHNICALLY - FLAG MAJOR ENVIRONMENTAL ISSUES TO ASSIST IN FINANCING AND ENGINEERING FEASIBILITY - SELECTION OF MANAGEMENT, ENGINEERING AND ENVIRONMENTAL TEAMS - INITIATE ENVIRONMENTAL MANAGEMENT STRATEGY - LIAISE WITH GOVERNMENT REVIEW AGENCIES - FORMALLY ENTERING GUIDELINE REVIEW PROCESS - FUNDING FOR ENGINEERING AND ENVIRONMENTAL STUDIES FOR STAGE I	- ALLOW FOR INTEGRATION OF ENGINEERING, ENVIRONMENTAL AND MANAGEMENT STUDIES. DEVELOP FLEXIBLE PROGRAMS - DANGER IN SUBMITTING UNREALISTIC AND UNRELIABLE MINE PLAN - THE COMPANY SHOULD REALISTICALLY FLAG POTENTIAL NO-GO ENVIRONMENTAL TECHNICAL ISSUES AND IDENTIFY POLITICAL SENSITIVITIES - INTEGRATION OF KEY ENVIRONMENTAL ISSUES AND ENGINEERING ALTERNATIVES	- KEY DECISION POINT FOR OBTAINING GOVERNMENT AGENCY APPROVAL. ESSENTIAL TO HAVE RELIABLE MINE PLAN AND INTEGRATION OF ENVIRONMENTAL AND ENGINEERING STUDIES. - RESOLVE MAJOR TECHNICAL ISSUES FOR OBTAINING PERMITS AND OTHER CONCERNS BY NON-PERMITTING AGENCIES. - DEVELOP POLITICAL SUPPORT MAY INCLUDE PUBLIC MEETINGS WITH SPECIAL INTERESTED GROUPS. - SELECTED INTERNAL ENVIRONMENTAL CO-ORDINATOR FOR GOVERNMENT LIAISON AND TO ENSURE INTEGRATED AND CREDIBLE STAGE II REPORT.	- HAVE APPROVAL-IN-PRINCIPLE FOR THE PROJECT (ELUC APPROVAL) - OUT OF GUIDELINES PROCESS - DEAL ONE-TO-ONE WITH PERMITTING AGENCIES - ALLOW SUFFICIENT TIME FOR PERMITS

BASELINE STUDIES MAY BE INITIATED IF PROJECT APPEARS FEASIBLE.

IDENTIFY KEY GOVERNMENT AGENCIES
INCREASE LIAISON WITH AGENCIES TO TAILOR STAGE II PROGRAMS
IDENTIFY AND SCHEDULE PERMITS
EXCHANGE INFORMATION AND IDEAS BETWEEN MINE MANAGEMENT AND REVIEW AGENCIES
AVOID SURPRISES AT STAGE II SUBMISSION

Norecol ENVIRONMENTAL CONSULTANTS LTD.
THURBER CONSULTANTS LTD geotechnical engineers

MANAGEMENT STRATEGY INTEGRATION OF STUDY PROCESSES

FIGURE NO. 3 DATE March 1982

Figure 3. Management Strategy Integration of Study Processes

- integrate key environmental concerns with the design of engineering alternatives,

- develop political support for the project.

This may frequently require management to initiate and hold public meetings with special interest groups.

The prime purpose of the Stage II report is for resolution of the problems identified in the earlier stages. The Stage II report should contain:

- a detailed mine plan which will permit a thorough review of the project,

- detailed baseline inventory information addressing areas of concern previously identified,

- detailed impact assessments and planned mitigation and impact management procedures,

- proposed Stage III level studies and monitoring programs.

The Stage II report is the key report for project approval, and all important issues identified in the government review and liaison process should be addressed and dealt with prior to submitting the report.[1] No major data gaps or surprises should occur during the formal report review.

A major weakness of many Stage II reports is the lack of engineering detail. A comprehensive, reliable mine plan is required along with detailed engineering studies. Common problems in Stage II submissions are the result of the lack of engineering detail and the lack of environmental consideration in the final engineering design. Both aspects should be integrated as much as practical to produce a technically sound and defensible Stage II report. As a guide, engineering inputs should be sufficiently detailed and advanced so that the company

[1]Tables 1 and 2 following this paper provide a list of the key government committees and agencies in the guidelines review process.

can file simultaneous draft permit applications (e.g. mine plan, waste water licence, reclamation plan) with the Stage II report.

When the Stage II requirements are completed and approval-in-principle for the project has been achieved, the project moves out of the guidelines process. Mine management will then deal on a one-to-one basis with the permitting agencies.

ELEMENTS OF A SUCCESSFUL ENVIRONMENTAL MANAGEMENT STRATEGY

Although the environmental impact assessment process is relatively new, it has become an established procedure which likely will remain with us for a long time. The present trend in mining impact assessment studies in British Columbia is clearly toward developing more stringent technical requirements for virtually all study parameters. Review agencies are increasing staff numbers to deal with a broader range of concerns and are requiring more technical detail. Failure to deal effectively with the guidelines process will impose significant constraints on developing a successful mining venture.

To obtain government approvals as quickly and efficiently as possible a specific environmental management strategy needs to be developed. Key elements in formulating this strategy are:

- Plan sufficient time for the studies. A minimum of approximately two years is required for project approval, but more likely about three years will be needed. Pushing study schedules due to unrealistic time requirements often leads to poor technical results, data gaps or poorly integrated studies which can result in increased delays and study costs.

- Understand the guidelines process. An appreciation is required of the complexities, uncertainties, hazards and critical decision points in the guidelines process.

- Develop credibility. Development of credibility and trust through good communication and a positive attitude will generate a favourable response in government and the community.

- Maintain initiative. Attempt to get approvals quickly and efficiently and avoid long delays in communication which can create uncertainty. Maintaining good communication with review agencies will minimize the possibility for surprises in the review process and potential delays.

- Develop sound technical programs. Sound biophysical and socio-economic technical programs should be developed that at least meet present requirements. It is likely that as the project develops, additional detail will be requested to address new problems or meet changing government requirements. The programs should be flexible to deal with potential changes.

- Integrate study processes. Environmental and engineering information needs to be integrated to provide a technically sound and defensible mining proposal.

- Realistically evaluate potential environmental concerns. The company should evaluate potential environmental constraints and concerns early in the review process as an aid to internal planning. This will help accurately to assess funding levels required to develop satisfactory study programs and will facilitate the early incorporation of acceptable solutions into the engineering design.

ACKNOWLEDGEMENTS

The authors greatly appreciate the encouragement and help received in preparation of this paper from:

J.D. McDonald - Chairman, Guidelines Steering Committee, Ministry of Energy, Mines and Petroleum Resources.

R.L. Crook - Guidelines Coordinator, Ministry of Energy, Mines and Petroleum Resources, Victoria.

M. Galbraith - Ministry of Energy, Mines and Petroleum Resources.

T.S. Hughes - Mining Consultant, Bank of Montreal, Vancouver.

TABLE 1

LIST OF MAJOR GOVERNMENT COMMITTEES

FOR ENVIRONMENTAL APPROVAL OF MINE DEVELOPMENT

COMMITTEE	FUNCTION	TIMING
Coal Guidelines Steering Committee (CGSC)	Coordinate review agencies. Consists of representatives from Ministries of Energy, Mines and Petroleum Resources (EMPR)*, Environment (MOE), Municipal Affairs (MMA), Lands, Parks and Housing (MLPH), Industry and Small Business Development (ISBD), Transportation and Highways (MTH), and Labour.	Guidelines process starts with submittal of Prospectus, ends when approval-in-principle is granted from ELUC and Stage II requirements completed.
Metal Mines Steering Committee (MMSC)	Coordinate review agencies. Consists of representatives from Ministries of EMPR,* MOE, ISBD, MMA, Labour, Forests (MOF).	Guidelines process starts with submittal of Prospectus, ends when approval in principle is granted from ELUC and Stage II requirements completed.
Minesite Advisory Committee (Sub-Committee of CGSC and MMSC)	Technical advice, mostly active in metal mines. Look at permitting advice to proponent and indicate government concerns. Consists of following agencies: EMPR*, Waste Management Branch, Water Management Branch, Fish and Wildlife Branch, MOF, and MLPH For metal mines, the Ministry of Agriculture and the Aquatic Studies Branch are also represented.	The committee is not active in coal but is attempting to regionalize functions. For metal mines committee functions from head-quarters. In metal mines, committee reviews Stage I and II reports.

* Chairs Committee

Table 1 (continued)

COMMITTEE	FUNCTION	TIMING
Socio-Economic Coordinating Committee (Sub-Committee of CGSC, MMSC and potentially by any Steering Committee)	Committee functions for all formal guidelines processes. Funnels socio-economic input to review process. Consists of the following Ministries: MMA*, ISBD, Health, Labour, Attorney General.	Reviews Stage I and II reports. Involved in developing Stage II study requirements.
Economic Evaluation Committee (Sub-Committee of CGSC and MMSC)	If province is asked to fund project and there can be a significant impact on other resource values, committee evaluates project. Composed of Ministries of EMPR*, ISBD.	Towards end of Stage II if there is a major issue.
Environment and Land Use Technical Committee (ELUTC)	Receives recommendation from CGSC or MMSC and makes representation to ELUC. Consists of Deputy Ministers of ELUC, chaired by MOE.	After Stage II review by CGSC or MMSC.
Environment and Land Use Committee(ELUC)	Cabinet Ministers (9) who make formal decision on government approval-in-principle. Consists of Ministers from: *MOE EMPR MMA ISBD Agriculture Forest MTH MLPH Health	After Stage II report has been reviewed by CGSC, or MMSC and ELUTC.

*Chairs Committee

Table 1 (continued)

COMMITTEE	FUNCTION	TIMING
Regional Screening and Coordinating Committee (RSCC)	Federal coordinating committee to review federal concerns (e.g. fisheries). Not developed for all coal projects. Federal concerns can be sent directly to MMSC without going through RSCC. Reports to federal cabinet and gives independent direction to the company. Consists of Departments of: Environment*, Fisheries and Oceans.	keview Stage I and II studies

* Chair Committee

TABLE 2
LIST OF GOVERNMENT AGENCIES
IN ENVIRONMENTAL REVIEW FOR MINING PROJECTS

GOVERNMENT AGENCY	FUNCTION	TIMING
(A) KEY BIOPHYSICAL RELATED AGENCIES		
Ministry of Energy, Mines and Petroleum Resources (EMPR)	Approval of mine plan (Chief Inspector's Approval of Mine Plan).	Review mine plan prior to Stage II submission-formal approval in Stage III
	Chairs CGSC and MMSC	Stages I to II
	Reclamation plan (permits)	Involved from exploration to abandonment
	Issues coal licence permit	Pre-Stage I
	Mine economics (chairs Economic Evaluation Committee)	Stage II review
Ministry of Environment (MOE)*		
Water Management Branch	Approvals for water licences and water management plan.	Stage II and III
	Looks for information sufficient for permit applications.	Pre-Stage II
	Land Improvement Licence.	Stage III
	Approvals for all stream crossings.	Stage III
	On Minesite Advisory Committee.	Stages I and II

* Includes input from region and head office.

Table 2 (continued)

GOVERNMENT AGENCY	FUNCTION	TIMING
(MOE continued)		
Waste Management Branch	Pollution control permits for effluents, emissions and refuse.	Stage III and liaison prior to Stage II submittal
	Can address concerns of non-permitting agencies by how they issue permits.	Stages II and III
	On minesite Advisory Committee.	Stages I and II
Fish and Wildlife Branch	Reviews wildlife and fisheries concerns. Comments on exploration licences and on MOE licences.	Prior to detailed field studies and formally through to Stage III
Assessment Branch	Official MOE contact and coordinating group for mining projects.	Throughout Stages I to III
(B) <u>ANCILLARY BIOPHYSICAL RELATED AGENCIES</u>		
Ministry Lands, Parks and Housing	Concerned about effects off mine licence.	Stage II
	Issues land leases on Crown land.	Pre-Stage I
Ministry of Forests	Mainly off exploration areas, licences cutting on Crown land and forest access roads.	Pre-Stage I
Ministry of Agriculture	Identifies Agricultural Land Reserves for Agricultural Land Commission.	Stages I and II

Table 2 (continued)

GOVERNMENT AGENCY	FUNCTION	TIMING
Heritage Conservation Branch	Evaluates the effects on historic and archaeological areas.	Stages I and II
Ministry of Transportation and Highways	Involved if a new public road is required.	Stage II
(C) KEY SOCIO-ECONOMIC RELATED AGENCIES		
Ministry of Municipal Affairs	Chairs Socio-Economic Coordinating Committee. Involved with community related impacts.	Stages I and II
Ministry of Labour	Member of Socio-Economic Coordinating Committee. Reviews manpower, recruitment and training concerns.	Stages I and II
Ministry of Industry Small Business	Member of Socio-Economic Coordinating Committee. Reviews labour supply, special interest groups (women, Indians, children).	Stages I and II
	Member of Economic Evaluation Committee which looks at mine economics.	Stage II

DISCUSSION RELATING TO ROB HAWES' PAPER

Neil Duncan, Energy Resources Conservation Board: In review committees of the government the only mention made of the public seems to be under Stage II where you say that developed political support may include public meetings.

Is that the only opportunity for the public to actually have input of their concern on the scheme?

What would your advice be to an applicant on how to present this to the public?

Answer: The public does not have to be directly involved. When Stage II is submitted, reports are normally distributed to community, libraries, and public comments can be received through the Coal Guidelines Steering Committee. The steering committee encourages public meetings, but there are no formal hearings and normally formal public meetings are not required though many companies now, and some that are here today, are on their own initiative having public information meetings with the community.

J.D. McDonald, MEMPR: Maybe I could just add to that Neil. There is no formal requirement in the stage process for hearings other than under the Pollution Control Act, the Water Management Act and the Environmental Land Use Act. Under the Pollution Control Act, and Water Management Act, if there are more than five objectors, then they can call a public hearing and of course the Environmental Land Use Committee under that Act can ask for a hearing. In Alberta you do have public hearings. I think at some point in time public hearings will be a formal requirement of the Guidelines process.

Malcolm Ross, Crowsnest Resources: You mentioned environmental studies but at the end you mentioned socio-economic. Could you comment on the balance of the environmental impact on the physical environment and the socio-economic impact.

Answer: A socio-economic report is required as part of the Guidelines process. It's very thorough in addressing housing and labour demands on the local community: where the housing will be, the companies policy toward housing, hiring practices and labour training.

Malcolm Ross, Crowsnest Resources: How does that fit in with the review process and with respect to a public hearing.

Answer: They are submitted together and they go through the review process together, although they are reviewed by separate agencies and committees.

Malcolm Ross, Crowsnest Resources: But there is no actual need for public input in the socio-economic studies?

Answer, J. McDonald, MEMPR: There is no legal legislation or regulation to that effect under the Municipal Act. The Ministry of Municipal Affairs certainly reviews socio-economic studies because the Municipal Act takes into account what is required in the way of housing, labour force and what monies the government has to put in to upgrade the community. In the review process the municipality itself gets involved through municipal affairs. We've had cases where a decision between using a new town, or an existing town for a new mine development had to be made. The existing community certainly made its position known and it became a political decision, based on a lot of studies mind you, of what is best for the area.

WATER MANAGEMENT FOR MINES

Paper Presented
by

Y. Fellman
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WATER MANAGEMENT FOR MINES

Last year my colleague Mr. Howie presented a paper on waste management for mines, and taking into account that the water act is presently under review and being rewritten, I think this year is an opportune time for a paper on water management.

The law of British Columbia with regard to water is based on the concept that water is property, and as such, under the British North America Act, comes under the jurisdiction of the Provinces. The jurisdiction of the federal government over water is therefore limited to special matters such as navigation, anadromous fish and international streams, while all use of water within the Province comes under the control of provincial statutes.

The most important single feature of British Columbia law with regard to water is the denial of "riparian rights" which are derived from England common law.

The riparian law still works well in countries where the supply of water is plentiful and where it is not used extensively for high-quantity use. However, the inadequacy of the riparian law under British Columbia conditions was recognized at a very early time by the hydraulic miners of the Cariboo gold rush days.

The first legislation with regard to water in British Columbia is contained in the Gold Fields Act of 1859, in which it was provided, in effect, that the Gold Commissioner could grant exclusive rights to the use of defined quantities of water, not necessarily for use by a riparian owner; that the water-user would pay a rental to the Crown; that neglect to use the water or wasting of the water would result in the cancellation of the privilege; and that the holder of the right could sell water, provided that he charged fair and non-discriminatory rates.

Under the Water Privileges Act of 1892, provision was made for the use of water for purposes not covered by the Gold Fields Act or the Land Act. The Act for the first time declared that all the water in the streams of the Province belonged to the Crown, and that no further riparian rights could be acquired. The Water Clauses Consolidation Act in 1897 consolidated the various laws dealing with water. The Water Act was amended in 1939 and was cut down from 300 sections to about 80. In 1960 the Water Act was amended to provide that groundwater areas are to be proclaimed by Order-in-Council.

The Water Act is at present being rewritten. The new act is in keeping with the government policy of decentralization where the maximum amount of decision-making will be done regionally. This revised Act will be more of a Water Management Act whereas the present Act is in the format of a Water Allocation Act.

Although we are very well endowed with water in this province, as the precipitation is so intense in many areas, there are vast areas where demand can exceed supply as here in the Okanagan Valley. Water uses and users are not always compatible even with adequate supply. Recently there has been a case where the licencee was shot by the riparian owner for trespassing. Supply is only one aspect of water management; drainage and flood control are other very important aspects, especially when there is danger to life and property which could possibly be triggered off by poor construction practices by an individual or group.

In the interest of safety, Section 22 of the Water Act holds an owner of land, mine or undertaking liable for damage after the abandonment, suspension, termination or cancellation of a water licence or approval resulting from a defect, insufficiency or failure of the works. Section 23 makes it illegal to flood Crown land without the appropriate permit.

Thus the Water Act has always been used to protect the environment, e.g. under Section 41, a person is guilty of an offence who puts into any stream any sawdust, timber, tailings, gravel, refuse, carcass, or other things or substance after having been ordered by the Engineer or Water Recorder not to do so. Also, approvals under the Water Act have included water quality stipulations requested by Federal Fisheries. Provincial Fisheries have also frequently requested conditions to be included in water licences.

Every mine will require one or more water licences. A Water Supply Licence would be required for such purposes as:

1. <u>Domestic Purposes</u>: Camp supply potable and sanitary water.

2. Hydraulicking Purposes: Using water head to move earth materials.

3. Industrial Purposes: Most mine site uses.

4. Mining Purposes: Recover mineral from ore or ground.

5. Storage purposes.

6. Power Purposes: If hydro power is feasible.

7. Land Improvement Purposes: For this licence a water management plan to cover diversions and drainage is required.

If a storage or diversion dam is required for water supply or power purposes, and the dam is more than 10 m high, then engineering design plans must be approved by the Dam Safety Engineer in Victoria; smaller dams must be submitted for approval to the Regional Water Manager.

To date practically all water supply licences have been required for only surface water sources. But if a well is pumping water from an aquifer that is being directly recharged by a spring or stream, it may be necessary to take out a water licence on that particular spring or stream. As an example, the District of Sparwood has a water licence on MacKenzie Creek for their groundwater pumping station. While Section 4 of the Water Act gives the Lieutenant-Governor in Council the right by Proclamation to fix a day, or days, upon which the Water Act shall commence to apply to groundwater in any part or parts of the Province, this date has not so far been proclaimed.

Legal objectors to the issuing of a water licence are any licencee, riparian owner or applicant for a licence who considers that his rights would be prejudiced by the granting of such licence: also, the Deputy Attorney-General, the Deputy Minister of Agriculture and the Deputy Minister of Lands, Parks and Housing.

For the temporary use of water in mining operations, and particularly for Placer mines which occur in certain areas for only the summer months, a water approval under Section 7 of the Water Act rather than a licence can be issued. Section 7 of the Water Act allows approval for non-recurring uses of water for a period of six months without issuance of a licence. The advantage of an approval over a licence is the shorter time required to obtain authorization. Whereas approval can be obtained in a very short time usually directly from the Regional Water Manager, a water licence normally takes over a year and often two years to process. However, an approval costs more, $100 per cfs compared to $20 per cfs for a licence. It is the policy of the Water Management Branch not to give a water approval as an interim measure to a proponent waiting for a water licence.

The function of Water Management includes all steps necessary to ensure the protection of watercourses throughout the development, construction, operation and abandonment phases of the project. Water management is necessary through the projected life to minimize disturbance, provide runoff control facilities, remove sediment from flowing water, stabilize banks and reclaim land aa expeditiously as possible; also, in some circumstances, to control or mitigate deposition into natural waterways of heavy metals, acid drainage, total nitrogen and other toxic substances. The plan will have to be modified with time.

The principal tools employed within the water management plan are surface hydrology and groundwater. The environmental impact statements are reviewed by a hydrogeologist within the Water Management Branch.

SUGGESTED FRAMEWORK FOR A HYDROGEOLOGICAL STUDY

1. Topography, drainage and geology.

2. <u>Groundwater</u>

- occurrence and movement of groundwater
- depth to water table
- aquifer characteristics
- surficial deposits
- groundwater flow systems
- chemical quality of groundwaters, to include sampling prior to exploratory development
- quantity and quality of groundwaters to be disposed of
- groundwater - surface water relationships
- present use of groundwater
- possible effect of development on the groundwater regime

3. Monitoring Program.

Hydrology studies will be required to substantiate adequacy of water supply, for the design of drainage works, stream diversions and settling ponds. Usually water quantity monitoring stations should be set up both upstream and downstream of the disturbed area and at least one station should be continuously monitored. At least one year of recordings is usually required before proceeding to the construction stage. Water uses should be illustrated on water balance diagrams.

HYDROLOGICAL DATA REQUIREMENTS

Stage I

Based on existing data.

- mean annual runoff
- maximum and minimum annual runoff
- mean monthly distribution
- mean and return period annual maximum daily discharge
- mean and return period annual minimum daily, seven day monthly discharge

Some basic watershed characteristics must be compiled including:

- drainage area
- elevation range
- median elevation
- channel profile

A proposed monitoring program should be outlined giving:

- location
- instrumentation (water level recorder, staff gauge, type of current metre or weir)
- observation frequency and period of operation (all year, seasonal)

Stage II reports should also include the following after at least one year of project-related monitoring:

- annual and monthly runoff regime
- flood (peak) and low flows
- watershed physiographic characteristics
- floodplain zones
- quality (include suspended sediment)
- water use

From the monitoring, it should be possible to provide estimates of streamflow characteristics which relate to:

- water supply
- design of settling and tailings ponds
- design of culverts and stream crossings
- delineation of floodplain areas
- fisheries requirements
- project drainage plan
- impact assessments

Effects of development on:

- surface drainage modification
- groundwater flow modification
- ground and surface water quality
- other water uses and users

Some streams are already fully recorded, e.g. the Similkameen River system, the Elk River by B.C. Hydro for power, and some streams for fisheries. This does not mean that no development is possible in a watershed whose stream is fully recorded - one solution is to develop storage of higher flows to augment periods of low flow. The Similkameen River has been fully recorded since 1960 to honour the Agreement with the U.S.A. for a stipulated flow at Nighthawk.

Present government policy in the Similkameen is not to abandon any existing water licence to prevent the U.S.A. from increasing their share of the flow. To develop storage or drawdown flows on existing lakes is virtually impossible as most lakes are completely surrounded by private land with expensive dwellings.

For the water management plan, a preliminary design would be required for "approval-in-principle," and a detailed design for the "land improvements" water licence. The plan could include detailed natural drainage, designed runoff diversions, interceptor ditches for natural runoff, contaminated drainage, settling ponds and treatment facilities for all disturbed areas, stabilization measures for watercourses and embankments, examination of the 200-year flood level encroachment into mine site facilities and the water supply distribution system.

Usually the design criterion for stream diversions, drainage of disturbed areas, and settling ponds is the 200 year, 24 hour flood event. A normally acceptable risk factor is a 10% chance of occurrence. A 200 year flood event has a 10% chance of occurrence in 20 years. Most mines have a life expectancy in excess of 20 years. Probability curves for various streams in this province have indicated 200 year storms which were about 1.5 times the 50 year storms that were already recorded. We do not consider a factor of safety of 1.5 over recorded storms and ones which will in all likelihood reoccur within the life of a mine as too conservative. Statistical reviews cannot allow for all possible events. Flood events occur in cycles, and in many areas there are no records during the early part of this century when high flooding events did occur. Present weather trends show extremes occurring more frequently i.e. within shorter time intervals than occurred during several previous decades. This trend would cause the 200 year flood event to occur within a shorter time period.

Storage dams over 10 m and all high-hazard or dams whose failure could cause loss of life are required to be designed for the probable maximum flood.

During construction of the W.A.C. Bennett Dam, the Peace River had to be diverted during 1963 and 1964. The maximum recorded flow measured at Hudson Hope to the date of design in 1961 was 270,000 cfs. For the duration of the four years of the diversion system, the diversion system was designed to contain an unprecedented flow of up to 320,000 cfs. However, in the spring of 1964, which was the most critical year of construction, the flow was 311,000 cfs - the highest recorded to date.

Stream diversions which mines require for many reasons (e.g. an ore body may lie below the streambed or the stream valley may be required for a waste dump or tailings pond), can no longer usually be solved by direct channelization. Loss of floodplain storage in the diverted section can cause flooding to riparian owners downstream. Also, channelization causes loss of fishery values, and increased velocities due to shortening of the original route and could cause erosion with downstream sediment problems. For this reason, a diverted section of stream could be required to duplicate floodplain areas, length, and fishery values of the original stream.

If a stream is diverted temporarily, as is often the case for valley waste dumps, then the reclamation plan must address the final drainage patterns that will sustain themselves naturally e.g. a stream cannot be left flowing along the side of a hill in a ledge-like manner. To let the stream run through the waste dump may not be permitted as this could have sediment problems downstream. Improper reclamation coald be one reason for some barren streams in the northern part of this province.

Channelization with loss of floodplain storage and change in stream regime can be caused by other activities than diversion. A road embankment can also cause channelization. Location and alignment of culverts can make the difference in whether or not drainage patterns are self-sustaining.

The water management plan should include water quality monitoring stations situated both upstream and downstream of the minesite and other disturbed areas. A year's monitoring is generally a minimum requirement prior to the construction of the mine. This background information can benefit the proponent as water quality under pristine conditions sometimes do not meet the B.C. drinking water standards. Parameters for water quality and loading allowance are a Waste Management Branch jurisdiction, but there are Water Approvals where conditions include water quality parameters.

Total nitrogen loading may pose a problem. Nitrogen can enter a stream from pit water due to blasting, particularly wet blasting; residual explosives in waste dumps can leach nitrogen and also from storage of explosives. The maximum limit for nitrite/nitrate nitrogen has been set as 10 mg/L combined for drinking water based on the susceptibility of infants to methemoglobinemia. Nitrite/nitrate concentrations have been recorded in the Fording River as high as 10.8 mg/L.

A Water Management Plan has now become an integral part of mine development just as a mining plan and a reclamation plan has for some time, although it is only relatively recent that mine development planning has progressed to the degree that it is possible to address the question of water management.

DISCUSSION RELATING TO YENON FELLMAN'S PAPER

Terry Martin, MEMPR: Yes Yenon I was wondering if you could explain the term "fully recorded."

Answer: The term "fully recorded" does not have an absolute definition; the comptroller and the regional water manager could have different definitions. A stream could be stipulated as "fully recorded" as, for instance, in the Elk River case where B.C. Hydro is saying they are licencing the entire flow for power purposes. The Similkameen River is "fully recorded" because of the stipulated flow at Nighthawk, and if you work out the minimum flow, and the number of water licences that make it up, there wouldn't be enough left. A stream could become fully recorded if the minimum recorded flow equals the requirements from a number of water licences while considering that so much is also required to be left for fisheries use. There is, therefore, no fixed definition.

Bill Fothergill, B.C. Hydro: Is there any new legislation on Water Rights on the amount of ground water control, that is on how much water you can take out of the ground?

Answer: The new Water Act is not yet published. I cannot say a thing about what will happen in the new Water Act until it's been seen by people much higher than myself.

B. Fothergill, B.C. Hydro: Yes, but you must have some ideas on how you would withdraw and measure amounts of water. Would it be like measuring air emissions?

Answer: Well I don't think that the new Water Act will be any more comprehensive than the present Act is. It will just have a stipulated day when it comes into effect. The Lieutenant-Governor will stipulate that.

Brendon Gordon, MEMPR: You mentioned that your permit system has been regionalized. What is your estimated time frame for issuing a water permit; the present system it takes about eight months?

Answer: Well water approvals can be done very quickly even at present.

Brendon Gordon, MEMPR: What is the time frame - weeks, months?

Answer: I would say it could go as low as weeks, the thing that takes the time is the referral system. The application is referred to fisheries and the other ministries and we have to wait to get a reply back from them. So that is probably the only hold-up in that approval.

Brendon Gordon: What exactly is the definition of a stream?

Answer: It is in the Water Act and is any natural body of flowing water.

Ben Asare-Quansah, Crowsnest Resources: Do you look at groundwater from the aspect of mine design, pit design or just from its use?

Answer: We look at the effect of mine water and what the effect of the pit will be on the groundwater, the quality and the quantity.

Ben Asare-Quansah, Crowsnest Resources: But don't you look at how the groundwater will affect the safety of the pit?

Answer: That is up to the Mines Inspection Branch.

Jack Thirgood, University of British Columbia: If I heard you correctly you said there were some streams in B.C. that have been rendered barren by past mining practices, could you give us some examples?

Answer: I didn't say that they were proven to be rendered barren but that it was possible that they were rendered barren. There are a lot of barren streams up near Alice Arm and that area. It is possible that in previous mining or in hydraulic mining, that heavy sediment loading being put into a stream has rendered them barren.

Neil Duncan, Energy Resources Conservation Board: Isn't regional groundwater being studied by government departments? A mine is a pretty small part of an overall groundwater regime and obviously you would need some advice on what exists there right now.

Answer: There is work being done by the water board all over the province. There are wells being monitored and any proponent should check with our groundwater staff to see what work has been done so there won't be duplication.

MOUNTAIN ROAD REHABILITATION AT SUNSHINE VILLAGE SKI AREA

Paper Presented
by

J. Buckingham
W. Bates
Sunshine Village

MOUNTAIN ROAD REHABILITATION AT SUNSHINE VILLAGE SKI AREA

INTRODUCTION

The Sunshine Village upper access road winds up a steep, narrow valley climbing 424 m in a 5 km length (Figure 1). The village at the top is at 2160 m elevation, just where the dense forest is starting to open out into alpine meadow. This road was built as a make-work project in the 1940's and as such was built to a very low standard. At present, it is characterized by, on the upslope side, deep eroding cutbanks, on the downslope side, by large amounts of mixed gravel and salt that have been plowed off the road's surface. Over forty years of increasingly heavy winter use by buses, the constant plowing and nearly daily gravelling necessary to keep the road open for buses has gradually widened not only the road surface, but the areas of erosion and vegetation damage both above and below the road. Our project is to stabilize these areas, get the drainage under control, reduce the width of the road to the minimum required to service the area, and revegetate the areas on either side of the road with species acceptable in the National Park. This is an interesting reclamation project because: the site is at high elevation with a very short growing season, the requirement to meet Parks Canada standards, and the need to produce a road which will handle bus traffic in the summer and be suitable for ski terrain in the winter.

Sunshine Village, 17 km southwest of Banff Townsite (Figure 2) is one of the major ski resorts in western Canada. The base facilities, hotel and staff quarters are located at an elevation of 2160 m. The ski terrain is right along the continental divide with a small portion of it actually in British Columbia. The skiing season runs from mid November until late May and the hotel is operated for a summer season from late June until early September. From the Trans Canada Highway, west of Banff, an 8.5 km long, all-weather public access road leads to Bourgeau parking area at an elevation of 1636 m. Until 1980, public access from this parking area to the village was a shuttle bus system operated by Brewster Transportation. In winter, the upper road was very heavily used, as on a peak day up to 29 buses were transporting up to 4,500 people to the village. Summer use of the road in comparison was very light, but steady.

There was no organized plan to widen the road, just random work by various cat drivers over the years. Tonnes of mixed gravel and salt were

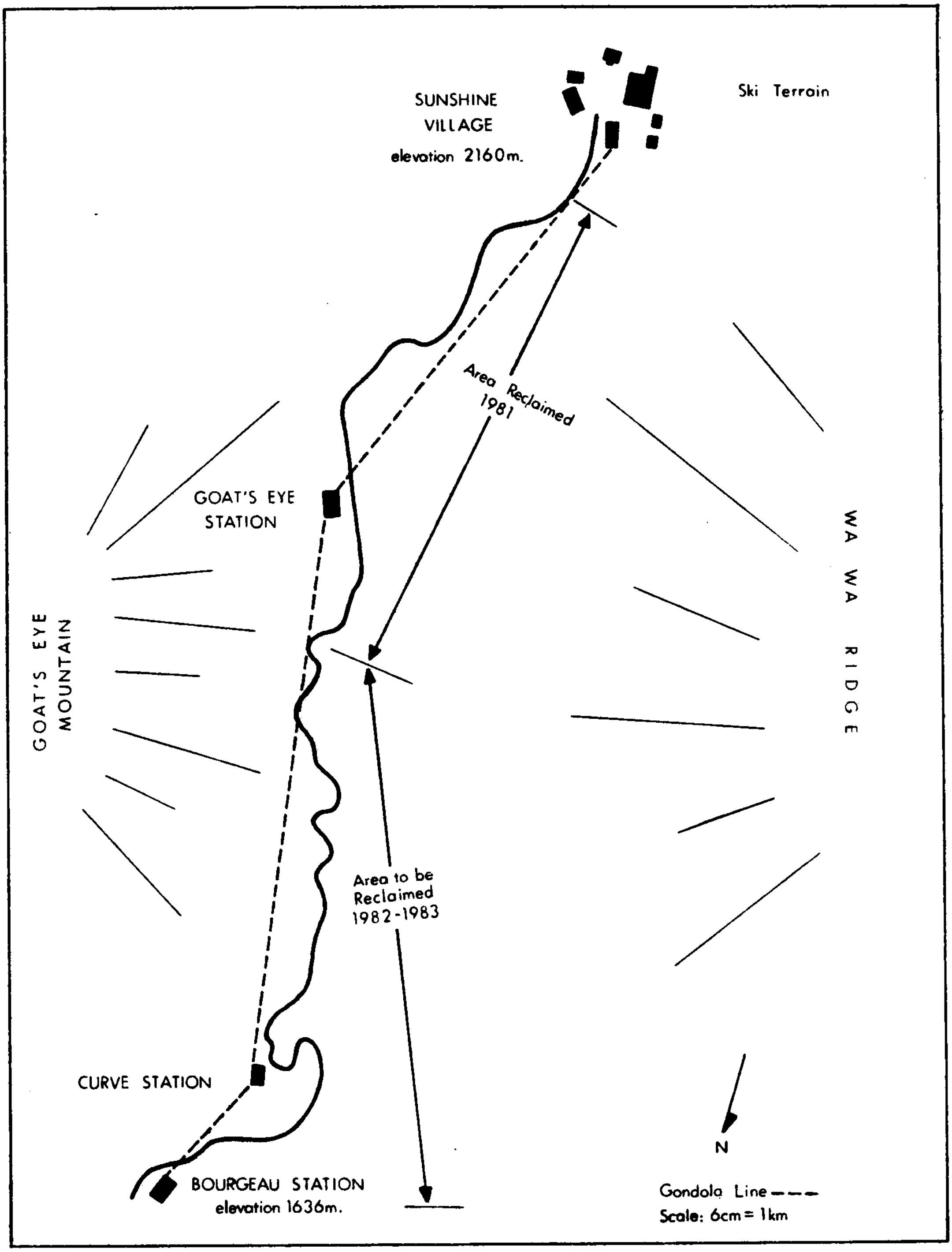

Figure 1. Sunshine Village Upper Access Road

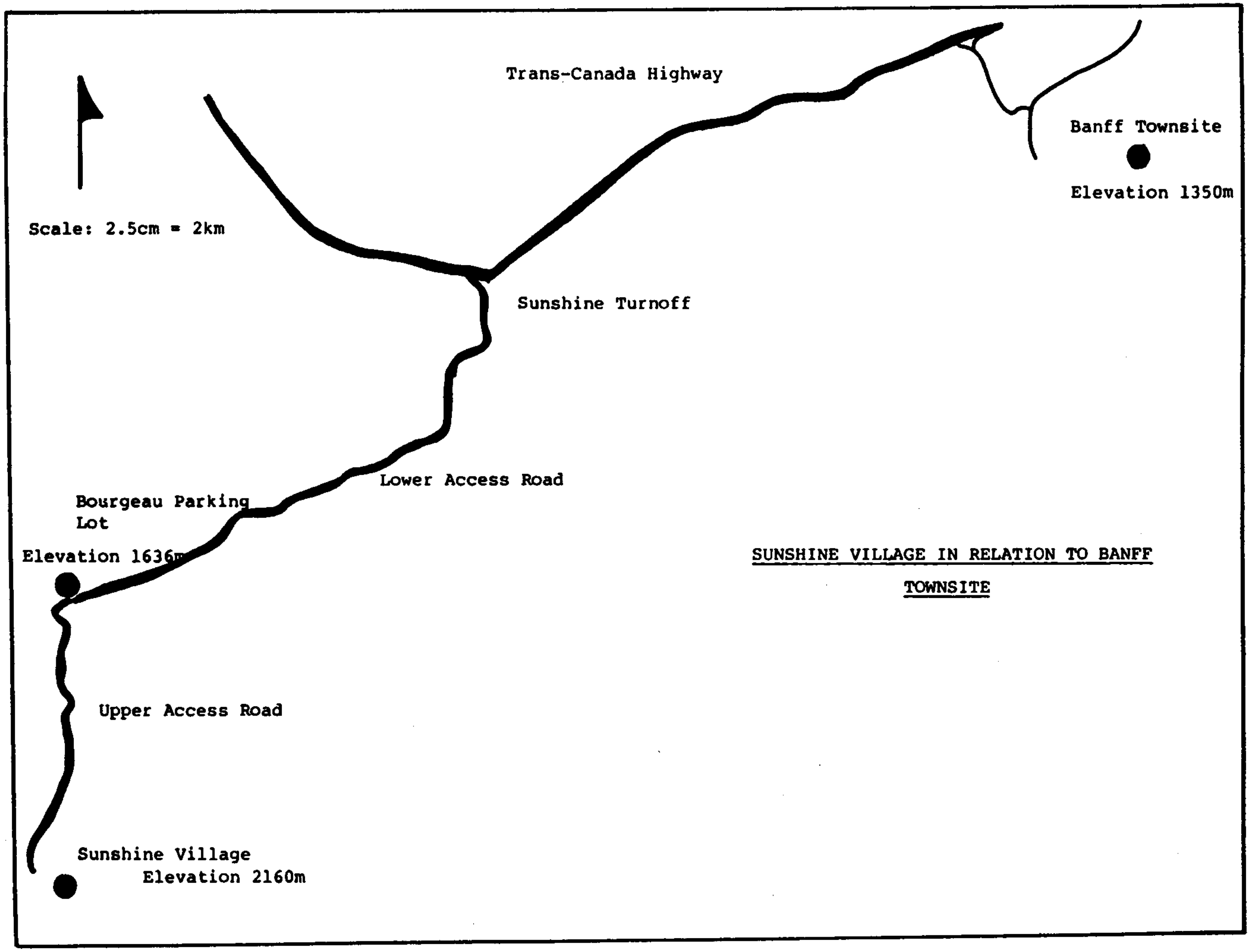

Figure 2. Sunshine Village in Relation to Banff Townsite

poured onto the road to keep it open through the seven month ski season. Many of the bulldozer operators who worked to keep the road open had no concern for the environment and, in fact, the main objective in many cases was to see how many trees they could plow over. Every year, by spring there were large banks on the lower side of the road of mixed snow, gravel, salt, and a few trees that had been uprooted over the winter. Trees on both sides of the road that were within reach, if not already pushed over, were badly scarred by repeated hits from the bulldozer.

