

Guidelines for Reclamation / Revegetation in the Yukon

YUKON ENERGY, MINES & RE... LIBRARY
P.O. Box ...
Whitehorse, Yukon Y1A 2C6

Yukon
Renewable Resources

Guidelines for Reclamation / Revegetation in the Yukon



Edited by
C.E. Kennedy

Habitat Management Section
Fish and Wildlife Branch

Yukon
Renewable Resources

This publication is produced on a Canadian made recycled paper containing 100% post consumer non-deinked fibre. No chlorine-based bleaching agents are used in the manufacturing process. This publication was printed with vegetable based inks.

ISBN 1-55018-519-5

March 1993

PREFACE

This manual evolved in response to an ever increasing number of requests received by the Habitat Management Section, from the private and public sector, for information regarding reclamation and revegetation of disturbed sites. In order to assist with mitigation of the impact of highway construction and mining developments, existing data appropriate for the Yukon environment was sought and compiled.

The original data from which the revegetation prescriptions have been formulated was obtained through research conducted from 1976 to 1981 by Herman and Manivalde Vaartnou, in the course of environmental studies for the construction of the proposed Foothills Pipeline, designed for the transport of natural gas from the Beaufort Sea to southern Canada.

This extensive and comprehensive demonstration program involved the collection of seeds of native species of grasses and legumes from widely geographically dispersed locations throughout the Yukon. Seed stocks were increased in nurseries; these propagated native seeds, as well as seeds of agronomic varieties of grasses and legumes, were then planted in test plots at numerous locations within the proposed pipeline corridors. Test sites were situated along the Alaska Highway from Watson Lake to Beaver Creek, along the Klondike Highway from Whitehorse to Dawson, along the Dempster Highway from km 0 to Inuvik, and north of Tuktoyaktuk .

The test plots received various surface preparation, treatments, mulches, and fertilizer applications. Seed trials, using both native and agronomic seeds, were conducted in replicate; plots were monitored continuously for a minimum of five years and again in 1985. In addition to grasses and forbs, the use of groundcover shrubs for revegetation was also investigated. Several test sites planted in the 1970's are still in existence and may be observed.

The description of the revegetation process and the case for the use of northern native seed varieties is a joint contribution of M.Vaartnou and Associates of Richmond B.C. and McKenna & Murray Geocon of Whitehorse, Yukon. The soil and vegetation relationships were outlined and schematically illustrated by Karen McKenna and David Murray. Site descriptions and fertilizer requirements are based on the work of the Vaartnous and extensive soil surveys and agricultural research conducted throughout the Yukon by the principals of McKenna & Murray Geocon.

At present, this manual provides guidelines only for those areas of the Yukon where revegetation research has been conducted and for which data is available. It is hoped that the manual can be expanded to cover the entire Yukon, with the establishment of additional test sites in the future.

This manual is intended to serve as a guide for successful revegetation of disturbed sites in the Yukon. Comments from users of the manual are encouraged, to assist with improvements in the recommendations in future editions.

Catherine E. Kennedy
Whitehorse, Yukon
October 1992

ACKNOWLEDGEMENTS

The editor extends a special thanks to C.A. Scott Smith, of Agriculture Canada in Whitehorse, for technical guidance throughout this project. The encouragement and support of John Murray, Highway Engineering, Department of Community and Transportation Services, at the inception of the manual and Len Mychasiw, Department of Renewable Resources, throughout its evolution, is gratefully acknowledged. Thanks also to Stoney Wright, State of Alaska Agriculture Division in Palmer, and Scott Smith for the helpful comments and suggestions provided in their critical review of the manuscript.

Maps and illustrations were drafted by Nicole Hulstein of the Department of Renewable Resources. Cover artwork was by Thom Rodger; graphic layout, design and typesetting was by Desktop Graphics Ltd. of Whitehorse. The contribution and enthusiasm of Don Allen is deeply appreciated.

This manual has been made possible, in part, by a financial contribution from the Yukon Conservation Stategy Demonstration Fund, a program administered by the Department of Renewable Resources Administration Branch.



TABLE OF CONTENTS

Section 1 Revegetation in the Yukon

1.0 HOW TO USE THIS MANUAL 1

1.1 Purpose of the Manual 1

1.2 The Users of the Manual 1

1.3 Layout of the Manual 1

1.3.1 Seed Recommendations by Plant Community 2
1.3.2 Seed Recommendations by Linear Project 2
1.3.3 Seed Recommendations for Special Problems 2
1.3.4 Fertilizer Recommendations 2

2.0 GENERAL REVEGETATION CONSIDERATIONS 6

2.1 Ecological Background of Revegetation 6

2.2 Definitions 7

2.2.1 Revegetation 7
2.2.2 Reclamation 7
2.2.3 Rehabilitation 7
2.2.4 Restoration 8

2.3 Objectives of Revegetation 8

2.3.1 Introduction 8
2.3.2 Prioritization of Objectives by Project 8
2.3.3 Discussion of Objectives 9

3.0 THE CASE FOR NORTHERN VARIETIES 10

3.1 Nutrient Availability 10

3.2 Plant Survival 11

3.3 Choice of Species 12

3.3.1 Definition of Introduced and Native Species 12
3.3.2 Relative Merits of Introduced and Native Seeds for Northern Revegetation 12

3.4 Seed Mixture Formulation 14

4.0 SITE CONDITIONS AND PREPARATION 16

4.1 Overview of Site Considerations 16

4.1.1 Climate and Microclimates 16
4.1.2 Soil Conditions 16
4.1.3 Thermal Regime 16

4.2 Surface Preparation 16
4.2.1 Introduction 16
4.2.2 Level Sites 17
4.2.3 Slopes 17
4.2.4 Stream Crossings 18
4.3 Mulch and Other Treatments 18
4.3.1 Definition of Mulch 18
4.3.2 Uses of Mulch 19
4.4 Time of Seeding 20
4.5 Methods of Seeding 20
4.5.1 Broadcast Seeding 21
4.5.1.1 Aerial Seeding 21
4.5.1.2 Hydroseeding 21
4.5.1.3 Cyclone Seeding 21
4.5.1.4 Slope Seeding 22
4.5.2 Drill Seeding 22
4.6 Rate of Seeding 23
4.7 Fertilization 23
4.7.1 Nutrient Testing 23
4.7.1.1 General Considerations 23
4.7.1.2 Soil Sampling Procedures 24
4.7.2 Fertilizer Formulation 24

Section 2 Regional Seed Specifications

1.0 INTRODUCTION 27
1.1 Delineation of Regions 27
1.2 Generalizing Existing Data to Other Areas 27

2.0 REGION 1: SOUTH-CENTRAL YUKON
2.1 Climate 29
2.2 Landforms and Soils 29
2.3 Vegetation 31
2.4 Plant Community Based Seed Mixtures 31
2.5 Seed Mixtures For High Elevations 48
2.6 Seed Mixtures For Linear Projects 51
2.7 Specific Problem Seed Mixtures 56
2.7.1 Highway-Cut Slope Seed Mixtures 56
2.7.2 Saline Soil Seed Mixtures 56
2.7.3 Sandy Soil Seed Mixtures 56

3.0 REGION 2: SOUTH-EAST YUKON 61
3.1 Climate 61
3.2 Landforms and Soils 61
3.3 Vegetation 63
3.4 Plant Community Based Seed Mixtures 63
3.5 Linear Development Seed Mixtures 82
3.6 Specific Problem Seed Mixtures 85
3.6.1 Highway-Cut Slope Seed Mixtures 85
3.6.2 Saline Soil Seed Mixtures 85
3.6.3 Sandy Soil Seed Mixtures 85

4.0 REGION 3: SOUTH-WEST YUKON 91
4.1 Climate 91
4.2 Landforms and Soils 91
4.3 Vegetation 93
4.4 Plant Community Based Seed Mixtures 94
4.5 Seed Mixtures For High Elevations 114
4.6 Seed Mixtures For Linear Developments 117
4.7 Specific Problem Seed Mixtures 120
4.7.1 Highway-Cut Slope Seed Mixtures 120
4.7.2 Saline Soil Seed Mixtures 120
4.7.3 Sandy Soil Seed Mixtures 120