Every spring there was a battle to keep the road from washing out. Because the road was of random tilt with inadequate ditches and too few culverts, water ran where it wanted along the surface. Large erosion rills were produced on the lower side, as well as slumps falling from the banks above. With progressive slumping the vegetation mat would overhang more and more and trees would start to lean out over the road. If not felled at this point the trees eventually blocked the road. It has been a deplorable situation both environmentally and aesthetically. Possibly the worst impact on the environment was due to the mixed piles of salt and gravel on the lower shoulder. These crept, slumped, and flowed into the vegetation on the lower side. At times some of this material was carried right down to the creek below.

The major advance which allowed resolution of this problem was the installation of a gondola to replace the upper road. The winter of 1980/81 was the first in 40 years during which the upper road had not been plowed. We proved at that time that we could operate the ski area without the upper road, and, in fact, started using the upper road as a ski trail. Last summer we began the reclamation. Since the road was built by the federal government, Parks Canada agreed to let us do the work, with them paying for it through a reduction of lease fee. In cooperation with Parks Canada the following specifications were agreed to.

SPECIFICATIONS

The upper banks were to be cut back to a maximum slope of 30°. To control drainage, the entire length of the road was to be tipped toward the inside, and a round-bottomed ditch with a minimum depth of 45 cm was to be provided along the entire upper length. On the lower side of the road, where possible, the slope would be reduced to 30° and the shoulder rounded off. In many places the downhill side of the road was so steep over such a distance that it was impossible to work on these banks with a bulldozer. All that could be done was to round off the outside shoulder of the road and re-seed it. In the summer of 1981 the upper 2,000 m of the 5 km road was to be worked on. Within this length, nine new culverts were to be added. At each of these culverts, inflow and outflow protection was to be provided by hand setting rocks. Rock work was continued as far down slope from the culvert as was likely to be a problem. All the areas of exposed ground were to be seeded except the actual travelling surface of the road. The specified grass mixture was: 30% Creeping Red Fescue (Boreal) *(Festuca rubra rubra)*, 25% Slender Wheatgrass *(Agropyron trachycaulum)*, 20% Canada Bluegrass (Reubens) *(Poa compressa)*, 15% Streambank Wheatgrass (Sodar) *(Agropyron riparium)*, and 10% Hard Fescue (Durar) *(Festuca ovina)*, at 55 kg/ha. In general, this mix is tolerant of slightly alkaline conditions, drought resistant, shade and cold tolerant and establishes well on soils with low fertility. Two fertilizers would be required: 34-0-0 11% S at 168 kg/ha and 6-24-24 at 336 kg/ha. Straw mulch was to be spread over the seeded areas at a rate of 4.5 tonnes/ha. The seed and fertilizer was to be spread and raked in by hand and the straw also applied by hand. When cutting back the upper bank as many small trees and shrubs as possible were to be dug out and set aside. As soon as possible, they were to be replanted at suitable locations.

CREWS AND EQUIPMENT

We had a labour crew of 18 people. The burning crew (three people and a supervisor) felled, piled and burned the brush and trees that had to be removed. The seeding crew (13 pepple and a supervisor) did the vegetation salvaging, raking, seeding, fertilizing and mulching. The heavy machinery we contracted consisted of: one D7 caterpillar with logging winch, straight blade and brush blade; a JD 450 with straight blade and logging winch; a standard rubber tired backhoe and loader combination; a ten tonne gravel truck; a grader; and, for a four day period, a gradall.

SEQUENCE OF WORK

In consultation with Parks Canada, the line to which the upper banks would be cut back were flagged and all trees which had to be removed on the downhill side were designated. We chose a starting date of June 15th as the earliest possible date that the road would be dry enough to work on. The road was divided into seven sections, in each section the sequence we attempted to follow was:

1. Vegetation Salvage: The seeding crew will dig out by hand with the help of a loader all small trees and shrubs that can be salvaged in one-half day's work.

2. Falling and Piling: The burning crew will cut all the timber and brush remaining on the uphill side of the road and the few designated trees on the lower side. All solid wood of over 10 cm diameter will be cut and piled for firewood. The brush will be piled along the shoulder of the road for burning.

3. De-Stumping: The D7 with brush blade will pull out all the stumps, clear them of earth, and push the smaller ones into the brush pile for burning. The larger stumps will be buried in areas requiring fill.

4. Burning of brush and stumps.

5. Rough Shaping of Banks: The D7 with straight blade will cut back the uphill banks to a stable shape.

6. Final Shaping: The JD 450 will produce the final smooth, curving shape on the uphill banks and where possible, shape the downhill shoulder. Where the JD 450 cannot work the downhill shoulder it will be shaped by the gradall.

7. Ditching and Road-Shaping: This will be done by the backhoe and grader. Fill will be hauled by gravel truck from where it is produced in surplus to where it is needed.

8. Seeding: The seeding crew will rake, seed, fertilize and mulch the exposed ground, and finally replant the salvaged vegetation. On the large banks, earth water bars will be installed at 5 m intervals, sloping toward the road on a 5° angle.

9. Culverts will be installed by backhoe and rock work at the inflow and outflow will be done by the seeding crew.

ACTUAL PROCEDURE

The above sequence was, to say the least, idealistic in comparison to what actually happened. Machinery unavailability, breakdowns and nearly continuous bad weather including three major snow storms, made the whole project a scramble to keep things rolling. The D7 was not available until the 20th of June, and then it had several breakdowns, which took it out of service for up to a week at a time. The JD 450 winch broke several times although it was a brand new machine. Heavy rain and snow storms brought work to a complete halt several times but when the rain or snow fall was light we managed to keep work going. How poor the working conditions were, is probably indicated by the attrition of the seeding crew which started with 13 people, but by August 1st was down to four people.

Another factor that we had not foreseen was frost. In some of the cuts we hit frost as late ae the first week of July. When this heppened, we could only scrape the melted ground off the frozen, leave it for three or four days to thaw out, blade off what had softened and start again. In one location we had to do this three times before we finally got rid of the frost. At times the project looked very disorganihed. The downhill shoulder had piles of earth, trees ready for replanting, brush piles ready to be burnt and we were still trying to keep the road open and have a few passing zones so that when cars and buses met they didn't have to back up too far until there was room to pass. One major trouble spot was a large bank known as the Zone 15 cut. At this area the road was very narrow, the bank above quite high and the natural wooded slope above the cut bank was nearly a 30° slope. We originally hoped that the gradall would reach up this bank and back slope it but we didn't think the bulldozers could work on it. We found, however, that the gradall had neither the power nor the reach for this job. We then started working from either end first with the big cat and then with the smaller one. Finally, through skill and perseverance the operator of the 450 managed to do the entire bank. The final slope produced was just under 30° which is very steep for a bulldozer to work on when it must go sideways across the hill. By the first of August all the banks were shaped, all the downhill shoulders rounded off and all areas were seeded. The entire length of the ditch had been brought to the correct depth and shape and the culverts were all placed. Work continued through August, placing the rocks in the inflow and outflow area of the culverts. Parts of the road surface still had not been tipped to the uphill ditch but this would be done as part of next year's work.

RESULTS

We were very pleased with the results. All of the banks seem to be stable. They have all gone through several rain storms during and after the construction period and the grass took well. The areas that were planted early showed very good growth, and of those areas planted near the first of August all were showing at least some green.

The mulch we used was straw purchased from an Alberta farmer. It was apparently barley straw and not too well thrashed; barley was the most obvious of the grasses that grew! Parks Canada was displeased with our introducing domestic grain onto the site although our early frost would probably prevent the seed head from maturing. We cut off all the seed heads in late August for insurance. We have received many positive comments on the improved aesthetic appearance of the road. As far as we can determine all the erosion problems are under control. The final test, of course, will be this spring's run off. We are now in negotiations with Parks Canada for this season's road work. We have asked to complete the road in one more season but it seems likely that Parks will require us to do it over two seasons, to spread out the expenditure. Some very interesting problems are apparent along this section including several banks much larger than we have cut before and one large eroding slope that cannot be cut back because a gondola tower base is right above it. We hope to use a combination of engineering and vegetative practices on this site. A very complicated situation arises at a switchback on the road which is also the location of the gondola curve station and has a rock cliff immediately above the road.

DISCUSSION RELATING TO J. BUCKINGHAM'S AND W. BATES' PAPER

Bruce Ott, Placer Development: Can you tell us what the bottom line was for the two kilometres?

Answer: $60,000.

THE REHABILITATION OF DISTURBED FOREST LAND

Paper Presented
by

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Research Branch
Ministry of Forests
Victoria, B.C.

THE REHABILITATION OF DISTURBED FOREST LAND

THE PROBLEM

Forest utilization leads to the inevitable disruption of stability and productive capability of forest soils. Disturbance can be permanent or temporary, mild or severe, but it cannot be fully eliminated. Some man-made disturbances can be tolerated and are even necessary for continuous resource management whereas others must be prevented or remedied for the sake of resource protection and the maintenance of productivity.

Two main classes of forest land disturbances are recognized as consequences of the removal of the protective vegetation cover and top soil horizon.

1. Exposed mineral soils, subjected to the forces of erosion, lead to the instability of slopes.

2. Depleted soil nutrient levels associated with unfavourable alteration of soil properties diminish or destroy the chances for forest establishment.

Damages to forest soils caused by management-related activities can originate both within and outside the road right-of-way.

Road-related damages are:

1. Impaired stability of the road structure on:

    a. cut and fill slopes
    b. roadbeds and associated drainage structures.

2. Damaged adjacent aquatic environment with respect to:

    a. fish habitat
    b. hydrology
    c. community water supplies

3. Impaired aesthetic values. Soil disturbances originating outside the road right-of-way are:

a. slides and gullies on logged mountain slopes

b. skid trails on clearcuts

c. landings

OPTIONS FOR PROBLEM SOLVING

In addressing the issue of forest land disturbances, several options are available to be chosen and applied in a logistical manner.

First, the two important concepts of prevention and actual rehabilitation must be observed before control methods are chosen.

Prevention calls for foresight, anticipation of damage, and planning. Activities in this area include the delineation of sensitive sites, geotechnic inventory, and engineering design of roads and drainage structures.

Rehabilitation is successfully applied when prerequisite criteria to prevent advanced site degradation, e.g. severe failures, are met. Reference is made to the MOF Land Management Report No. 4, under "Construction Criteria" on page 8. The recognition of surface versus mass erosion problems has priority in the decision-making process. Surface erosion can be dealt with under "rehabilitation" whereas major mass soil movement in the forest area can only be "prevented."

The most economical and most effective means of surface erosion control is provided by revegetation techniques. This can be accomplished by:

1. Grass-legume seeding through:

   a. direct or dry seeding of slopes not exceeding 27% steepness, or

   b. hydroseeding or hydraulic seeding of steep slopes. This is more costly but also more effective than dry seeding.

2. The establishment of shrub and tree species on slopes where failures cannot be controlled by grass-legume mixes alone is most effective when woody plants are superimposed on an established grass-legume cover.

Both methods prove useful on cut and fill slopes, slides and gullies. Further, the timely application of surface erosion control methods can also prevent the eventual subsequent escalation of surface erosion problems to mass soil erosion; for instance, rills developing into gullies, undermining the slope.

The rehabilitation of laadings involve the improvement of physical, chemical, and biological properties of compacted and nutrient-depleted forest soils. Unless rehabilitated, the total area of many landings add up to a significant area of forest land which is removed or "alienated" from forest production.

The problem of skid trails calls for principles and techniques listed under forest roads and landings, involving both erosion control and soil improvement measures. The most comprehensive practical handbook is currently under review, titled "Ground Skidding Handbook for the Nelson Forest Region" by H.L. Hammond.

The tools of rehabilitation by revegetation range from the simple cyclone seeder for dry seeding to the more sophisticated hydraulic slurry applicators. Aerial seeding techniques on mountain slopes not accessible with ground-based equipment are also in use. Dry seeding from helicopter is a simple and widely used technique. Currently the MOF is designing an improved version of an aerial hydroseeder to treat steep gully slopes and slides.

ACCOMPLISHMENTS AND RESULTS

The Ministry of Forests started a roadside revegetation research project in 1977 on a modest scale. Soon it became evident that the rehabilitation of all disturbed forest areas had to be included in a larger program. The propagation of shrub species was added to the revegetation program, followed by efforts directed toward landing rehabilitation. Earlier efforts to improve landing sites in the Cariboo Forest Region were experimentations with deep and shallow ripping of the compacted soil, followed by seeding with grasses and two tree species.

As most of the land rehabilitation research and semi-operational work concentrated on roadside hydroseeding, most slides shown here illustrate the erosion control aspect of land rehabilitation. The "shrubs" and "landings" are still in the research phase whereas roadside erosion control is now being implemented.

Seeded test sites of "early" and "late" application were established in all six Forest Regions and in most biogeoclimatic zones. These test sites are monitored annually. Per cent slope cover and representation of the dominant grass and legame species are recorded. Foliar and soil analysis of the earliest test sites on Vancouver Island already indicated an increasing nutrient capital. Plant and soil N increased more than three-fold, and significant increases of Ca, Mg, P and K were also recorded.

Either simultaneously with or separately from test site establishments, training seminars and field demonstrations were given to MOF and industry personnel. Consultation and assistance was provided to Regions, Districts and licensees to help them initiate local operational roadside erosion control programs, and to convert existing implements into hydroseeder units. Technology transfer from research to MOF operations is formalized in a five year plan.

The collection and propagation of native shrub species commenced two years ago. Three propagation facilities exist in the province. At present, 4,000 coastal cuttings are ready for outplanting and another 3,000 are expected from the Chilliwack nursery. The initial plot-trial plantations on steep slides on the Queen Charlotte Islands, Lower Mainland and Kootenay locations have already been established during 1980 and 1981. Grass-legume data from aerial-seeded slides and gullies have not been analysed to date but cursory examination indicates slope cover in excess of 70%. The technique was tried on the Queen Charlotte Islands with great efficiency.

THE "BACKUP" SYSTEM

An administrative framework is necessary for the effective use of land rehabilitation methods in forest resource management. Besides guidelines and handbooks, the following important features support resource protection efforts.

1. Regional policies with regards to "putting roads to bed" and controlling surface erosion with dry seeding already exist in several forest regions.

2. The Valuation Branch formulates means of compensation to licensees and funding for MOF operations for costs expended on site protection projects.

3. A Policy Statement by the MOF addressing revegetation for various purposes has been drafted.

4. Revision of Chapter 6 of the Engineering Manual of the MOF is now completed. This chapter deals with revegetation of forest road slopes by grass-legume mixes, shrubs and tree species for stabilization purposes.

FUTURE PLANS

Activities planned for the future include the following features.

1. The "Five-Year Plan for Implementation of Research Results, Rehabilitation of Disturbed Forest Land."

   a. Seeder units to be acquired and operated by Forest Regions.

   b. Shift of research input from one area of land rehabilitation to another: grasses-legumes, shrubs, landings.

   c. Continuing test site assessments.

   d. Continuing training, consultation, assistance in starting Regional, District and industry plans for forest land rehabilitation.

2. Physical and chemical soil amendments in erosion control for critical failure-prone sites.

3. Improved engineering design and location of roads, with special emphasis on watershed values and maintenance of slope stability.

GENERAL PRINCIPLES OF OBJECTIVES

In general terms, endeavour should be directed to two important principles:

1. Improved, revegetated sites should provide favourable conditions for the establishment or re-establishment of indigenous vegetation to perpetuate the vegetation cover of slopes. Landings, skid trails should regain their former productive capability to support forest stand establishment and development.

2. Revegetation and engineering should blend into an inseparable unit. Revegetation should become an integral part of forest road design, construction and maintenance activities.

THURSDAY, MARCH 11TH SESSION

Chairman
A. Milligan
B.C. Coal Ltd.

RECLAMATION BUDGETING AND COSTS
IN COAL EXPLORATION

Panel Discussion with:

D.M. GALBRAITH
INTRODUCTION

E. FABRO
CROWS NEST RESOURCES LIMITED EXPERIENCE

G. HELLYER
GULF CANADA RESOURCES EXPERIENCE

R.J. BERDUSCO
FORDING COAL LIMITED EXPERIENCE

INTRODUCTION
by
D.M. Galbraith

There is a need to determine realistic reclamation cost statistics which are related to: the type of terrain being explored; the nature of the work involved; and the sensitivity of the resources being protected. These costs are useful both for the companies in the estimating of future costs, and for the Inspection and Engineering Branch in assessing bonding under Section 9 of the Coal Mine Regulation Act.

The maximum limit of reclamation bonding is $2,400 per ha. The actual cost of reclamation may be much higher (for example the pulling back of a road cut on steep terrain) or much lower (for example a drill site on flat terrain).

Factors which are considered in establishing bonding are:

1. Total cost of reclamation.

2. Operator's capability:

   - past record
   - current capability
   - proposed program

3. Environmental values.

Cost statistics are of value, particularly to reclamation inspectors in the field who review proposed programs and make recommendations for approval to the Chief Inspector.

In 1981, 69 programs were approved, which compares with 71 programs approved in 1980.

CROWS NEST RESOURCES LIMITED EXPERIENCE

by

E.W. Fabro and R. Aiello

ABSTRACT

Due to the minimal amount of reclamation required, exploration reclamation costs are not usually included as a separate budget item when exploration program costs are estimated for the plains and foothills. Reclamation costs are normally less than 1% of the plains programs and range from 3% to 5% of the total program costs of the foothills programs. Depending on program size, exploration reclamation in the foothills and mountains may or may not be included as a separate budget item. In these areas budgeting for exploration reclamation can be very difficult due to the number of topographic and environmental variables involved. Within Crows Nest Resources Limited to date, logistic personnel have budgeted costs for exploration and reclamation in mountainous areas by estimating costs without the benefit of detailed cost figures from previous programs for comparison. Detailed accounting sheets in use for present exploration programs will assist in budgeting for new work. Budget estimates will improve as itemized cost data is collected.

CROWS NEST RESOURCES LIMITED MAJOR PROSPECT AREAS

Crows Nest Resources Limited has under coal licence, lease or freehold title a total of 381,000 ha (941,000 acres) of coal lands in western Canada. Scattered throughout Saskatchewan, Alberta and British Columbia, the areas vary tremendously in their topography and environmental conditions, factors which can make exploration and reclamation budgeting complex and difficult.

The greatest portion of these lands have had minimal exploration done on them and we are currently in a major exploration phase with hopes to develop those that are environmentally and economically feasible.

EXPLORATION BUDGETING

The topographic, geologic and environmental variations in the various prospect areas make it difficult to estimate the cost of an exploration and reclamation program. Costs can vary tremendously in any given situation and there is no general rule or formula that can be followed. The best estimates for these programs comes from a person who has had experience in exploration and reclamation. Within CNRL, logistics personnel estimate total program costs (exploration and reclamation) with input as required from geologists and environmental personnel. Although there are great differences in the individual prospect areas we can group the properties into three topographic units; plains, foothills and mountains.

PLAINS

Exploration on the plains has in the past resulted in minimal environmental disturbance. Reclamation on these project areas consists of the spreading of drill chips from rotary holes, and seeding and fertilizing of the roads and drill sites. The reclamation expenses have been of such a low amount (less than 1% of the total exploration budget) that they have not been included as a separate item when exploration programs are estimated.

FOOTHILLS

Reclamation undertaken in the foothills consists mainly of slashing (where required), provisions for adequate drainage and erosion controls as well as seeding and fertilizing roads and drill sites.

Greater variations in the topography, and tree cover and the additional drainage control requirements in these areas result in higher costs for reclamation than what is required for the plains. However, as in the plains a separate reclamation budget item is not included in the total exploration budget due to the minimal reclamation costs relative to the overall exploration budget. Reclamation costs in the foothills are estimated at 3% to 5% of the cost of the total exploration program.

MOUNTAINS

Extremely large variations in topographic and environmental factors in the mountains creates difficulty in estimating exploration costs. Major factors which are considered by the logistic personnel in estimating exploration programs include:

1. length and slope of roads;

2. strike, dip and type of rock strata exposed or estimated to be subsurface (rock strength and orientation affects construction costs);

3. timber values (generally merchantable timber creates increased road building costs over non-merchantable timber due to increased costs of salvaging timber along narrow roadways. Non-merchantable timber is buried within the road bed and/or slashed, which results in lower costs);

4. type of equipment required to construct roads and drill sites which will minimize environmental disturbance;

5. drainage and erosion control requirements;

6. type of reclamation required and the degree to which it is carried out.

Reclamation costs are not considered as a separate budget item if the program is small and the requirement for adequate reclamation is minimal. In these cases, as in the plains and foothills areas, reclamation costs are budgeted as a part of road-building costs.

In cases where reclamation is considered to be a major consideration in the overall exploration program it is designated as a separate budget item. Logistic personnel in liaison with environmental personnel can estimate reclamation costs by examining the major factors that go into making up a reclamation program.

These factors are:

1. type of machine(s) required and the estimated number of hours for each (including operators);

2. need and extent of slash abatement required;

3. drainage and erosion control requirements;

4. cost of seed and fertilizer;

5. manhour time for seed and fertilizer spreading;

6. helicopter time (if required) for seed and fertilizer spreading;

7. various miscellaneous items.

Reclamation costs for major programs can vary from 5% to 10% of the total program budget depending on the type and amount of reclamation required.

RECLAMATION COSTS FOR TWO MOUNTAIN PROSPECTS IN BRITISH COLUMBIA

As indicated previously, reclamation eosts can vary widely depending on the site specific conditions. Two of CNRL's prospect areas are compared to give the reader an idea of the cost differences (see Tables 1[a] and 1[b]). The Ewin Pass area may not represent true reclamation costs for a subalpine environment as a large amount of reclamation was undertaken on prelegislation disturbances.

COST ACCOUNTING FOR EXPLORATION

During the course of an exploration program detailed daily costs sheets are completed that indicate where expenditures occur (Table 2). These are completed to:

1. reduce the chances for budget overruns;

2. assist in the future estimating of exploration and reclamation costs for upcoming programs in similar terrain;

3. define where expenditures lie for work credits against coal licences (required only in British Columbia as per the form, "Extending the Terms of a Coal Licence").

This basic accounting system is a modified version of the system used by our parent company, Shell Canada Resources Ltd. in their oil and gas exploration programs. Our "coal" version has not been used long enough to be of significant value when estimating budgets for new programs. As further cost data is accumulated for the various programs, better estimates will result.

TABLE 1(a)

RECLAMATION COSTS ON TWO MOUNTAIN PROSPECT AREAS
(1981 DOLLARS/HECTARE)

	Pine Pass Northeast B.C. Elevation 700 m to 1370 m	Ewin Pass Southeast B.C. Elevation 2100 m to 2190 m
Slash Abatement	$7,600 less 520 (Timber sale) $7,080	not required
Drainage Control	900	$ 240
Pull back to contour	not required	9,300
Seed, fertilizer and application	380	640
Maintenance Seed and Fertilizer Application	not required	350
Total	$8,360	$10,530

TABLE 1(b)

DETAIL OF RECLAMATION UNDERTAKEN

Pine Pass	
Slash abatement	Includes cutting of the road right-of-way (10 m) and decking all merchantable timber.
Drainage control	Includes culvert installation, ditching of all access roads and cross-ditching right-of-ways at the end of the season.
Seed and seed	Includes cost of labour and machinery. Fertilizer application was not required.
Ewin Pass	
Drainage control	Includes the re-installation of culverts and the re-opening of existing ditches on the major existing access road at the beginning of the season and removing culverts at the end of the season to allow for unrestricted drainage during the following spring.
Pull back to contour	Includes the cost of a Caterpillar 225 backhoe and a Caterpillar D7-G doser. Costs are high as previously constructed pre-legislation, steep gradient roads were reclaimed using the dozer to anchor the backhoe (effectively doubling the equipment costs).
Seed, fertilizer and application	Includes cost of seed, fertilizer and labour, supervision and support costs.
Maintenance seed and fertilizer	Includes the cost of seed, fertilizer, labour, helicopter, supervision and support costs.

TABLE 2

SIMPLIFIED DAILY COST SHEET

PROJECT: ________ **A.F.E.:** ________ **DATE FROM:** ____ **TO:** ____

CONTINGENCY ___ **%** **PROGRAM TOTAL:** ________

	DATE	DRILLING CORE	DRILLING	BITS	DRILLING MUD	LOGGING	WATER HAULING	BULL DOZING	CONSULT. GEO-TECH.	HELI-COPTER	AUTO & TRUCK	FUEL & LUBE.	COMMUN-ICATION	CATERING	FIELD MOVING	NO-COM. LABOR	ADITS	TRENCH	LAND SURVEY	LINE CUTTING	SEED & FERTI LIZER	TOTALS
DRILLING																						
TOTAL																						
TOTAL FORWARD																						
PROGRAM TOTAL																						
ADITS																						
TOTAL																						
TOTAL FORWARD																						
PROGRAM TOTAL																						
GEOLOGY																						
TOTAL																						
TOTAL FORWARD																						
PROGRAM TOTAL																						
ROAD CONSTRUCTION																						
TOTAL																						
TOTAL FORWARD																						
PROGRAM TOTAL																						
RECLA-MATION																						
TOTAL																						
TOTAL FORWARD																						
PROGRAM TOTAL																						

DISCUSSION RELATING TO M. GALBRAITH'S AND G. FABRO'S PAPERS

Jack Thirgood, U.B.C.: What are your costs of your program in Alberta?

Answer, Gene Fabro: Well as I mentioned previously it is usually less than 1% in the prairies and 3% to 5% in the foothills area so depending on the general exploration program I guess probably a ball park estimate would be a figure of $1,000 a hectare or less.

Jack Thirgood, U.B.C.: So it is less than in B.C.?

Answer, Gene Fabro: Well probably because of the topographic conditions.

Ned Pottinger, Hardy Associates: In your slash figures you mentioned $7,000 and then you mentioned something about salvaging the timber costing you more than it was worth?

Answer, Gene Fabro: Well yes we've got the roadway so narrow that it would cost a lot of time and money to salvage the merchantable timber compared to cutting and burying the timber.

Neil Duncan, Energy Resources Conservation Board: I have a question for both men - how does the actual reclamation bond placed at the beginning compare with the actual reclamation costs?

Answer, Murray Galbraith: Well its a fairly subjective assessment because of the number of factors involved. I think that one principal that might have already been mentioned is the fact that it is probably best to start with low bonding because then you have the option of rewarding good performance. Secondly I suppose also that if other mines spent money on reclamation where it is supposed to be spent, then bonding is a secondary consideration; you can always go up, but its difficult to come down.

Jack Thirgood, U.B.C.: How can you reward good performers if you have already started with a bond that is assessed at less than the actual cost?

Answer, Murray Galbraith: Well as you saw Jack the amount of reclamation being done exceeds the legislative limit, and that is the object of the whole exercise in the first place.

Jack Thirgood, U.B.C.: Couldn't you make a case for increasing the legislative limit?

Answer, Murray Galbraith: No I don't think so because what we're trying to do is get the reclamation going and if that is done at no cost to reclamation bonding then you've achieved what you've set out to do.

Answer, Art O'Brian: The original bond is placed on the submission of the initial work so that on subsequent projects bonding can be reviewed. Bonding can then fluctuate on an annual basis depending on whether you increase or decrease your activity in sensitive areas, plus your past year's performance.

Neil Duncan, Energy Resources Conservation Board: Is there a waiting period between the actual examination and completion of reclamation and the return of the bond? Doesn't it require a long period until the natural vegetation re-establishes?

Answer, Murray Galbraith: It varies with the type of work done and the particulars of the site. The cost of recontouring is probably 80% of the total cost. If the recontouring is done then you're safe in returning the reciprocal amount of bonding.

GULF CANADA RESOURCES

EXPERIENCE

by

G. Hellyer

DISCUSSION RELATING TO GARY HELLYER'S PAPER

Jack Thirgood, U.B.C.: On the area where you reclaim for forest are you required to make productive forest land?

Answer: In the areas that we've been exploring right now we haven't been making that large a disturbance and the sites themselves are usually not far off of existing roads. We usually drill along the road allowance. We haven't done replanting of forest because of the smallness of the areas of disturbance. For what we're doing, the seeding is quite adequate.

Jack Thirgood, U.B.C.: (Distorted reading. The question related to the extent of revegetation activities.)

Answer: Not in the true sense. We're not replanting trees. The areas of disturbance really aren't large enough for a tree-planting operation.

FORDING COAL LIMITED EXPERIENCE

by

R.J. Berdusco

Fording Coal Limited's Fording River operation lies within the East Kootenay region of British Columbia at elevations between 1,500 m and 2,500 m above sea level.

Exploration activities (access road construction, drilling and adit work) have been ongoing since 1967.

The total area disturbed by exploration to the end of 1981 was 137 ha, while the area reclaimed (including 13 ha in 1981) is 78 ha.

The balance of 59 ha represents exploration access roads required for long term use or disturbances that lie within areas to be mined in the near future.

Average road widths are 6 m running surface on average 60% side slopes.

A summary of the cost experience for 1981 reclamation activities on exploration disturbances follows:

1.	Resloping with 225 cat excavator[1]	$2.29/m
2.	Ripping with D5 cat dozer[1]	.13/m
3.	Ditching and waterbarring with D5 cat dozer	.72/m
4.	Seeding and fertilizing	
	- Seed cost	.20/m
	- Fertilizer cost	.07/m
	- Labour to seed/fertilize	
	- with backhoe operation	.27/m
	- with D5 operation	.03/m
5.	Helicopter Bell 206B (maintenance) fertilizing	
	- Machine	.13/m
	- Labour	.02/m
	- Fertilizer	.15/m
	Total	$ .30/m

[1]Including culvert removal and watershed re-establishment.

Representative average total costs for the two major reclamation activities would then be:

1. Resloping, seeding and fertilizing:

$2.29/m + $ .20/m + $ .07/m + $ .27/m = $2.83/m

2. Ripping, ditching, waterbarring, seeding and fertilizing:

$ .13/m + $ .72/m + $ .20/m + $ .07/m + $ .03/m = $1.15/m

The figures used are direct costs and do not include administrative and overhead costs.

RECLAMATION OF MINERAL EXPLORATION AREAS

Paper Presented
by

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RECLAMATION OF MINERAL EXPLORATION AREAS

INTRODUCTION

Reclamation of mineral exploration areas has been largely neglected by past reclamation symposia. To my best recollection we have never had a paper describing reclamation of mineral exploration areas.

CURRENT EXPLORATION ACTIVITY

During 1981 exploration for minerals remained at a high level of activity. An estimated $113 million was spent on mineral exploration. Mineral claim staking remained at a very high level with 71,666 units recorded, a slight decline from 1980. The number of claim units recorded has risen steadily since 1975. Another indication of a high level of activity is in the number of free miners certificates issued which remained above 15,000. Of these, it is estimated that at least 1,000 actively explore for minerals.

Approximately 2,000 Notices of Work on a Mineral Property were received in Ministry of Energy, Mines and Petroleum Resources' offices during 1981, and approximately 300 reclamation permits were in existence in this year.

Prior to the recent turnaround in metal prices, 1981 was a year of major expansion in the mining industry in British Columbia. Twelve mines commenced production during the year and five increased their production capacity (Figure 1).

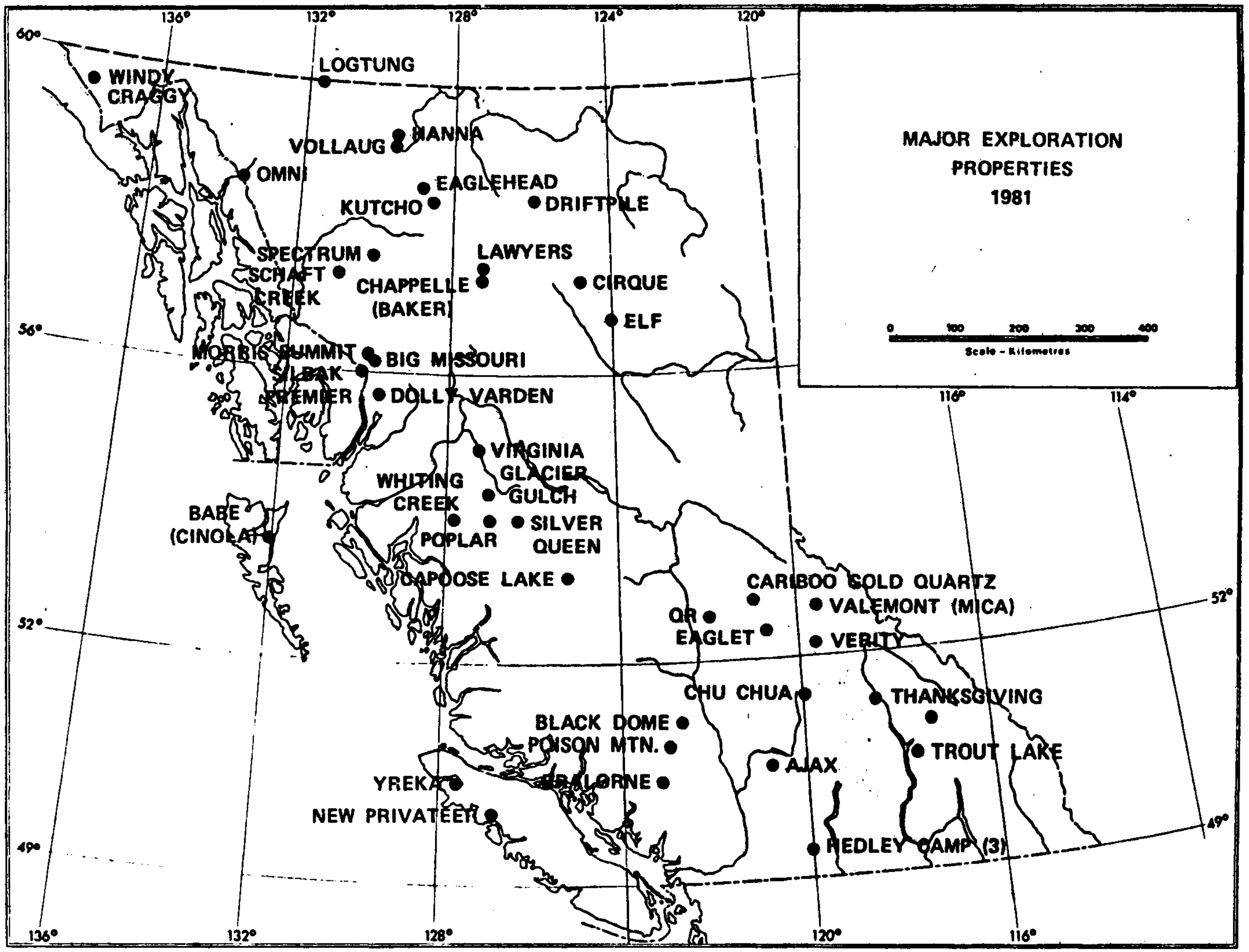
Some of the most active exploration areas in the province are (Figure 2):

- Toodoggone River: Centered on Lawyers and Chappelle gold-silver deposit.

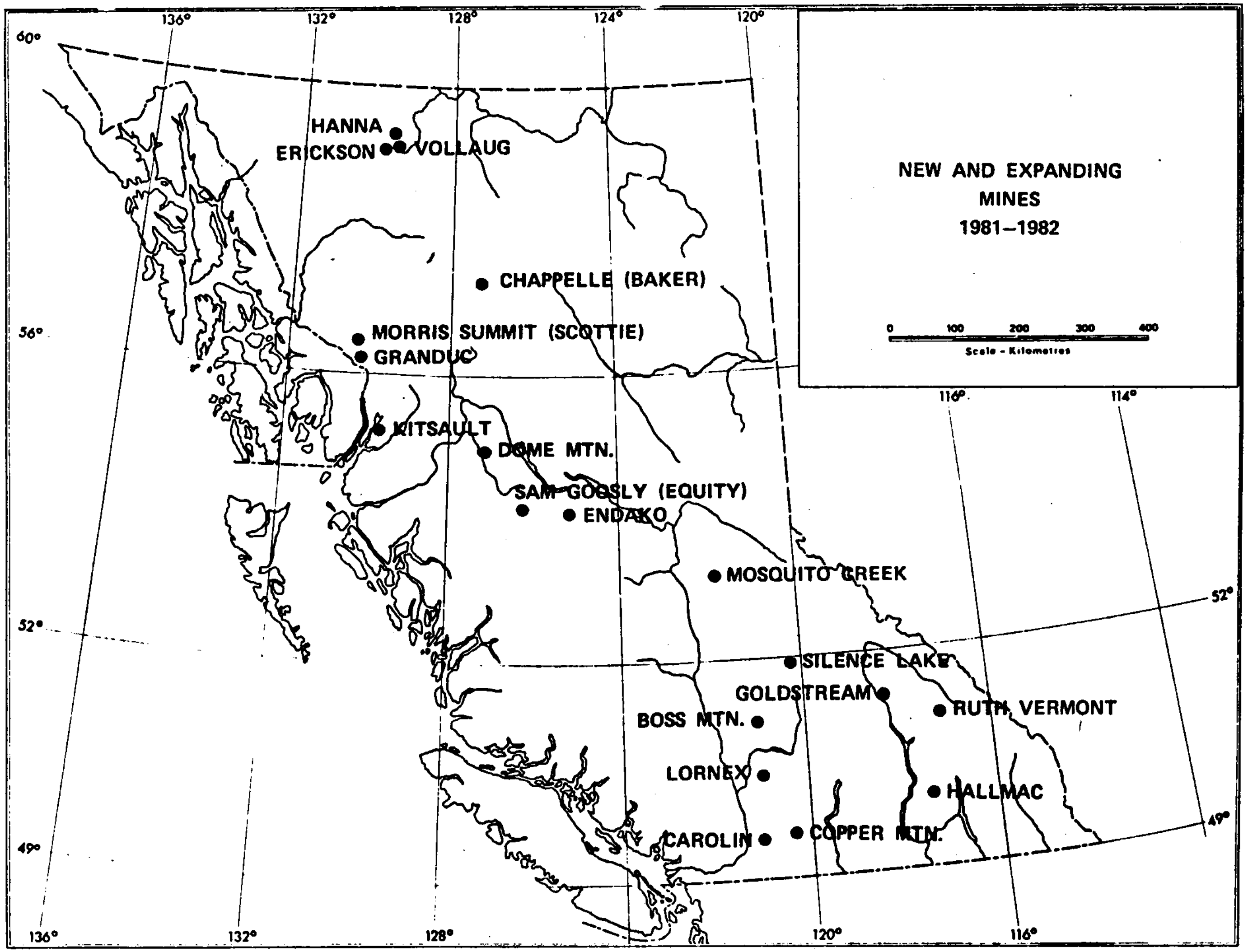
- Akie River: Centered on Cirque lead-zinc-silver-barite deposit.

- Cassiar.

- Hedley.



MAJOR EXPLORATION PROPERTIES 1981


NEW AND EXPANDING
MINES
1981–1982
0 100 200 300 400
Scale - Kilometres
HANNA
ERICKSON
VOLLAUG
CHAPPELLE (BAKER)
MORRIS SUMMIT (SCOTTIE)
GRANDUC
KITSAULT
DOME MTN.
SAM GOOSLY (EQUITY)
ENDAKO
MOSQUITO CREEK
SILENCE LAKE
GOLDSTREAM
RUTH, VERMONT
BOSS MTN.
LORNEX
HALLMAC
CAROLIN
COPPER MTN.
60°
56°
52°
49°
136°
132°
128°
124°
120°
116°
114°

- Queen Charlotte Islands: Centered on Consolidated Cinola's Babe gold deposit.

- Stewart area: Gold-silver.

- Revelstoke area: Tungsten and molybdenum.

LEGISLATION

There are several acts and statutes which may govern mineral exploration. The approvals required by the Ministry of Energy, Mines and Petroleum Resources (MEMPR) under the Mines Act[1] are initiated by an operator completing a Notice of Work on a Mineral Property and a Reclamation Program and submitting them to the Inspector of Mines and Resident Engineer. Depending upon the nature of the exploration program, up to two months may be required before all permits and approvals will be issued.

REQUIREMENT TO GIVE NOTICE (Section 6[1], Mines Act)

The Notice of Work on a Mineral Property must be received by the Inspector of Mines and Resident Engineer at least seven days before commencing exploratory work and at least seven days before ceasing work.

APPROVAL OF UNDERGROUND WORK (Section 6, Mines Act)

Under Section 6(2) of the Mines Act, the owner, agent or manager of the mine must have the written approval of the Chief Inspector of Mines before working underground.

APPROVAL OF RECLAMATION PROGRAM (Sections 7-11, Mines Act)

A reclamation permit must be obtained before commencing an exploration program involving surface disturbance. The procedure for obtaining this permit is outlined below and involves an application, a review by other resource agencies, establishment of special terms and conditions on the permit and placing of a performance bond. Four factors enter into

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[1]The Mines Act is not yet law but will supercede the Mining Regulation Act upon proclamation.

consideration in determining the total size of the reclamation bond: the amount of land disturbed; ease of reclamation; environmental sensitivity; and the companies' past performance. The advantages to a company maintaining a progressive reclamation program are obvious. The maximum bond is $2,500.00 per hectare of disturbance. The minimum bond is $500.00 per hectare.

Procedure for Obtaining a Reclamation Permit

Applicant: Sixty days before commencing work on a mineral property, the applicant contacts Ministry of Forests and completes and submit a Notice of Work on a Mineral Property and a Reclamation Program to the Inspector of Mines and Resident Engineer.

MEMPR: Inspector of Mines and Resident Engineer circulates Reclamation Program to other resource agencies.

At the end of 30 days, comments are received, bonding and recommendations are forwarded to the Senior Reclamation Inspector in Victoria. If any resource agencies have statutory responsibilities, and the applicant has not taken steps to fulfill these then the applicant will be notified at this time. Chief Inspector of Mines approves program (within 60 days of the time that the application is first received).

Senior Reclamation Inspector notifies applicant of the amount of bonding.

Applicant: Arranges for bonding at bank and sends Receipt and Agreement form to Senior Reclamation Inspector.

MEMPR: Once the completed Receipt and Agreement form has been received, the Reclamation Permit is issued to the operator.

Operator: Upon completion of Reclamation Program, the operator can either request return of bonding or maintain the permit in good standing.

MEMPR: If the operator requests a return of bonding then the Reclamation Inspector-Technician inspects the property and, providing all terms and conditions of the permit have been met, bonding is returned.

Procedure For Maintaining A Reclamation Permit

Existing permits can be amended by annually submitting a Notice of Work on a Mineral Property and Reclamation Program at least 60 days prior to commencement of work. The existing permit will be either amended to approve this work without an increase in security or the permittee will be asked to post an additional security. Upon receipt of this security the permit will be amended approving the proposed reclamation program.

General Reclamation Permits

General Reclamation Permits can be issued, upon application by letter to the Chief Inspector of Mines, to those companies which maintain a number of projects in the Province of British Columbia. This permit covers all the company's projects, thereby greatly simplifying the bonding procedure. The company is still required to submit to the Inspector of Mines and Resident Engineer, for each property, a Notice of Work on a Mineral Property and a Reclamation Program annually and these are circulated to other resource agencies. Bonding and terms and conditions of a general reclamation permit may be revised at any time depending upon the extent of exploration activity, comments from review agencies, and on the operator's performance record.

To terminate a general permit, the operator must apply for release of the bond. The Senior Reclamation Inspector, upon a satisfactory inspection of all properties, will arrange for release of bond.

FOREST ACT

On Crown land administered by the Ministry of Forests a free miner may be required to obtain the following when necessary.

Free Use Permit: To cut and use timber fon mining purposes on mineral claims.

Licence to Cut: To cut timber for camp sites, roads, drill sites, adit sites.

Right of Way: For roads throngh forest reserve land, but does not include work on mineral claims.

LAND ACT

Ministry of Lands, Parks and Housing has jurisdiction over Crown land other than that land administered by the Ministry of Forests.

Right of Way: For access roads to a mineral property but does not include roads on a mineral property.

WATER ACT

The Ministry of Environment, Water Management Branch issues water licences for water use from creeks, rivers, or lakes.

FISH AND WILDLIFE, MINISTRY OF ENVIRONMENT

There is no act governing the protection of wildlife habitats other than the Federal Fisheries Act. The Regional Fish and Wildlife Branch receives copies of Notice of Work on a Mineral Property from the Inspector of Mines and Resident Engineer. Any concerns are taken into consideration and any conflicts are usually resolved at the regional level. The company doing the exploration work may be instructed to avoid or minimize impacts on habitats or fisheries.

POLLUTION CONTROL ACT

Depending on the size of the exploration camp, sewage and garbage disposal are covered under the Public Health Act or Pollution Control Act.

GUIDELINES FOR MINERAL EXPLORATION

WORK GUIDELINES

These guidelines described below will replace the existing guidelines for coal and mineral exploration and are expected to be published shortly. In summary, these guidelines emphasize:

Planning by

- designing roads to avoid sensitive areas
- locating roads to fit the topography
- supplying sufficient culverts

- ordering sufficient seed and fertilizer before commencing work

Minimizing disturbance by

- helicopter access drilling in some sensitive areas
- using existing roads
- building the narrowest road possible
- confine the use of tracked vehicles in alpine to selected routes
- endhauling material on steep slopes

Construction Procedures

- flagging routes in advance of construction
- clear minimum area
- winter construction guidelines

Drainage Control

- considered very important
- culvert design and construction techniques
- ditches
- water bars

Stream Crossings

- general guidelines
- simple bridge design
- use of culverts only recommended for structures which do not support fish populations
- fords may be used on some channels but require permission of the Fish & Wildlife Branch
- debris bridges are not permitted

Drilling

- not within 50 m of a water course
- topsoil to be removed and stockpiled
- close circuit for drilling mud

Trenching

- only on slopes less than 26°
- hand and backhoe trenching is encouraged
- bulldozer trenching not permitted except with permission of an Inspector

Underground Work

- guidelines developed to ensure associated surface disturbances are reclaimed and stable

Reclamation Requirements

- reclamation requirements follow

RECLAMATION OF EXPLORATION AREAS

Objectives

The objectives in reclamation of exploration disturbances are usually for the purpose of erosion control or aesthetics and the majority of reclamation programs are instituted for these reasons.

The secondary reclamation objectives to limit access and restore wildlife habitat, grazing, forestry and recreation all apply in certain instances.

Reclamation Guidelines

The following guidelines are minimum requirements and, depending upon the nature of the exploration activity and the environmental sensitivity of the area, increased standards may be required as a condition of the permit.

<u>Campsites</u>: Campsites which are to be abandoned shall be dismantled at the end of operations. All refuse shall be burned, buried, or removed. Pits shall be backfilled. The site shall be ripped, if necessary, to break surface compaction and revegetated.

Campsites which are to be left for reuse shall be cleaned up. All refuse shall be burned, buried, or removed. Pits shall be filled.

<u>Trenches, Drill Sites, and Major Excavations</u>: All trenches, drillsites and major excavations shall be backfilled and recontoured as nearly as possible to the previously existing slope. Stockpiled topsoil shall be spread over the site and the entire site shall be revegetated. Overland drainage shall be conducted around disturbances. Where this is not possible, erodible material must be protected by rip-rapping or other measures.

Roads: It is important to identify those roads which can be abandoned and those roads which are necessary for future exploration. Roads that will not be used the following field season should be treated as abandoned. Some portions of the road system may be required by the Ministry of Forests for permanent fire access. It is in the operator's interest to contact the Ministry of Forests in this regard.

Permanent Roads: Roads that are to be retained for permanent access shall be maintained annually.

Cut banks and fill slopes shall be revegetated.

Abandoned Roads: All abandoned roads should have a system of permanent erosion control. All culverts shall be removed and suitable permanent drainage structures installed. Erosion bars shall be placed at frequent intervals to ensure stability.

The requirement for recontouring roads will vary according to its location and the environmental sensitivity.

- Roads on environmentally sensitive areas will require complete recontouring.

- Roads in alpine and high subalpine areas will require the pulling back of topsoil material.

- Other roads will require ditching at their junction with permanent roads and ripping of compacted surfaces.

All abandoned roads shall be revegetated.

CONCLUSION

In a recent address to students at the University of Victoria, the Hon. R.H. McClelland, Minister of Energy, Mines and Petroleum Resources, stated that "there are currently 98 proposals to restrict exploration activity in the province. These proposals would limit and possibly exclude exploration, on a minimum of 4.4 million hectares of land in addition to the current 9.2 million hectares which are currently contained within Parks, Ecological Reserves and Agricultural Land Reserves." I believe that these figures were challenged and upon a re-evaluation the 98 proposals rose to 114, and the 4.4 million hectares doubled to almost 9 million hectares.

Conflicts currently exist between parks and areas of high mineral potential, the most notable being, Tweedsmuir Park, Wells Gray Park and Kwadacha Park. The establishment of Kwadacha Park was very unfortunate in that it was created without a thorough review of its mineral potential. The mineralization was obvious, existing on the edge of the park and could have been accommodated with a small alteration of the park boundary.

In conclusion, it is up to the exploration industry to show that it can explore for mineral in an environmentally prudent manner. It is up to Government to show that it can control exploration by considering other interests and minimizing the impact of exploration. Without this effort, the mining industry and, in turn, the province of B.C. will suffer.

CONTROL OF VEGETATION DAMAGE BY SMALL RODENTS ON RECLAIMED LAND

Paper Presented
by

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CONTROL OF VEGETATION DAMAGE BY SMALL RODENTS ON RECLAIMED LAND

INTRODUCTION

Land disturbed during the mining of the oil sands of northeastern Alberta will require extensive programs of reclamation and revegetation. The long term reclamation objective is to establish a self-sustaining plant community of similar productivity to that of the predisturbed state (Fedkenheuer 1979). Typically a dense ground cover of agronomic grasses and legumes has first been established to stabilize the sand dykes. Tree and shrub planting programs have then been implemented on some reclamation sites once a dense ground cover has been established. The tree and shrub planting program is considered one means of accelerating the establishment of an early seral forest community.

The afforestation programs have been only moderately successful, however, because of the high mortality of some species of young trees (Selner and Thompson 1977; Fedkenheuer 1979; Shopik 1980). Sapling death has been attributed to insect defoliation, to damage during planting, to disease, to nutrient and moisture deficiencies, to competition with ground cover (e.g., grasses and legumes), and to small rodent damage (Radvanyi 1978; Sherstabetoff et al. 1978; Fedkenheuer 1979; Shopik 1980). Damage by small rodents, particularly *Microtus pennsylvanicus* (the meadow vole) is believed to be one of the major causes of sapling death.

A study of the small rodent problem in afforestation sites was begun by LGL Limited in 1977. First, an extensive review of the literature on small mammal damage to plants and methods of control was completed (Green 1978). Field studies of small rodents, small rodent damage, vegetation cover, and tree and shrub performance in reclamation areas on the Suncor lease were begun in 1978 (Green 1980b, 1980c). Similar field studies of small rodent populations and small rodent damage in natural forest and shrub communities in the Athabasca Basin were conducted during 1978 and 1979 (Green 1980c).

METHODS

STUDY PLOTS

Six reclamation study areas were established on the Suncor Inc. lease during 1978 (Figure 1). All six areas were on Slope 6 (305 m to 320 m level) of the Suncor Inc. Tar Island dyke. Construction of Slope 6 was completed in the fall of 1977 and preparation for seeding was begun in the spring of 1978. Details of preparation and seeding are summarized by Green (1980a). All study plots were of similar design. Each consisted of a 1.13 ha (250 m x 45 m) vegetation treatment area within which was located a 0.76 ha small rodent live-trapping grid (Figure 2).

Three methods of controlling small mammal damage that were recommended by Green (1978) were initially evaluated in this study--the application of an animal repellent to seedlings, the provision of supplementary food supplies, and a reduction of ground cover. The experimental plots included a control plot, four single treatment plots, and one plot that combined three of the treatments. However, beginning in 1980, emphasis was placed on an evaluation of ground cover manipulation as a method of control. The repellent and supplementary food treatments subsequently were discontinued; a discussion of these latter treatments is included in Green (1980a).

Two basic types of ground covers were assessed in this study. The first treatment involved the hydroseeded application of agronomic grasses such as creeping red fescue, brome grass, crested wheatgrass, and pubescent wheatgrass and of legumes such as alfalfa, common clover, alsike clover, and sanfoin. This seed mix was applied to the entire treatment area of the Supplementary Food, Repellent, and Control study areas. On the Stripping Trial study area, however, only a horizontal 15 m wide strip along the top and bottom of each study area was hydroseeded, such that a central 15 m wide strip was left unvegetated. The second treatment initially involved only revegetation by natural means; following preparation of the soil in 1978, no amendments or seed were applied to either the Reduced Cover or Combined Treatment study areas. In summer 1980, however, a seed mix of *Agropyron violacium, Festuca saximontana,* and *Poa palustris* was sparsely hydroseeded on these two sites.

During May and early June of 1979, Suncor Inc. planted approximately 1,200 tree and shrub seedlings on each experimental plot. Twelve

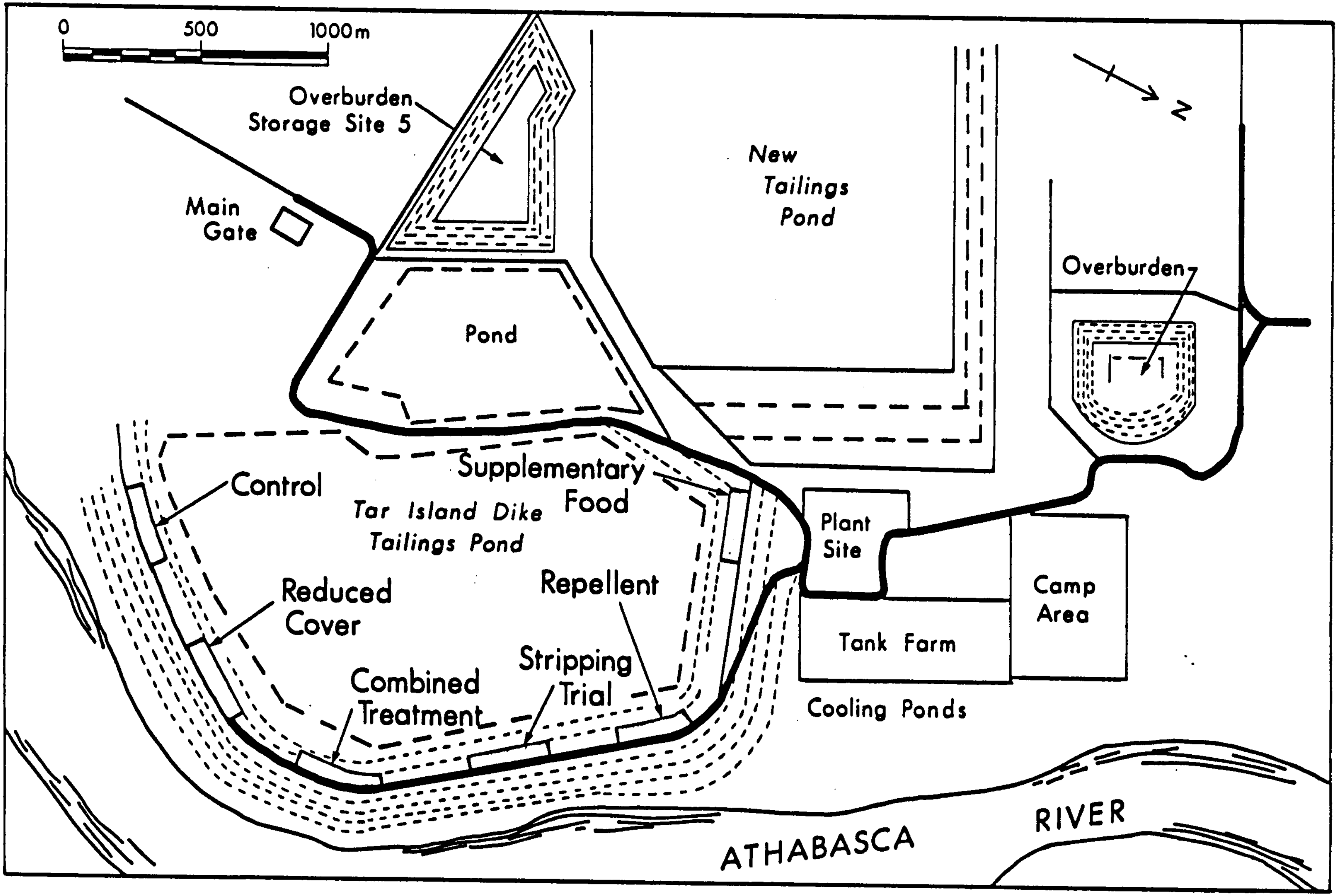

Figure 1. Location of the six study areas on the Suncor Inc. reclamation sites

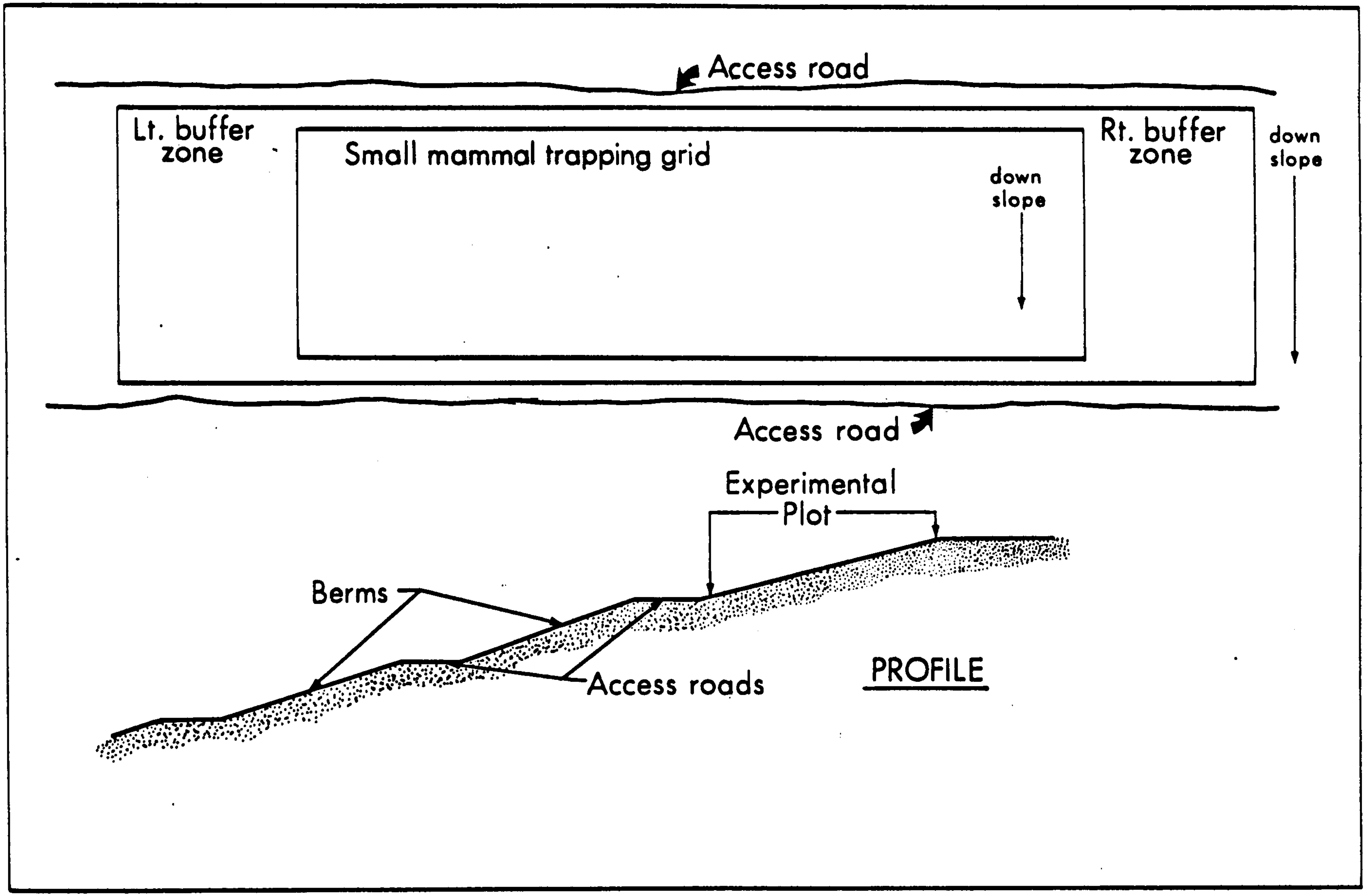

Figure 2. Standard layout of the six study areas on the Suncor Inc. Tar Island Tailings Dike

species of trees and shrubs were planted at 2.1 m spacings in blocks consisting of double rows of each species that varied from 14 to 20 seedlings long. Species planted were dogwood, Laurel willow, Siberian larch, Basford willow, caragana, Northwest poplar, acute willow, white spruce, Scots pine, chokecherry, Walker poplar, and Russian olive. Three blocks of seedlings were established on each study plot. The tree and shrub planting blocks on the Stripping Trial differed from the remaining five study areas in that planting blocks of paper birch, trembling aspen, alder, and Siberian larch at 1 m spacings also were established within the central unvegetated area.

VEGETATION ANALYSES

Vegetation analyses were conducted by LGL Limited on the six study plots during late June of 1979, 1980 and 1981. Estimates were made of the density, species composition, and vertical distribution of vegetation cover. Within each study area, information was obtained from 30 random sampling locations during 1979 and 50 random sampling locations during 1980 and 1981. The percent ground cover of each plant species present within a 1 m^2 quadrat was estimated using a Braun-Blanquet cover scale (Kershaw 1966) (Figure 3). Vertical composition of vegetation was estimated following Nudds (1977). Tree and shrub densities and amounts of small rodent damage within a 16 m^2 quadrat were estimated.

Enumeration and evaluation of all seedlings were conducted by Suncor Inc. during June and August of 1980 and 1981. Tree and shrub assessments included a measure of plant height, condition, and rodent damage. Survival rates also were determined for each species.

SMALL MAMMAL TRAPPING TECHNIQUES

Small mammal live-trapping techniques were similar to those described by Krebs et al. (1969). The trapping grid on each study area consisted of a 5 x 20 grid of trapping stations at 10 m intervals. One live trap was placed within a 1.5 m radius of each trap station. Each study area was live-trapped for three days, once every three weeks from late April/early May to late November during 1979 to 1981. During 1978, all study areas were live-trapped only during September and October.

All new animals were ear-tagged with a numbered fingerling fish tag when first captured. After tagging or when tagged animals were captured

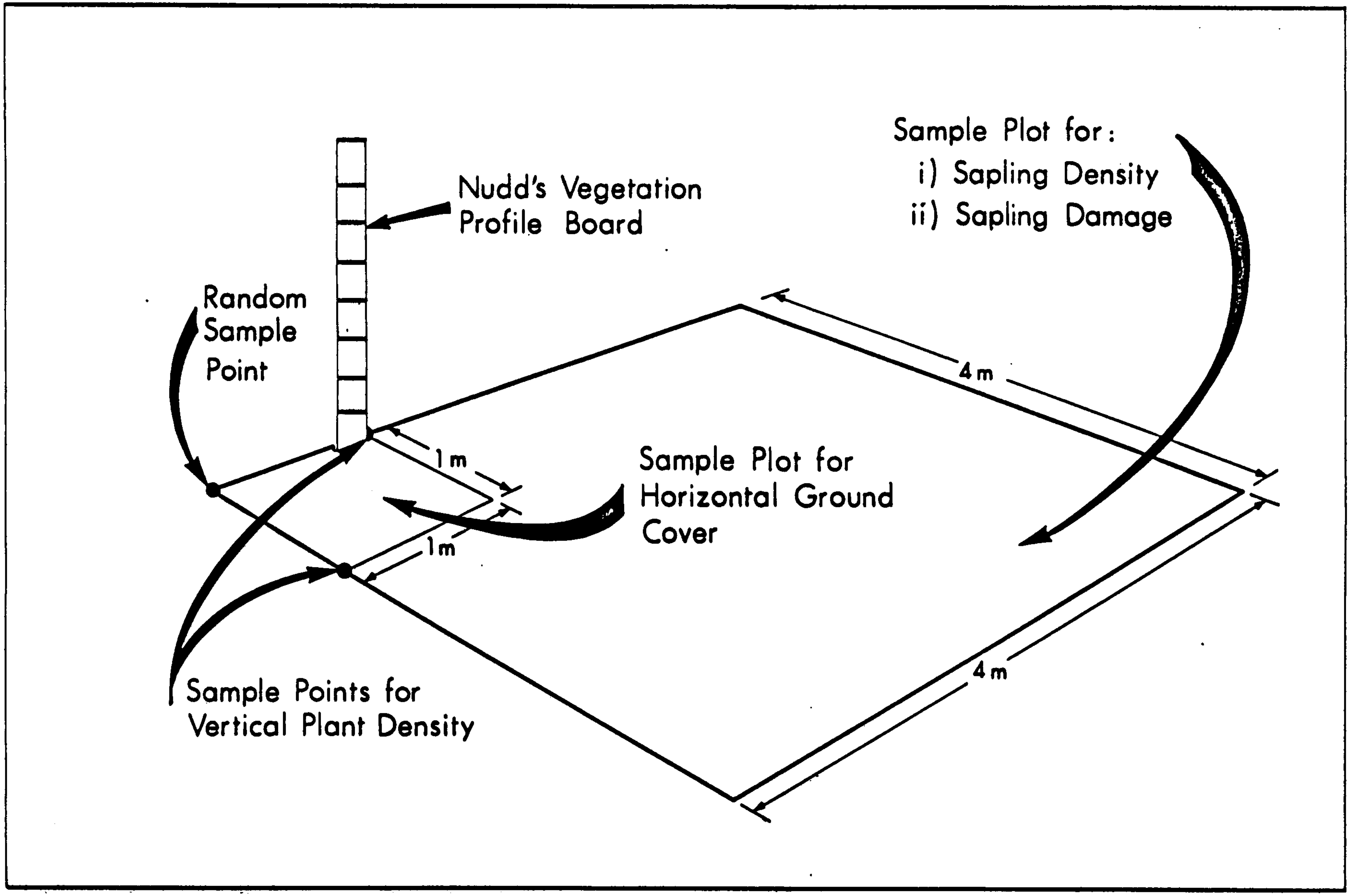

Figure 3. The configuration of the vegetation sampling quadrats. (The 16 m^2 quadrat for sapling densities and damage, the 1 m^2 quadrat for ground cover densities, and the vertical cover sample points are shown.)

during subsequent trapping periods, the tag number, species, trap location, sex, breeding condition, weight, body length, an estimate of age, number of wounds on the posterior portion of the body, and number of sub-dermal parasites *(Cuterebra* spp.) were recorded.

RESULTS

SMALL RODENT POPULATIONS

During this study, four species of small rodent, *Clethrionomys gapperi, Microtus pennsylvanicus, Peromyscus maniculatus,* and *Zapus hudsonicus,* were captured on the six study areas. In addition, two species of shrews, *Sorex cinereus* and *Sorex obscurus,* and two species of mustelid, *Mustela erminea* and *Mustela nivalis,* were captured. Woodchucks *(Marmota monax),* snowshoe hares *(Lepus americanus),* and red fox *(Vulpes vulpes)* were observed but not captured on the reclamation sites. Because only *C. gapperi, M. pennsylvanicus,* and *P. maniculatus* were captured regularly and in moderate to high numbers, demographic analyses were restricted to these three species.

Population changes of small rodents were assessed using the minimum number known to be alive (MNA) (Chitty and Phipps 1966) as a biased estimate of population size. Comparisons of MNA estimates of *C. gapperi, M. pennsylvanicus,* and *P. maniculatus* on each of the six study areas (Figures 4 to 6) indicate that habitat use and seasonal population trends differed among study areas and among species.

Microtus pennsylvanicus was the most abundant species of small rodent on most study areas. Numbers were consistently highest on the Supplementary Food study area, followed by the Repellent and Control study areas (all areas with agronomic grass and legume cover). Numbers of *M. pennsylvanicus* increased appreciably between 1979 and 1980 on almost all study areas except the Reduced Cover study area. Peak numbers of *M. pennsylvanicus* were attained on most study areas by mid- to late September 1980 and remained high on some areas until spring 1981. Numbers declined rapidly on all areas during early summer 1981.

Based on this study and on information obtained by Radvanyi (1978) and Michielson and Radvanyi (1979) during a four-year study of small rodent populations on established reclamation sites within the Suncor Inc. lease, it appears that *M. pennsylvanicus* populations in reolamation

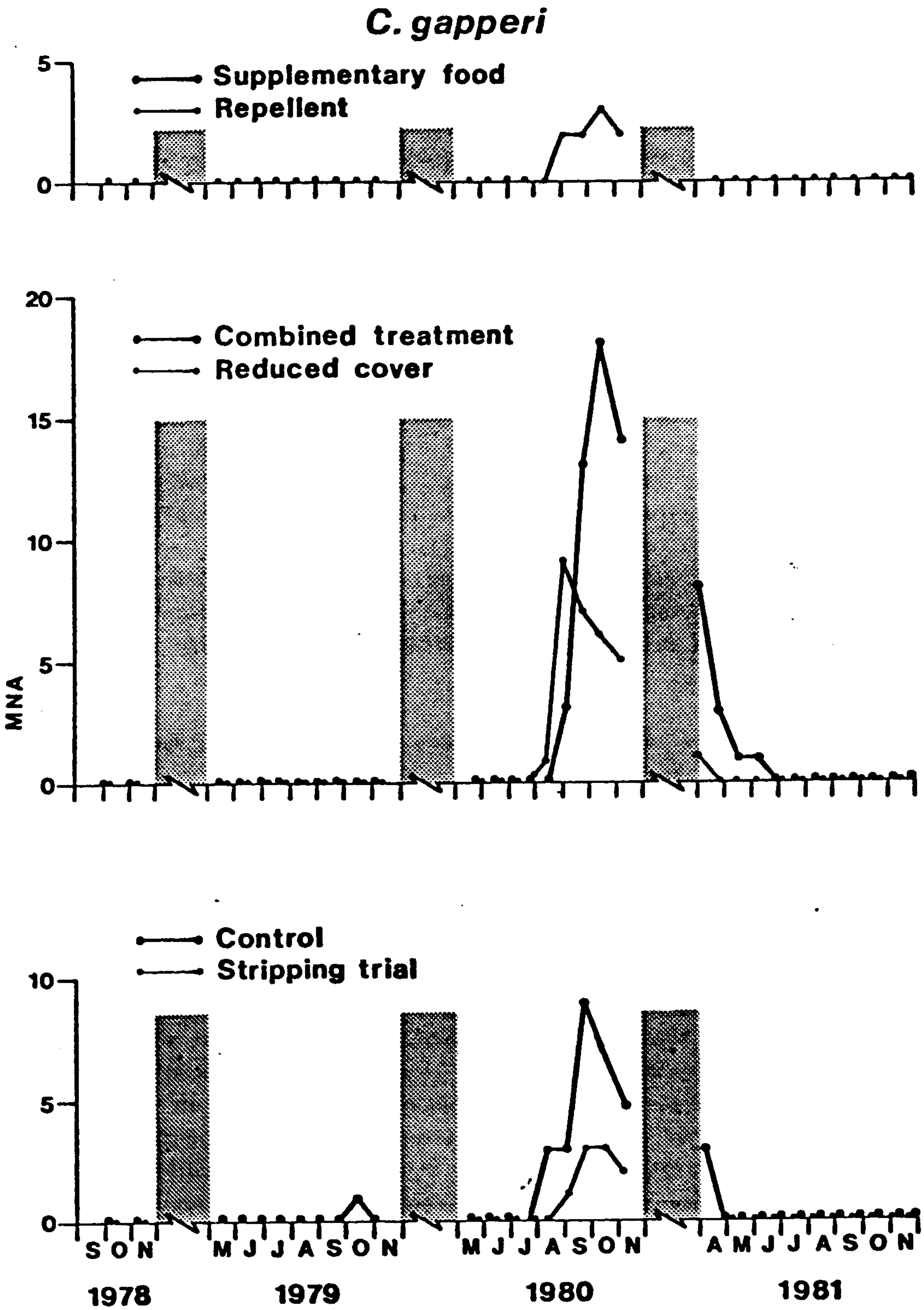

Figure 4. Population estimates of *C. gapperi*. (The MNA during each trapping period is indicated. No *C. gapperi* were captured on the Supplementary Food study area. The shaded areas indicate periods when no trapping was conducted.)