5.0 REGION 4: PELLY/CASSIAR MOUNTAINS 125
5.1 Climate 125
5.2 Landforms and Soils 125
5.3 Vegetation 127
5.4 Plant Community Based Seed Mixtures 127
5.5 Seed Mixtures For High Elevations 140
5.6 Seed Mixtures For Linear Developments 145
5.7 Specific Problem Seed Mixtures 147
5.7.1 Highway-Cut Slope Seed Mixtures 147
5.7.2 Sandy Soil Seed Mixtures 147

Literature Cited 153

APPENDICES

APPENDIX A - Relevant Traits of Species Included in the Revegetation Seed Mixtures 159

APPENDIX B - Botanical and Common Names of Plant Species 164

APPENDIX C - Additional References 168

APPENDIX D - Seed Suppliers of Western North America 169

APPENDIX E - Soil Properties Class Ranges 170

APPENDIX F - The Major Nitrogen, Phosphorus, Potassium and Sulphur Fertilizers Available in Western Canada and Their Characteristics 172

APPENDIX G - Calculation of Correct Fertilizer Application Rates 175

APPENDIX H - Glossary of Terms Used in Site Characteristics Tables 176

LIST OF FIGURES & ILLUSTRATIONS

1a The Revegetation/Reclamation Process: An Overview 3
1b The Revegetation/Reclamation Process: Non-Linear Projects 4
1c The Revegetation/Reclamation Process: Linear Projects 5
2 A terraced cutback along a highway right-of-way 17
3 Installation of erosion mats in ditches 18
4 Installation of erosion control mesh on slopes 19
5 Application of an organic tack mulch 20
6 Hydroseeder applying seed, fertilizer and mulch in one operation 21
7 Packstrap style broadcast seeder used for seeding small areas 22
Soil sampling tools and techniques for nutrient testing:
8a Soil probe for sampling finer textured soils 25
8b Soil sampling with a shovel for coarser textured soils 25
8c Distribution of soil sampling points 25
9 Location of Regions 28
10 Region 1: South-Central Yukon 30
11 Vegetation and Landform Relationships - Region 1 33
12 Region 2: South-East Yukon 62
13 Vegetation and Landform Relationships -Region 2 65
14 Region 3: South-West Yukon 92
15 Vegetation and Landform Relationships -Region 3 95
16 Region 4: Pelly/Cassiar Mountains 126
17 Vegetation and Landform Relationships -Region 4 129
18 Agronomic Soil Texture Classes 179
19 Unified Soil Classification (USC) 180

LIST OF TABLES

Section 1

1. Species characteristics considered in formulation of seed mixtures 15

Section 2

REGION 1

2. Site characteristics of alkaligrass-foxtail barley *(Puccinellia-Hordeum)* communities 34

3. Seed mixture and fertilizer specifications for alkaligrass-foxtail barley *(Puccinellia-Hordeum)* community soils 35

4. Site characteristics of sage/grass *(Artemisia/Calamagrostis-Festuca)* communities 36

5. Seed mixture and fertilizer specifications for sage/grass *(Artemisia/Calamagrostis-Festuca)* community soils 37

6. Site characteristics of willow/sedge *(Salix/Carex)* communities 38

7. Seed mixture and fertilizer specifications for willow/sedge *(Salix/Carex)* community soils 39

8. Site characteristics of lodgepole pine *(Pinus contorta)* communities 40

9. Seed mixture and fertilizer specifications for lodgepole pine *(Pinus contorta)* community soils 41

10. Site characteristics of black spruce *(Picea mariana)* communities 42

11. Seed mixture and fertilizer specifications for black spruce *(Picea mariana)* community soils 43

12. Site characteristics of white spruce *(Picea glauca)* communities 44

13. Seed mixture and fertilizer specifications for white spruce *(Picea glauca)* community soils 45

14. Site characteristics of mixed deciduous/ coniferous tree communities 46
15. Seed mixture and fertilizer specifications for mixed deciduous/coniferous tree community soils 47
16. Seed mixture and fertilizer specifications for subalpine environments 49
17. Seed mixture and fertilizer specifications for alpine environments 50
18. Seed mixture and fertilizer specifications for linear project seeding from Whitehorse to Teslin 52
19. Seed mixture and fertilizer specifications for linear project seeding from Whitehorse to Haines Junction 53
20. Seed mixture and fertilizer specifications for linear project seeding from Haines Junction to Kluane Lake 54
21. Seed mixture and fertilizer specifications for linear project seeding from Whitehorse to McCabe Creek 55
22. Seed mixture and fertilizer specifications for sand and gravel cut slopes 57
23. Seed mixture and fertilizer specifications for silty-clay cut slopes 58
24. Seed mixture and fertilizer specifications for saline soils 59
25. Seed mixture and fertilizer specifications for sandy soils 60

REGION 2

26. Site characteristics of lodgepole pine *(Pinus contorta)* communities 66
27. Seed mixture and fertilizer specifications for lodgepole pine *(Pinus contorta)* community soils 67
28. Site characteristics of white spruce *(Picea glauca)* communities 68
29. Seed mixture and fertilizer specifications for white spruce *(Picea glauca)* community soils 69
30. Site characteristics of mixed deciduous/ coniferous tree communities 70
31. Seed mixture and fertilizer specifications for mixed deciduous/coniferous tree community soils 71

32. Site characteristics of white spruce/black spruce *(Picea glauca/Picea mariana)* communities 72

33. Seed mixture and fertilizer specifications for white spruce/black spruce *(Picea glauca/Picea mariana)* community soils 73

34. Site characteristics of black spruce/larch *(Picea mariana/Larix laricina)* communities 74

35. Seed mixture and fertilizer specifications for black spruce/larch *(Picea mariana/Larix laricina)* community soils 75

36. Site characteristics of white spruce/balsam poplar *(Picea glauca/Populus balsamifera)* communities 76

37. Seed mixture and fertilizer specifications for white spruce/balsam poplar *(Picea glauca/Populus balsamifera)* community soils 77

38. Site characteristics of aspen/soapberry *(Populus tremuloides/Shepherdia)* communities 78

39. Seed mixture and fertilizer specifications for aspen/soapberry *(Populus tremuloides/Shepherdia)* community soils 79

40. Site characteristics of aspen/kinnikinnick *(Populus tremuloides/Arctostaphylos)* communities 80

41. Seed mixture and fertilizer specifications for aspen/kinnikinnick *(Populus tremuloides/Arctostaphylos)* community soils 81

42. Seed mixture and fertilizer specifications for linear project seeding from Rancheria to Upper Liard 83

43. Seed mixture and fertilizer specifications for linear project seeding in the greater Watson Lake region 84

44. Seed mixture and fertilizer specifications for sandy cut slopes 86

45. Seed mixture and fertilizer specifications for gravel cut slopes 87

46. Seed mixture and fertilizer specifications for silty-clay cut slopes 88

47. Seed mixture and fertilizer specifications for saline soils 89

48. Seed mixture and fertilizer specifications for sandy soils 90

REGION 3

49. Site characteristics of willow/shrub birch *(Salix/Betula glandulosa)* communities 96

50. Seed mixture and fertilizer specifications for willow/shrub birch *(Salix/Betula glandulosa)* community soils 97

51. Site characteristics of black spruce/white spruce *(Picea mariana/Picea glauca)* communities 98

52. Seed mixture and fertilizer specifications for black spruce/white spruce *(Picea mariana/Picea glauca)* community soils 99

53. Site characteristics of white spruce/balsam poplar *(Picea glauca/Populus balsamifera)* communities 100

54. Seed mixture and fertilizer specifications for white spruce/balsam poplar *(Picea glauca/Populus balsamifera)* community soils 101