M. pennsylvanicus

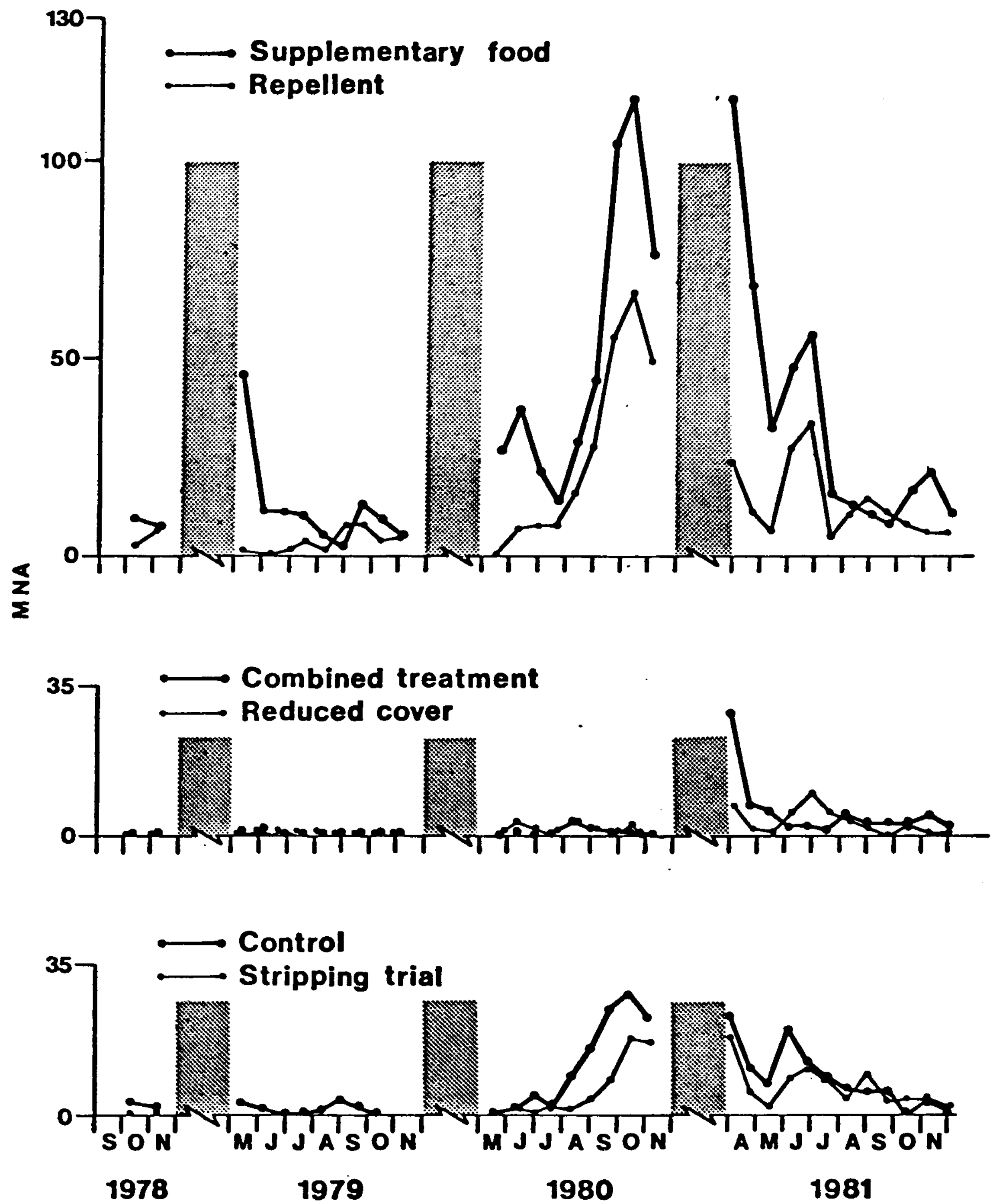

Figure 5. Population estimates of M. *pennsylvanicus*. (The MNA during each trapping period is indicated. The shaded areas indicate periods when no trapping was conducted.)

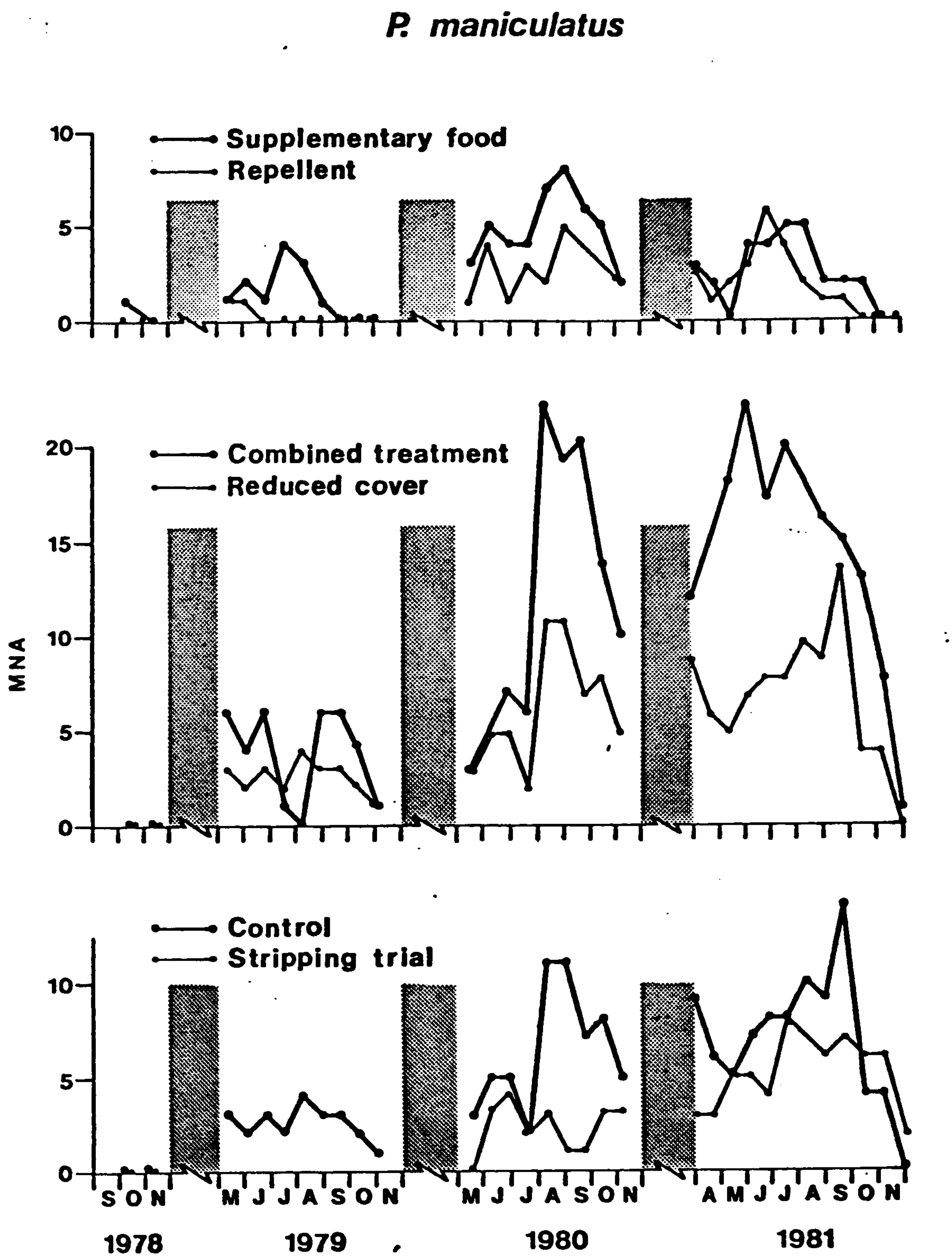

Figure 6. Population estimates of *P. maniculatus*. (The MNA during each trapping period is indicated. The shaded areas indicate periods when no trapping was conducted.)

sites undergo cyclic fluctuations in population size every three to four years. Michielson and Radvanyi (1979) indicated that their study populations increased from low numbers in 1975 to peak numbers during spring 1978, and then declined to low numbers in fall 1978. In this study, most study populations increased from low numbers in fall 1978 to peak numbers during May and June 1981 and then declined sharply. These cyclic changes in number are similar to the 3 tb 4 year cycles observed in a number of microtine populations in natural areas (Krebs and Myers 1974).

Peromyscus maniculatus was present in low numbers on all study areas but was most abundant on the Reduced Cover, Combined Treatment, and Control study areas. Population trends on these three study areas and the Stripping Trial study area indicate that numbers of *P. maniculatus* have increased gradually over the 1979/81 period. Numbers on the Supplementary Food and Repellent study areas, however, have changed little during the same period (0 to 9 animals).

Prior to 1980, only one *C. gapperi* had been captured on any of the reclamation study areas. However, during late summer 1980, numbers of *C. gapperi* increased on all areas with the exception of the Supplementary Food study area, where no *C. gapperi* were captured. Numbers of *C. gapperi* were highest on the Combined Treatment, Reduced Cover, and Control study areas. During 1981, *C. gapperi* were absent from all study areas with the exception of the Reduced Cover, Combined Treatment and Control study areas during the early spring.

These population trends plus reproductive information (i.e., proportions of mature animals in breeding condition, pregnancy rates) showed that *M. pennsylvanicus* and *P. maniculatus* rapidly established resident, breeding populations in reclamation areas. In contrast, *C. gapperi* were only sporadically abundant and appeared to be transient, non-breeding animals.

VEGETATION COVER

Assessments of vegetation cover on the six study areas during 1979/81 show that the vertical and horizontal structure and species composition of plant cover differed greatly among grids hydroseeded in 1978 (Supplementary Food, Repellent, Stripping Trial, and Control study areas) and those allowed to revegetate by natural means until hydroseeding in 1980

(Reduced Cover and Combined Treatment study areas). As of 1981, ground cover on the former group of study areas was dense and consisted primarily of a few agronomic grasses and legumes (Table 1). Tree and shrub cover generally was minimal (Table 2). In contrast, ground cover on the latter two study areas (the Reduced Cover and Combined Treatment study areas) was sparse and consisted of a wide variety of native herbaceous plants, a number of "weeds," agronomic grasses, and some legames. Tree and shrub cover on these two areas was well developed and included natural introductions of several native species as well as the species planted in 1979. Vertical distribution of plant cover was minimal on the four study areas hydroseeded in 1978; most plant cover was <25 cm tall (Table 3). In contrast, vertical cover on the two naturally-revegetating areas was well developed; a variety of ground cover species were present 0 cm to 50 cm above ground level and good development of tree and shrub growth accounted for much of the plant cover 50 cm to 150 cm above ground.

TREE AND SHRUB PERFORMANCE

Based on the tree and shrub assessments during 1980 and 1981, striking differences existed between the growth, condition, and survival of trees and shrubs on the areas with reduced cover and trees and shrubs on areas with dense grass/legume cover (Table 4). Trees and shrubs on the areas with reduced cover were characterized by good growth, good condition and high survival. In contrast, trees and shrubs on the areas hydroseeded in 1978 were characterized by poor to moderate growth, poor to fair condition and moderate survival.

DAMAGE

Before 1981, there was little damage to trees and shrubs on most study areas. Damage during 1979/80, however, tended to be greatest on the Supplementary Food study area. Damege to seedlings increased sharply during winter 1980/81.

At the time of the 1981 assessments, amounts of damage were high on the Supplementary Food study area and modeeate on the Repellent, Stripping Trial and Control study areas (Tables 2 and 4). All of these areas had dense ground covers predominated by agronomic grasses and legumes. In contrast, very little damage to trees and shrubs was recorded on either of the two study areas with reduced ground cover.

Table 1. Density and species composition of ground cover on the six study areas during 1981. (Mean percent cover for the 50 sample quadrats on each study area is indicated.)

Species	Supplementary Food	Repellent	Combined Treatment	Reduced Cover	Stripping Trial	Control
Agropyron albicans	-	0.10	0.50	0.05	0.10	0.40
Agropyron cristatum	0.90	1.40	-	0.15	1.55	2.95
Agropyron violacium	-	-	-	2.16	-	-
Alnus spp.	-	-	0.30	-	0.05	-
Aster spp.	-	-	0.05	-	-	-
Avena sativa	-	-	0.10	-	-	-
Betula papyrifera	-	-	-	-	0.30	-
Bromus spp.	14.20	10.70	0.90	0.90	6.30	5.80
Calamagrostis spp.	-	-	0.40	2.80	-	-
Caragana aborescens	-	0.60	0.30	-	-	-
Carex spp.	-	-	0.35	-	-	-
Chenopodium album	0.35	0.05	1.25	1.25	-	0.05
Cornus stolonifera	-	-	-	0.30	-	-
Convolvulus sepium	-	-	0.20	-	-	-
Deschampsia spp.	-	-	1.55	0.60	-	-
Elaeagnus angustifolia	-	-	-	-	-	0.30
Epilobium angustifolium	0.15	-	3.15	1.75	-	-
Equisetum sylvaticum	-	0.05	0.20	0.05	-	-
Festuca spp.	42.10	22.10	3.30	1.55	13.00	18.30
Fragaria virginiana	-	-	0.30	-	-	-
Galium trifolium	-	-	-	0.30	-	-
Hieracium canadense	0.05	-	0.55	0.20	-	-
Hieracium umbellatum	0.10	-	0.60	3.45	-	-
Larix siberica	-	-	-	0.10	0.05	-
Medicago sativa	13.65	4.95	0.55	0.15	1.30	2.45
Petasites sagittatus	-	-	-	0.30	-	-
Phleum spp.	-	-	-	0.05	-	-
Populus deltoides	0.30	0.35	0.30	1.90	-	1.95
Populus tremuloides	-	0.05	-	0.30	-	-
Prunus pensylvanica	-	-	0.30	0.05	-	0.10
Salix spp.	0.35	0.05	2.55	1.80	-	0.30
Sanfoin	0.20	-	-	-	0.05	0.05
Trifolium hybridum	0.05	0.05	0.15	0.05	0.15	-
Trifolium pratense	0.40	-	-	-	0.05	-
Litter	84.00	58.10	1.75	1.55	29.05	29.65
Deadfall	-	-	-	-	-	0.15
TOTAL GROUND COVER (± 1 S.E.)	156.8 (150.6)	98.5 (96.4)	19.6 (17.9)	21.8 (19.0)	51.9 (49.2)	62.4 (59.1)

Table 2. Estimates of tree and shrub stem densities and small rodent damage on the six study areas during 1981. (Densities of live trees and shrubs [stems/ha] and the proportion of all trees sampled that were damaged by rodents are indicated for each species on each study area.)

Species	Supplementary Food		Repellent		Combined Treatment		Reduced Cover		Stripping Trial		Control	
	Stem Density	Damage	Stem Density	Damage	Stem Density	Damage	Stem Density	Damage	Stem Density	Damage	Stem Density	Damage
Acute willow	75	0.0	13	0.0	3063	0.0	1088	0.0	-	-	75	0.0
Alder	-	-	-	-	163	0.0	25	0.0	75	0.0	-	-
Aspen	38	0.34	75	0.51	213	0.0	113	0.0	-	-	-	-
Basford willow	75	0.0	213	0.36	588	0.0	863	0.04	88	0.0	213	0.12
Caragana	25	0.0	425	0.0	188	0.0	113	0.0	-	-	50	0.0
Chokecherry	63	0.79	63	0.60	200	0.0	38	0.0	-	-	313	0.0
Dogwood	188	0.40	25	0.0	125	0.0	913	0.03	400	0.0	75	0.0
Gooseberry	-	-	-	-	75	0.0	-	-	-	-	-	-
Laurel willow	113	0.66	275	0.0	1125	0.12	625	0.0	-	-	113	0.44
Northwest poplar	125	0.90	238	0.10	63	0.21	538	0.0	63	0.0	88	0.15
Paper birch	-	-	-	-	-	-	-	-	175	0.0	-	-
Raspberry	-	-	-	-	638	0.0	-	-	-	-	-	-
Russian olive	88	0.57	-	-	-	-	213	0.0	-	-	250	0.0
Salix spp.	-	-	-	-	38	0.0	575	0.0	100	0.0	-	-
Saskatoon	-	-	-	-	-	-	-	-	88	0.0	-	-
Siberian larch	75	0.51	-	-	38	0.0	113	0.0	25	0.0	100	0.0
Walker poplar	125	0.60	-	-	238	0.0	375	0.0	113	0.34	563	0.04
White spruce	50	0.0	13	0.0	38	0.0	38	0.0	50	0.0	-	-
Wood rose	-	-	-	-	138	0.0	-	-	-	-	-	-

Table 3. Vertical distribution of vegetation cover on the six study areas during 1981. (The mean cumulative percent cover ± 1 S.E. in each 25 cm vertical segment is indicated. Means are based on cumulative estimates of percent cover for all species present in the 1 m^2 quadrat for the 50 samples on each study area.)

Study Area	Mean Percent Vertical Cover					
	0-25 cm	25-50 cm	50-75 cm	75-100 cm	100-125 cm	125-150 cm
Supplementary Food	84.7 ± 18.9	17.8 ± 18.5	1.8 ± 2.6	0.1 ± 0.3	0.0 -	0.0 -
Repellent	65.8 ± 33.3	10.0 ± 10.6	2.3 ± 3.0	0.8 ± 3.0	0.0 ± 0.2	0.0 ± 0.2
Combined Treatment	31.8 ± 31.3	18.2 ± 26.0	10.0 ± 19.9	6.5 ± 13.5	4.0 ± 13.1	1.6 ± 6.4
Reduced Cover	34.1 ± 31.2	16.7 ± 22.1	10.8 ± 19.6	6.0 ± 14.8	4.8 ± 14.0	2.4 ± 9.5
Control	48.1 ± 36.7	8.5 ± 14.5	2.3 ± 5.9	0.7 ± 2.5	0.2 ± 1.2	0.0 ± 0.2
Stripping Trial	52.2 ± 34.9	8.7 ± 14.3	2.5 ± 5.8	0.3 ± 0.6	0.0 ± 0.2	0.0 -

Table 4. Summary of the Suncor tree and shrub assessments during 1981. (Mean values ± 1 S.E. for rodent damage, plant height, plant conditions, and percent survival of seedlings are indicated for all species on each study area.)

Study Areas	Total Number	Rodent Damage[a]	Total Height (cm)	Plant Condition[b]	Percent Survival
Agronomic Grass/Legume Cover					
Supplementary Food	1148	3.1 ± 0.7	26.7 ± 11.0	1.5 ± 0.5	50.2 ± 19.8
Repellent	1047	1.1 ± 0.1	51.8 ± 22.8	2.8 ± 0.3	41.5 ± 27.9
Stripping Trial	1113	1.1 ± 0.1	42.4 ± 17.5	2.7 ± 0.3	68.3 ± 25.4
Control	1314	1.1 ± 0.1	61.7 ± 31.1	2.5 ± 0.4	47.9 ± 20.2
Naturally-Revegetating Areas					
Combined Treatment	1382	1.0 ± 0.1	97.4 ± 54.0	3.0 ± 0.6	75.7 ± 23.8
Reduced Cover	770	1.0 ± 0.0	108.6 ± 64.4	3.1 ± 0.7	78.5 ± 20.2

[a]A value of 1.0 indicates no damage; 4.0 indicates complete girdling of the stem.

[b]A value of 1.0 indicates poor condition; 4.0 indicates excellent condition.

Comparisons of the amount of damage to different tree species during 1981 suggested that willows and poplars were most susceptible to damage, whereas white spruce and caragana were almost resistant (Green 1982). Other species such as chokecherry, dogwood, Siberian larch, Scots pine, and Russian olive suffered intermediate amounts of damage.

MULTIVARIATE ANALYSES

Several multivariate statistical techniques were used to assess relationships between habitat structure, amounts of damage, small rodent abundance, and tree/shrub performance. Initially a factor analysis was used to reduce a large number of habitat variables to a smaller number of independent factors that characterized vegetation cover. Factor analyses were performed on the combined vegetation data for 1980 and 1981 using the BMDP4M program (Dixon and Brown 1979). The factor analysis was performed by a standard method--a principal component analysis followed by Varimax (orthogonal) rotation of those principal components with eigenvalues exceeding 1.0. Biological interpretations of the eight habitat factors are summarized in Table 5. Values of each factor were calculated for each habitat sampling point. These values provide indices of the eight habitat characteristics measured by these factors and used in several multivariate analyses described below.

Small Rodent Damage and Habitat Structure

Previous studies of small mammal damage to saplings and shrubs have suggested that amounts of damage ane related to habitat structure (e.g., density of ground cover, abundance, and diversity of food types, density of trees and shrubs) (e.g., Eadie 1953; Howard 1967; Buckner 1970). In this study, a stepwise multiple discriminant analysis (BMDP7M; Dixon and Brown 1979) was performed to determine which indices of habitat structure and small rodent abundance best distinguished those tree planting blocks with no damage from tree planting blocks with damage.

Based on damage estimates obtained during 1980, none of the eight habitat factors or small rodent numbers were significant predictors of damage. In 1981, however, the presence or absence of damage was significantly related to the local abundance of *M. pennsylvanicus* and to the value of the *Agropyron* / hawkweed factor. The local abundance of *M. pennsylvanicus* was the predictor variable that best separated the two categories of damage; tree planting blocks with damage tended to occur

Table 5. Factor analysis of vegetation cover. (Habitat variables that characterize the eight habitat factors are described. Only variables whose factor loadings were greater than ± 0.250 are included in the descriptions below. Names assigned to each factor are used in all further discussions of the analysis.)

Factor	Name	Description
1	Grass/legume	- positive values represent a high percent ground cover and vertical cover of fescues, brome grass, alfalfa and litter, a dense accumulation of plant litter, a dense vertical cover (by all plant species) up to a height of 25 cm, and a moderate percent ground cover of common clover and crested wheatgrass.
2	Vertical cover	- positive values represent the presence of vertical cover in 25 cm increments from a height of 25 to 150 cm above ground.
3	*Agropyron*/hawkweed	- positive values represent a dense vertical cover and ground cover of *Agropyron violacium* and hawkweed (common ground cover components of the two study areas with reduced plant cover).
4	Fescue/*P. maniculatus*	- positive values represent the presence of dense vertical and ground cover of *Festuca saximontana*, a dense ground cover of hawkweed, and moderate numbers of *P. maniculatus*.
5	Common clover	- positive values represent the presence of dense vertical and ground cover of common clover.
6	Lamb's quarters	- positive values represent a dense vertical and ground cover of Lamb's quarters.
7	Crested wheatgrass	- positive values represent a high percent ground cover and vertical cover of crested wheatgrass.
8	Sanfoin	- positive values represent a dense vertical and horizontal growth of sanfoin.

where *M. pennsylvanicus* was abundant, whereas tree planting blocks with no damage tended to occur where *M. pennsylvanicus* was not abundant. Planting blocks with no damage also tended to be located in areas with dense ground covers of *A. violacium* and hawkweed, whereas planting blocks with damage tended to occur where such ground cover was sparse. High values of the *A. violacium* / hawkweed factor were recorded on the two study areas with reduced plant cover, so the results show that damage tended to be least on those study areas. The discriminant model accurately predicted the damage category in 65.8% of the 120 tree planting blocks.

Small Rodent Abundance and Habitat Structure

Relationships between small rodent abundance and habitat structure also indicated that ground cover communities strongly influenced the local abundance of *M. pennsylvanicus*. Stepwise multiple regression (SMR) analyses of the relationship between habitat structure and small rodent abundance were performed using the BMDP2R program (Dixon and Brown 1979). Four separate SMR analyses were performed; two for *M. pennsylvanicus* in 1980 and 1981, and two for *P. maniculatus* in 1980 and 1981. Only habitat factors with F-ratios larger than 4.0 were allowed to enter the SMR model.

During 1980, three habitat factors explained 42.5% of the spatial variation in the abundance of *M. pennsylvanicus* on the six study areas (Table 6). The grass/legume factor was the most important predictor variable and was positively associated with numbers of *M. pennsylvanicus*. The sanfoin factor and the common clover factor were both positively associated with the abundance of *M. pennsylvanicus* and accounted for an additional 2.8% and 2.6% of the variance in captures, respectively.

The relationship between spatial variation in the abundance of *M. pennsylvanicus* and vegetation structure in 1981 was similar to that in 1980. Three habitat factors, the grass/legume, the crested wheatgrass, and the common clover factors, accounted for 38.8% of the spatial variation in *M. pennsylvanicus* (Table 6). The grass/legume factor and the common clover factor were positively associated with abundance whereas the crested wheatgrass was negatively associated with numbers of *M. pennsylvanicus*.

Table 6. SMR analysis of the relationship between *M. pennsylvanicus* abundance and habitat factors during 1980 and 1981. (See Table 5 for explanation of variable names. Small rodent abundance is expressed as the number of captures per trap-night and was transformed using a log [x+1] transformation for use in the MRA.)

Factor Name	Step at which Factor Entered Equation	Regression Coefficient at Last Step	S.E. of Regression Coefficient at Last Step	R^2 at Each Step	Increase in R^2 Attributable to Factor	P^b
<u>1980 Analysis</u>[a]						
Constant		0.019				
Grass/legume	1	0.020	0.002	0.360	0.360	***
Sanfoin	2	0.004	0.001	0.388	0.028	***
Common Clover	3	0.006	0.001	0.415	0.027	***
<u>1981 Analysis</u>[c]						
Constant		0.013				
Grass/legume	1	0.020	0.002	0.316	0.316	***
Crested Wheatgrass	2	-0.008	0.002	0.367	0.051	***
Common Clover	3	0.012	0.004	0.388	0.021	***

[a] Multiple R-square=0.415, standard error of estimates=0.0255, df=2,297, F-ratio=94.19, $P < 0.001$.

[b] Two-sided significance levels: *** means $0.001 \geq P$.

[c] Multiple R-square=0.3883, standard error of estimates=0.0268, df=2,296, F-ratio=62.63, $P < 0.001$.

Multiple regression analyses for *P. maniculatus* indicated that local variation in the abundance of this species during both years was poorly associated with all of the habitat variables measured.

Tree and Shrub Performance and Habitat Structure

Total height, survival, and condition for each of 12 tree and shrub species were evaluated by Suncor on each study area. We wanted to reduce these 36 values (3 variables x 12 species) to just a few indices of height, survival, and condition. To do this, three separate principal component analyses (BMDP4M; Dixon and Brown 1979) were performed on the Suncor estimates of growth, survival, and condition, respectively. The first two principal components of growth, the first principal component of condition, and the first principal component of survival were used in all further analyses as indices of the respective parameters. Seven habitat factors, similar to those described in Table 5, were used to describe plant cover on the five study areas (the Stripping Trial was excluded from the analyses because the tree planting blocks on this area were not identical to the other five areas). Three separate stepwise multiple regression analyses (BMDP2R; Dixon and Brown 1979) then were used to assess relationships between growth, condition, and survival, respectively, and the factors describing vegetation cover and small rodent abundance. Results of the analyses are summarized in Table 7; further details are provided by Green (1982).

During 1980, when amounts of damage to trees and shrubs were small, tree and shrub performance was related to the density and composition of ground cover. Trees and shrubs in better condition tended to be taller than plants in poor condition. Trees and shrubs that were located in areas with ground covers dominated by *F. saximontana* and Lamb's quarters (i.e., the Reduced Cover and Combined Treatment study areas) or with high local abundances of *P. maniculatus* (again the two reduced cover study areas) also tended to be taller. This suggests that during 1980, sparse ground covers such as those present in the Reduced Cover and Combined Treatment study areas were most suitable for tree and shrub growth. In contrast, tree and shrub growth in areas dominated by a dense cover of agronomic grasses and legumes tended to be poor.

Tree and shrub condition during 1980 was negatively associated with the local abundance of *M. pennsylvanicus* and the density of grass/legume cover. Because damage was included in the analysis but was not a

Table 7. Stepwise multiple regression analyses of tree/shrub performance variables in relation to habitat factors and rodent abundance during 1980 and 1981.

Variable Name	Step at which Factor Entered Equation	Regression Coefficient at Last Step	S.E. of Regression Coefficient at Last Step	R^2 at Each Step	Increase in R^2 Attributable to Factor	p[a]
1980 PC1 Plant Height						
Constant		0.026				
Condition	1	0.212	0.061	0.094	0.094	***
1981 PC1 Plant Height						
Constant		0.029				
Condition	1	0.247	0.067	0.103	0.103	***
1980 PC2 Plant Height						
Constant						
P. maniculatus (captures/TN)	1	-6.043	1.781	0.105	0.105	***
Condition	2	-0.220	0.059	0.178	0.073	***
F. saximontana	3	-0.566	0.206	0.224	0.045	***
Lamb's quarters	4	-0.176	0.046	0.268	0.045	***
Damage	5	-2.169	1.056	0.294	0.026	***
1981 PC2 Plant Height						
Constant		0.369				
Damage	1	-0.233	0.035	0.269	0.269	***
1980 Condition[f]						
Constant		0.289				
M. pennsylvanicus (captures/TN)	1	-13.787	1.777	0.372	0.372	***
Grass/legume cover	2	-0.476	0.055	0.592	0.229	***
Vertical cover	3	0.709	0.270	0.609	0.017	***
1981 Condition[g]						
Constant		0.599				
Damage	1	-0.595	0.051	0.703	0.703	***
Grass/legume cover	2	-0.198	0.049	0.755	0.052	***
P. maniculatus (captures/TN)	3	3.485	1.489	0.769	0.014	***
F. saximontana cover	4	0.112	0.029	0.782	0.013	***
A. violacium/hawkweed cover	5	0.096	0.027	0.797	0.015	***
Vertical cover	6	0.081	0.028	0.805	0.008	***
Common clover/sanfoin cover	7	-0.274	0.115	0.815	0.010	***
1980 Survival[h]						
Constant		0.236				
Condition	1	0.626	0.050	0.655	0.655	***
Crested wheatgrass cover	2	-0.124	0.032	0.704	0.049	***
F. saximontana cover	3	-0.317	0.115	0.722	0.018	***

...continued

Table 7. Continued

Variable Name	Step at which Factor Entered Equation	Regression Coefficient at Last Step	S.E. of Regression Coefficient at Last Step	R^2 at Each Step	Increase in R^2 Attributable to Factor	P[a]
1981 Survival[i]						
Constant		-0.470				
Grass/legume cover	1	-0.325	0.037	0.378	0.378	***
Lamb's quarters cover	2	0.300	0.056	0.558	0.180	***
F. saximontana cover	3	0.179	0.032	0.601	0.043	***
Vertical cover	4	0.109	0.028	0.648	0.047	***
A. violacium/hawkweed cover	5	0.100	0.028	0.683	0.035	***
P. maniculatus (captures/TN)	6	5.059	1.494	0.712	0.024	***

[a]Two-sided significance levels *** $P < 0.001$.

[b]R^2=0.094; S.E. of estimate=0.447; df=1,118; F-ratio=12.30; $P < 0.001$.

[c]R^2=0.103; S.E. of estimate=0.630; df=1,118; F-ratio=13.59; $P < 0.001$.

[d]R^2=0.294; S.E. of estimate=0.370; df=5,114; F-ratio=9.51; $P < 0.001$.

[e]R^2=0.275; S.E. of estimate=0.356; df=1,118; F-ratio=44.76; $P < 0.001$.

[f]R^2=0.609; S.E. of estimate=0.429; df=3,116; F-ratio=60.09; $P < 0.001$.

[g]R^2=0.815; S.E. of estimate=0.382; df=7,112, F-ratio=70.40; $P < 0.001$.

[h]R^2=0.722; S.E. of estimate=0.326; df=3,116; F-ratio=100.58; $P < 0.001$.

[i]R^2=0.712; S.E. of estimate=0.397; df=6,113; F-ratio=46.64; $P < 0.001$.

significant predictor variable of condition, the negative association between condition and *M. pennsylvanicus* numbers probably reflects habitat conditions that supported high numbers of these species (dense horizontal and vertical ground cover dominated by agronomic grasses and alfalfa, common clover, and sanfoin).

During 1981, tree and shrub height again appeared to be negatively related to ground cover. Height of coniferous trees and most shrubs was positively associated with tree/shrub condition. In turn, tree/shrub condition was negatively influenced by increasing densities of ground cover dominated by agronomic grasses and legumes. Height of willows and poplars was negatively associated with damage or, in other words, height was negatively affected by damage. Becasse damage tended to be highest in areas preferred by *M. pennsylvanicus*, growth of poplars and willows, by inference, was poorer in areas with a dense ground cover of agronomic grasses and legumes. The close association between low tree/shrub survival and a dense ground cover of agronomic grasses and legumes and between good tree and shrub survival and habitat parameters typical of the sparse ground covers on the two reduced cover study areas (i.e., a ground cover predominated by Lamb's quarters, *F. saximontana*, *A. violacium*, and hawkweed, a high local abundance of *P. maniculatus*, and good vertical development of vegetation cover 25 cm to 150 cm above ground level) are in diract agreement with this conclusion.

In summary, the results of the three multivariate analyses during 1980 and 1981 generally are in agreement and suggest:

1. Dense ground covers predominated by agronomic grasses (creeping red fescue, brome grass, and crested wheatgrass) and legumes (alfalfa and common clover) seriously hinder tree and shrub performance (e.g., poor growth, condition, and survival); and

2. Sparse herbaceous ground covers, such as that present on the Reduced Cover and Combined Treatment study areas, appear to be the most suitable vegetation cover for good tree and shrub performance (good growth, condition, and survival).

SYNTHESIS AND CONCLUSIONS

Based on this study and previous research by Radvanyi (1978), Michielsen and Radvanyi (1979), and Green (1980a, 1980c), a number of conclusions concerning small rodent damage to trees and shrubs on reclamation areas and the performance of tree and shrub species on reclamation areas can be stated (characteristics of small rodent populations, vegetation, tree performance, and small rodent damage on each study area are summarized in Table 8).

1. The grass/legume ground cover used to stabilize tailing sand berms creates a vegetation community highly suitable to *M. pennsylvanicus*.

2. Once established in new reclamation sites, *M. pennsylvanicus* populations can increase rapidly and undergo cyclic fluctuations in abundance on the order of once every three to four years.

3. New reclamation sites are only moderately suitable for *P. maniculatus* and are poorly suited to *C. gapperi* (these two species of small rodent are the most abundant species in adjacent natural forested communities).

4. High local abundances of *M. pennsylvanicus* are closely associated with development of dense grass and legume ground cover.

5. Damage to trees and shrubs tends to be most severe in areas with a high local abundance of *M. pennsylvanicus*, strongly suggesting that this species is largely responsible for the girdling damage on reclamation areas.

6. Assuming this relationship is correct, local abundances of *M. pennsylvanicus* appear to be the proximate cause of damage, whereas the development of dense vegetation cover dominated by agronomic grasses and legumes is the ultimate cause of damage.

7. Development of dense ground covers of grass and legumes can result in reduced tree and shrub performance (poor growth, condition and survival), possibly as a result of competition for nutrients and water.

In addition to providing information on these aspects of small rodent demography, small rodent damage, vegetation cover, and tree/shrub performance, this study has provided an opportunity to observe the

Table 8. Characteristics of small rodent populations, vegetation, and small rodent damage on the six study areas of 1981.

	Supplementary Food	Repellent	Combined Treatment	Reduced Cover	Stripping Trial	Control
C. gapperi						
Numbers[a]	0	3	18	9	3	9
Breeding activity	-	low	high	low	none	low
Pregnancies	-	none	none	none	none	none
M. pennsylvanicus						
Numbers[a]	116	67	32	11	19	31
Breeding activity	high	high	moderate	moderate	high	high
Pregnancies	moderate	moderate	low	low	moderate	moderate
P. maniculatus						
Numbers[a]	8	6	22	14	6	8
Breeding activity	low	moderate	moderate	high	high	moderate
Pregnancies	low	none	moderate	low	none	none
Ground Cover						
Total percent cover	156.8	98.5	19.6	21.8	62.4	51.9
Dominant species[b]	Red fescue Brome grass Alfalfa	Red fescue Brome grass Alfalfa	*Festuca saximontana* Fireweed Willows	Hawkweed Reed grass *Agropyron violacium*	Red fescue Brome grass Crested wheatgrass	Red fescue Brome grass Crested wheatgrass
Litter (percent cover)	84.0	58.1	1.8	1.6	29.7	29.1
Trees and Shrubs						
Growth	poor	moderate	high	high	moderate	moderate
Condition	poor	fair	good	good	fair	fair
Survival	moderate	moderate	high	high	moderate	moderate
Small Rodent Damage						
Suncor assessments	high	moderate	low	negligible	moderate	moderate
LGL assessments	high	moderate	low	low	low	moderate

[a]Peak MNA during 1979-1981.

[b]The three most dominant ground cover species, based on estimates of mean percent ground cover during 1981, are shown.

establishment of two types of ground cover communities in reclamation areas--agronomic grass and legume ground cover and a natural successional ground cover--and the subsequent use of these areas by small rodents.

At the start of this study (summer 1978), no plant cover was present on any of the six study areas and it is likely that all areas were uninhabited by small rodents. Following hydroseeding of four of the six study areas and the subsequent establishment of sparse grass and legume cover, small rodents had begun to utilize the hydroseeded areas by the early fall 1978.

In adjacent natural forest communities *C. gapperi* is the most abundant species of small rodent, *P. maniculatus* is moderately abundant, and *M. pennsylvanicus* is only common within pockets of suitable vegetation (Green 1980c). However, the creation of reclamation areas with good development of grass and legume cover has provided a large area of habitat, highly suitable for habitation by *M. pennsylvanicus* and, to a lesser extent, *P. maniculatus*. It appears, then, that the creation of grass and legume-dominated reclamation areas has allowed *M. pennsylvanicus* to establish large resident, breeding populations in an area that formerly was not well suited for this species. These populations increased rapidly and now appear to undergo cyclic fluctuations in number (as described by Krebs and Myers [1974]) on the order of once every three to four years.

In contrast, *C. gapperi* has not become well established in reclamation sites even though it is abundant in adjacent forested sites. Because *C. gapperi* prefers mature forested communities, failure of this species to establish on the existing reclamation sites is not unexpected. However, as tree and shrub cover increases on the reclamation sites, increased use of these areas by *C. gapperi* can be expected.

The reclamation study areas appear to provide an adequate habitat for *P. maniculatus;* breeding populations have become established and numbers are similar to those in some adjacent forested areas. *Peromyscus maniculatus* prefers natural areas with well-developed tree and shrub cover and will likely increase in number as trees and shrubs become better established on the reclamation sites.

Reclamation practices, currently in use in the Fort McMurray area generally involve hydroseeding with a mix of a soil stabilizer, agronomic grasses and legumes. This results in the rapid establishment of a vegetation mat that reduces soil erosion. Tree and shrub planting programs have been undertaken in order to accelerate the establishment of a self-sustaining vegetation community and to aid in soil stabilization.