55. Site characteristics of black spruce *(Picea mariana)* communities 102

56. Seed mixture and fertilizer specifications for black spruce *(Picea mariana)* community soils 103

57. Site characteristics of white spruce *(Picea glauca)* communities 104

58. Seed mixture and fertilizer specifications for white spruce *(Picea glauca)* community soils 105

59. Site characteristics of willow/sedge *(Salix/Carex)* communities 106

60. Seed mixture and fertilizer specifications for willow/sedge *(Salix/Carex)* community soils 107

61. Site characteristics of sage/grass *(Artemisia/Calamagrostis-Festuca)* communities 108

62. Seed mixture and fertilizer specifications for sage/grass *(Artemisia/Calamagrostis-Festuca)* community soils 109

63. Site characteristics of willow/aspen *(Salix/Populus tremuloides)* communities 110

64. Seed mixture and fertilizer specifications for willow/aspen *(Salix/Populus tremuloides)* community soils 111

65. Site characteristics of mixed deciduous/coniferous tree communities 112

66. Seed mixture and fertilizer specifications for mixed deciduous/coniferous tree communities 113
67. Seed mixture and fertilizer specifications for subalpine environments 115
68. Seed mixture and fertilizer specifications for alpine environments 116
69. Seed mixture and fertilizer specifications for linear project seeding from Kluane Lake to Pickhandle Lake 118
70. Seed mixture and fertilizer specifications for linear project seeding from Pickhandle Lake to the Alaska Border 119
71. Seed mixture and fertilizer specifications for sand and gravel cut slopes 121
72. Seed mixture and fertilizer specifications for silty-clay cut slopes 122
73. Seed mixture and fertilizer specifications for saline soils 123
74. Seed mixture and fertilizer specifications for sandy soils 124

REGION 4

75. Site characteristics of white spruce/lodgepole pine *(Picea glauca/Pinus contorta)* communities 130
76. Seed mixture and fertilizer specifications for white spruce/lodgepole pine *(Picea glauca/Pinus contorta)* community soils 131
77. Site characteristics of white spruce/black spruce *(Picea glauca/Picea mariana)* communities 132
78. Seed mixture and fertilizer specifications for white spruce/black spruce *(Picea glauca/Picea mariana)* community soils 133
79. Site characteristics of mixed deciduous/ coniferous tree communities 134
80. Seed mixture and fertilizer specifications for mixed deciduous/coniferous tree community soils 135
81. Site characteristics of black spruce *(Picea mariana)* communities 136
82. Seed mixture and fertilizer specifications for black spruce *(Picea mariana)* community soils 137
83. Site characteristics of alpine fir *(Abies lasiocarpa)* communities 138
84. Seed mixture and fertilizer specifications for alpine fir *(Abies lasiocarpa)* community soils 139

85. Site characteristics of alpine fir/shrub birch-willow *(Abies lasiocarpa/Betula glandulosa-Salix)* communities 141

86. Seed mixture and fertilizer specifications for alpine fir/shrub birch-willow *(Abies lasiocarpa/Betula glandulosa-Salix)* community soils 142

87. Site characteristics of sedge/cottongrass *(Eriophorum/Carex)* communities 143

88. Seed mixture and fertilizer specifications for sedge/cottongrass *(Carex/Eriophorum)* community soils 144

89. Seed mixture and fertilizer specifications for linear project seeding from Johnson's Crossing to Rancheria 146

90. Seed mixture and fertilizer specifications for sandy cut slopes 148

91. Seed mixture and fertilizer specifications for gravel cut slopes 149

92. Seed mixture and fertilizer specifications for silty-clay cut slopes 150

93. Seed mixture and fertilizer specifications for sandy soils 151

SECTION ONE - REVEGETATION IN THE YUKON

1.0 HOW TO USE THIS MANUAL

1.1 Purpose of the Manual

The successful revegetation of disturbed sites is the ultimate purpose of this manual. It is intended to be useful in a range of revegetation applications, from borrow pit and mine site reclamation, to highway and pipeline corridor revegetation.

The major strength of this manual is that it contains revegetation and reclamation recommendations designed specifically for the Yukon. By taking advantage of the availability of northern varieties, revegetation in the Yukon will be able to achieve permanent solutions to revegetation problems with accompanying gains in terms of erosion control, aesthetic values and reduction in maintenance costs.

1.2 The Users of the Manual

The user of this manual does not need to be a revegetation specialist or an expert in horticulture, although some technical knowledge is assumed. The ability to conduct scientific assessments of soil as a growth medium and an understanding of plant communities and vegetation mapping is an asset that would increase the effective use of this manual. Obviously, the greater the knowledge of revegetation procedures brought to the project, the greater the likelihood of success.

The manual attempts to provide the essential background information of the revegetation process. A careful reading of the manual should enable the user to establish the priorities of their revegetation project and adopt practical procedures to attain their goals in terms of site preparation, seeding techniques, fertilizer requirements and seed formulations.

1.3 Layout of the Manual

Section 1 gives the necessary background to plan and execute a revegetation project. This section moves from the more theoretical context of revegetation methodologies toward increasingly technical revegetation considerations, which will be helpful for users who have only a general knowledge of revegetation or for those who are not familiar with revegetation in northern areas. Parts 3.0 and 4.0 of Section 1 deal with technical aspects of the revegetation project.

Of special importance is the section on seed mixture formulation (3.4). The discussion of seed formulations explains the correct way to use the seed mixture tables which are the central focus of the revegetation guidelines.

Section 2 outlines the seed recommendations for the Yukon by region. The regional information is further subdivided in three ways:

- by plant community
- by linear project
- by specific problem



Detailed seed formulations and fertilizer recommendations are made for each of these three subdivisions. Figures 1a, 1b, and 1c provide a schematic overview of the manual and map the progress of a revegetation project.

1.3.1 Seed Recommendations by Plant Community

The recommendations made by plant community are applicable when the original vegetation of the site is known or can be extrapolated from the surrounding areas, and where the surface materials and underlying soil horizons remain relatively undisturbed. The plant community based seed formulations are the best method of insuring successful revegetation and should be considered wherever the plant communities are large enough in extent to make the procedure practical.

1.3.2 Seed Recommendations by Linear Project

Where the site conditions change frequently over short distances, as is typical along linear projects such as highway or pipeline corridors, using the seed formulations on the basis of vegetation community types may be prohibitively expensive. The linear project seed mixture is a comprehensive approach that applies a variety of seeds adapted to a wide range of micro-environments.

1.3.3 Seed Recommendations for Special Problems

Highway cut slopes, saline soils and very sandy soils are isolated as specific problems for revegetation in each region.

The highway-cut slope mixtures described are best estimates when individual site investigations are impossible. Saline soils, (which are of significant extent in the south central Yukon), are a severe problem for revegetation. No truly satisfactory seed mixtures for saline soils are yet available, but those recommended are the best available at the present time. Sandy soils combine severe erosion potential with poor moisture holding capability. Seed mixtures for these soils are adjusted to compensate for these problems.

1.3.4 Fertilizer Recommendations

It is preferable to conduct investigations of available soil nutrients at each revegetation project site, in order to formulate site-specific nutrient requirements and fertilizer applications. The guide-lines for fertilizer application which are presented in this manual are suggested for use when it is not possible to do on-site soil testing. Fertilizer recommendations in this manual are based on extensive field testing in the Yukon conducted over an eight year period (78-86). Detailed discussion of the purpose and limitations of the fertilizer recommendations are found in Section 1 part 4.7.