Results of this study indicate, however, that the dense ground covers and tree planting programs are not compatible for two major reasons. First, the dense grass and legume ground covers probably compete with the young trees and shrubs for water and nutrients. The poor growth, condition, and survival of trees and shrubs in areas of dense ground cover suggests that the grass and legume species used are capable of reducing tree and shrub performance. Trees and shrubs stressed by competition would be less able to withstand the additional stress of small rodent damage and consequently would be more susceptible to damage. And second, the development of dense grass and legume cover creates a vegetation community highly suitable for *M. pennsylvanicus*. Girdling damage by *M. pennsylvanicus* can reach high levels during the peak phase of this small rodent's population cycle. Because trees and shrubs in areas of dense grass and legume cover may already be stressed by competition and because the same ground cover ultimately results in increased amounts of damage (as a result of high *M. pennsylvanicus* numbers), poor tree and shrub performance can be anticipated.

Because stabilization of the tailings sand berms is necessary to reduce erosion by wind and water, the use of ground covers cannot be totally eliminated. Some form of ground cover and/or soil stabilizer is necessary. Widespread use of an artificial soil stabilizer, such as hydromulch, is not feasible because of the large size of the reclamation areas. The solution appears to be the development of a seed mix which will result in a ground cover community with several characteristics:

1. a well-developed root system to help stabilize the tailings sand;

2. a poor capability to compete with trees and shrubs for water and nutrients;

3. a minimal development of above-ground plant cover to reduce the attractiveness to *M. pennsylvanicus;* and

4. a reproductive capability sufficient to maintain a self-sustaining vegetation community.

Several species of grasses, which may meet these criteria, are currently being tested on the Reduced Cover and Combined Treatment study areas.

Tree and shrub survival might also be enhanced through timing of the reclamation program. For example, trees and shrubs might first be planted on reclamation sites and allowed to establish prior to the application of a sparse ground cover mix. In addition, because *M. pennsylvanicus* populations appear to reach high numbers only once every three to four years and because damage can be expected to increase to critical levels during these peak years, trees and shrubs should be planted immediately following the population decline. The trees and shrubs consequently would have two to three complete growing seasons before the next population peak of *M. pennsylvanicus* and likely would be better able to withstand the stress of girdling damage.

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ACKNOWLEDGEMENTS

A number of individuals contributed much to the study throughout 1978 to 1981. In particular, I would like to thank Vance Buchwald, Hazel Hurtak, Kathy Bruce, and Brian Braidwood for their contributions to the field study, data analyses and report preparation. I also would like to thank D. Whitford for key punching of the field data and preparation of the typescript; K. English and B. Harvie for assistance in computer analyses; and D. Dabbs, J. Richardson, and T. Shopik for their review of an earlier version of this paper.

I also would like to thank D. Klym (Land Environment Manager, Suncor Inc.) and D. Dabbs (Alsands Energy Ltd.) for their support and assistance and T. Shopik (Lands System, Suncor Inc.) for provision of the tree and shrub assessment data for 1980 and 1981.

Funding of this program was provided by the Alberta Oil Sands Environmental Research Program during 1978 and 1979 and by Alsands Energy Ltd. and Suncor Inc. during 1980 and 1981.

DISCUSSION RELATING TO JEFF GREEN'S PAPER

Frank Pells, Brenda Mines: Is the cycle of mice independent of your planting cycle?

Answer: It could be coincidental and I really can't answer your question. We started our study in 1978 and unfortunately that was the year that the microtene populations declined very rapidly on the older reclamation sites that had already been established. It's interesting that Al Kennedy, when speaking about the Esso Project at Judy Creek yesterday said that they also had high population numbers for 1981 and high amounts of damage. One of the things that has been suggested, for natural populations anyways, is that these populations cycle circuitously across very wide geographical regions so perhaps it doesn't really matter when you start your areas - you still may have cycling populations which could be influenced by immigration of animals from older reclamation sites. When the numbers go up there, you're probably going to get very high influx into your reclamation sites.

Phil Burton, Monenco Consultants: Jeff, would you say that rodent damaged is associated more with high shoot cover of the ground (grasses and legumes) or with litter accumulation?

Answer: Our analysis couldn't distinguish that - I think both are important. Basically they both add to the ground cover which protects the small rodents from predation and climatic extremes. Rodents definitely go for areas of very high ground cover accumulation. They need to have some green shoot material for food, but they also like to have a lot of plant accumulation for nesting, and building runways.

Jack Thirgood, U.B.C.: How do you apply the grass turf in strips?

Answer: One of the treatments which I didn't go into very much is called the stripping trial. What we did was to seed a ten metre wide horizontal band at the top of the berm and another ten metre band across the bottom, leaving a band which varied between 20 m and 25 m wide in the middle which was unseeded. Then trees were planted into that. The trees have done somewhat better, but one of the problems we face with working on a slope is water washing grass seed down into the area so that it begins to seed over like the other areas.

Jack Thirgood, U.B.C.: I hope not (interval of unclear recording). Have you tried removing the turf?

Answer: We haven't tried that. Prior to our study Suncor did try a manipulation in which they would clear off one and a half metre radius and plant the trees into that. The area wasn't big enough and the grass came back very quickly. An alternative reclamation strategy might be to do something like we've done on our two reduced-cover plots in which you plant your trees first and use physical means of controlling erosion be it through soil stabilizers or sand-bagging or whatever. It's fairly labour intensive. But get the trees well established, let the roots get going, then plant your sparse shrubbery.

Jack Thirgood, U.B.C.: Could you plant the trees and then use a herbicide?

Answer: That would probably be a very acceptable technique.

Dave Fraser, University of Victoria: Did anybody try habitat manipulation to increase predation pressure?

Answer: One of the problems with that technique is that predators only remove excess of microtene populations. Predators can keep that peak population down, but in natural situations they can't stop the cycling. I suspect that predation might reduce the population but it isn't going to be as effective as habitat manipulation which can result in very large changes in population numbers.

Dave Fraser, University of Victoria: How about leaving islands of natural vegetation to relieve pressure on reclaimed areas?

Answer: Yes, and that would also be one route of investigation into making these reclamation sites more suitable for other types of wildlife species as well.

C.J. Lloyd, U.B.C.: (Distorted recording. The question related to selecting damage resistant species for planting.)

Answer: Among the tree species we planted there is a definite preference for white spruce and caragana. There are clearly certain species which they leave strictly alone.

LINE CREEK MANAGEMENT PHILOSOPHY AND THE ENVIRONMENT

Paper Presented
by

Don Riva
Manager, Operations
Line Creek Mine

and

Jim Lant
Manager, Environment
Line Creek Mine

LINE CREEK MANAGEMENT PHILOSOPHY AND THE ENVIRONMENT

INTRODUCTION

I would like to set the stage for Jim Lant's presentation on Line Creek's environmental program by giving you some background to the development of our approach to management at Line Creek.

Over two years ago when the Line Creek project was initiated, an Operations Management Group was formed. The makeup of this group was a mix of ages, experiences and came from various parts of Canada and the world.

As a group we got together to decide how and what we should be doing in starting up and managing a coal mine in British Columbia during the 1980's.

The first thing we did was discuss and list those things we did not like about the mines we had come from and those we see around us. This was a very easy and obvious task and some of the items identified were:

- poor labour-management relations
- poor public image
- poor environmental image
- high turnover
- low productivity

I'm sure you can list many more.

It was decided that we would develop an operating philosophy which would be a guideline for the management group of the Line Creek Mine.

This was a difficult and time consuming task when you imagine seven people of widely different backgrounds getting together to agree upon a set of values by which an organization should live.

The result was a document containing seven philosophy statements which state the general direction and purpose of the mine and nineteen goal statements which give direction on how to implement the philosophy.

In broad terms the statements cover the following four areas:

- production
- corporate relations
- internal relations
- external relations

A summary of the philosophy statement would be that we believe in order to be successful we must effectively manage and be involved in all the areas that impact the production of coal at Line Creek.

This operating philosophy is the basis for all planning at the Line Creek Mine. An integral part of the management plan and the philosophy is our approach to environmental management. Jim Lant will explain our program to you.

ENVIRONMENTAL MANAGEMENT - JIM LANT

It is my pleasure to be here with you at this, the Sixth Annual Reclamation Symposium and to explain the impact that the type of management we are introducing has upon the Line Creek Environmental Department.

I find it extremely rewarding and unique; and I hope to convey this to you in the next few minutes.

The first items derived were the philosophy and goal statements: the objectives and activities related to each goal. In retrospect, all simply tie in as follows:

1. Philosophy Statements: Long term five year statements that generally describe how the operation should be operating only accomplished with the successful achievement of goals. In general this is the culture of the organizational setting.

2. Goal: More finite than philosophy statements - generally describe the program to be completed - generally of one year duration.

3. Objectives and Activities: Spell out the immediate actions required noting who is accountable and when the activity is to be completed.

In summary, if you successfully complete your activities you achieve your goal and if you continuously achieve these goals the philosophy will be set in place. This last stage of assembling the objectives and activities for each goal on a time line, brought forward the immediate impact.

It happened as follows. The managers, having formulated the 19 goals, took these statements back to their respective departments and put together the lists of objectives and immediate activities that must be accomplished per goal in order to achieve it. To me the results were dramatical and completely unexpected. An example of the maintenance department's work follows:

EXTERNAL GOAL #1

The Line Creek operation recognizes and supports the concept of preserving and enhancing our natural environment and, to this end, will employ the most practical, current state-of-the-art technology to minimize the impact of our operation on the environment while meeting or exceeding all legal requirements.

Objective

By July 1, 1981 standards and systems will be set up to ensure that the Maintenance Department will conduct its business in such a way as to preserve and enhance the natural environment.

Activity #1

Establish procedures for waste oil handling. Accountability maintenance engineer by July 1, 1980.

Activity #2

Establish procedures for scrap iron and garbage disposal.

As you can see, the results are rewarding with the total impact being:

1. Incorporated environmental planning in each department.

2. Incorporated environmental concern and environmental commitment through participation. They, themselves, drew up the work program. I didn't force anything on them.

3. Changed the role of the environment department to a resource role away from the policing role (as illustrated - maintenance activities).

In turn, the objectives and activities formulated by the Environment Department, this goal statement became the major portion of my Department's work program.

GOAL

The Line Creek operation recognizes and supports the concept of preserving and enhancing our natural environment and, to this end, will employ the most practical, current state-of-the-art technology to minimize the impact of our operation's environment while meeting or exceeding all legal requirements.

Objective #1

Operational reclamation will be kept current and all disturbances will be treated as soon as reasonably possible.

Activity

Roadside ditches and slopes are to be grassed in 1981 (spring and summer).

Activity

Plantsite sewage field will be revegetated in the spring of 1981.

Objective #2

Indigeneous fish and wildlife will be identified and quantified and the information gathered will assist in the sound management of the renewable resources.

Activity

1981 Line Creek Sport Fish Enumeration
1981 Bighorn Sheep Study

Ladies and gentlemen, that concludes our presentation.

DISCUSSION RELATING TO J. LANT'S AND D. RIVA'S PAPER

Murray Galbraith, MEMPR: Jim, you mentioned about doing some radio work with fish - is that very far off?

Answer, Jim Lant: Yes, I would say that at the present time we are very seriously considering using the teleonics transmitters on some of the larger Dolly Varden. In terms of work with the Regional Biologist, it will tie in very nicely with our monitoring movements so that when we do make a pass over the area we can detect the fish, the elk and the sheep.

Eric Beresford, Union Oil: Were these programs as a result of external funding?

Answer: No, these studies are strictly internal.

WORKSHOP ON PUBLIC INVOLVEMENT IN RESOURCE DEVELOPMENT

Workshop Introduced
by

Chairman
Bruce Fraser
Ministry of Forests
Victoria, B.C.

PUBLIC INVOLVEMENT IN A MINE RECLAMATION PLAN

SCENARIO

Monarch Mines is in the process of establishing a lead-zinc mine near Queen's Crossing, B.C. The mine itself has been approved by government as a major economic development that the province needs, but it has left the question of acceptable reclamation up to a process of public review. The Ministry of Energy, Mines and Petroleum Resources has established an independent review panel of resource experts and citizens who will soon be holding their first public meeting in the local town recreation centre. They will be trying to gain a wide agreement on what constitutes an acceptable reclamation plan for the impact sites of this open pit mine.

The mine itself will impact land ranging from 3,800' to 5,000' ASL, which contains valuable timber land, fish-bearing streams, elk wintering range and traditional native land, subject to a land claim. At this stage, most parties have accepted the fact of a mine, but many have strong views about the nature of the reclamation levels which would meet their agency or group objectives.

All participants in this brief initial public review session will be striving to put forward ideas for reclamation which they feel are reasonable for the company to adopt. The participants who are preparing for the meeting are:

Monarch Mines Public Relations Department
Ministry of Energy, Mines and Petroleum Resources
Ministry of Forests
Ministry of Fisheries and Oceans
Local Recreation Interests
Sierra Club
Chamber of Commerce
B.C. Wildlife Federation
Indian Band Council
Public Review Panel

The process of this workshop is designed to place the various groups in a situation which requires working compromises to be developed and proposed. It is also intended that time will be spent considering and discussing the approaches to constructive public involvement in the preparation of a reclamation plan.

TECHNICAL DETAILS OF THE MINE, SITE AND COMMUNITY

1. Production level of 50,000 tons/day lead-zinc ore.

2. Open pit of 20 years duration in first of two possible phases.

3. Concentrator effluent and other wastes potentially acid, tailings pond siting and controls a major problem.

4. Elevation of mine site ranges from 3,800' to 5,000' ASL.

5. South-facing slopes are at the upper elevation limit of the Interior Douglas fir zone, while cooler slopes fit into the Engelmann Spruce-Subalpine Fir Zone.

6. The local community of Queen's Crossing, presently contains about 4,000 people and is supported by lowland ranching and forestry with a sawmill as the greatest single local employer. Residents have enjoyed the intended mine area for many years as major wilderness recreation and hunting area, while Native Indian residents also consider the area part of their Aboriginal territory.

GENERAL INSTRUCTIONS TO ALL GROUPS

1. Read the scenario.

2. Gather into the assigned groups and choose a group leader whose role will be to chair your working session. A spokesman should also be chosen who will present your statement to the Review Panel.

3. Read your specific role description.

4. Prepare a basic position for your group.

5. Visit with other groups to negotiate joint positions and to attempt compromises before the panel calls its public meeting.

6. Prepare your final position.

7. Present to the Review Panel.

8. Participate in the discussion which follows the presentations.

ROLE DESCRIPTION FOR MONARCH MINING LTD., PUBLIC RELATIONS DEPARTMENT

1. Your job is to communicate public demands, inquiries, and dissatisfaction to company technologist and reclamation engineers (and vice-versa).

2. You are also in charge of educating the various public interest groups as to the operation of the lead-zinc mine, as most of them don't know much except for what they have read in the papers.

3. You are also in charge of informing the media as the developments progress, since the newspapers like to sensationalize stories. You must be careful what gets out.

4. The main job is to inform public of benefits that will come to the community as a result of mining - emphasizing employment both in mining and in reclamation work. Also involved here are minimizing negative effects. The ultimate goal here is <u>Enthusiasm</u> from local citizens for the procedure of planning reclamation work.

5. Your role is to present the company to the public in the best light. Throughout the working session, you will be issuing company originated press releases after discussions with all of the participating groups. Arrange to halt all proceedings in order to read aloud your releases.

MINISTRY OF ENERGY, MINES AND PETROLEUM RESOURCES

As a governmental Ministry, you are primarily concerned with attaining an acceptable balance between the plans of the mining company and the concerns of other agencies. Your mandate simply states that the companies must return mined areas to acceptable land-use; it is up to you to interpret what is "acceptable."

You are concerned that:

- the companies follow the reclamation plans they have proposed

- the demands of other agencies are financially realistic

- the mining company keep on good terms with the public and other government agencies

- you want to do an effective job of mediating between the company and other agencies, and finally come up with a decision acceptable to everyone.

In order to fulfill this role you will make a serious attempt to bring parties together during the working sessions before the public meeting, and will state what you feel to be the ground rules as the first speaker at the public meeting.

MINISTRY OF FORESTS ROLE

1. Your immediate concern is the loss of climax forest and the time it will take to return to this state as it represents lost revenue for Ministry of Forests and the provincial economy.

2. The productivity of the reclaimed land will also be an issue, i.e. less productive land means longer before harvest of wood.

3. Where are the overburden and slag piles going to be located? Valley bottoms are the likely areas for dumping but they also tend to be the most productive growing areas.

4. There is also concern that the overburden piles may have slopes in excess of 29° which is the highest angle able to sustain complete revegetation.

5. Reclamation usually does not involve the replanting of native species because they are not available on the commercial market in any quantity. Therefore, time involved to reach climax forest is that much longer.

As a Ministry, your job will be to present the case for having the reclamation plan take into consideration the economic value of good timber producing land. Some of your foresters are working in other areas with Federal Fisheries and may wish to make a joint proposal.

DEPARTMENT OF FISHERIES AND OCEANS

REAL POSITION

Area of proposed mine site encroaches on, and may threaten, habitat of streams spawning ground used for Native food fishery.

One of the main tenets of Department of Fisheries and Oceans is protection of environment habitat of river streams and spawning beds, which constitute Native food fishery areas.

ROLE DESCRIPTION

You are only concerned about protection of fish bearing streams and will focus most of your energy on ensuring that the mine development meets your water quality objectives.

Collaboration with the Indian Band and with the Ministry of Forests is what you will promote during this hearing by the review panel.

LOCAL MUNICIPAL PARKS

As the land in question is not within the boundary of a Provincial Park, the Provincial Parks Branch is not involved in the reclamation of this area. However, the local Municipal Parks Branch is interested in the area becoming developed into a park/recreation area for use by the local citizens.

The Municipal Parks Branch justifies its proposal for creating a municipal park for various reasons: firstly, they feel that the land will be so disturbed by man's mining activities, that to expect to return the land to a completely "natural" area is unrealistic. Man's intensive activities in the area have long since disturbed the natural wildlife and vegetation. However, they do feel that the area could be converted into a municipal park that would be both aesthetically pleasing and create benefits for use by man.

The Municipal Parks feels that since the area has been such an ugly, unsafe area for local people to use, especially children, that it is only fitting that the area now be converted to a beautiful, safe and useful area for the enjoyment of all the local people.

Actual plans for the park include such suggestions as a chip trail winding throughout the park, with various "fitness stops" along the way, e.g. bars to do chin-ups, to create a total "fitness" track. A moderately sized recreation centre is a possibility. For younger children, an "adventure playground" could be constructed incorporating use of natural materials to blend into the outdoors emphasis of the park. A series of small interconnecting ponds would create an area to attract birds, provide a canoe/kayak area for fun, or other water-based activities. Park trails and benches provide an area around the ponds, and throughout the park for walking, enjoying the view, etc. Local sports teams also would like to see a soccer field and baseball diamond incorporated into the plan.

In performing your role, you may wish to join forces with the Chamber of Commerce and the Public Relations Department of Monarch Mining.

SIERRA CLUB

As a group of environmentalists, you are committed to preserving the natural beauty of British Columbia. You believe that the land has an intrinsic value that cannot be measured by the needs or financial considerations of man. Consequently, you would like to see every possible effort made toward restoring the land to its original state.

Some of your concerns are:

- that are reclamation be done in a way that will encourage the return of all indigenous plants and wildlife

- that the mining company and government spend adequate time and money in planning and carrying out the reclamation plans

- that the reclamation plans aim at aesthetically integrating the mined area with the surrounding environment

- that sufficient funding be put aside to continue care of the area after the initial planting is done.

Pursuit of your goals will likely require the formation of alliances with other environmental interest groups to strengthen your presentation to the public meeting.

CHAMBER OF COMMERCE

You would like to see the mine site reclaimed to allow a hotel/convention centre complex with a golf course to be developed.

- this would provide employment in the construction phase as well as long-term service needs
- this would encourage business people to come and survey the area for their own prospects
- tourists (with tourist dollars) would come to golf, or for special attractions sponsored by the town.

All in all, this would be a boost in the economy, providing jobs for residents and revenue in the form of tourist dollars.

B.C. WILDLIFE FEDERATION

1. Your immediate concern is the loss of winter habitat for ungulates, primarily Elk. With the loss of the winter range, the ungulates become dependent on humans for feed (if such a program is set up).

2. There are anticipated problems of increased sediment loads in local streams, especially when overburden is dumped in valley bottoms.

   Associated with increased suspended solids, is the potential leaching of acids and heavy metals from overburden and slag piles.

3. When "mines" are in the exploration phase, the damage created by test stripping, seam tracing and access roads, interrupt migration patterns. This is particularly evident in areas of high density ungulate populations.

4. After reclamation, the introduction of agronomic species creates a false impression of plentiful food supplies upsetting the "natural balance."

Your team will argue for reclamation plans which include a balance between preservation of winter range and creation of summer range for ungulates.

You will probably want to join forces with the Sierra Club but your approach is generally one of practical conciliation and is based upon wildlife research results.

INDIAN BAND COUNCIL

REAL POSITION

A B.C. Indian Band laid claim to 10,000 ha of land and sought Federal action to block a proposed open pit lead-zinc mine planned for the area.

The Band says the project would upset irreparably their traditional elk hunting ground and threaten the spawning beds of their food fishery area.

The Band is one of a few B.C. Indian Bands which never surrendered title of their lands to the Canadian Government in Treaty 8, a turn of the century agreement.

ROLE DESCRIPTION

1. Your Band deals from an individual position for land claims - you are not bound by terms of other Band settlements.

2. Expectations of the Band in Land Claim disputes: (varying with specific physical areas, land use plans, degrees of interference accompanying development, Band culture)

   - recognition of charter rights

   - legal formalization of charter and Aboriginal rights

   - recognition of cultural philosophy based on resource use, i.e. traditional values being defined by fishing, trapping, etc.

   - compensation for extraction of resources (related to Aboriginal rights)

   - any development done to be extended as much as possible to benefit the Band, i.e. isolated areas to be supplied with improved road systems to enable Band members to have better access to employment and educational opportunities

- as much as possible in land claim settlements, training for, and employment with, developer of Band members.

3. Department of Fisheries and Oceans has as one of their main tenets: protection of streams, rivers, and spawning beds, which involves Native food fisheries against any negative effects of any development.

4. The Native peoples stand on development includes the recognition of the possibility that development may have the ability to enhance and strengthen traditional values and culture. But the Native people feel that development cannot continue unimpeded if none of the benefits accrue to them, while they are expected to beat the negative impacts of distorted long-term stability of the physical and cultural environment caused by too rapid expansion of development.

REVIEW PANEL

Your purpose is to integrate the results of the simulation game so that the maximum value can be extracted from the discussion. You have three jobs:

1. Observe: All the interest groups in action, listen to their deliberations and make notes on their ideas and the methods they are using to contact other interested groups.

2. Conduct: A public meeting in which you attempt to receive all the proposals from the interest groups and try to gain a degree of consensus that will help the reclamation team prepare a publicly acceptable plan. You will arrange for the Ministry of Energy, Mines and Petroleum Resources to speak first.

3. Lead: A discussion of the results of the game and the participants' views on public involvement in mining activity.

PRESENTATION OF SIXTH ANNUAL
BRITISH COLUMBIA MINE RECLAMATION AWARDS

REPORT OF THE AWARDS SUBCOMMITTEE
TECHNICAL AND RESEARCH COMMITTEE ON RECLAMATION

Under the auspices of the British Columbia Ministry of Energy, Mines and Petroleum Resources, and the Mining Association of British Columbia, a Reclamation Award has been established to recognize outstanding achievement in mine reclamation in British Columbia. In addition to this award, three citations are given to recognize merit in reclamation of Exploration, Metal Mining and Coal Mining.

The Awards Subcommittee has reviewed all nominations for the Reclamation Award and citations and, as in past years, many of the choices have been difficult.

Mr. A. Freyman presented the awards on behalf of the Minister, the Honourable R.D. McClelland.

RECLAMATION AWARD

The 1981 Reclamation Award is presented to Crows Nest Resources.

This award is presented to the Line Creek Operation in recognition of a unique management system which addresses itself to environmentally sound mine planning and mine development practices. One of the primary management objectives of the Line Creek Operation is to recognize and support the concept of preserving and enhancing the natural environment. To this end they have committed themselves to the most practical current "state-of-the-art" technology to minimize the impact of their operations on the environment while meeting or exceeding all legal requirements. The unique aspect of this system is that each department becomes committed to environmental (reclamation) concerns through their participation in setting the work activities necessary to achieve this goal.

Crows Nest Resources Limited activities are the product of their own planning, and not imposed from the outside, commitment is immediate. What the management system accomplishes is to change the role of the environmental department from a clean-up and policing department to one that will help other departments accomplish their specific environmental goals.

The award recognizes the current level of environmental protection which has been achieved at Line Creek.

CITATION FOR EXPLORATION

The 1981 citation is presented to Fording Coal Ltd.

Fording Coal Ltd. has demonstrated that with effective application of technology disturbed terrain at high elevations can be rehabilitated. Fording Coal utilizes years of research and reclamation experience to reclaim the land. Total recontouring and prompt reclamation the same year as disturbance is a way of life at Fording Coal.

Honourable mention is given to Gulf Canada Resources.

CITATION FOR METAL MINING

The 1981 citation is presented to Cominco Ltd.

Cominco's Pinchi Lake operation ceased production in September 1975. The approach to revegetation has been based upon laboratory, growth room and field research conducted since 1970. Revegetation has been carried out on 62 ha. Of these 21 ha are revegetating by native species aided, where required, by fertilizer. The remaining 41 ha have been seeded with agronomic grass and legume species and fertilized. The approach and methods used by Cominco's reclamation staff have yielded excellent results at Pinchi Lake.

Honourable mention is given to Craigmont Mines Ltd.

CITATION FOR COAL MINING

The 1981 citation is presented to B.C. Coal Ltd.

B.C. Coal has continued to maintain its high standard of reclamation achievement. Since its inception a decade ago, B.C. Coal has continued to maintain a positive practical attitude toward reclamation planning by combining a field scale operational approach, with an excellent research program.

FRIDAY MARCH 12TH SESSION

Chairman
R.T. Gardiner
Cominco Ltd.

AN INTEGRATED RECLAMATION MANAGEMENT PLAN
FOR THE HIGHLAND VALLEY MINING COMPLEX

Paper Presented
by

C.J. Lloyd
Faculty of Forestry
University of British Columbia

AN INTEGRATED RECLAMATION MANAGEMENT PLAN FOR THE HIGHLAND VALLEY MINING COMPLEX

ABSTRACT

In the Highland Valley, reclamation of large areas of mining disturbance is being undertaken by several mining companies. Methods and objectives for this reclamation are being studied.

Soil and vegetation surveys are used to classify disturbed materials into site types which have characteristic reclamation requirements. By integrating site type information, land-use options and reclamation research, reclamation techniques and objectives are proposed for each site type.

This approach is suitable for the design of reclamation programs for extensive areas when physical conditions are diverse and mining operations complex.

INTRODUCTION

The Highland Valley, in the Southern Interior Region of British Columbia, has the greatest concentration of open-pit hardrock mines in western Canada. The area was selected by the Reclamation Section of the Ministry of Energy, Mines and Petroleum Resources (MEMPR), to be the subject of a study which was undertaken by the author during the summer of 1981. The purpose of the study was to evaluate methods and objectives for the reclamation of land disturbed by mining activity in the Highland Valley.

This paper describes the study method and presents a summary of its results.

RATIONALE OF STUDY METHOD

At present, there are three mines operating in the Highland Valley and a fourth is expected to come into production soon (Table 1). Changes in mining technology and fluctuations in the price for copper make it hard to make accurate, long-term predictions of the output of ore, waste-rock and tailings. As a result, it is difficult to predict what the extent of reclamation will eventually be. The objective of this study was to

TABLE 1

CURRENT STATUS OF MINES IN THE HIGHLAND VALLEY

NAME AND OWNERSHIP	OPERATION PERIOD BEGIN	OPERATION PERIOD END	PRODUCT	VOLUME OF ORE (T/day)	AREA DISTURBED TO DATE (ha)	AREA RECLAIMED TO DATE (ha)	TOTAL ANTICIPATED DISTURBANCE (ha)	ELEVATION OF DISTURBED AREAS (m a.s.l.)
Bethlehem - Cominco	1962	198-	Cu & Mo	20,500	878.9	22	932	1200 - 1550
Highmont - Teck Corporation	1981	?	Cu & Mo	25,000	976	14	1160	1450 - 1900
Lornex - member of Rio Algom/ Rio Tinto Corporation	1972	1993?	Cu & Mo	85,000	1341	221	3280 + 1820	1200 - 1550 1300 - 1400[2]
Valley Copper - Cominco	?	?+20?	Cu & Mo	100,000	384[1]	-	+ 750	1160 - 1370

[1]Logged during exploration.
[2]Tailings disposal area jointly operated.

assess areas to be reclaimed, as shown by present conditions, so that prescriptions might be made for the future. Disturbed areas were to be classified into reclamation site types. Each reclamation site type would describe areas of disturbed materials that presented similar conditions for plant establishment and growth and had characteristic reclamation requirements (Figure 1). This classification scheme would be used:

1. to acquire more information about the problems associated with each reclamation site type;

2. to select reclamation techniques for each reclamation site type, based on results of reclamation trials carried out by mining companies in the Highland Valley and other reclamation research;

3. to identify "problem site types" where further reclamation research should be directed;

4. to propose land-use objectives for each reclamation site type using the distribution of natural vegetation in the area as an indication of "what grows where."

It could also be used to facilitate prediction of the results of reclamation of the Highland Valley, whatever the size of the area that will eventually be reclaimed.

PROPOSED CLASSIFICATION SCHEME

Numerous methods of classifying land are described in the literature (Hills, 1961; Krajina, 1965; Environment Canada, 1970). To fulfill the objectives of this study, the classification scheme had to fulfill three requirements:

1. it had to be at a scale suitable for management purposes;

2. it had to be based on information that could be acquired from the available maps and aerial photographs of the area;

3. it could not incorporate natural vegetation as a factor since it was to be applied to areas denuded of natural vegetation.

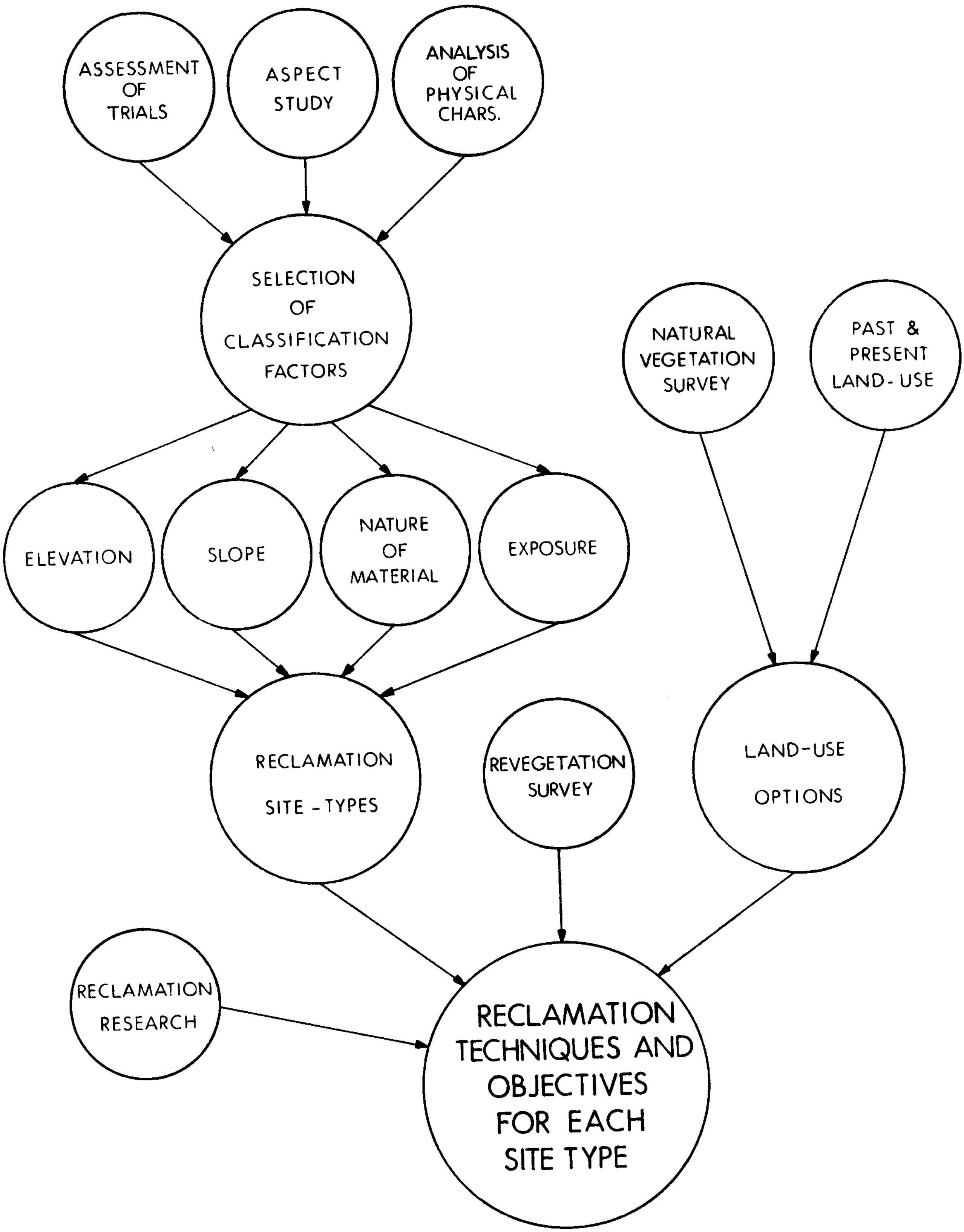


Figure 1. Reclamation techniques and objectives for each site type.

Review of Hills' method of classification indicated that disturbed areas in the Highland Valley might be classified according to the following factors:

- elevation
- aspect
- physical properties of material
- slope

These factors were selected on the assumption that local climate and the retention of moisture in the soil would be the most important factors affecting plant establishment and growth. Slope and physical properties also affect the stability of disturbed areas; reclamation techniques may therefore be modified by the need to control erosion and by constraints on the operation of machinery.

Aspect was selected as a factor in the proposed classification scheme because it is commonly assumed to affect local climate and soil moisture content. However, in semi-arid areas differences due to aspect may not be significant (Clark, 1969). At the Bethlehem mine, shelter from prevailing winds affects the success of reclamation (Walmsley, 1977). In the Highland Valley, prevailing winds are from the southwest.

Chemical properties of materials (pH, available nutrients, etc.) were not included because:

1. research by Lornex Mining Corporation (1973; undated), Dept. of Soil Science (1975; 1976/77) and Valley Copper Mines Ltd. (1980) on disturbed materials in the Highland Valley has shown that levels of available nutrients are generally limiting to plant growth;

2. fertilization has been required wherever seeding has taken place. Slope and physical characteristics have an effect on the retention of fertilizer in disturbed materials and therefore on their artificially-created chemical characteristics;

3. chemical characteristics are not readily identified from maps or aerial photographs.

An additional factor, "visibility from public areas," may be incorporated into the classification scheme. This factor is the subject of another study, the results of which will be published at a later date.

PRE-FIELD WORK

Information on elevation and slope of disturbed materials was obtained from maps and aerial photographs.

Disturbed materials could not be classified immediately according to their physical characteristics since this information could not be obtained from maps or aerial photographs. They were initially grouped according to differences in appearance on aerial photographs. Seven kinds of disturbed material could be distinguished:

1. areas of glacial till whose natural soil covering had been removed,
2. free-dumped waste-rock piles,
3. compacted waste-rock dumps,
4. areas of end-dumped waste-rock,
5. tailings areas,
6. access roads,
7. plant sites and machinery dumps,
8. stockpiled overburden,

End-dumped waste-rock will probably not remain after mining operations end (Munroe, 1981). Access roads will not be reclaimed (Highmont Operating Corporation, 1980) or will be ripped (Valley Copper Corporation, 1980). They and the plant sites, once cleared, will probably revert to a condition similar to the compacted waste-rock dumps or areas of glacial till. Free-dumped waste-rock piles may be covered with a thin layer of overburden as part of the reclamation operation.

Therefore, four kinds of disturbed materials were selected for field investigation:

1. glacial till lacking a natural soil covering (referred to hereafter as "raw till"),

2. waste-rock piles covered with overburden ("overburden/rock"),

3. compacted waste-rock ("compacted rock"),

4. tailings.

The distribution of natural vegetation communities was interpreted from aerial photographs and marked on transparencies. Results of a previous vegetation survey of the area (B.C. Research, 1971) assisted in the preliminary identification of communities.

FIELD WORK

1. Identification of each kind of disturbed material was checked in the field and samples were taken for the determination of physical properties in the laboratory.

2. Differences in the temperature and moisture content of disturbed materials associated with differences in aspect were investigated. However, a detailed account of this investigation is outside the scope of this paper.

3. All accessible reclaimed sites were assessed using the reclamation inventory method (MEMPR, undated). These sites included roadways, pipelines, test plots and "final configuration" dumps.

4. A selection of naturally revegetated areas was surveyed.

5. Interpreted boundaries of natural vegetation communities were field checked and representative areas were described in detail from the vegetation communities found in these areas.

LABORATORY WORK

Textural composition of the disturbed materials and soils was determined using the hydrometer method of particle size analysis described by the Department of Soil Science (1978).

RESULTS

PHYSICAL CHARACTERISTICS OF DISTURBED MATERIALS

The physical characteristics of disturbed materials and natural soils sampled are summarized as follows:

1. Raw till and tailings differed significantly in textural composition from each other and from overburden/rock and compacted rock. Raw till contained more sand-sized and less silt-sized particles. Tailings contained no particles greater than 2 mm in diameter but were highly variable in composition of particles less than 2 mm diameter.

2. No significant differences in textural composition were found between overburden/rock samples and compacted rock samples. (However, since it was not possible to sample more than one area of compacted rock and since rock type varies throughout the Highland Valley, this result should be interpreted with care.)

3. Overburden/rock and compacted rock were classed as sandy loam according to the USDA classification system (Brady, 1974). Raw till was classed as sand or loamy sand. Tailings were classed as sandy loam or loamy sand.

4. Natural soils sampled were classed as sandy loam and did not differ significantly in textural composition from overburden/rock or compacted rock samples.

Differences in bulk density between types of disturbed material were not significant.

EFFECT OF ASPECT

The investigation into the effect of aspect on moisture content and temperature of disturbed materials showed that south-facing slopes were only significantly hotter and drier than north-facing slopes when they were exposed to prevailing winds.

Areas of raw till were significantly drier than overburden/rock areas and compacted rock areas.

ASSESSMENT OF RECLAIMED AREAS

Results of the assessment of reclaimed sites are summarized in Table 2. All sites were seeded with grass or grass/legume mixes. All sites were within the elevation range 1300 m to 1400 m. Details of treatment were very variable but records indicated that all sites had been adequately seeded and maintained with fertilizer. Although differences in length of establishment period, seeding rate and fertilizer treatment must be taken into account, it appears that establishment of grass/legume cover has been least successful on exposed, steeply-sloping sites and on a non-irrigated raw till site.

THE NATURAL REVEGETATION SURVEY

The natural revegetation survey indicated that invasion of disturbed sites does occur when there are sources of propagules nearby and when more sheltered micro-sites exist.

NATURAL VEGETATION SURVEY AND LAND-USE INFORMATION

During the natural vegetation survey of the Highland Valley, ten natural vegetation communities were distinguished. Community type varies according to elevation, topography, local drainage pattern and soil texture. The distribution of natural vegetation is illustrated in a generalized cross-section of the Highland Valley (Figure 2).

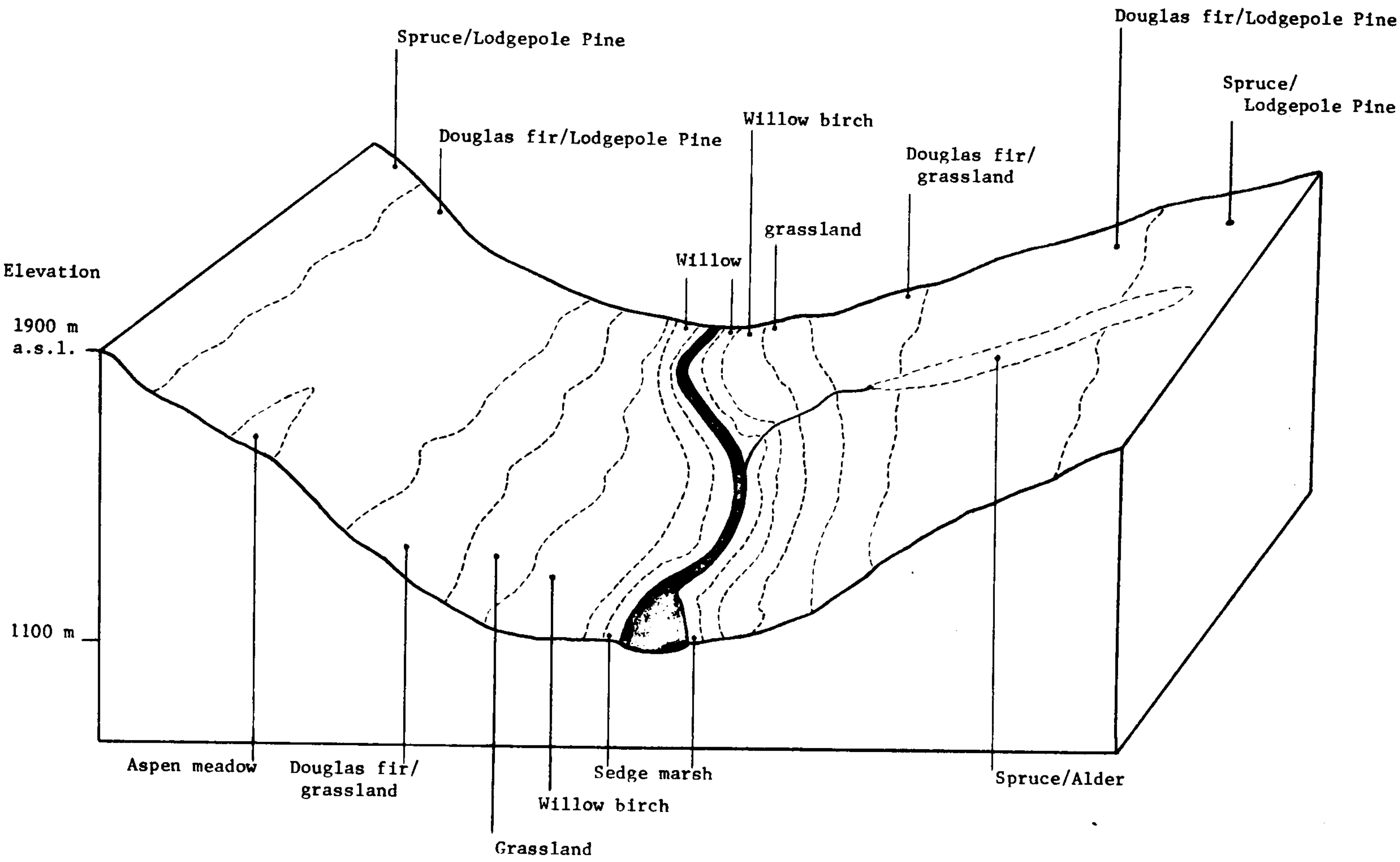
The middle slopes of the valley support either Douglas fir communities or, where fire has occurred, lodgepole pine communities. As elevation increases there is a gradual transition to lodgepole pine/spruce communities with spruce becoming increasingly abundant at higher elevations. With decreasing elevation, the forest becomes more open and the

TABLE 2

SUMMARY OF RESULTS OF ASSESSMENT OF RECLAIMED AREAS

Site Type	Date of Establishment	Percent Ground Cover			
		Min.	Max.	Mean	S.D.
Exposed south-facing slope; overburden/rock	1970	7	30	21	10.1
Exposed west-facing slope; overburden/rock	1972 - 1977?	6	35	19	11.7
Sheltered west-facing slope; overburden/rock	1977	30	50	38	7.5
Flat; overburden/rock	1977	25	65	38	16.4
Sheltered north-facing slope; overburden/rock (1)	1972	7	60	34	27.1
Sheltered north-facing slope; overburden/rock (2)	1972	20	40	32	8.3
Flat; overburden/rock	1979	25	40	31	5.4
Sheltered north-facing slope; raw till	?	35	40	24	11.5
Flat; raw till (irrigated)	?	8	80	59	17.4

Figure 1. Generalized cross-sectional diagram of Highland Valley and its natural vegetation



lower slopes support Douglas fir/grassland communities. The forest communities are found on sites whose slope varies from 0° to 38° (the steepest natural slope found) and on soils with predominantly sandy loam textures.

Two other types of plant communities are found within the forest area. Spruce/alder communities are located on the edges of creeks draining the valley sides. These areas are poorly drained and have silt and silt loam textured soils. Aspen meadow communities are found on small, almost flat areas with silt loam textured soils. These communities have apparently originated from natural infilling of bogs and/or small ponds that developed in depressions on the valley sides.

Well-drained areas in the valley bottom support grassland communities. These areas are almost flat and have sandy loam textured soils. However, in many parts of the valley bottom, the distribution of vegetation is markedly influenced by the drainage pattern and various stages of hygric succession can be identified. Sedge/marsh communities are found in areas of shallow standing water and are bordered by willow communities. Adjacent areas, with hummock-and-hollow topography and which are less water-logged, support willow-birch communities.

Of the ten natural plant communities, two are of commercial significance. The grassland communities provide grazing for cattle. Before mining began, ranching was the major land-use in the Highland Valley.

Some of the Douglas fir communities were commercially logged before mining activity necessitated more widespread clearing of the forest cover. However, almost all the forest sites in the Highland Valley are rated as "poor" (B.C. Forest Service, 1980).

The other vegetation communities found in the Highland Valley are commercially insignificant. The wetland communities are important as habitat for wildlife chiefly deer, moose, elk and waterfowl. Deer, elk and moose, though at present scarce in the Highland Valley because of the mining activity, have in the past used the area for range in the fall and spring (B.C. Fish and Wildlife, 1981). Competition with cattle for grazing has limited wildlife use of the area (B.C. Research, 1971).

No crops are grown in the Highland Valley; this is probably due to the dry climate and the lack of suitable sites, sources of irrigation water and economic incentive.

Fishing is the only important recreational activity, although some hunting is done in the high elevation areas furthest from the centres of mining activity.

DISCUSSION

CLASSIFICATION OF DISTURBED AREAS

The analysis of physical characteristics of disturbed materials, the investigation into the effect of aspect, and the assessment of reclaimed sites indicate that disturbed areas in the Highland Valley should be classified according to the following factors; slope, nature of material, exposure to prevailing winds and elevation.

Using these factors eleven reclamation site types were identified:

- I low elevation tailings
- II high elevation tailings
- III low elevation flat overburden/rock (and compacted rock?)
- IV high elevation flat overburden/rock (and compacted rock?)
- V low elevation sheltered steeply-sloping overburden/rock
- VI high elevation sheltered steeply-sloping overburden/rock
- VII low elevation exposed steeply-sloping overburden/rock
- VIII high elevation exposed steeply-sloping overburden/rock
- IX low elevation gently-sloping raw till
- X high elevation gently-sloping raw till
- XI low elevation flat raw till

OPTIONS FOR POST-MINING LAND-USE

When mining has ceased, land-use in the Highland Valley will be determined by the economic climate and the degree of industrial development in the area. There are, however, a number of land-uses that should be considered now, since choice of an appropriate land-use objective for each reclamation site type has an important bearing on the choice of technique.

Past and present land-uses and the distribution of natural vegetation indicate that the following land-uses should be considered for the Highland Valley.

1. Range: This would require the establishment of grass and/or legume swards in areas where cattle is not restricted. Slopes of 30° or more would be little used by cattle for grazing unless forage was in very short supply (Pitt, 1982). Above 1400 m productivity would probably be low.

2. Agriculture: Flat or gently-sloping low elevation areas, near to sources of water and where the surrounding topography would maximize water retention, could be irrigated and used to grow crops.

3. Forestry: Flat to steeply-sloping areas from 1200 m to 1700 m could be used for forestry. Productivity would probably be low but the eventual value of the crop as well as the aesthetic effect should be taken into account. Natural invasion of areas close to sources of seed would probably occur. More extensive areas would require planting.

4. Wildlife: Areas supporting grasses and shrubs, particularly those in early seral stages, not used by cattle, would be of particular value to wildlife. Close proximity to forest cover would be an advantage.

5. Recreation: Well-stocked artificial lakes and ponds would increase the recreational use of this area which is already popular for fishing. The existence of a few roads providing access to both fishing and hunting areas would be advantageous.

PROPOSED RECLAMATION TECHNIQUES

The combination of information about reclamation site types, natural vegetation, natural revegetation and possible land-use options suggests particular reclamation techniques for each site type. Outlines of these techniques are given here; more details are available.

Low Elevation Tailings

These could be used for range or agriculture. Research on the potential of tailings for plant growth has been undertaken in the laboratory (Department of Soil Science, 1976/77). A large test plot was established on tailings in the Highland Valley in 1981. Creation of wetland communities might be attempted also, although more research into this kind of reclamation is required (Olson, 1981).

High Elevation Tailings

It is unlikely that these would be valuable for range or agriculture but they could provide grazing for wildlife. These sites could be reclaimed to a condition similar to the aspen meadow communities. Testing of grass, legume or shrub species suitable for high elevation sites is required. Information acquired in other parts of western Canada could be applied to this site type.

Low Elevation Flat Overburden/Rock (and compacted rock)

The feasibility of establishing grass/legume mixtures on these sites has been well proven by the mining companies in the area. These sites may be used for range.

High Elevation Flat Overburden/Rock (and compacted rock)

These sites would have less value for range than the preceding type but could provide for wildlife use. Establishment of commercially available legumes at this elevation might be difficult. Trials with "native" species would be informative.

Alternatively, these sites could be managed with a view to establishing tree and shrub cover. Local lodgepole pine stock and shrubs could be planted with, following or in place of grass/legume cover.

Low Elevation Sheltered Steeply-Sloping Overburden/Rock

Establishment of grass/legume cover on this site type is evidently possible. Though this site type has little potential range value, establishment of cover will increase slope stability and reduce erosion. The appearance of these sites, which are highly visible to the public, would also be improved. If operation of machinery is a problem on these sites they may benefit from treatment similar to site types VII and VIII.

High Elevation Sheltered Steeply-Sloping Overburden/Rock

These sites are similar to high elevation flat overburden/rock but modification of the species mix will probably be necessary to ensure successful reclamation.

Low and High Elevation Exposed Steeply-Sloping Overburden/Rock

Both low and high elevation types pose problems for reclamation. There are two ways of avoiding the problems of applying seed to these exposed sites:

1. create mini-terraces to provide microsites. This may not be operationally feasible.

2. hand-plant dry-land shrubs. Much research on the use of shrubs for reclamation is being undertaken at present. With emphasis on the selection of species suitable for the climate of the Highland Valley a more intensive approach such as this would probably be justifiable for these particular site types.

Low Elevation Gently Sloping Raw Till

This site type poses slight problems due to the dry conditions which develop. However, many raw till areas are narrow strips resulting from pipeline construction. If a sparse grass and/or legume cover can be established, sufficient to reduce the extreme temperature and moisture conditions, natural invasion by trees and shrubs will occur. These sites would then provide wildlife habitat and eventually become re-forested. Complete restocking of these areas may not be desirable if they are to provide access. Extensive raw till areas may require artificial shrub establishment similar to steeply sloping exposed site types.

High Elevation Gently Sloping Raw Till

The choice of species for this site type is important. On small areas of this site type establishment of grasses and legumes may not be necessary before natural invasion occurs.

Low Elevation Flat Raw Till

Areas of this site type have potential for use as range and, if irrigated, agriculture. Grass and legume establishment is evidently the most appropriate treatment.

CONCLUSIONS

Developing a reclamation plan in this manner accomplishes the following:

1. makes best use of the knowledge and on-site information acquired by the mining companies in their reclamation activities to date.

2. provides a tool to assist in future reclamation work. Now that the factors that should be included in the classification scheme have been selected, the scheme can be applied to other areas of disturbance as they are created. It can be used as a means of extrapolating results of trials to other parts of the Highland Valley.

3. enables assessment of the outcome of reclamation to be made, whatever the extent of the disturbance that eventually occurs.

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RECLAMATION AT ELCO MINING, SOUTHEAST BRITISH COLUMBIA

Paper Presented
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*** this paper was not available for publication ***

REVEGETATION TRIALS AT SUKUNKA COAL MINE

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REVEGETATION TRIALS AT THE SUKUNKA COAL MINE

ABSTRACT

Revegetation trials were established in 1979 on BP Canada's Sukunka Coal property in the Northeast Coal Block. The trials were designed to test the effects of four levels of fertilizer application on alpine revegetation and to determine the optimum fertilizer treatments for revegetation of subalpine disturbances. The use of native species grown from locally collected seed was also tested in both alpine and subalpine environments. Field assessments were undertaken in August 1980 and 1981. In the alpine the greatest first year response to fertilization was on xeric sites. Heavy first year growth resulted in excessive mulching retarding second year emergence. In the subalpine heavy fertilization resulted in reduced legume establishment, thus, reducing second year cover. Establishment of native species in the alpine was very poor while there was a good establishment in the subalpine. Further assessments are planned as part of BP Canada's ongoing reclamation research program.

INTRODUCTION

BP Canada Inc. holds coal licences known es the Sukunka Coal Property in the Northeast Coal Block. This property has potential for production of coal by underground mining. Programs to evaluate the feasibility of mining these reserves have included several major exploration programs. A network of roads to access drill sites and trenching sites has been developed. Pilot scale mining has been undertaken for bulk sampling and to determine the characteristics of the host rock. These activities have created surface disturbances in the area.

In the summer of 1979 a series of revegetation and fertilizer test plots were established on the Sukunka Coal Property. The objectives of these plots were:

1. to test the effects of various levels of fertilizer application on natural revegetation of exploration disturbances in an alpine setting;

2. to test the use of locally collected native seed for reclamation of alpine sites; and

3. to test the growth and maintenance of both native and agronomic species and the effects of various fertilizer regimes in a subalpine setting similar to that anticipated for the proposed tailings structure.

This paper outlines the results of the 1979, 1980 and 1981 evaluations of test plot performance. Recommendations for the ultimate reclamation of disturbances in the area are made based on the information derived thus far. As this program of field testing has been designed to continue for another three years, these results and recommendations must be regarded as preliminary.

METHODOLOGY

ALPINE FERTILIZER AND NATIVE SPECIES TRIALS

BP Canada Inc., Coal Division Environmental Group in cooperation with biologists from the B.C. Ministry of Energy, Mines and Petroleum Resources determined the experimental design and established plots on xeric (D), mesic (M) and hygric (W) sites in the alpine region of Bullmoose Mountain. Four test sites (replicates) were located in each of the xeric and mesic moisture regimes, and two in the hygric regime. Four levels of fertilization, 0 (Control), 330 kg/ha, 660 kg/ha and 1320 kg/ha 17-17-17 fertilizer were broadcast in July 1979. The plots have received no further treatments.

Two native species seed test plots were located adjacent to each of the xeric and mesic fertilizer test plots, and one plot near the hygric plots. Seeding of these plots, with previously gathered native species seed, took place on September 13, 1979. Prior to seeding all vegetation was removed from the plots. Some species, however, have regenerated from root and rhizome systems.

SUBALPINE TAILINGS DYKE TRIALS

Agronomic and native seed plots were established on waste materials thought to be representative of future tailings dyke materials. Treatments of no fertilizer (Control), 150 kg/ha, 300 kg/ha and 600 kg/ha fertilizer were applied. Each year, for up to four years, one less sub-plot will be fertilized to examine the effectiveness of one-year, two-year, three-year and four-year fertilization maintenance programs.

Agronomic species were broadcast seeded on September 1, 1979 with a mixture consisting (by weight) of Boreal Creeping Red Fescue *(Festuca rubra)* (40%), Climax Timothy *(Phleum pratense)* (20%), Red Top *(Agrostis alba)* (15%) and Alsike Clover *(Trifolum hybridum)* (25%). Native species were collected by vacuum cleaner from areas close to the site and broadcast seeded on separate plots at the same time as the agronomics. Additionally, native seed plots were planted with six hardwood cuttings taken from species growing near the study site.

DATA COLLECTION - ALPINE FERTILIZER TRIALS

The alpine fertilizer trial sites were visited in the fall of 1979 and the late summer of 1980 and 1981. Visual estimates of individual species cover, total plant cover, height and vigour were recorded. Photographic records were made.

DATA COLLECTION - TAILINGS DYKE TRIALS

The tailings dyke site was visited at the same time as the Alpine site visits. Photographic records were made. Total cover and cover of individual species was estimated for both agronomic and native seed plots. One-quarter metre square (0.0625 m^2) plots were clipped, air-dried and weighed to determine above-ground biomass of the agronomic species.

RESULTS AND DISCUSSION

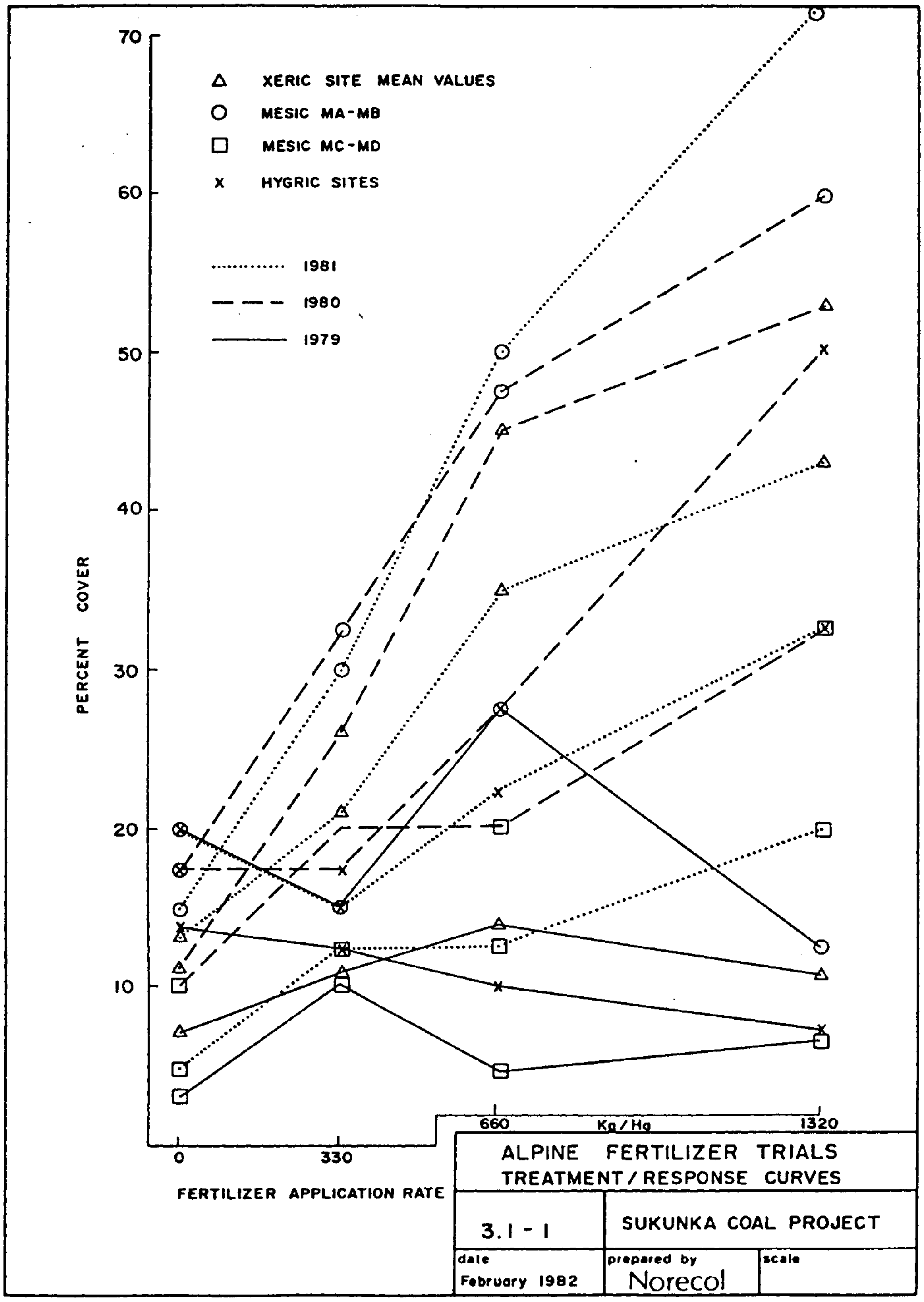
ALPINE FERTILIZER TRIALS

The mean total percent vegetation cover under four fertilizer treatments at the three moisture regime sites for the three years since treatment is shown in Figure 1. On the mesic sites, adjacent plots, MA/MB and MC/MD are treated separately. Results from the three moisture regimes are presented in the following sections.

Xeric Sites

Percent cover on the xeric sites is illustrated in Figure 2. The application of fertilizer in 1979 produced a significant increase in vegetation cover in 1980. Most of the cover was made up by agronomic species. The greatest percent increase in cover was achieved at the

Figure 1.



70
60
50
40
30
20
10
PERCENT COVER
XERIC SITE MEAN VALUES
MESIC MA-MB
MESIC MC-MD
HYGRIC SITES
1981
1980
1979
0
330
660
Kg/Hg
1320
FERTILIZER APPLICATION RATE
ALPINE FERTILIZER TRIALS
TREATMENT/RESPONSE CURVES
3.1 - 1
SUKUNKA COAL PROJECT
date
February 1982
prepared by
Norecol
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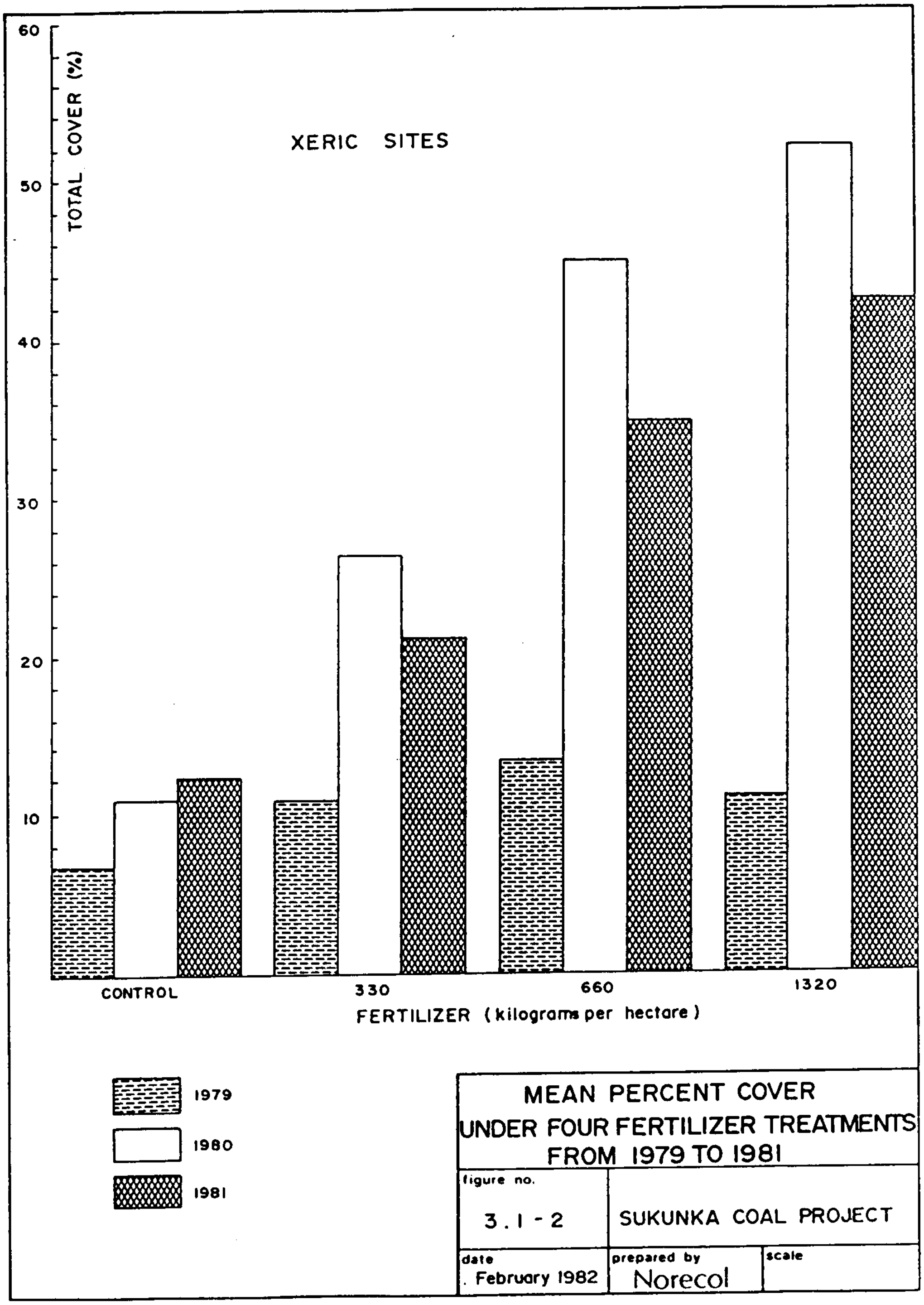
Figure 2.



XERIC SITES
TOTAL COVER (%)
60
50
40
30
20
10
CONTROL
330
660
1320
FERTILIZER (kilograms per hectare)
1979
1980
1981
MEAN PERCENT COVER
UNDER FOUR FERTILIZER TREATMENTS
FROM 1979 TO 1981
figure no.
3.1-2
SUKUNKA COAL PROJECT
date
February 1982
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scale

330 kg/ha level of fertilization, with response dropping off at the higher applications, indicating a saturation of the fertilizer responses at the higher levels. It is expected that growth limiting factors such as moisture stress and cold temperatures may replace nutrients as the main growth limiting factor. Large amounts of above ground biomass were produced in all of the fertilized plots relative to either the unfertilized control or the adjacent native vegetation.

Vegetation cover on the fertilized plots dropped in 1981 from the 1980 levels. This drop in cover is thought to be due to the excessive mulching caused by the 1980 plant matter. Nutrients may be bound up in this mulch which, due to the dryness of the sites, did not break down. In addition, the heavy mulching may have insulated the soil, preventing warming in the spring and hence retarding growth. Compared to 1980 the cover of all major species decreased except for the two native grasses, Alpine Bluegrass *(Poa alpina)* and Broad-Glumed Wheatgrass *(Agropyron violaceum)*. Species diversity was greater in the lower fertilizer rates than the higher rates.

The optimum rate of fertilization appears to be the 660 kg/ha rate. Doubling the fertilizer rate to 1320 kg/ha resulted in a 17% increase in cover in 1980 while doubling the 330 kg/ha application to 660 kg/ha resulted in a 73% increase in cover. Similar trends were noted in 1981.

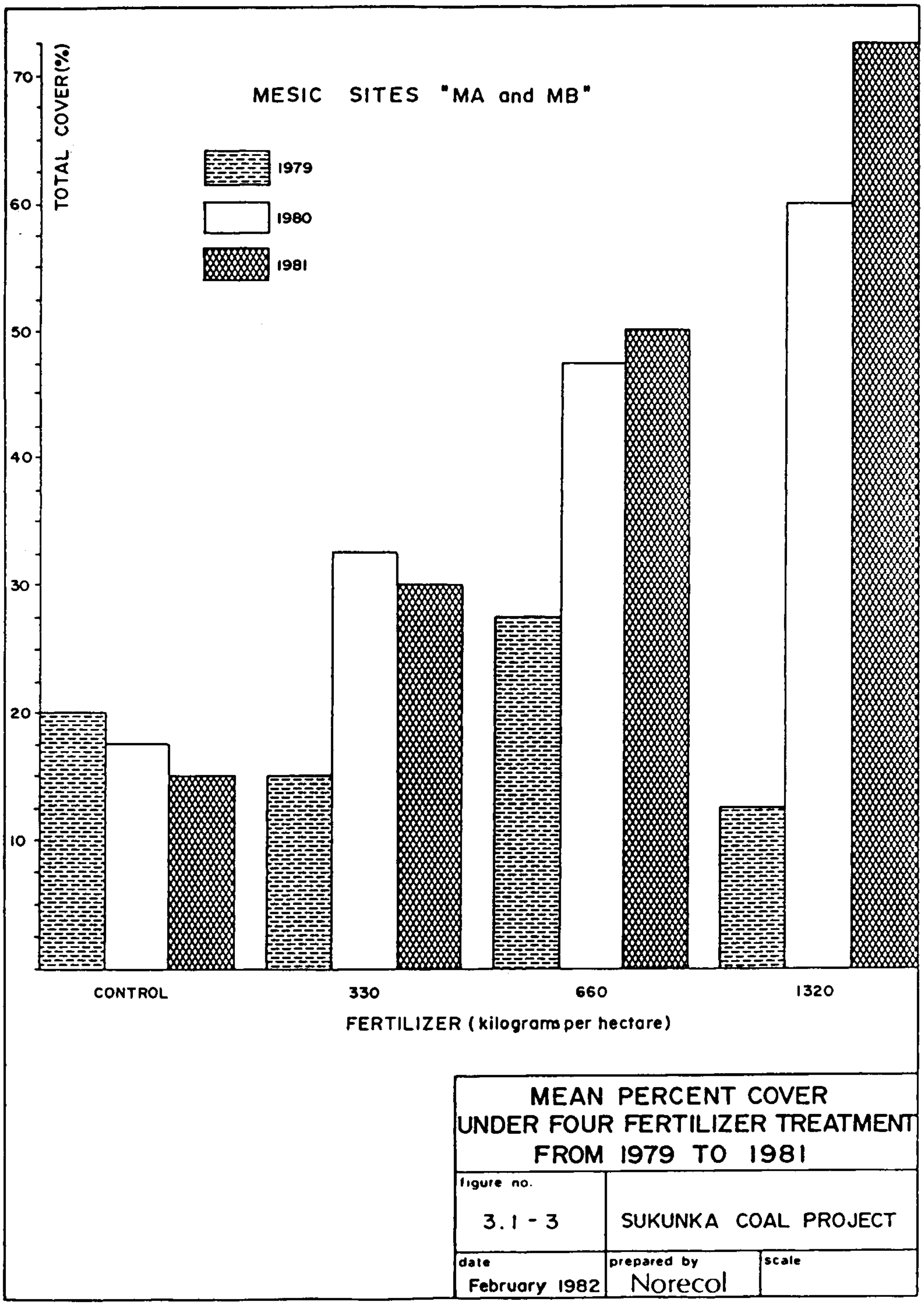
Native vegetation cover in the xeric sites area averages from 20% to 50% depending on specific site condition. It is not realistic to expect that reclaimed cover will be maintainable at greater cover without continual fertilizer maintenance.

Mesic Sites

In 1980 there were significant differences in growth response among non-adjacent plot replicates on the mesic plots. For this reason the results obtained from the two sets of adjacent plots (MA/MB and MC/MD) are presented separately. Figures 3 and 4 show the mean vegetation cover on plots MA/MB and MC/MD respectively for the last three years.

Fertilization resulted in an increase in cover on the MA/MB plots in 1980 and 1981. Unlike the xeric plots, there was a further increase in cover in 1981 at the higher fertilizer application rates, while there was a slight decrease in cover on the control and 330 kg/ha plots. It

Figure 3.


MESIC SITES "MA and MB"
1979
1980
1981
TOTAL COVER (%)
70
60
50
40
30
20
10
CONTROL
330
660
1320
FERTILIZER (kilograms per hectare)
MEAN PERCENT COVER
UNDER FOUR FERTILIZER TREATMENT
FROM 1979 TO 1981
figure no.
3.1 - 3
SUKUNKA COAL PROJECT
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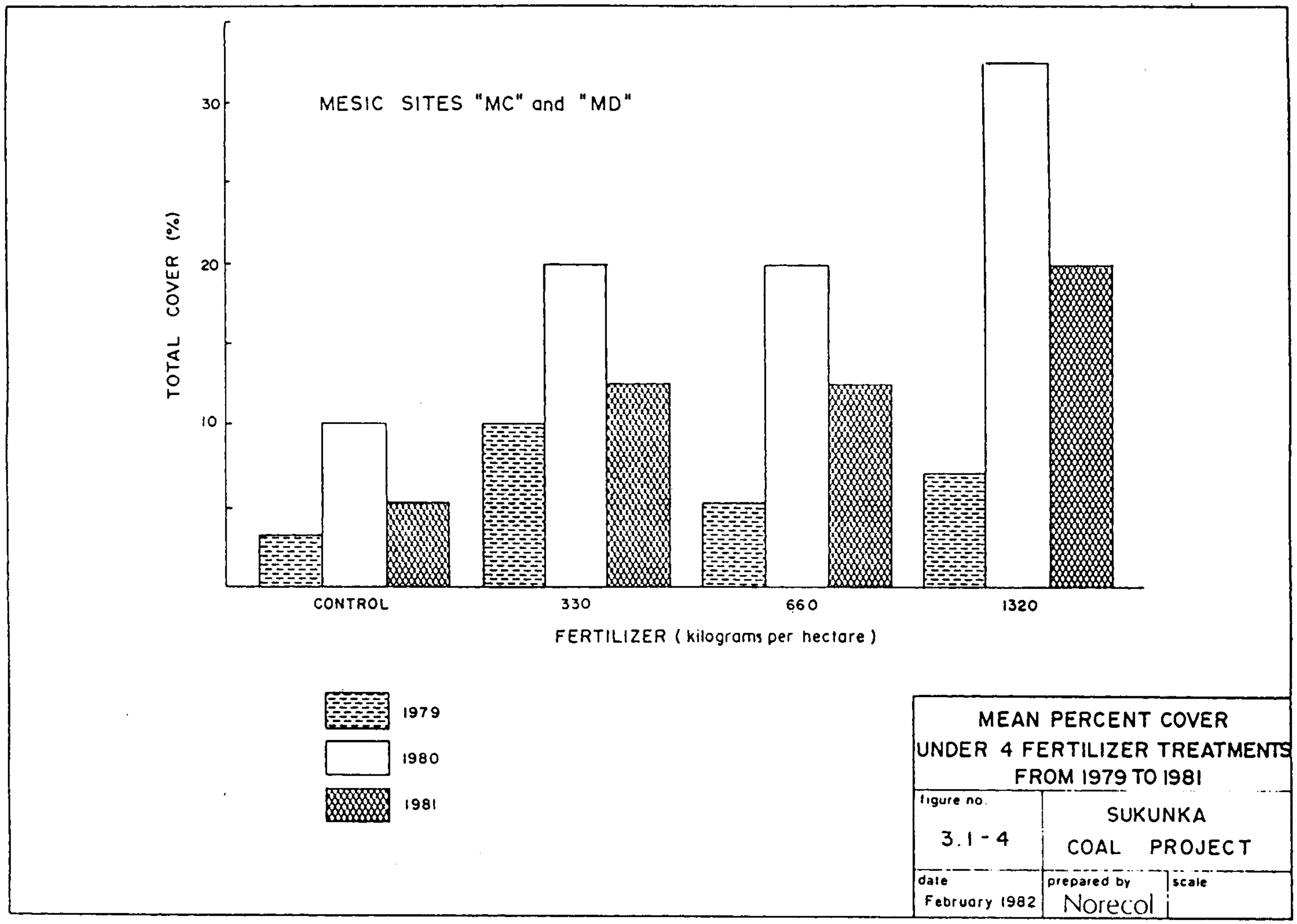
scale

Figure 4.