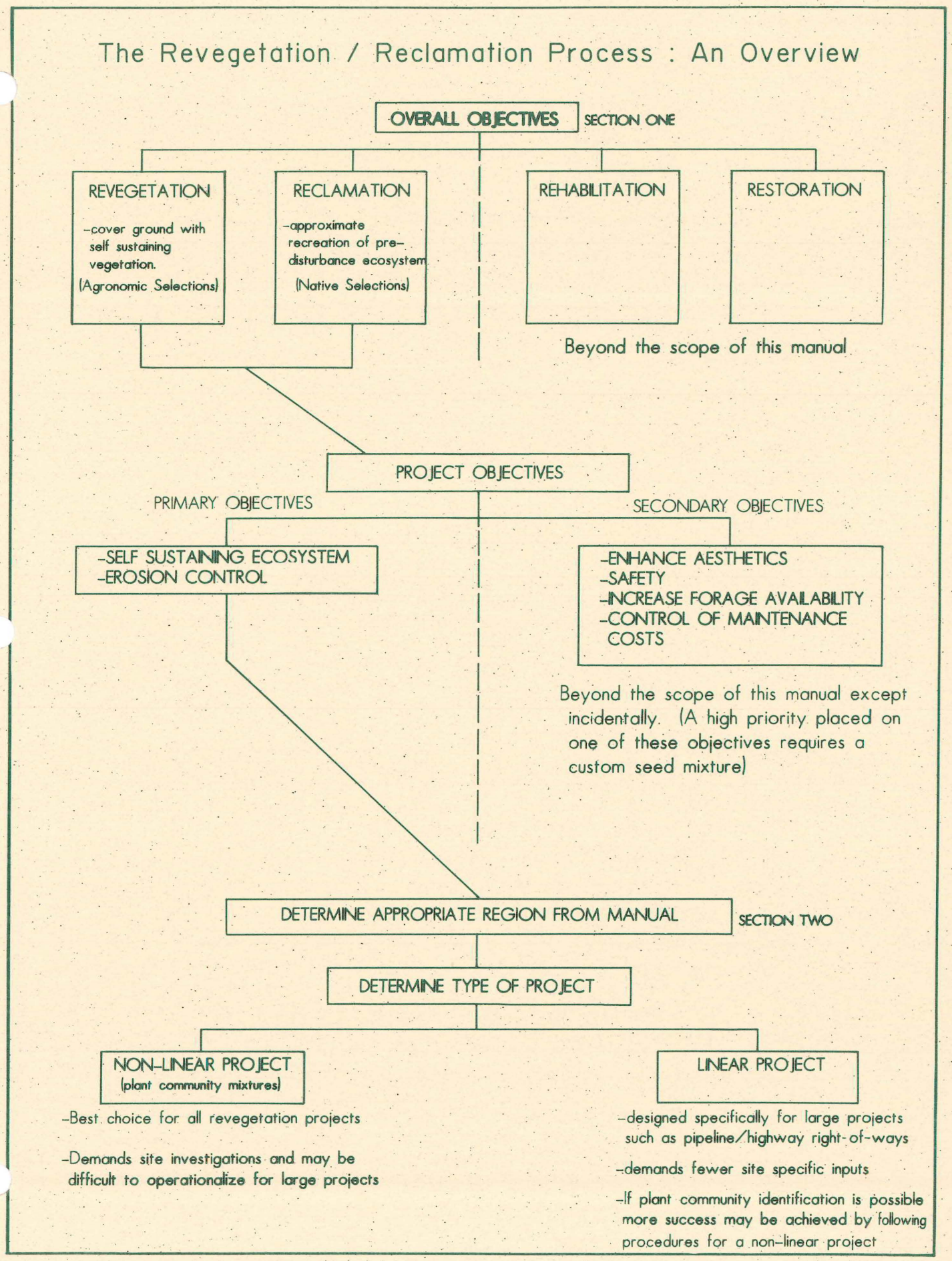


Figure 1a : The Revegetation/Reclamation Process as outlined in this manual.

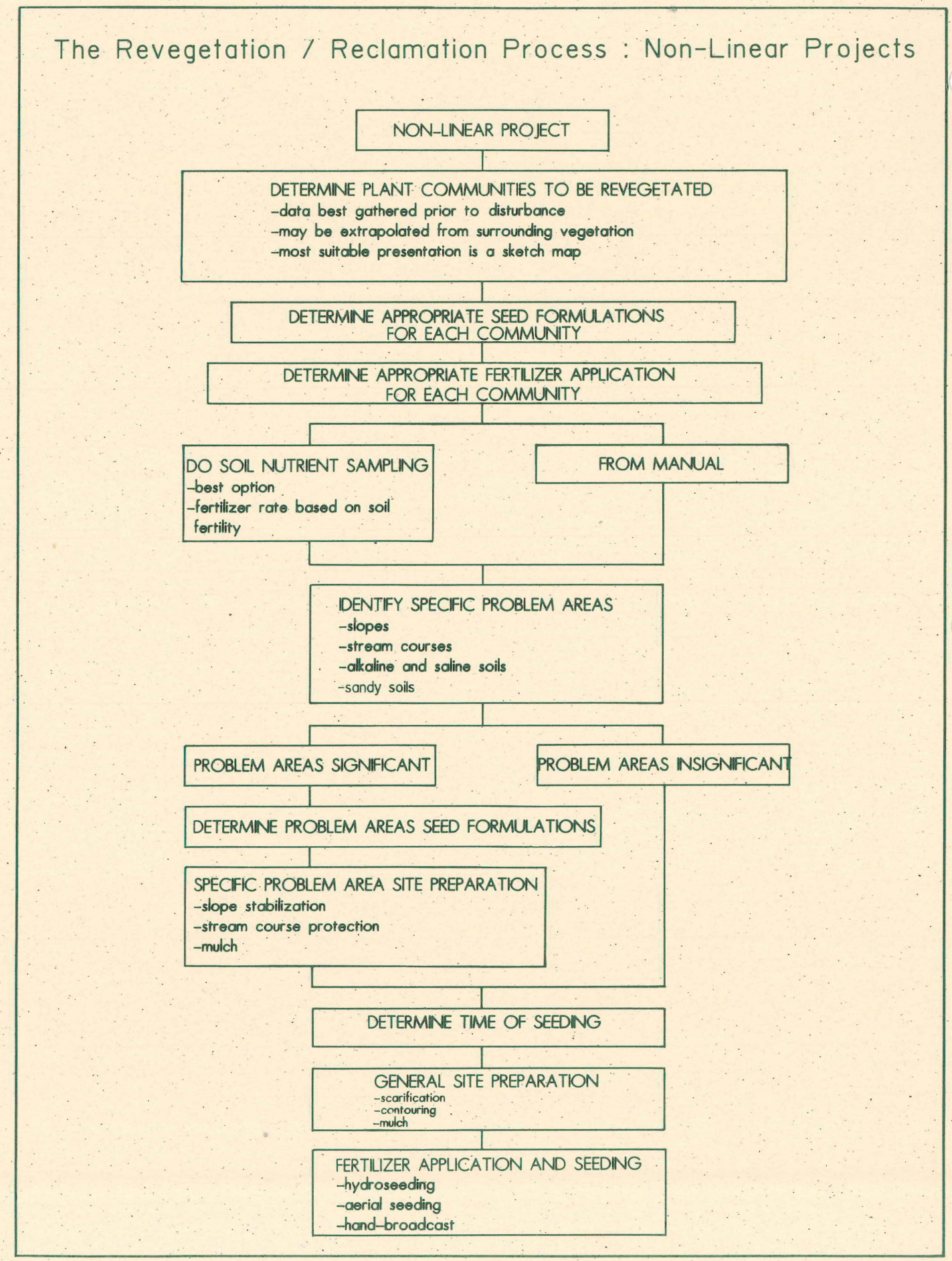


Figure 1b : The Revegetation/Reclamation Process as outlined in this manual for Non-Linear Projects.

The Revegetation / Reclamation Process : Linear Projects

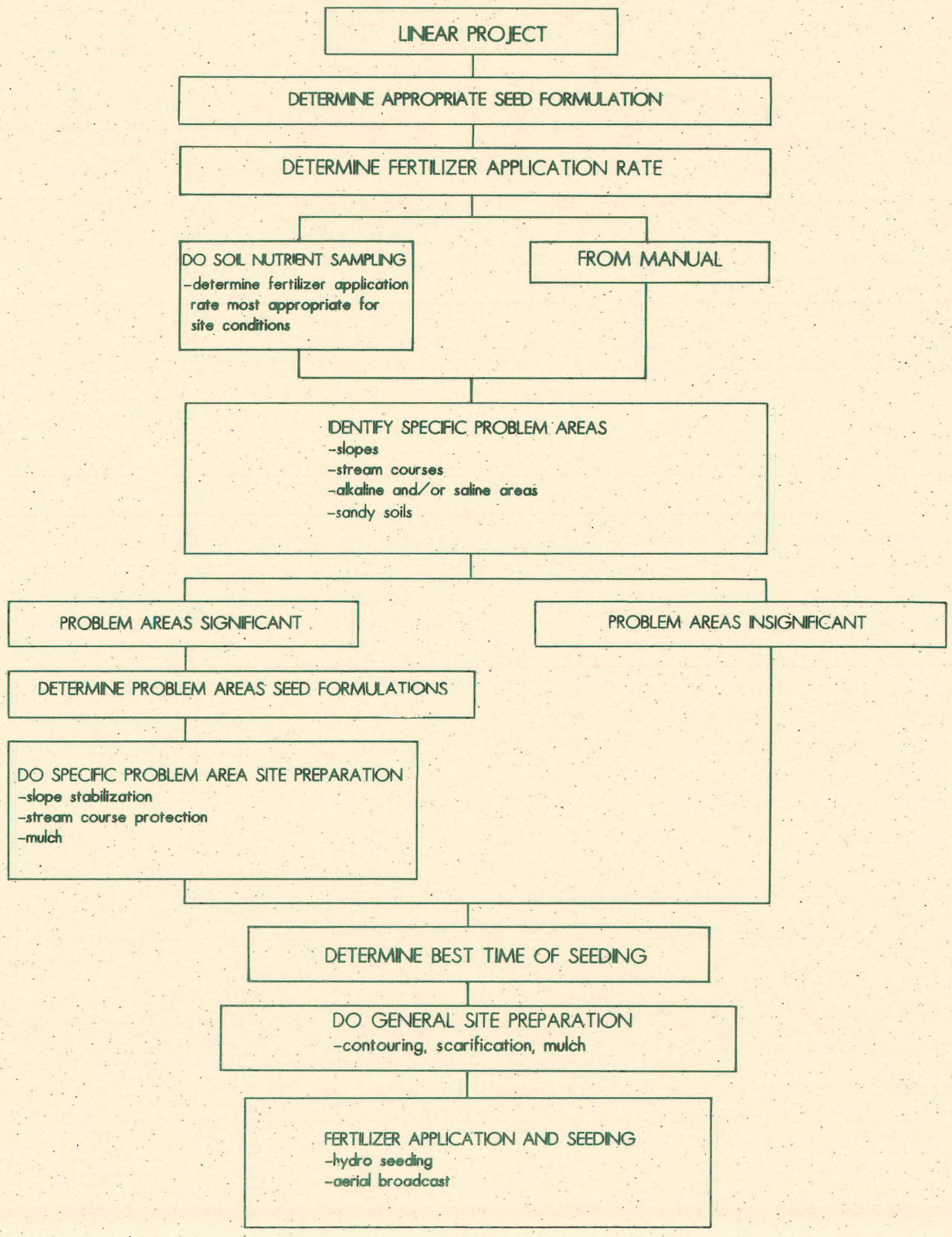


Figure 1c : The Revegetation/Reclamation Process as outlined in this manual for Linear Projects.

2.0 GENERAL REVEGETATION CONSIDERATIONS

2.1 Ecological Background of Revegetation

Construction and other human related activities result in disturbance to the physical and biotic environment. Even if disturbance is minimized, development projects will inevitably alter some components of the environment (104,105). One biological component which will be affected is the flora, as construction and other industrial activity will result in disturbance to existing vegetation.

Construction techniques that minimize disturbance to vegetation should be employed; if disturbance is unavoidable, a program of revegetation will be necessary. This may involve encouragement of secondary succession and natural colonization by invader species, or may entail artificial revegetation through reseeding and vegetative propagation. The course of action will depend upon site-specific conditions. In areas where substantial erosion or sedimentation of waterways is a potential problem, an active revegetation program should be implemented to ensure a rapid return of vascular plant cover. Similarly, in areas visible to the public, a revegetation program should be employed to improve aesthetics.

Prior to any attempt at revegetation, it is necessary to understand the chemical and physical properties of the soils which need revegetation. Information regarding the nutrient status of various soil types which support different plant communities on both disturbed and undisturbed sites is mandatory for the appropriate planning of a fertilizer program (29). The preferred growth habit of components of seed mixtures proposed for a revegetation program must be consistent with existing soil properties of the site requiring revegetation. Similarly, fertilization and other treatments, used to re-establish a plant community expected to maintain itself as part of a self-supporting ecosystem, must be compatible with the plants to be grown from the seeds in the mixture used in the program.

At present, only some selections of native Yukon stock are available for revegetation purposes. However, the development of a native seed industry is proceeding and native seed selections should be available in quantity in the next few years (103). Some Yukon native seed is presently commercially available, but the quantities are small. Thus, alternative agronomic seed specifications are presented in this manual.

Until native seed stocks are developed, the agronomic species listed under Agronomic Selections recommendations in this manual are the preferred choices. As native seed comes on line, each local selection should replace the agronomic selection(s) adjacent to it in each table. Native seed production will not proceed uniformly. Once seed of some native selections is available the optimal mixture will incorporate these selections as well as agronomic selections yet to be replaced.

Some of the seed recommendation tables include varieties developed from native species in Alaska, which are available commercially in quantity (e.g. Tundra, Arctared, Nortran).

2.2 Definitions

2.2.1 Revegetation

Revegetation can be defined as the reestablishment of vegetation on land which previously had vegetative cover. The necessity for revegetation can arise from natural events (such as fire, landslides or earthquakes) or from the activities of man.

Following a natural disturbance, the successional process may provide a fair]y rapid return of vegetative cover through natural revegetation. This can occur north of the 60th parallel in 10 years or less (30). The invader species of graminoids, forbs, and pioneering shrubs will eventually be succeeded by climax species.

In contrast, a revegetation program administered by man is usually initiated to reclaim man-made disturbance. Major causes of disturbance include highway construction, mining, logging, land development for housing and agriculture, air pollution and numerous aspects of the exploration, extraction and transport of hydrocarbons. After termination of the disturbance, the site requiring revegetation usually differs in a number of aspects from its pre-disturbance condition. Site characteristics affected include soil moisture and density, nutrient status, aeration, temperature and depth of thaw. Also affected are microrelief, microflora and the composition of the vascular plant cover (110).

Revegetation is inter-related with the processes of reclamation, rehabilitation and restoration, illustrated in Figure 1a and defined following.

2.2.2 Reclamation

Reclamation implies a return of the disturbed site to such a condition that it will again be a suitable environment for those organisms which previously inhabited the site (67). Species density and composition should be comparable to pre-disturbance conditions. However, it is generally accepted that this goal has been fulfilled if other organisms, which closely approximate the original, find the site a suitable habitat. In other words, if the replacements fill the same ecological niche, then the reclamation process has been completed in an acceptable manner (9). This concept is accepted by most environmentalists with the proviso that species native to the ecological region under consideration should be used in the reclamation process whenever possible.

Figure 1a: The Revegetation/Reclamation Process as outlined in this manual

Figure 1b: The Revegetation/Reclamation Process as outlined in this manual for non-linear projects

Figure 1c: The Revegetation/Reclamation Process as outlined in this manual for linear projects

2.2.3 Rehabilitation

Rehabilitation refers to the return of a site to a specific use previously designated in a land use plan (67). Thus, both the form and productivity of the land are predesignated prior to the reclamation process and the final land use may vary considerably from the original. However, rehabilitation does imply



that the designated land use will not result in a deterioration of the land and will be consistent with prevailing aesthetic values (9). This allows for a change in land use to the most useful option, regardless of the former use, prior to disturbance. Under these conditions, agronomists, botanists and ecologists recognize and support the concept of rehabilitation. Rehabilitation denotes alteration of land use to something other than what was the case prior to disturbance.

2.2.4 Restoration

Restoration implies that the exact conditions which prevailed at any given location prior to disturbance will be replicated after completion of the activity causing the disturbance (67). Complete restoration is seldom possible as some values are lost or altered (9). Even in semi-urban areas of Europe, where an effort is made to map each tree and rock in extensive landscape surveys and a plan is formulated for precise replacement of these and other features, the exact restoration or duplication of a site is impossible (2,108). From a practical aspect, exact restoration should only be attempted in heritage areas which contain archaeological and historical artifacts which are deemed worthy of preservation for the long-term benefit of society.