MESIC SITES "MC" and "MD"
TOTAL COVER (%)
10
20
30
CONTROL
330
660
1320
FERTILIZER (kilograms per hectare)
1979
1980
1981
MEAN PERCENT COVER
UNDER 4 FERTILIZER TREATMENTS
FROM 1979 TO 1981
figure no.
3.1 - 4
SUKUNKA
COAL PROJECT
date
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scale

is thought that the nutrients held in the dead material may be more available to the new growth on the mesic sites due to an increase in the amount of nutrients being cycled on these sites.

Vegetation cover on the MC/MD plots was about half of that on the MA/MB plots. The MC/MD plot area is subjected to late spring snow cover which may result in a leaching of nutrients or reduced growing season and hence a reduction in cover. There has been a drop in cover on the MC/MD plots from the 1980 levels. As in the other sites agronomic species showed the greatest response to fertilization.

Hygric Sites

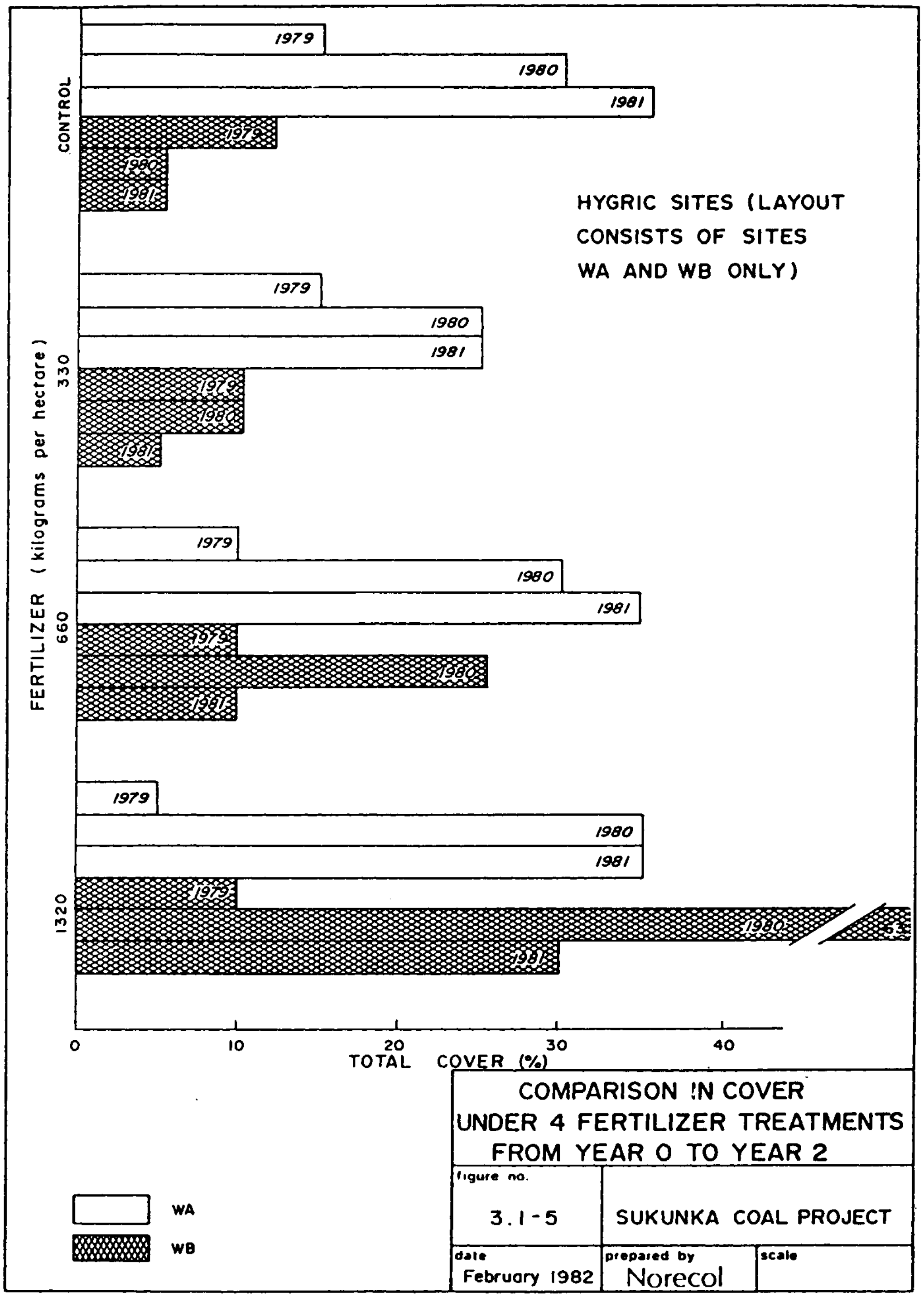
Plant growth on the two hygric sites was found to be radically different from each other in terms of both apparent response to fertilizer treatment and in species composition. Test site WA had almost no agronomic species, while the largest proportion of vegetation cover on site WB was composed of agronomic species. Agronomic species respond more strongly to fertilizer additions than do native species, hence one would expect that the site WB vegetation would show a greater response than that of site WA. Figure 5 shows the effects of the four fertilizer treatments on these two sites. There is only a 10% difference in cover between the control and the highest level of fertilizer addition on the WA plots for each year of the three years data. WB shows a marked fertilizer response with a large increase in cover in the higher application rates. It is interesting to note that in 1980 on test site WB there was no "levelling off" of fertilizer/response curve, as would be expected with the extremely high fertilizer applications. This may be due in part to an increase in leaching on the wet sites combined with the effect of the late snow patch kill suffered on the WB-2 and WB-3 plots.

There has been a decrease in cover in 1981 from the 1980 levels on the WB plots. Excessive nutrient leaching may be responsible for this drop in cover.

ALPINE NATIVE SPECIES TRIALS

The growth of native species in the alpine has not been encouraging. None of the native species plots have obtained greater than 10% cover in the three years since establishment. Poor development on these sites

Figure 5.


HYGRIC SITES (LAYOUT
CONSISTS OF SITES
WA AND WB ONLY)
FERTILIZER (kilograms per hectare)
CONTROL
330
660
1320
1979
1980
1981
0
10
20
30
40
TOTAL COVER (%)
WA
WB
COMPARISON IN COVER
UNDER 4 FERTILIZER TREATMENTS
FROM YEAR 0 TO YEAR 2
figure no.
3.1-5
SUKUNKA COAL PROJECT
date
February 1982
prepared by
Norecol
scale

may be due to poor initial establishment caused by low germination rates and possible loss of seed. Some species such as Stalked-Pod Locoweed *(Oxytropis podocarpa)*, Alpine Hedysarum *(Hedysarum alpinum)* and Reed Polar Grass *(Arctagrostis latifolia)* may warrant further assessments as these species appear to be successfully invading the plots.

SUBALPINE TAILINGS DYKE REVEGETATION TRIALS

Agronomic Species Trials

Results of the agronomic species trials are presented in Table 1. Figure 6 shows the above ground biomass for the control and fertilized plots in 1980 and 1981. The fertilized plots established in 1979 have been refertilized in 1980 following the 1980 assessment, and 1981 after the 1981 assessment. The application of 150 kg/ha of fertilizer yielded the greatest percent increase in cover, both in 1980 and 1981. Doubling the fertilizer rate resulted in increases in the absolute cover however, the percent increases were considerably less than the application of 150 kg/ha.

The Year 1 plots have received no fertilizer since the initial fertilization in 1979. Results for Year 1 are shown in Figure 7. Biomass yields generally increased in the first year (1980) for the fertilized plots. In 1981 the highest biomass was found in the control (unfertilized) plot and decreased as the fertilizer application rate increased. This decrease can be attributed to the mulching effect caused by the 1980 growth and by the decrease in clover cover (Table 1). Figure 8 shows the percent clover cover and above ground biomass for the Year 1 plots in 1981.

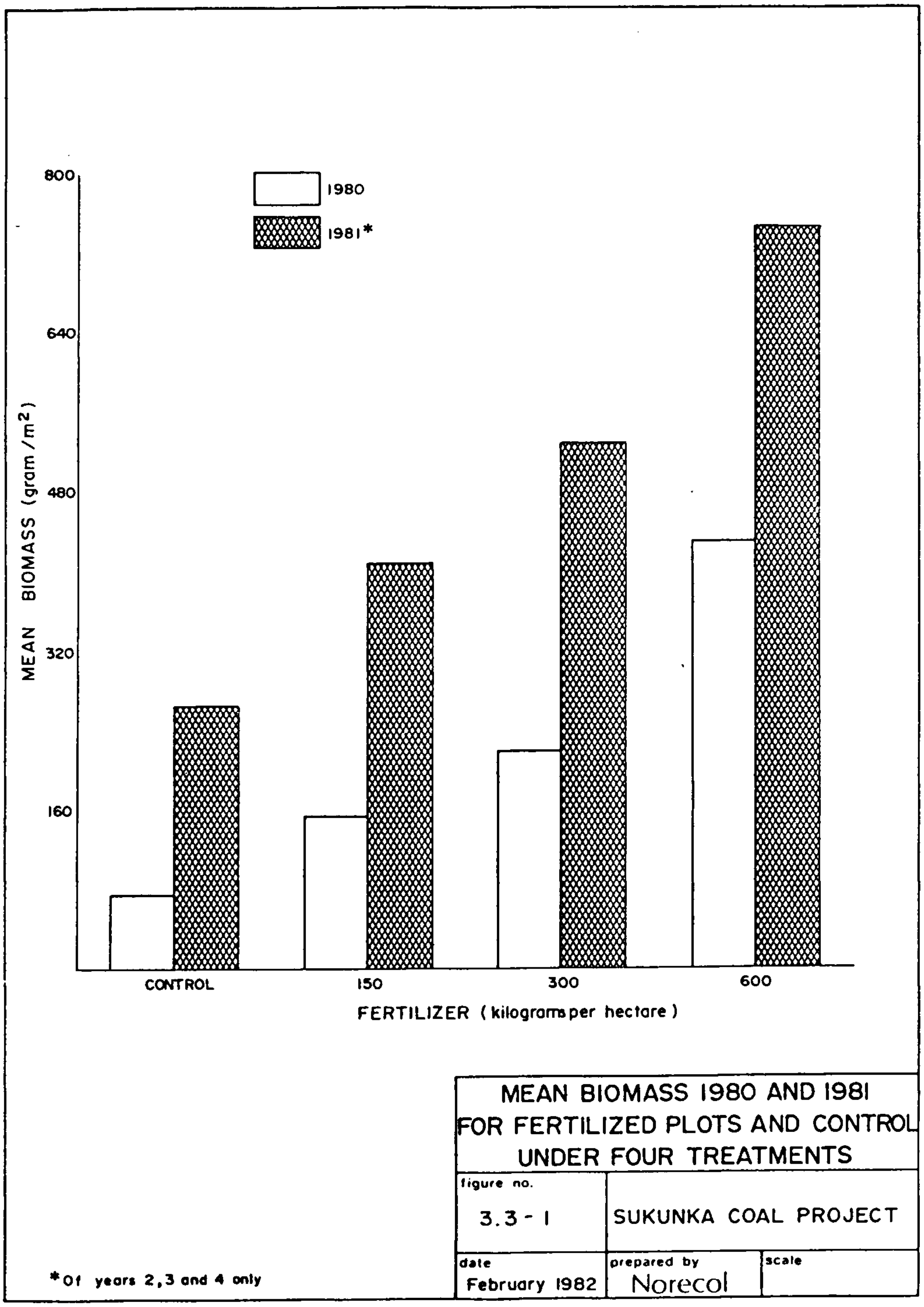
Fertilization increases the cover and above ground biomass of the agronomic species tested except for alsike clover where only at the lowest level of fertilization were increases noted. Higher rates of fertilization and repeated fertilizer application stimulate the shoot growth for graminoid apecies, however, clover growth is retarded. In order to achieve an erosion suppressing cover rapidly, and to provide continued cover under minimal maintenance, the applioation of 150 kg/ha of fertilizer at the time of seeding only is suggested.

Table 1. Tailings dyke plots - agronomic species trials.

Agronomic Species	Plot 1 (control)					FERTILIZER Plot 2 (150 kg/ha)					Plot 3 (300 kg/ha)					Plot 4 (600 kg/ha)				
1980 RESULTS	Year					Year					Year					Year				
	1	2	3	4	x̄[1]	1	2	3	4	x̄	1	2	3	4	x̄	1	2	3	4	x̄
Total cover	50	45	35	35	41	70	75	50	60	64	60	80	75	75	73	85	90	80	90	86
Above ground biomass (g/m^2)	72	102	83	52	77	165	181	104	160	152	167	257	230	191	211	457	365	354	528	426
Height (cm)	6-8	5-8	5	5	-	10-20	10-15	5-8	10-15	-	10-15	10-15	10-20	15-20	-	15-30	50	60	20-35	-
Cover by species (%)																				
Agrostis alba	10	10ff	10f	10	10	10f	15f	10f	15	12.5	10f	15f	20f	15f	15	25f	20f	25f	20f	22.5
Festuca rubra	10	10	10	15	11.25	15	20	15	15	16.25	10	20	15	10	13.75	20	20	10	15	16.25
Phleum pratense	5	5	5	5	5	15f	5f	5	10	8.75	15f	10f	10f	10ff	11.25	15f	20f	25f	15f	18.75
Trifolium hyoridum	25	20	10	15	17.5	30f	35f	20ff	20	26.25	25ff	35f	30f	40f	32.5	25f	30f	20ff	40f	28.75
1981 RESULTS																				
Total cover (%)	80	65	40	35	47[2]	75	75	60	60	65	55	80	85	85	83	65	95	100	98	98
Above ground biomass (g/m^2)	421	432	226	141	305	338	645	266	312	390	267	498	542	542	462	254	639	888	646	607
Height (cm)	35	10-25	5-15	5-10	-	20-35	15-25	30-35	25-30	-	5-25	15-40	70-80	65-75	-	10-20	25-75	80-100	75-85	-
Cover by species (%)																				
Agrostis alba	20f[3]	10f	10ff	10ff	10	15f	15f	20f	20f	18.33	15ff	25ff	35f	35f	31.67	30f	35f	40f	35f	36.67
Festuca rubra	15ff[4]	15ff	15	15ff	15	15	10ff	10	30ff	16.67	10	25ff	25ff	30	26.67	15ff	30ff	35ff	35	33.33
Phleum pratense	5ff	5	5	2ff	4	5	5	5ff	3f	4.33	5	10ff	5f	10	8.33	5	10f	15f	20f	15.00
Trifloium hybridum	40f	35f	10f	8f	17.67	40f	45f	25f	7f	25.67	20f	20f	20f	10f	16.67	15ff	20f	10f	8f	12.67

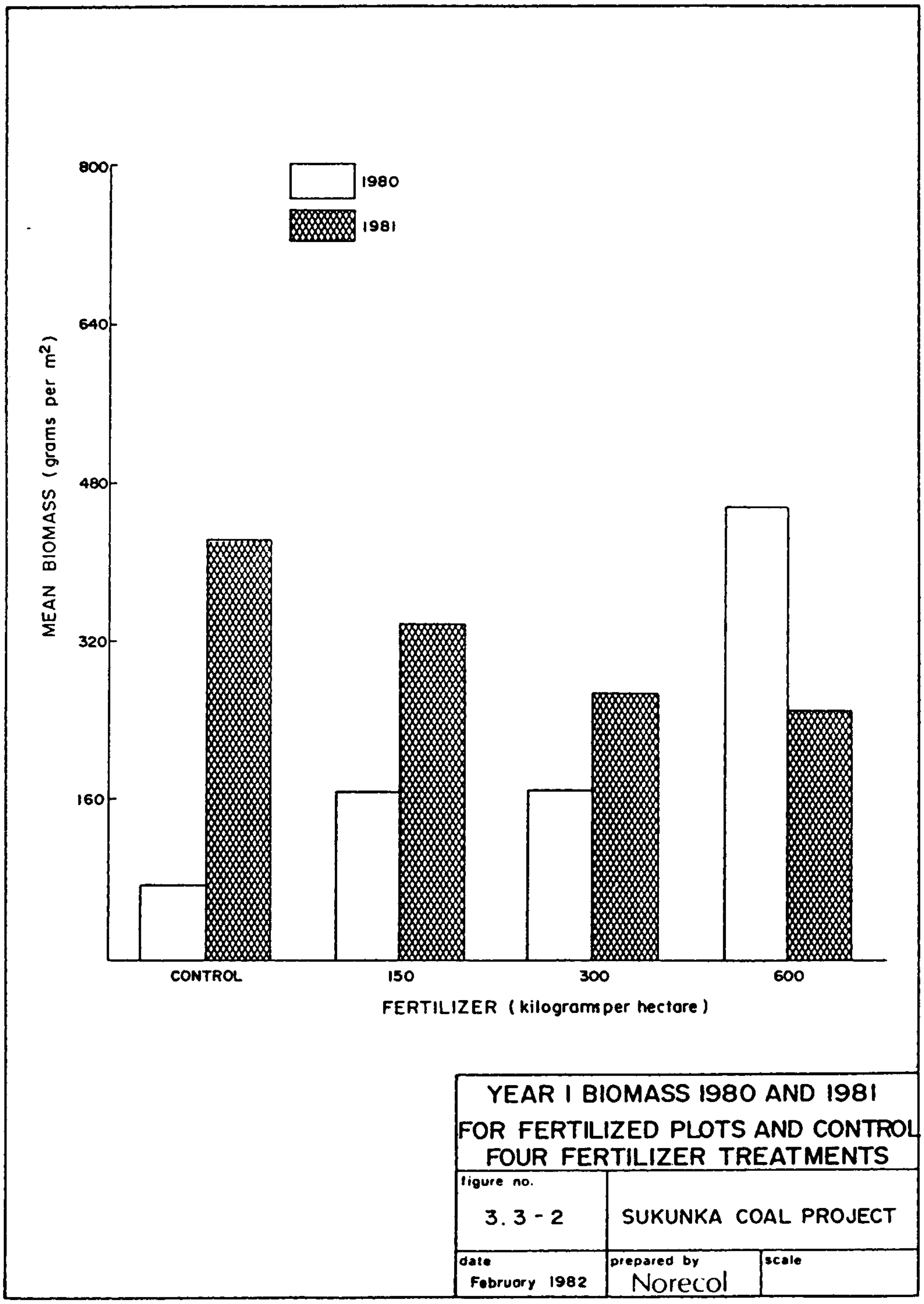
1 Mean of all four years.
2 Mean of years 2, 3 and 4 only.
3 f = flowers
4 ff = few flowers

Figure 6.



1980
1981*
800
640
480
320
160
MEAN BIOMASS (gram/m²)
CONTROL
150
300
600
FERTILIZER (kilograms per hectare)
MEAN BIOMASS 1980 AND 1981
FOR FERTILIZED PLOTS AND CONTROL
UNDER FOUR TREATMENTS
figure no.
3.3 - 1
SUKUNKA COAL PROJECT
date
February 1982
prepared by
Norecol
scale
*Of years 2,3 and 4 only

Figure 7.


1980
1981
800
640
480
320
160
MEAN BIOMASS (grams per m2)
CONTROL
150
300
600
FERTILIZER (kilogramsper hectare)
YEAR I BIOMASS 1980 AND 1981
FOR FERTILIZED PLOTS AND CONTROL
FOUR FERTILIZER TREATMENTS
figure no.
3.3-2
SUKUNKA COAL PROJECT
date
February 1982
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Norecol
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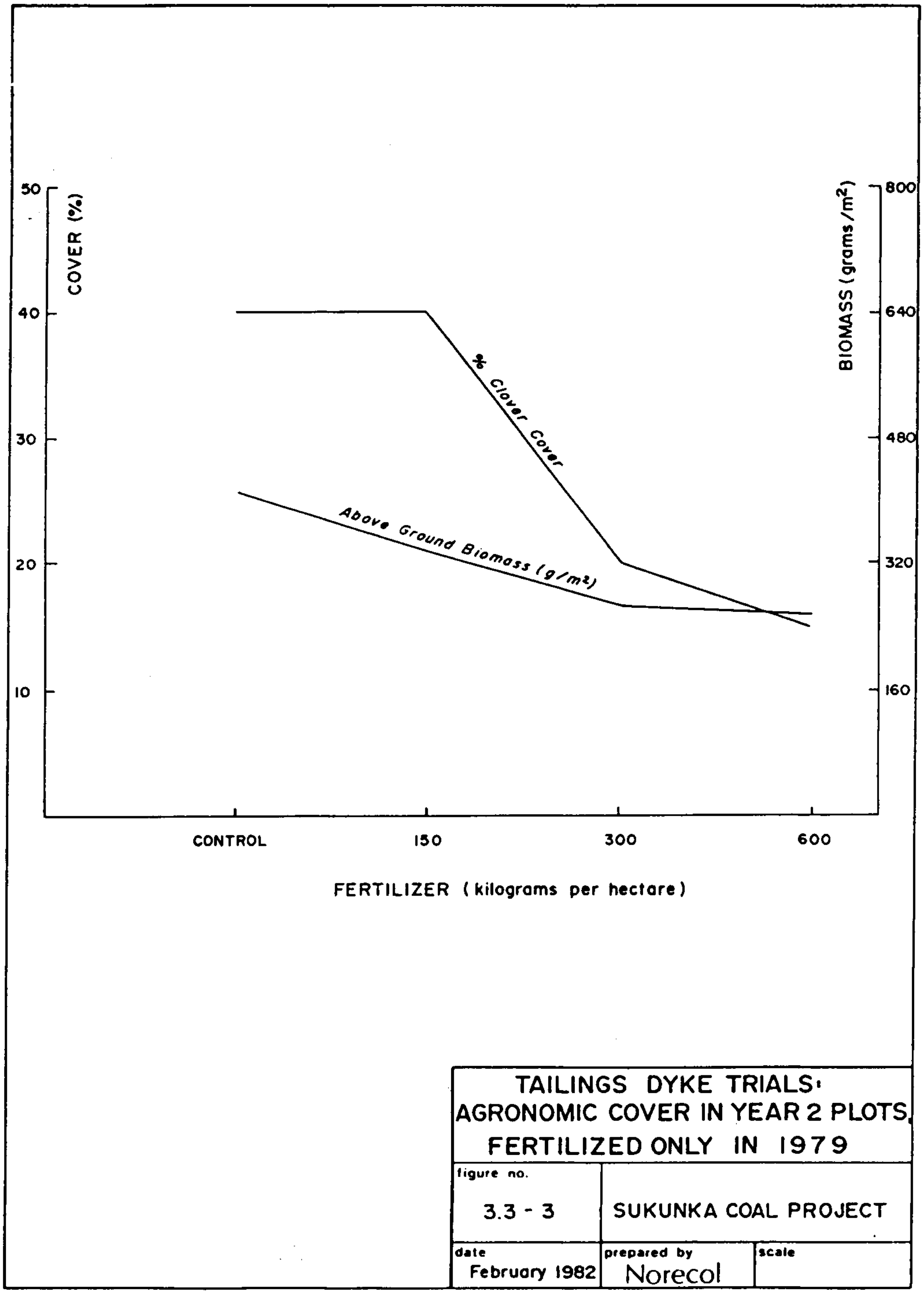
Figure 8.



COVER (%)
50
40
30
20
10
BIOMASS (grams/m²)
800
640
480
320
160
% Clover Cover
Above Ground Biomass (g/m²)
CONTROL
150
300
600
FERTILIZER (kilograms per hectare)
TAILINGS DYKE TRIALS:
AGRONOMIC COVER IN YEAR 2 PLOTS,
FERTILIZED ONLY IN 1979
figure no.
3.3 - 3
SUKUNKA COAL PROJECT
date
February 1982
prepared by
Norecol
scale

Native Species Trials

The native species trials have developed slowly compared to the agronomic trials, although there have been highly significant increases in the 1981 cover values over the 1980 values for fertilized plots (Figure 9). Cover in the control plots has not increased significantly. Grasses and sedges have been the main contributors to the increased cover. To date 37 species have become established. The effects of eliminating maintenance fertilization are, at present, unclear although there appears to be a general drop in the cover of unfertilized plots compared to their fertilized counterparts.

Woody species have fared poorly. No conclusions can be reached regarding the effects of fertilizer on the growth of woody species at this time.

CONCLUSIONS

The assessments conducted to date, although preliminary in nature, have indicated that, in the alpine:

1. Heavy fertilizer applications provide high first year responses in most cases;

2. Heavy first year growth generally retarded growth in the second year;

3. Agronomic species responded far better to fertilizer applications than native species;

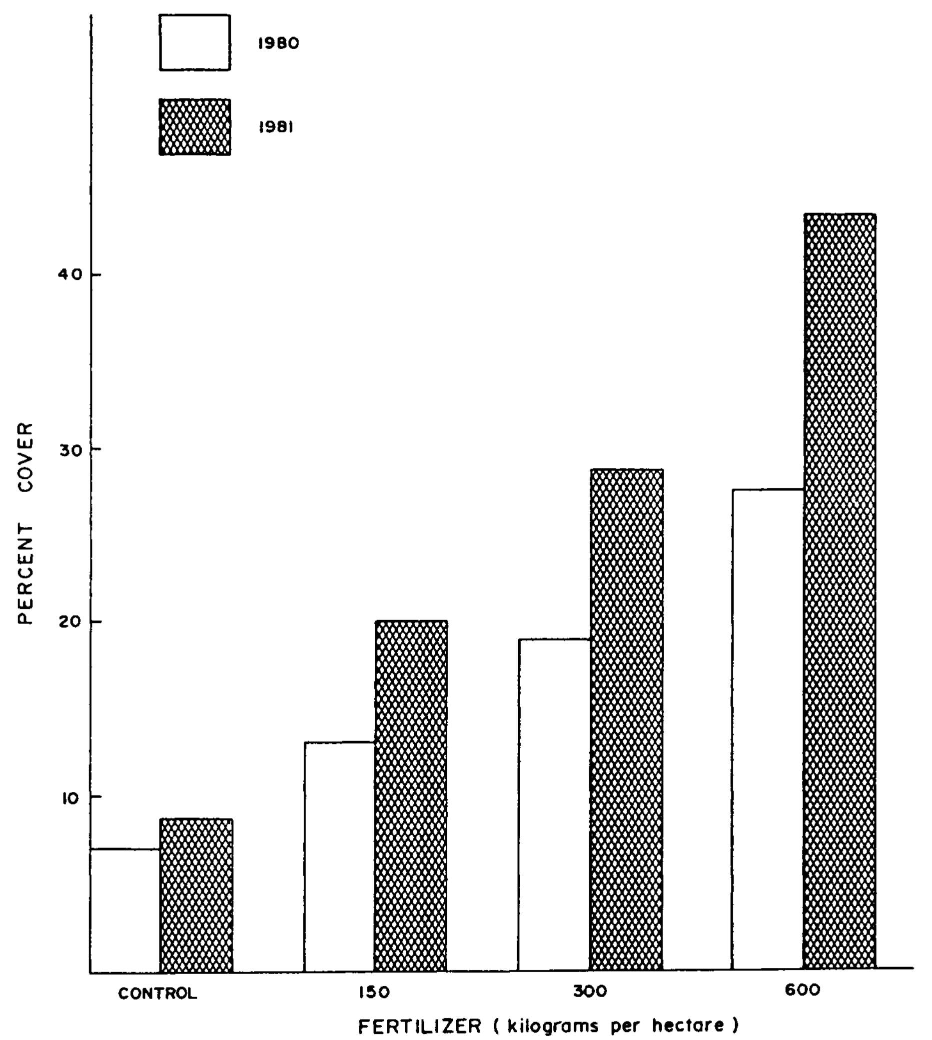
4. The use of native species as applied in these studies are not currently feasible as growth results are poor and seed collections difficult; and

5. Site differences resulted in greater differences in cover than did treatment differences.

In the subalpine, results indicated that:

1. Fertilization results in increased biomass and cover in both native and agronomic stands;

Figure 9.



TAILINGS DYKE PLOTS:
NATIVE SPECIES TOTAL COVER
UNDER FOUR FERTILIZER TREATMENTS
FOR YR.1 (1980) AND YR.2 (1981 *)

figure no.	
3.3-4	SUKUNKA COAL PROJECT

date	prepared by	scale
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* Mean of years 2,3 and 4 only

2. Higher fertilizer application rates reduce the legume cover in agronomic stands resulting in reduced cover upon discontinuation of fertilizer applications; and

3. Native species are slow to become established but may provide greater long-term benefits.

The current results are relatively preliminary however general trends are apparent which may be applied to future reclamation programs. Further assessments may provide greater clarity on the questions of fertilizer effectiveness for reclamation. It is expected that the general trends noted for the Sukunka property will apply elsewhere in B.C.

ACKNOWLEDGEMENTS

The authors wish to thank the following organizations for their help on this project:

BP Exploration Canada Ltd., Calgary, who provided funding for the project.

B.C. Ministry of Energy, Mines and Petroleum Resources, particularly John Errington and Ted Hall who assisted in test plot design and seed collection.

Techman Engineering Ltd., Calgary, who, under contract to BP, conducted the 1980 and 1981 assessments.

Norecol Environmental Consultants Ltd., Vancouver, who provided drafting and word processing services for the preparation of this paper.

DISCUSSION RELATING TO DAVID POLSTER'S PAPER

Chandler: I was wondering why you chose that particular combination of fertilizer?

Answer: It was chosen as an all-around fertilizer. Basically, they wanted something that would work in most instances, so specific soil tests and assessment of fertilizer requirements for each site were not addressed. Looking at the broader picture was also in keeping with practices suggested for the area by the Ministry of Energy, Mines and Petroleum Resources.

Dr. Weijer, University of Alberta: (Distorted recording. The question related to the method of seed collection.)

Answer: I would fully agree with you that the manner of seed collection (vacuum cleaner) was an idea that might make collection easier. I'd add a few things to what you said. In addition to not knowing the germination rate or the species composition, because the seed was collected from what might be considered climax stands of alpine tundra, we are dealing with climax species rather than invaders. One would expect that the invading species which would not be as predominant in the climax stands, could do considerably better. In fact the arctic bluegrass and alpine bluegrass and one of the wheatgrasses did quite well on some of the sites which were out of our plot area, just invading naturally. So I agree completely that one must look at this in the context of the way in which it was set up. It was a good idea that didn't work out very well.

Harry Quesnel, Ministry of Environment: I was wondering if you were considering doing any further studies to determine the species which have grown on native plots.

Answer: Although I didn't present that data, we have a complete listing by species and cover all species growing on the various plots--those which have grown first year, second year, etc. We are planning to continue the study for another couple of years so that we will eventually have much more information than I have been able to present here. Of course the reports are on file with the Ministry and more information will be included in the proceedings.

THE AVAILABILITY AND PROCUREMENT OF NATIVE SEED SOURCES SUITABLE FOR ALPINE AND MOUNTAIN RECLAMATION

Paper Presented
by

J. Weijer
D.L. Weijer
Department of Genetics
University of Alberta

THE AVAILABILITY AND PROCUREMENT OF NATIVE SEED SOURCES SUITABLE FOR ALPINE AND MOUNTAIN RECLAMATION

The interest in the use of indigenous plants for reclamation purposes has created a demand for seed sources of native grasses, legumes and other flowering elements. For the temperate zone of the North American continent not including the mountainous regions, the choice of suitable material for reclamation is considerable. For the more northern region of this continent and especially for alpine elevations, this choice is somewhat restricted, not only by the number of species, but also by the heritable characteristics of hardiness, drought and wind resistance and above all earliness. For example, an *Agropyron* collected at sea level and improved genetically for yield, is lacking the necessary resistance for survival in a boreal environment. Hence, the seed sources necessary for reclamation in these regions are highly specialized. Commercially, these seed sources are not as yet available and what is now produced in the United States for reclamation purposes is of a highly questionable origin and cannot be guaranteed to survive in the mountainous regions of British Columbia and Alberta.

A recent market survey of December 1981 by Jacklin Seed Company rates the immediate supply of reclamation seed as poor to fair for native grasses and cultivars. For legumes a sufficient supply is indicated. No supply was indicated for native grasses suitable for our regions and for high elevation reclamation. As with other commodities in our world, supply is dependent on demand and in the case of native reclamation material it will take still a considerable time before new cultivars suitable for the Canadian reclamation market will become available commercially. Before a seed grower is able to supply the market, several years have to pass before a new variety can be licensed. Our present, most antiquated Canadian licensing procedures make it unattractive to the plant breeder, to devote time and effort to service our agricultural industry. It can be expected that the cost of seed suitable for reclamation and adapted to our harsh climate will be considerably higher than what is presently offered for sale in the U.S.A. The reason for this cost differential finds its origin in the fact that the demand for this specialized material will always be limited when compared to crops suitable for multiple purposes. Recently it has become clear that some of our *Agropyrons* are excellent seed producers in their first year of production but fall off sharply in their yield in subsequent years. From a seed grower's point of view an early rotation of these grasses (especially *Agropyron subsecundum)* will therefore become necessary. At this moment the Department of Genetics, University of Alberta, under Contract by Alberta Environment and Parks Canada, has developed the following native grasses:

Agropyron dasystachyum
A. latiglume
A. riparium
A. subsecundum
A. trachycaulum
Agrostis scabra
Deschampsia caespitosa
Festuca altaica
F. saximontana
Koeleria cristata
Phleum alpinum
Poa alpina
P. artica
P. cusickii
P. interior
Trisetum spicatum

These species were selected over a time span of seven years and taking into account that grasses flower in their second year of growth, the total number of selection cycles carried out on these grasses amounts to three. From a genetical point of view three selection cycles for material that is highly heterozygous in nature, is barely adequate. It is clear that some efforts have to be made in the near future to continue with further selection in order to produce highly improved seed material. In this respect, it is not so much seed yield which is important, but the further development of other potential present in these species. Recent observations point to the fact that several of our native grass species not only have a great adaptability toward a boreal environment but also to high alkaline or to acid soil conditions. These latter potentials are of great value to industry which often deal with soil conditions of this nature. Indeed in many reclamation projects, the success of revegetation will be dependent on the development of these cultivars. In this respect, *Deschampsia caespitosa* and *Poa interior* are very promising. The introduction and use of reclamation grasses suitable for this northern region is in need of guidance and in my view it would be most advantageous for industry to have available to them an organization which pools experiences with this material and makes available to industry their advice and seed for testing. I firmly believe that when one considers the Coal Research Institute as it is funded at this time by the Government of the Province of Alberta and the industry, there is equal justification for a Soil Reclamation Institute which in its ultimate form could develop new species and new varieties and serve as an extension service to the mining industry. Such an institute would be able to contract with the seed growers the necessary supply of reclamation seed for the entire industry. Since it can be expected that new selections may result from such a cooperative effort, a delay of six years, the time necessary for licensing, can be avoided and industry can take immediate advantage of these new seed sources. Canada is late in the development of these types of interactions. Anybody acquainted with the work of Dr. Dewey in Logan, University of Utah, is aware of the great benefits that Institute provides to the reclamation industry. When I read over the present regulations on surface mining in my own Province of Alberta, I find these requirements awesome at least. It requires the industry to reclaim spoils to a standard equal or better than before the disturbance was established. Provided that no lip service is given to this requirement, a horrendous responsibility rests with the mining industry. Government as well as industry should be aware that in order to fulfill this requirement, a concerted effort has to be made to provide industry, i.e. the life-line of our economy, with a reclamation extension service. Our governments, Provincial as well as Federal are very anxious to fill their coffers with the tax revenues of our resources, but indeed there is very little willingness on behalf of these governments to put facilities in place for the needs of the provider. In this respect the Federal Government has made inadequate provisions, and it is time to correct this for the benefit of Canada, the mining industry and the population at large. We have also carried out a selection program with legumes and other flowering plants.

We have concentrated on our native *hedysarums,* that is to say *H. sulphurescens, H. alpinum* and *H. mackenzii*. These species are useful in the reclamation of disturbances at mountain elevations but are not satisfactory above 6,000'. In addition, lines of *Lupinus argenteus* have been developed for Parks Canada's use in Waterton National Park where this lupine is indigenous. It appears that our Alberta soils are well supplied with the bacteria *Rhyzobium,* the necessary symbiont of the native legumes, and seedlings are able to establish themselves without soil inoculation. The use of these legumes should be promoted because of their unique feature of being able to fix nitrogen. It should be pointed out, however, that the ability of nitrogen fixation is correlated with soil temperature and length of growing season. Unfortunately neither of these two are optimum in mountainous regions. Of all the flowering plants, *Dryas* species seem to have the greatest potential for reclamation purposes. *Dryas hookeriana* is limited on this continent to the Alaska-Yukon region and in our region to high mountains of the Rocky Mountains complex. It can be found on otherwise bare mountain tops and is able to survive the most severe environmental conditions. Its demand for soil and soil texture is minimum. The small seed size of *Dryas* determines the method of its application. Hydro-seeding or broadcasting in pellet form appears to be the most efficient way of seeding. *Dryas drummondii,* is a Mountain Aven of a lower altitude although still alpine. In our National Parks system it often appears as a pioneering species on dry river beds and otherwise denuded locations. Both species, *D. drummondii* as well as *D. hookeriana* are quite fast-growing species forming a very dense mat with excellent erosion abating capacity. *Verbascum thapsus,* the Common mullein, a weed common in British Columbia, and now spreading through Alberta has excellent reclamation possibilities. Its natural habitat is a dry rocky location. A biennial, non-toxic, plant, especially appreciated by our feathered friends, produces very large amounts of organic material during its life cycle. In our trails *Verbascum* encourages the invasion of other flowering elements. In our view an initial establishment of *Verbascum* on a disturbed area might be very helpful for future reclamation by native grasses.

USE OF VEGETATION SURVEY DATA IN RECLAMATION

Paper Presented
by

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USE OF VEGETATION SURVEY DATA IN RECLAMATION

"Civilised man was nearly always able to become master of his environment temporarily. His chief troubles came from his delusions that his temporary mastership was permanent. He thought of himself as 'master of the world,' while failing to understand fully the laws of nature.

"Man, whether civilised or savage, is a child of nature - he is not the master of nature. He must conform his actions to certain natural laws if he is to maintain his dominance over his environment. When he tries to circumvent the laws of nature, he usually destroys the natural environment that sustains him. And when his environment deteriorates rapidly, his civilisation declines.