2.3 Objectives of Revegetation

2.3.1 Introduction

Objectives of revegetation can be diverse and numerous. It is necessary to assess priorities and then precisely define the objectives for any given project. If this is done, conflicting objectives can be recognized and ranked. It may become apparent that some objectives can be achieved simultaneously, but that others are nearly irreconcilable. For instance, alleviation of a serious short-term erosion problem may thwart attempts at promotion of maintenance-free long-term ecosystem recovery. This can occur if rapidly growing, but short-lived, grasses are seeded to such an extent that more stable vegetation is crowded out.

Also, it may become apparent that some goals cannot be achieved through revegetation alone, or that some revegetation techniques must be avoided because of the potential for other related difficulties. Examples include the necessity for non-vegetative techniques to stabilize steep slopes; the possibility of not seeding at the optimal time because of disturbance to wildlife at critical stages in their life cycles; or minimization of fertilizer due to possible eutrophication of water bodies (66).

2.3.2 Prioritization of Objectives by Project

It is possible to differentiate between primary and secondary objectives of revegetation in general terms. Failure to meet either of the two primary objectives means the failure of the revegetation project. The other four objectives are considered secondary because failure to meet them does not mean the failure of the revegetation project by definition.

Primary Objectives

- a return to a self-supporting ecosystem
- short and long-term erosion control

Secondary Objectives

- maintenance of the thermal regime
- enhancement of aesthetic values
- provision of forage
- reduction of maintenance costs

Each of these objectives is discussed briefly below.

2.3.3 Discussion of Objectives

A return to a self-supporting ecosystem

The return of the disturbed site to a maintenance-free self-supporting state is the ultimate goal of any revegetation or reclamation program. A revegetation program is not successful if repeated reseeding or refertilization is required to sustain a living ground cover. Touch-up work may be required, but massive reseeding or maintenance suggests inadequate planning of the initial program. Unnecessary costs will be incurred and the disturbance caused by repeated follow-up operations will retard the achievement of a self-sustaining plant community. Therefore, the planning of a revegetation program must not only address whatever short-term concerns are most important, but also must encourage long-term stabilization of a site.

Short and long-term erosion control

Erosion can cause irreparable damage to construction projects, to specific sites and to the wider environment. The utility of vegetation in reducing erosion has long been recognized throughout the world. The prevention or reduction of erosion is often the most important immediate objective of a revegetation program.

Maintenance of the thermal regime

The prevention or minimization of thermokarst is another objective of revegetation in subarctic regions which have discontinuous permafrost, which includes most of the Yukon. However, evidence from revegetation in the arctic, where permafrost is generally continuous, indicates that revegetation is unlikely to prevent thermokarst and may only aid in restoration of the thermal balance after several years (19). Prevention of wind and water-induced erosion is a reasonable goal, but immediate protection against subsidence through revegetation is unlikely (30,54). However, in the boreal forest, revegetation may minimize thermal degradation (18).

Enhancement of aesthetic values

Scenic enhancement is another objective of revegetation. Usually a vegetative cover is considered more aesthetically appealing than barren soil. Also, untended areas which are unsightly can be hidden through the planting of visual barriers of shrubs and trees. These can also act as buffers to minimize noise. In high profile tourist areas, the implementation of an attractive revegetation program can bring economic benefits to the overall community.

Provision of forage

It is possible to increase forage availability through revegetation(45,46). This may be beneficial if native species are used to improve habitat for wildlife. However, it may also prove detrimental if the revegetation program induces



wildlife or domestic animals into the vicinity of transportation corridors. In order to minimize the accident potential for wildlife, domestic livestock and humans, preferred forage species (native or agronomic) should not be seeded in the proximity of major transportation corridors. However, wildlife habitat improvement is a legitimate goal of revegetation in other specific areas.

Reduction of maintenance costs

Another objective of a revegetation program is the reduction of maintenance costs. This applies primarily to linear projects such as highway construction, pipeline construction and powerline construction. Since visibility must not be impeded, and as access is needed for maintenance purposes, the regrowth of trees or tall shrubs is undesirable. Through the use of grasses, legumes and low shrubs, tree invasion can be retarded without the use of chemical agents. Maintenance may not be completely eliminated, but reductions in long-term costs can be achieved through appropriate revegetation techniques.

3.0 THE CASE FOR NORTHERN VARIETIES

3.1 Nutrient Availability

Two of the more important factors in revegetation are the amount of nutrients in the growth medium and the availability of these nutrients to plants. The nutrient requirements of the plants must be met if revegetation is to be successful. Arctic and alpine soils, and to a lesser extent, subarctic and subalpine soils, are usually deficient in the major plant nutrients (25). The greatest problems are a lack of either nitrogen or phosphorus, or in some cases, both (29,94). Potassium is usually not a limiting factor in the Yukon (94), but soil sampling is recommended to verify this at any given location.

Availability of nutrients is governed by the amount of nutrients and the rate of nutrient cycling. The interaction of these factors determines the nutrients available to the plant (114). The nutritional status of northern soils is influenced by the low soil temperatures characteristic of the arctic and subarctic (15). Cold temperatures decrease the rate of chemical reactions and microbial metabolism within the active layer, thereby reducing important processes such as mineral weathering and organic matter decomposition, with a concomitant reduction in nutrient cycling (25). This reduction in nutrient cycling is accentuated by immobilization of other nutrients beneath the active layer (104).

Another consideration regarding nutrients is that disturbed sites which have had most of the topsoil removed, such as highway cut slopes, are likely to have lost much of the nutrient capital of the soil. In cases where the topsoil is buried beneath or is mixed with subsoil, such as highway fill slopes, strip mines or pipeline trenches, the available growth medium may also be extremely deficient in nutrients. Nutrient supply is also dependent upon soil texture, as finer textured soils usually retain more nutrients than coarse textured soils.

Evidence clearly indicates that nutrient uptake by introduced southern revegetation varieties is reduced by the low soil temperatures of the north (55,56). Although nutrient uptake by northern native species is less hampered, native plant development may be retarded to

some extent by low temperatures through a reduction in phosphorus metabolism and subsequent reduction in growth (14,15,25).

A subarctic locality that is deficient in available nutrients requires application of a complete fertilizer. Limited soil nutrient information is currently available for northern conditions (16,80,81); nutrient information obtained from undisturbed sites may not be applicable to disturbed sites (2,94). The amount of increased growth which can be achieved from incremental rates of each nutrient cannot be extrapolated from southern studies as northern plant physiology may differ from that found in plants of temperate regions.

3.2 Plant Survival

Winter kill is often a problem in northern revegetation. The major causes of injury or death through low temperature stress are direct low temperature kill, winter desiccation or the presence of low temperature pathogenic microorganisms. Under low temperatures, intra- or extra-cellular ice crystals may be formed. Intra-cellular crystals can cause mechanical disruption of the protoplasm tissue and subsequent seedling mortality. If extra-cellular ice formation continues for sufficient time, desiccation of the protoplasm can occur. As the protoplasm is dehydrated, it becomes brittle and can be subject to tension which results in mechanical damage (3,78). Plant mortality can also occur through the activity of pathogens such as the northern snow mold fungus *(Sclerotinia borealis)* which can survive very low temperatures (90), and which is active at relatively mild temperatures (-5 deg. Celsius) under snow cover.

Plants have adapted physiologically and morphologically to the extreme climate to which they are subjected (4,5). They have acquired both summer and winter cold hardiness to cope with outbreaks of frost during the growing season and the extremely low winter temperatures. Many native plants combat snow abrasion and desiccation by adopting low growth forms such as rosettes or cushions. They frequently grow in depressions where snow can accumulate to protect them (38,78).

Northern plants normally have a high ratio of belowground to aboveground biomass (20). This increases their survival potential because many disturbances, such as light fires or grazing, may only remove aboveground organs. The extensive underground system also contributes to their survival through vegetative reproduction. Many arctic plants, and to a somewhat lesser degree, subarctic plants, rely heavily upon vegetative reproduction (16). Thus, vegetative cover can be reestablished from root propagules remaining in the soil after disturbance (95).