"One man has given a brief outline of history by saying that 'civilised man has marched across the face of the earth and left a desert in his footprints.' This statement may be somewhat of an exaggeration, but it is not without foundation. Civilised man has despoiled most of the lands on which he has lived for long. This is the main reason why his progressive civilisations have moved from place to place. It has been the chief cause for the decline of his civilisations in older settled regions. It has been the dominant factor in determining all trends of history.

"The writers of history have seldom noted the importance of land use. They seem not to have recognised that the destinies of most of man's empires and civilisations were determined largely by the way the land was used. While recognising the influence of environment on history, they fail to note that man usually changed or despoiled his environment.

"How did civilised man despoil this favourable environment? He did it mainly by depleting or destroying the natural resources. He cut down or burned most of the usable timber from forested hillsides and valleys. He overgrazed and denuded the grasslands that fed his livestock. He killed most of the wildlife and much of the fish and other water life. He permitted erosion to rob his farm land of its productive topsoil. He allowed eroded soil to clog the streams and fill his reservoirs, irrigation canals, and harbours with silt. In many cases, he used and wasted most of the easily mined metals or other needed minerals. Then his civilisation declined amidst the despoliation of his own creation or he moved to new land. There have been from ten to thirty different civilisations that have followed this road to ruin (the number depending on who classifies the civilisations)."

Dale and Carter, 1955

Reclamation in British Columbia has gone past an initial stage, where a green cover of agronomics was used, to a second stage where native material is sometimes planted after an initial cover has been created. A third stage needs to be a goal for reclamation in the province. This includes 1) determining the productive potential of the lands on and surrounding a minesite or other disturbance, 2) determining set land-uses after mining that are compatible with this productive potential, and provincial and regional land use objectives and 3) reclamation aimed at this land use which generally will necessitate the planting of pioneering vegetation (using natives and/or agronomics) that will promote site conditions appropriate for encouraging early seral vegetation and ensuing succession to mature vegetation with little or no maintenance.

The first step in this process, determining the productive potential of an area, requires an assessment of the environmental conditions of the minesite and surrounding area. This will determine constraints to use of the area as well as the species, both native and agronomic, that can be used for the variety of environmental conditions on the minesite. Included in this assessment should be a determination of natural succession including what pioneering species are present. An assessment of native vegetation and soils found under disturbed conditions is useful for identifying potentially successful reclamation species.

Once potential is assessed, a future land use for the minesite must be determined that will be compatible with local, regional and provincial perspectives. Present uses of the land in and around the minesite need to be assessed and long-term reclamation goals must be set in consultation with regional and provincial resource and user groups.

The most important factor in creating a vegetative cover on reclaimed lands is providing a suitable growth medium. Alberta guidelines (Land Conservation and Reclamation Council, 1977) state that:

> "the operator shall place soil or other plant-supporting materials on the surface of the reclaimed lands so that a restructured soil, having a depth, and chemical and physical characteristics suitable and sufficient for supporting plant life, is available to achieve the prescribed post-disturbance land use."

The development of the necessary chemical, physical, and biological properties in raw mine tailings is a slow process. Topsoil application to mine tailing materials will greatly increase the ease and speed of revegetation. For this purpose stockpiling of topsoil is recommended.

Revegetation should be done in two steps: 1) create an initial cover, and 2) create a pioneering vegetation that will develop (succession) to a self-maintaining vegetative cover. The first consideration with establishing an initial cover is to prevent erosion. Generally grasses and legumes are suited to prevent surface erosion. However, seeding with grasses alone may form a shallow layer of sod which will initially reduce surface erosion but on steep slopes under wet conditions the sod may slough off (Ministry of Energy, Mines and Petroleum Resources, 1981). An initial cover should include deeper rooting species such as shrubs or trees to prevent this. As well, the initial cover cannot be such that it will prevent the invasion or establishment of native species by either creating too much competition, a thick, impenetrable sod layer or by creating site conditions inhospitable to establishment of natives. This may be the case in many of the "grasslands" created at minesites in the province. Initial establishment of native species will allow them to compete as they will become prominent early.

The initial cover should be followed by vegetation that will allow easy manipulation or will succeed naturally toward vegetation required for the proposed final land use on the site. Pioneer species, adapted to the environment conditions in the area, are most valuable as they initiate humus accumulation and nutrient cycling in the early stages of succession making the site suitable for other species of later successional stages (Bell and Meidinger, 1977), by modifying microclimate, soil microflora, and establishing soil formation processes.

Plant species, for both initial cover and for ultimate land use, must be chosen to be adapted to the environmental conditions present and to be compatible with the chosen land use. Table 1 gives some advantages and disadvantages of th use of agronomic species and native species. Native species clearly have many advantages to their use but presently are unavailable commercially or they are expensive. This may change in the future. Hubbard and Bell (1977) give a listing of species that have been used or may be suitable for reclamation in parts of the province.

TABLE 1

COMPARISON OF AGRONOMIC AND NATIVE SPECIES FOR USE IN RECLAMATION

Plant Type	Advantages	Disadvantages
Agronomics	- seed easily attainable	- require long-term fertilization
	- inexpensive	
	- good for agricultural	- may be unpalatable to wildlife
	- rapid establishment	- not necessarily adapted for environmental conditions particularly harsh conditions
		- not biologically balanced (weedy or outcompeted)
Native	- little maintenance - establishment	- seed and stock is unavailable commercially
	- self-perpetuating - lead to natural communities by improving soil conditions, in balance with natural vegetation	- expensive
	- visually integrated with surrounding environment	
	- wildlife adapted to them	
	- pioneer species are usually tolerant to low nutrient and moisture conditions	
	- pioneer species are especially adapted to withstand bright sunshine and extremes in temperatures	
	- adapted for environmental conditions, including harsh ones such as alpine, south aspects	

Selection of plant species for a particular site should be based on the following factors (Watson and others, 1980):

- climatic adaptation
- land use value (for agriculture, forestry, wildlife)
- availability and cost
- establishment requirements and success
- rehabilitation value (e.g. soil binding, nutrient additions)
- physical and chemical microsite tolerances
- ecological role
- bio compatibility
- ease of propagation
- nutrient and maintenance requirements
- elevational tolerances
- resistance to disease, insects, grazing, winterkill and similar factors

The Terrestrial Studies Branch and other branches of the Assessment and Planning Division of the British Columbia Ministry of Environment collect data and produce maps and written documents concerning vegetation, soils, surficial geology and climate. The applications of this information to reclamation is generalized in Table 2.

The main areas in the province surveyed by the vegetation unit have been the Northeast Coal area, East Kootenays, West Kootenays, Vancouver Island, Hazelton-Prince Rupert area, Shuswap and the southwest coast to Bute Inlet (see Map).

One of the major deficiencies of our data collection, in regard to mine reclamation, has been a severe shortage of data collected on recently disturbed areas and the species pioneering on these sites. However, this kind of information was collected for 15 sites in the Northeast Coal project area.

In the future much work needs to occur in research dealing with native species (see Bell and Meidinger, 1977). A report for British Columbia similar to the two volume report Manual of Plant Species Suitability for Reclamation in Alberta (Watson and others, 1980) would be a valuable addition to reclamation in the province.

It would also be beneficial to long-term reclamation if:

1. short- and long-term land-use objectives were specified

2. the use of native vegetation were promoted by increasing research to improve propagation techniques and facilities to supply seeds and planting stock.

If use of native material is stressed, research will be encouraged and planting stock may become available through time. This must be a long-term objective of reclamation in the province.

TABLE 2

DATA AND PRODUCTS AVAILABLE AND APPLICATION IN RECLAMATION: VEGETATION

Type of Information	Application
Zonation Maps	- broad climatic perspective; tree species limitations; broad successional trends within an area and general species suitability
Vegetation Landscape Maps (see Figures 1 and 2)	- variety of environmental conditions and associated plant communities that can be expected in an area; species that are successful under certain environmental conditions; specific species suitability
Succession Information and Tables (see Figure 3)	- species and their role in vegetation dynamics; what species occur from early succession to climax; communities that may be attainable under certain environmental conditions in the landscape (can serve as a guide in long-term reclamation plans of an area?)
Vegetation Types (see Figure 4)	- listing of plant communities and the environmental conditions under which each group of species is found including soils and site conditions; can relate environmental characteristics to individual species and their suitability for particular sites
Soil Association/ Vegetation Type Correlation Tables (see Figure 5)	- listing of soil associations and the vegetation types that have been found on each; allows relating vegetation types to soils maps to determine what plant species may be suitable on a particular soils map unit or soil in an area
Plot Descriptions	- plot survey data which includes a listing of species, percentage cover, phenology, physical site characteristics and soils data; can be used to indicate specific site conditions for individual plant species and the soils they are successful on; species distribution
Reports	- summary of most of the above information in written form

OTHER BIOPHYSICAL DATA[1]

- Climate Maps - freeze-free period - heat units - moisture deficits - growing season precipitation - climate capability for agriculture	- valuable to indicate the conditions available for plant growth
- Climate Data - for various sites throughout the province	- valuable to indicate the conditions available for plant growth
- Soil Maps and Reports - agriculture capability - forestry capability	- indicate the physical and chemical conditions available as a growth medium for reclamation; laboratory analysis of many samples exists; erodability of soils; soils stability
- Terrain Maps and Reports	- engineering characteristics of surficial materials; potential hazards such as avalanches and landslides; availability of aggregate sources

[1]From Davis (personal communication) and Lacelle (personal communica tion).

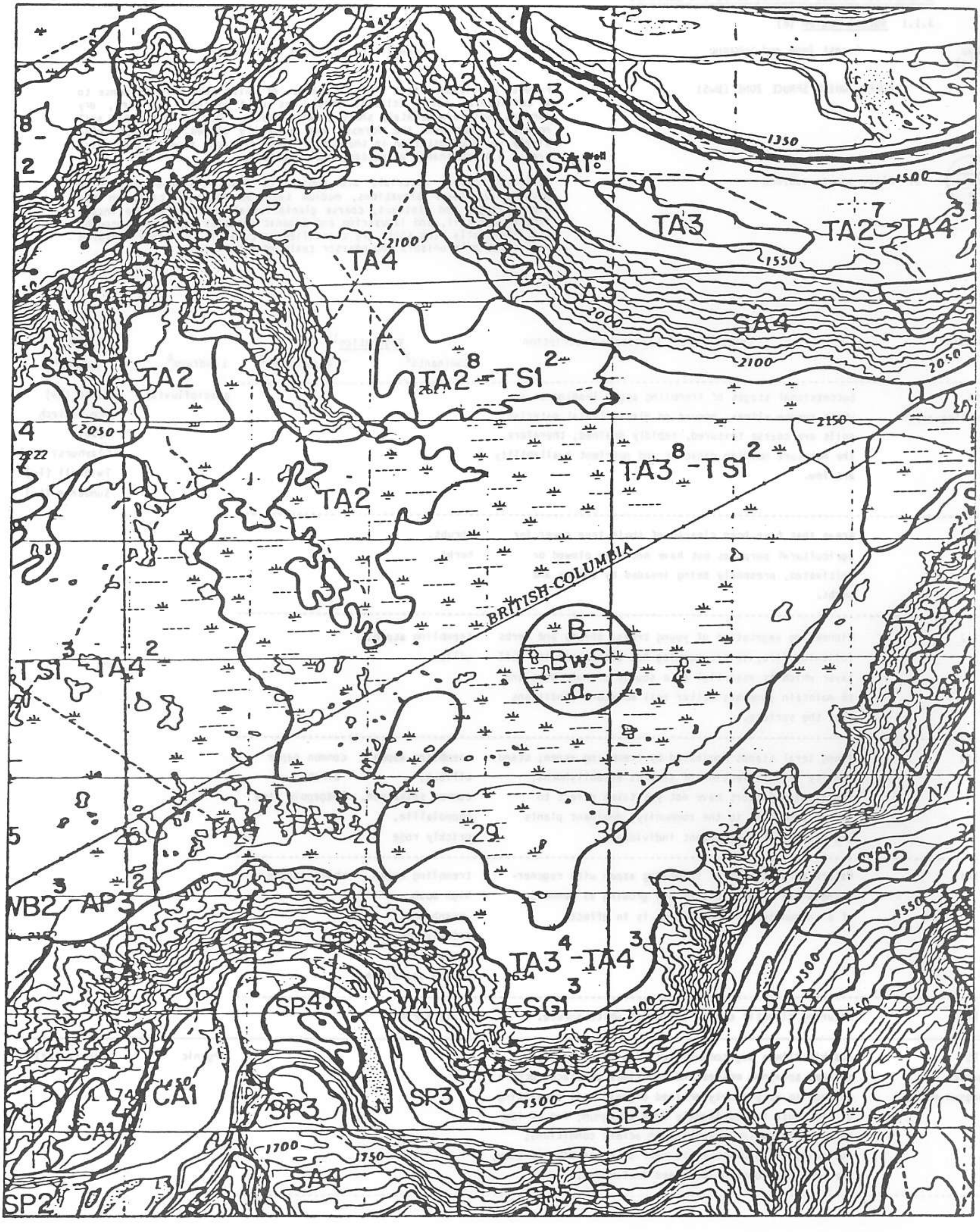

Figure 1. An example of a vegetation landscape map for the Pine-Moberly area (Thompson and others, 1980).

3.1 Biophysical Forest Regions, Zones and Subzones

3.1.1 Boreal Region (B)

Map Label	Forest Zone and Subzone	General Environmental Description
	BOREAL WHITE SPRUCE ZONE (BwS)	Forests are leading to a climatic climax of white spruce in response to a continental Boreal climate which has cold winters and warm, dry summers, with a moderately short growing season. Due to favourable soil moisture conditions the forests are generally closed, although relatively low precipitation in the summer allow frequent forest fires which create a predominance of successional vegetation.
B / BwS / a	a. Black spruce subzone	Surficial parent materials are dominantly finer textured lacustrine deposits at lower elevations, medium textured morainal tills on the higher ridges and plateaus, coarse glaciofluvial deposits at the interface of the till, and lacustrine and organic deposits scattered throughout. Generally, the soils are classified as Luvisols (on finer textured materials) or Brunisols (on coarser textured materials).

Map Label	Environmental Landscape Description	Vegetation[1] Dominants[2]	Vegetation[1] Associates[3]	Landform[4]	Soil Series[5]
TA trembling aspen	Successional stages of trembling aspen leading to a white spruce climax; occurs on glaciofluvial material; soils are coarse textured, rapidly drained; therefore, the moisture holding capacity and nutrient availability are low.			glaciofluvial	Davis (Dv) Groundbirch (Gb) Clayhurst (Cy) Twidwell (Tw) Sundance (Su)
TA1	Areas that have been cleared of their tree cover for agricultural purposes but have not been plowed or cultivated; presently being invaded by shrubs and herbs.	shrubs, herbs			
TA2	Pioneering vegetation of young trees, shrubs and herbs following fire; severe burning has eliminated the duff layer which is essential as a source of nutrients and to maintain somewhat better soil moisture conditions near the surface.	trembling aspen, willow			
TA3	Young seral stands dominated by trembling aspen; stand density is a reflection of species establishment, competitive factors have not yet taken effect to impart structure to the community; dominant plants are growing as independent individuals.	trembling aspen willows, common saskatoon, soopolallie, prickly rose	common paper birch, lodgepole pine		
TA4	Mature seral stands of trembling aspen with regenerating white spruce, plants are growing as members of a community and competition is in effect.	trembling aspen, high bush cranberry, prickly rose, soopolallie, common saskatoon	white spruce		
TA5	Maturing climatic climax stands of white spruce.	white spruce			
TS tamarack - sphagnum moss	Edaphic climax bog communities, dominated by black spruce, sphagnum mosses and sometimes tamarack; occurs on poor to very poorly drained organic soil consisting of peat moss formed largely from sphagnum; fed by low-nutrient rainwater resulting in acidic conditions; following a disturbance the rate of succession is slow; the unit may contain non-treed inclusions.			organic	Kenzie (Kz)

Figure 2 - Selected portion of the legend for the Vegetation Landscape Maps for the Pine Moberly area (see Figure 1)

Succession Sequence Number	Moisture Regime	Habitat
38	Dry	coarse-textured soils on level fluvial terraces

Recent Disturbance

-shrub-herb cover of soopolallie, pine grass and fireweed

Young Seral

-closed forests of lodgepole pine, soopolallie, pine grass and dwarf blueberry (41, 57)[1]

Maturing Seral

-closed forests of lodgepole pine, soopolallie, pine grass and dwarf blueberry (41, 62)

Overmature Seral

-closed forests of lodgepole pine, Englemann spruce, alpine fir, smooth Pacific menziesia, dwarf blueberry and mosses

Climax

-closed forests of alpine fir and Engelmann spruce with an understory of smooth Pacific menziesia, northern twinflower and mosses

Comments	Major Soil Association Components[2]
-slow rate of succession due to poor nutrient status and low moisture availablity; litter buildup is slow and is easily destroyed by disturbance	GC_1, GL_1, KG_1

Figure 3 - A selected successional trend for the East Kootenay area (Lea, in preparation)

DU 3	Western hemlock — western red cedar — western yew — bluebead clintonia

VEGETATION CHARACTERISTICS

Region: Interior Wet Belt
Section: Trout Lake
Zone: Interior western hemlock - western red cedar
Subzone: Rocky Mountain Douglas-fir

Successional stage: overmature seral
Stand appearance: mixed forested dense

SPECIES COMPOSITION

Layer (% crown cover)	Dominants	% crown cover	Associates	% crown cover
Tree layer (70)	western red cedar western hemlock	20 20	common paper birch black cottonwood	15 15
Tall shrub layer (25)	western red cedar western hemlock	10 7	western yew Rocky Mountain maple	5 5
Low shrub layer (12)	western hemlock western yew black cottonwood	4 3 3	western red cedar Rocky Mountain maple	2 2
Herb layer (10)	bluebead clintonia Indian pipe	7	large-leaved rattlesnake orchid lesser pyrola common western pipsissewa	<1 <1 <1
Moss, lichen and liverwort layer (7)	layered moss	4	common moss	3

CHARACTER SPECIES

Present	Absent
western red cedar western hemlock bluebead clintonia western yew	common water crowfoot common mare's-tail coyote willow

TERRAIN AND SOILS

Terrain: fluvial level

Soil Texture: gravelly sand/fine loamy sand
Soil Association Comp: Fruitvale 2
Moisture regime: mesic
Drainage: moderately well

TOPOGRAPHY

Elevation: 542 m
Slope: 0%
Aspect: NA
Landscape position: valley floor

ECOLOGY

Climatic climax species starting to regenerate.

CLIMATE

Figure 4 - An example of a vegetation type description for the Lardeau Flats area (Rafiq, 1980)

Soil Association[1]	Soil Association Component Map Symbol	Vegetation Types	
		Climax	Seral
Minitown	MN1	3, 14	14, 18, (9, 15, 22, 26, 32)
	MN2		
	MN3	1, 5	
	MN4		34, 55, 57
	MN5		19
	MN7		
	MN8	(13, 128)	
Odlumby	OD1	70, 127	
	OD11		
Rainbowl	RG1		(3, 5, 8, 10, 12, 15, 16, 17, 19, 32, 35, 90, 92)
	RG2		
	RG3		
	RG4		
	RG5	1, 9	9, 15, 16
	RG6		
	RG7	5	
	RG8	1, (13, 128)	
Rocky Ridge	RK1		(3, 5, 8, 10, 12, 15, 16, 17, 19, 32, 35, 90, 92)
	RK2		
	RK3		
	RK4		
	RK5		
	RK6		
	RK7		
	RK8	(13, 128)	

1 For descriptions of soil associations and their components see Biophysical Resources of the East Kootenay Area: Soils (Lacelle, in preparation).

Figure 5 - Selected table of Soil Association/Vegetation Type Correlation Tables for the East Kootenay area

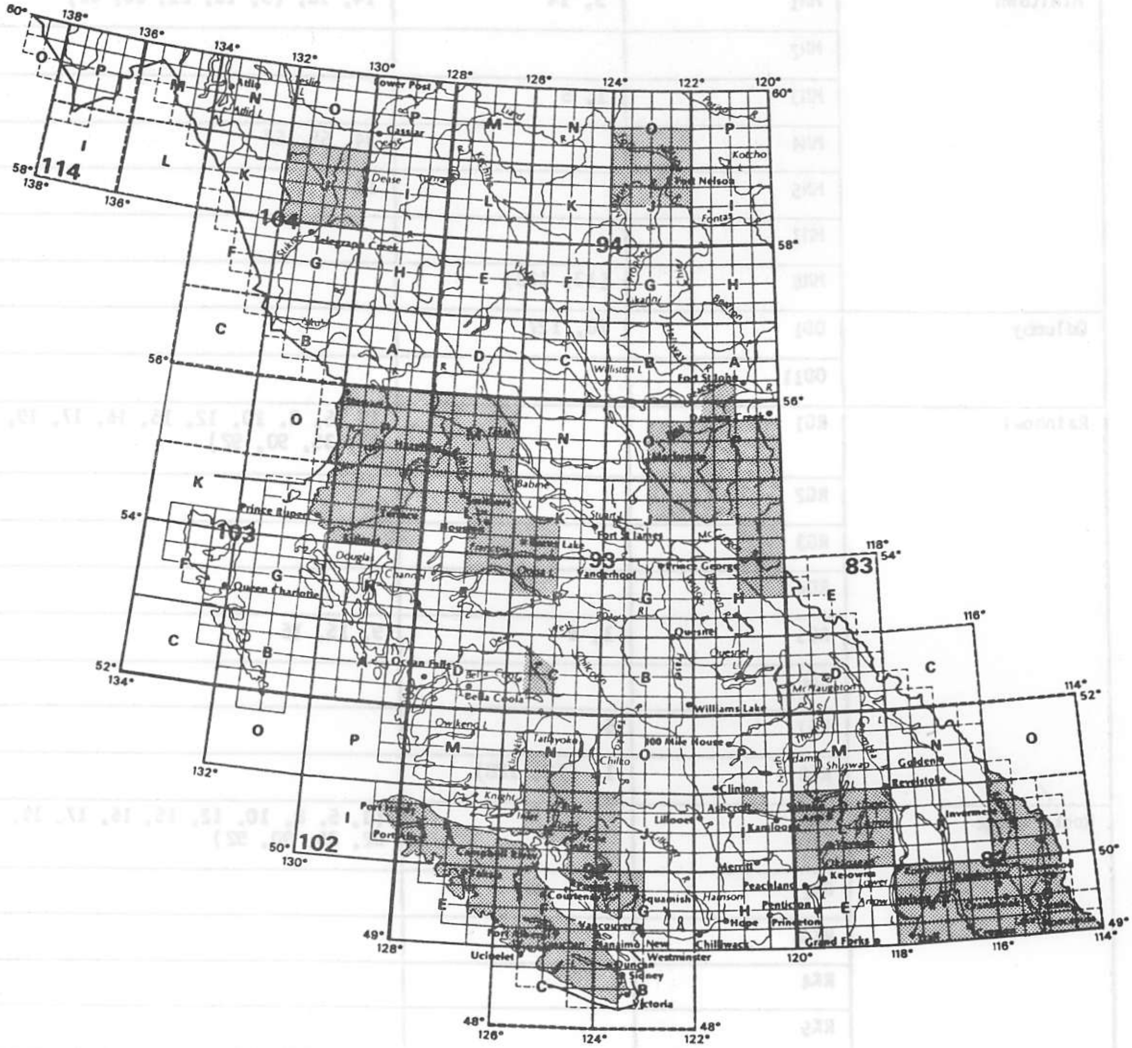

Figure 6:
Areas of Vegetation Surveys

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DISCUSSION RELATING TO TED LEA'S PAPER

Bruce Ott, Placer Development: Could you tell us Ted what's the scale of your mapping and also is that index map you flashed up there available?

Answer: For your second question, we have a booklet that describes all the areas that we have studied in the province as well as what products are available for those areas including vegetation and soils. In answer to the first question, scales vary but the standard scale is 1:50 000. The zonation scales are often 1:100 000 to 1:250 000.

Bruce Ott, Placer Development: Do you use any of the information available from the Ministry of Forests and their forest cover maps.

Answer: Yes, we do. We use all available information we can find.

Bruce Ott, Placer Development: For some applications your maps would be more useful because the Forestry maps are a very large scale.

Answer: Yes that's true.

Jack Thirgood, U.B.C.: One of the troubles in B.C. is the lack of communication. It is not generally known that certain information is available in certain parts of the province but not in others.

Answer: Our information is published by the Provincial Government and it is all made available. A booklet is available which describes all of the information we have.

Jack Thirgood, U.B.C.: But, if people don't know you are producing the booklet or gathering this information they won't use it.

Answer: That is one of the reasons I'm here! But yes, you're right, we have done a poor job in communication.

Frank Pells, Brenda Mines: I'm amazed that this material has been studied and is available.

Answer: That is unfortunate since we're in Kelowna and you're in Peachland! Unfortunately we haven't done any work on the Okanagan area yet; although we operate from Kelowna.

Jeff Greene, LGL: I was wondering once you get to the point where you have species you feel are appropriate for different climatic zones, do you see yourself working with Fish and Wildlife to determine how critical certain species are to wildlife?

Answer: Yes, a lot of our studies right now are with Fish and Wildlife in improving habitat. We've moved away from Forestry since they do their own studies. In the future we will be working mainly with Fish and Wildlife and with our own Assessment and Planning Branches.

(Distorted recording of discussion on fertilizers between J. McDonald [MEMPR], John Dawson [Dawson Seed Co.], and Jack Thirgood [U.B.C.]).

John Dawson, Dawson Seed Co.: I'd just like to add a comment or two about native species versus agronomics. Firstly, native species are becoming available, they may not be available in plenty as of today, but they are more available today than they were last year, and more last year than the year before. There's a lot of work being done on native species as demonstrated by Dr. Weijer from Alberta. Native species are being multiplied for specific use by one firm, Foothills Pipeline, which has considerable areas underway. I think it also fair to consider that although certain agronomics will always be necessary in the mixture. Yes natives will volunteer and creep in, but probably a good argument could be made for inclusion of a native tree mix in your agronomic mixture to hasten the development of the final community.

Jack Thirgood, U.B.C.: Well just a couple of points. If you wait 30 or 40 years the natives may invade. If you leave the land alone for

30 or 40 years the natural vegetation may return. The whole purpose of revegetation however is to speed the process up. There is no use applying agronomics at the beginning if they are going to die off. Surely if you can start native vegetation from the outset and speed up the process that is better, since that is the whole purpose of the exercise. Otherwise, it we take nature's course we do nothing but just wait on nature.

Bob Gardiner, Cominco Ltd.: I think the obvious thing is that we still don't have all the answers.

RECLAMATION RESEARCH AT B.C. COAL

Paper Presented
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RECLAMATION RESEARCH AT B.C. COAL

INTRODUCTION

B.C. Coal's Balmer Operation is located near Sparwood in southeastern British Columbia. The area is one of rugged relief ranging from 1125 m to 2100 m above sea level. The mine is a truck and shovel operation using wrap-around dump construction, and rock types encountered include a mixture of sandstones, siltstones and carbonaceous shales. These materials are slightly to moderately alkaline with pH's ranging from 7.5 to 9.5, and all materials present erode fairly quickly producing fines which greatly aid reclamation efforts. The standard reclamation practice for these large areas is to recontour the dumps to less than 26°, then apply seed by helicopter in the autumn. Following application the seed is harrowed in, using a large bulldozer-pulled pipe harrow to break surface crusts and create favourable microsites for germination. The areas are given annual fertilizer applications of 13/16/10 at a rate of 200 kg/ha in the early spring before growth commences.

By the year 2023 the mine operation will have approximately 16.5 square miles of land disturbed by mine activity, and to date the company has about one-sixth of that area dormant and reclaimed. Research activities have started on these sites in order to make reclamation activities more efficient.

The purpose of this paper is to outline some of the reclamation research activities that are currently underway at B.C. Coal.

In general, research activities fall into one of four overlapping classes:

1. Baseline research and inventory on lands prior to mine activity.

2. Nursery and greenhouse research.

3. Monitoring of reclaimed lands.

4. Ecosystem development and characterization studies.

BASELINE RESEARCH AND INVENTORY

A number of research projects currently underway at B.C. Coal fit into the category of baseline research and inventory. One study examines in detail the effects of slope, aspect and rock type in governing the patterns of vegetation on local slopes prior to mine activity. This will aid in the planning of island plantings; the next stage in the reclamation procedure. Deciduous and coniferous stock will be used, in order to provide both heterogeneity of vegetation and wildlife cover.

Two wildlife research projects also fall into the category of baseline research. The first is designed to give some idea of elk population dynamics and is trying to establish patterns of elk use on the property. Identification of habitat use by these and other ungulate species will enable us to better predict the impact of expansion of mine activity.

It is generally believed that winter range is the limiting factor for ungulate populations in the Rockies. Therefore a second wildlife study was initiated to provide an estimate of browse productivity and utilization on those areas that have been identified as useful winter range. This information will be used to estimate the carrying capacity of ungulates in the area.

GREENHOUSE AND NURSERY RESEARCH

B.C. Coal has two 15 m x 9 m greenhouses and 6.8 ha of nursery in production at Sparwood, B.C. These facilities are used to produce native trees and shrubs for outplanting on lands disturbed by mine activity. Research activities in these facilities are aimed at establishing techniques for large scale production of species that will be potentially useful in reclamation efforts. In 1981 research was aimed at testing common herbicides as suitable weed control agents in a nursery devoted to native tree and shrub production. In addition, long term studies investigating pretreatments of a number of native shrubs are underway.

RECLAMATION MONITORING

Reclamation monitoring involves annual sampling to give estimates of species composition, detritus cycling and total productivity on each of the major reclaimed sites. Particular attention is given to those sites that have been removed from the annual fertilizer program.

ECOSYSTEM DEVELOPMENT AND CHARACTERIZATION STUDIES

A number of the research projects undertaken at B.C. Coal are designed to increase our knowledge of ecosystem development on revegetated spoil materials. Since organic matter turnover and nitrogen budgets are two of the more important cycles in the development of terrestrial ecosystems it is in these two areas that research efforts have been directed.

NITROGEN

Microorganisms that are capable of fixing atmospheric nitrogen are easily divided into two groups: those that are free-living organisms and those that are associated with higher plants. A number of studies involving nitrogen fixation have been undertaken at B.C. Coal; one on the role that free-living N-fixers (blue green algae and bacteria) play in reclaimed sites, and others looking at nitrogen fixation by legume-associated microorganisms. This year tentative identification of those organisms that were actually fixing nitrogen were made. Quantification of amounts fixed will be studied in future research projects.

Research involving the role of fertilizer inputs into the reclaimed ecosystem is also underway. During 1982 one study will utilize N15 a heavy isotope of nitrogen to label fertilizer. This will allow us to trace the flow of nitrogen through the system; how much goes into the plants and how much is lost from the cycle. This will also hopefully allow us to determine which organisms are responsible for the majority of the cycling of nitrogen in these systems.

DETRITUS TURNOVER

Organisms that are responsible for decomposition are mainly bacterial and fungal. However work done by Fyles (1980) indicated that these microorganisms alone could not explain the amount of decomposition that was observed on the reclaimed sites. Further study indicated that soil fauna may be responsible for turning over much of the above ground detritus present.

Preliminary results correlate high detrital loss with high collembola (springtail) populations. A research project is being organized to identify other organisms important in organic matter incorporation into the spoil on these sites.

CONCLUSION

Much of the work that has been described in this paper is work done by graduate students at the University of Victoria, the University of British Columbia and the University of Alberta. Cooperative research programs such as this help industry to make contacts with a wide range of expertise in the form of graduate students, their supervisors, and committee members, while at the same time answering questions related directly to their operating procedures. At B.C. Coal an effort is made in gaining a better biological understanding of the ecosystems that are being created, in order to aid in the delineation of suitable land-use planning and to avoid potential problems before large areas of land have been affected.

LITERATURE CITED

Fyles, J.W., 1980. Vegetation and soil development on reclaimed mine lands at high elevation in southeastern British Columbia. M.Sc. Thesis. University of Victoria.

DISCUSSION RELATING TO DAVE FRASER'S PAPER

Harry Quesnel, Ministry of Environment: I'd just like to make a comment. People often talk about the economics of native species versus agronomics. I suppose just for the straight cost of the seeds, native species are most expensive, but I wonder if people consider the value and cost of fertilizer and its application with agronomics - especially considering that the money could be in the bank collecting 15% to 20% interest over the length of the project. The reason I mention this is that you were saying that you use a large number of agronomics which represents a large capital cost.

Answer: Well all our returns are not in. We're looking in the near future at how much fertilizer is actually required by the agronomics. The standard information you get when you come to symposia like these is that agronomics die out, require more fertilizer, and at high elevations don't produce viable seed. I'm not seeing hard-core scientific data coming out of our sites that would support all of that. We certainly have viable seed production of agronomic species and these seeds are actually germinating, but we are going to have some fairly strong selection pressures acting on the seeds. We may well be producing ecotypes of agronomic seeds, providing that we have a large enough genetic base to begin with, that will survive some of the conditions we're asking for. I think that in the next little while we will have to reduce fertilizer application on the sites and give them the acid test and see whether or not they actually survive on their own. Certainly we're going to have organic matter cycling and nitrogen cycling. Preliminary work seems to indicate that a lot of agronomics are going to go. The other information I've got from my own work with native grasslands is only partially complete, but suggests that some of these agronomics we're putting in are very aggressive. They are moving across native grasslands at those elevations quite readily without any application of fertilizers. That, to me, suggests that they have a much wider tolerance than we give them credit for.

Harry Quesnel, Ministry of Environment: Just another comment. Many agronomics are used with the philosophy of putting lots of nitrogen and phosphorous and other nutrients into the crop, then harvesting the crop along with the nitrogen and phosphorous. Maybe one thing to consider is that here you're not harvesting the crop except for feeding by the elk, and maybe the nutrient cycle is not being completed as fast. For that reason the nitrogen fertilizer might have a greater longevity than you expect.

Answer: Yes, that is very true. Our approach is to seed with agronomics and fertilize them to produce high amounts of organic matter. This organic matter will eventually be turned into soil material. It is a way of topsoiling without actually going out with a truck and doing it, and is a lot cheaper.

APPENDIX A

FUTURE SYMPOSIA TOPIC SUGGESTIONS

RESPONSES TO REQUEST FOR SUGGESTIONS FOR FUTURE TOPICS

Numbers in parentheses indicate approximate frequency of mention.

1. Stated land end-uses. Development of same. Uses of reclaimed land other than grassland. (6)

2. Economic considerations generally (6)

    - reclaiming land of little initial value?
    - total costs involved in use of native versus agronomic species
    - costs, problems, success/failure rates of specific products under different conditions

3. Panel discussion

    - resource and service agencies, to show integration and overlap of concerns and land-use conflicts and resolution
    - broader spectrum of integrated resource management, e.g. Hydro, Highways, land development (9)

4. Workshops by experts in specific areas (5)

    e.g. tree planting
    grass ecology
    fertilizer
    soil requirements for commercial forestry

5. Reclamation of other types (6)

    - shift in some emphasis to metal mines and metal exploration reclamation
    - methods of tailings ponds reclamation, development, abandonment
    - acid tailings
    - high attitude, acute environment reclamation, e.g. steep slopes
    - coarse and/or acid-producing overburden

6. Reclamation in other areas and other disturbances (5)

    - in other ecological zones, provinces, countries
    - of forest roads and logging disturbances

7. Natives (5)

- pioneer versus climax species
- definition of "native"
- results of non-fertilizer trials on agronomics

8. Water Management generally (3)

- problems with and control of iron in underground effluent

9. Evaluation of ecological stability versus productivity. Definition of successful reclamation. (2)

10. Uses of remote sensing. (3)

11. List of delegates at symposium available while symposium is running. (3)

12. The role of science in field day-to-day decision-making.

13. Is more regulation necessary?

Response to question, "Are you in favour of holding the symposium annually, every second year, or every third year?

Annually	52
Every 2 years	6
Every 3 years	0
(Two times per year	3)

APPENDIX B

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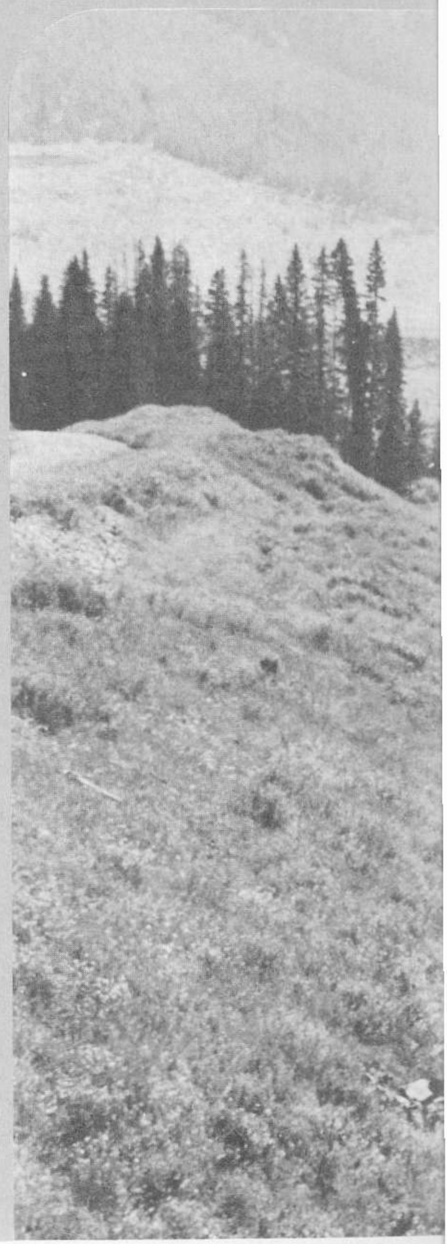

Queen's Printer for British Columbia ©
Victoria, 1983

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