Regeneration from underground parts can be especially relevant in revegetation of subarctic areas. By use of construction techniques in which above ground vegetation is only bladed off and grubbing is kept to a minimum, revegetation success can be greatly enhanced. In addition to rhizomatous grasses, shrubs such as willow *(Salix* spp.*)* and soapberry *(Shepherdia canadensis)* can regenerate from undisturbed root stalks after termination of the disturbance.



While natural shrub regeneration can greatly enhance the success of a revegetation project, introduction of shrub cuttings as part of the revegetation program is labour intensive and not required under most circumstances.

3.3 Choice of Species

3.3.1 Definition of Introduced and Native Species

One of the major focal points in the discussion of northern revegetation is the merit of native species versus introduced species. Introduced species are those that do not occur in the undisturbed vegetation communities of a region. Native species are those that occur in undisturbed communities in a specific region.

In the revegetation context, the comparative merit of introduced and native species are frequently discussed. Varieties (or cultivars) are plants that have been cultivated for the specific purpose of fixing desirable traits, such as high yield, drought hardiness and pest resistance. Varieties are the product of a breeding program and are licensed. Common seed, the other possibility for revegetation programs, is seed of a particular species and does not have the same rigorous standards applied to it.

However, in reality, these general definitions are of limited use. Some species that are frequently considered native may have been introduced by man at an earlier date or may have migrated from other regions. For instance, most botanists concur that Kentucky bluegrass *(Poa pratensis)* is not native to North America. It has been a component of the flora for so long, however, that it is called a naturalized landrace and where adapted, responds in the manner of true native species (21).

Other introduced species are already present in the subarctic as forage or turf species. Thus, their use will not create new problems, even though they are inappropriate if restoration is the goal. In addition, there are agronomic varieties, such as Drylander alfalfa *(Medicago sativa x Medicago falcata)*, which are hybrids between two introduced species. Other agronomic varieties such as Polar brome *(Bromus inermis x Bromus Pumpellianus)* are hybrids between an introduced and a native species (33).

Such semantic problems are best left to theoretical botanists and ecologists. In the following sections "native" will refer to selections from northern populations for which commercial agronomic varieties and extensive seed supplies have yet to be developed.

3.3.2 Relative Merits of Introduced and Native Species for Northern Revegetation

The use of introduced species in northern revegetation work has both advantages and disadvantages. Until recently, most species used in northern revegetation programs have been agronomic varieties developed and studied in the south for many years. Consequently, there is considerable information in the literature regarding fertilizer requirements, germination percentage, disease resistance, seed production and winter survival capacity of these varieties under southern conditions. Plant breeding, whether through selection or hybridization, has been directed towards the retention or elimination of specific traits desirable in revegetation

(17,107). In this manner, varieties which will be successful under certain conditions have been developed. This increases the likelihood of success of particular varieties on certain types of sites, but may reduce the range of conditions under which the variety can be grown. By contrast, seed from native selections may be adapted to a broader range of environmental conditions.

Commercial seed supplies are readily available for numerous agronomic varieties. Large amounts of seed are available for most varieties developed in southern Canada or the continental United States and varying amounts of seed are available for northern varieties developed in Alaska. (The symbol (+) used throughout the seed specification tables in reference to variety, indicates varieties developed in Alaska.) Consequently, although native seed may be desired and preferred for northern reclamation projects, it may be necessary to use agronomic seed until suitable native seed becomes available.

Unfortunately, most southern agronomic varieties have not persisted in the north (10,65,98,113). These varieties were usually developed under optimum nutrient conditions, prior to acceptance as licensed varieties. In order for these agronomics to achieve long-term success under the nutrient-limited conditions typical in the Yukon, refertilization may be required(22). Conversely, fertilization may also increase the chances of winter kill and snow mold damage (58,62).

Revegetation trials north of the 60th parallel have consistently indicated that agronomic varieties developed in more southerly regions fare poorly in the north (97,98,100). Ground cover production is intermittent and decreases from south to north (27,28). Even if success is attained in the year of seeding, cover usually decreases after a few years and many varieties die within three years (10,18,100,113). This has been the case in the attempt at revegetation of the Alaska Highway right-of-way in the vicinity of Whitehorse during the early 1980's.

Agronomic varieties developed from northern native species will surmount most of these problems, especially if their latitudinal provenance is comparable to the latitude of the site where they are to be used for revegetation (49,51,53,87).

It is important to note that the ground cover of native varieties may appear sparse in the initial years of establishment, (despite their superior long-term survival rate) by comparison to southern agronomics, which often emerge lush and green in the year of planting, but subsequently die off.

If seed is imported into the north there is the potential for accidental introduction of an undesirable species into a new habitat. A good example in the Yukon is the introduction of foxtail barley *(Hordeum jubatum)*. Contaminated seed lots can lead to the introduction and establishment of new weedy species. Such establishment does not appear likely in the harsh climate of the northern Yukon, but is conceivable in the southern boreal forest area (48). Prevention of such an occurrence is one of the reasons for insistence on the use of native seeds in national parks. Other potential problems associated with the use of southern agronomic varieties include unwanted forage production on



roadsides and visual incongruity, as some introductions may not blend in with the surrounding landscape.

These potential problems indicate that there should be renewed energy in developing agronomic varieties and commercial seed supplies of native Yukon northern grasses and legumes. The development of a licensed agronomic variety is a lengthy process. It is more practical to meet short term needs by developing seed supplies of northern selections which have proven successful in revegetation trials in the north (102). Many traits in licensed agronomic varieties which are useful in the south are irrelevant to northern revegetation, where the main priority is plant survival with a minimum of maintenance. The quantity of seed produced from northern selections varies between species (59,61,63,91,92). Some species pose major difficulties for seed production in significant quantities (44,48,50,111), but others produce large amounts of seed very readily (32,34,101). However, if insufficient multiplication of native seed has occurred at the time the seed is required for a northern project, then judicious substitution of agronomic varieties will be necessary. The seed recommendations found in Section Two of these guide-lines include both agronomic varieties and the preferred native seed selections. As native seeds become commercially available, they will replace the temporary agronomic varieties.

3.4 Seed Mixture Formulation

The composition of seed mixtures used in revegetation is dependent upon the characteristics of each site to be revegetated. Appropriate mixtures of seeds are then selected which will best germinate and flourish under the site conditions. The parameters considered in preparation of the seed mixtures are shown in Table 1. Appendix A indicates the relevant traits considered for each species included in the seed mixtures. The species, and percentage by weight of each, were selected on the basis of their morphological and phenological characteristics. Adaptability to various edaphic and climatic conditions was also considered. Other considerations included the results of field trials carried out in the north (97,104) and the seed production potential of the native species listed in the seed mixture recommendations (91,92).

The seed mixtures were formulated by combining species which have diverse growth habits and which have differing tolerances to various microenvironmental problems. Each mixture includes selections which are adapted to the widest range of potential microenvironments. This offers the greatest possibility of success, as a vegetative cover more tolerant of pathogens, edaphic conditions and climatic extremes will be established.

The agronomic selections mixtures contain more seed by weight per hectare than the native selections mixtures recommended for use. The lesser quantity of native seed required reflects the higher long-term survival percentage of adapted native species in the Yukon (10,100).

The species are not listed in order of priority as all are useful in each mixture If a native selection is unavailable, then the agronomic selection adjacent to it in each table should be used. If seed of any agronomic variety is unavailable, common seed of that species is the preferred alternative. If that also is unavailable, then the species should be omitted and the other selections in the mixture should be increased proportionately.

Table 1: Species characteristics considered in formulation of seed mixture recommendations

PLANT CHARACTERISTIC	DESIRABLE FEATURES
Gross morphology	• growth habit: low, bunch • rhizomatous • low fire hazard potential • extensive ground cover production
Growth characteristics	• high root to shoot ratio • rapid emergence • early spring growth • late summer growth • strong competitive ability
Adaptation to different soils	• tolerance of low nutrient levels • tolerance of alkaline soils • tolerance of saline soils • tolerance of organic soils • tolerance of permafrost • tolerance of wet soils • tolerance of acid soils
Other parameters	• tolerance of drought • tolerance of high altitudes • resistance to northern diseases



4.0 SITE CONDITIONS AND PREPARATION

4.1 Overview of Site Considerations

There is a wide range in the favourability of sites for seed germination and seedling survival. This results in considerable differences in the success of both human-assisted and natural revegetation.

Biotic factors which affect vegetation establishment include soil, climate and moisture. Abiotic factors are equally important. Topography will influence revegetation success; small differences in elevation, slope and aspect can create important microclimatic changes affecting soil moisture availability and soil thermal regimes (5,11).

4.1.1 Climate and Microclimates

Climate of the Yukon generally increases in severity from the boreal forest latitudes to the arctic (70). Availability of moisture during the growing season is a major concern, particularly for successful revegetation of drier regions such as the south-central Yukon. Lack of moisture can greatly reduce seed germination and emergence of seedlings in any given year (96) .

4.1.2 Soil Conditions

The type and condition of the substrata after the termination of disturbance will determine the soil moisture, aeration and amount of nutrients available for the new stand of vegetation. Possible growth media include organic, gravel, sand, silt or clay soils; topsoil and subsoil may be intermixed. The substrate may possess some favourable soil properties but may be deficient in others required for subsequent plant development and growth. For example, nutrient requirements may be met but moisture retention may be insufficient. Also, excessive slash debris can reduce plant emergence and establishment to inadequate levels (99).

4.1.3 Thermal Regime

The thermal regime at a site can substantially affect successful revegetation. Arctic and alpine sites are within the continuous permafrost zone while subarctic and subalpine regions are characterized by discontinuous permafrost. The northern Yukon is generally underlain by continuous permafrost, whereas in the southern Yukon, it is discontinuous (70). The presence of permafrost serves to maintain low soil temperatures which retards root growth and affects the availability of nutrients.

4.2 Surface Preparation

4.2.1 Introduction

The amount and type of surface preparation required for successful revegetation is dependent upon construction procedures, topography, climate and soil properties. Proper surface preparation will enhance the prospects of success in any revegetation program and may also increase natural revegetation, resulting in lower seed and fertilizer costs. Mulch can be an invaluable surface preparation procedure for insuring a good catch on steep slopes or dry southern exposures.

4.2.2 Level Sites

Areas which are relatively level will require a minimum of preparation prior to seeding. In level areas with a mesic (i.e. moderate) moisture regime, surface preparation can be omitted except where heavy machinery has extensively compacted the soil. A light scarification will suffice to loosen the soil adequately in order to provide a suitable medium for germination and emergence.

On xeric (i.e. dry) sites, more preparation will be required to loosen the soil and provide furrows for water conservation. The most satisfactory method of creating micro-sites favourable for germination is a discing of the compacted material to a depth of 5cm. This will result in germination in the tiny furrows and subsequent plant expansion to the ridges. In xeric areas, rolling and compaction of the soil to gain a level surface should be minimized as this will reduce water conservation possibilities (109). The use of machinery such as rippers, chisel plows, gougers and land imprinters will only be required if large-scale reclamation (e.g. mine site) is undertaken in arid regions where moisture conservation is a prime requisite.

4.2.3 Slopes

More extensive surface preparation will be required on slopes and stream crossing approaches. Physical erosion control structures may be necessary to initially stabilize the slopes. Cut and fill slopes may require berms, water diversion dikes, slope drains or riprap to minimize immediate erosion (89). Roadside ditches may require check dams, sediment traps, straw bale filters, riprap or available rubble to reduce water velocity (89).



Photo by C.E. Kennedy

Figure 2

A terraced cutback along a highway right-of-way, designed to resist erosion and enhance revegetation through improved moisture and soil retention.

Subsequent to stabilization, furrows should be created horizontally across the slope. The depth of these furrows should vary from 5cm on gentle slopes to around 30cm in a stair-step benching technique used on steep, highly erodible slopes. The stair-step grading technique should be used on all slopes exceeding 27 degrees (2:1). Slopes should not be steeper than 33 degrees (1.5:1) as estimated maintenance costs rise drastically with steeper slopes and vegetation can be established more easily on shallow slopes (109). In order to minimize soil loss prior to emergence of the seeded ground cover, all slopes must be treated on a site-specific basis.

4.2.4 Stream Crossings

At stream crossings, compaction of soil may be necessary to minimize siltation of waterways and consequent damage to fish populations. However, this should only be done if clearly necessary, as excessive compaction will inhibit water infiltration and root development (109). A wide variety of physical erosion control techniques may be required to minimize soil loss prior to revegetation. These include the use of construction dikes, cofferdams, temporary culverts, rock liners, riprap and temporary stream channel changes (89). Stream crossings must also be treated on a site-specific basis.

4.3 Mulch and Other Treatments

4.3.1 Definition of Mulch

Mulch is a covering for the ground that creates conditions that enhance the survival potential of the plants planted beneath it. Mulches may be inorganic

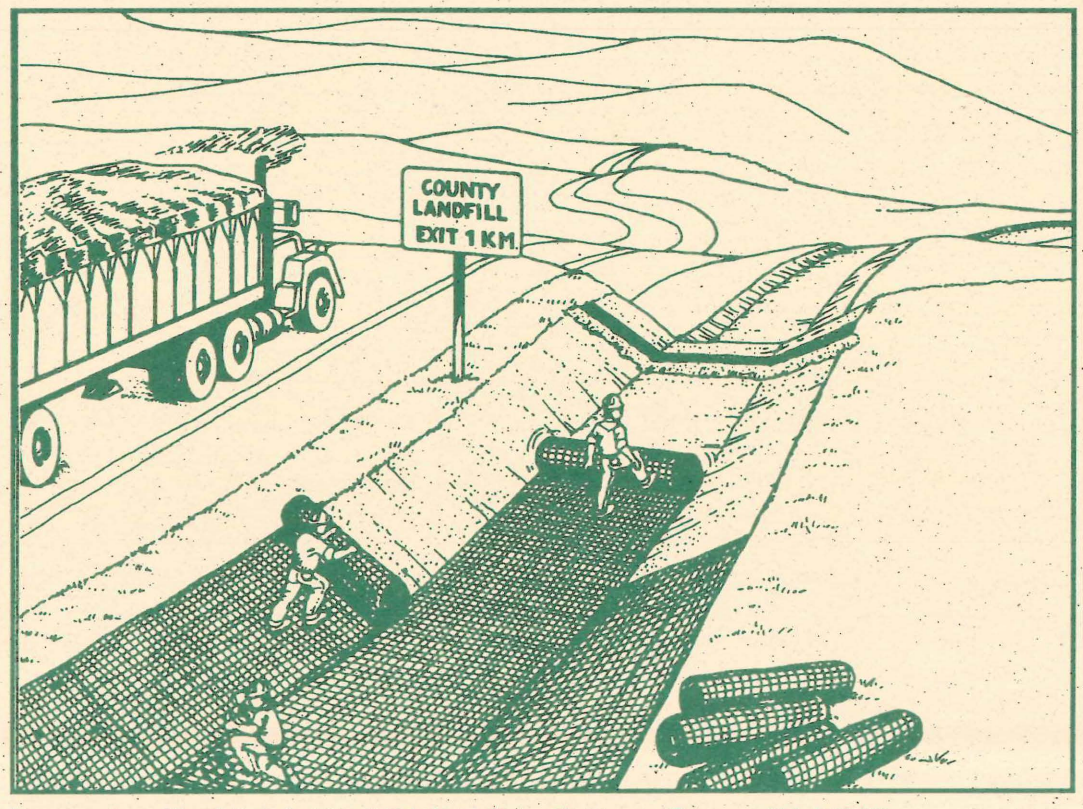


Figure courtesy of Synthetic Industries, 4019 Industry Drive, Chattanooga, Tennessee, U.S.A. 37416

Figure 3

The installation of erosion mats in ditches prior to seeding serves to reinforce turf establishment and reduce erosion.

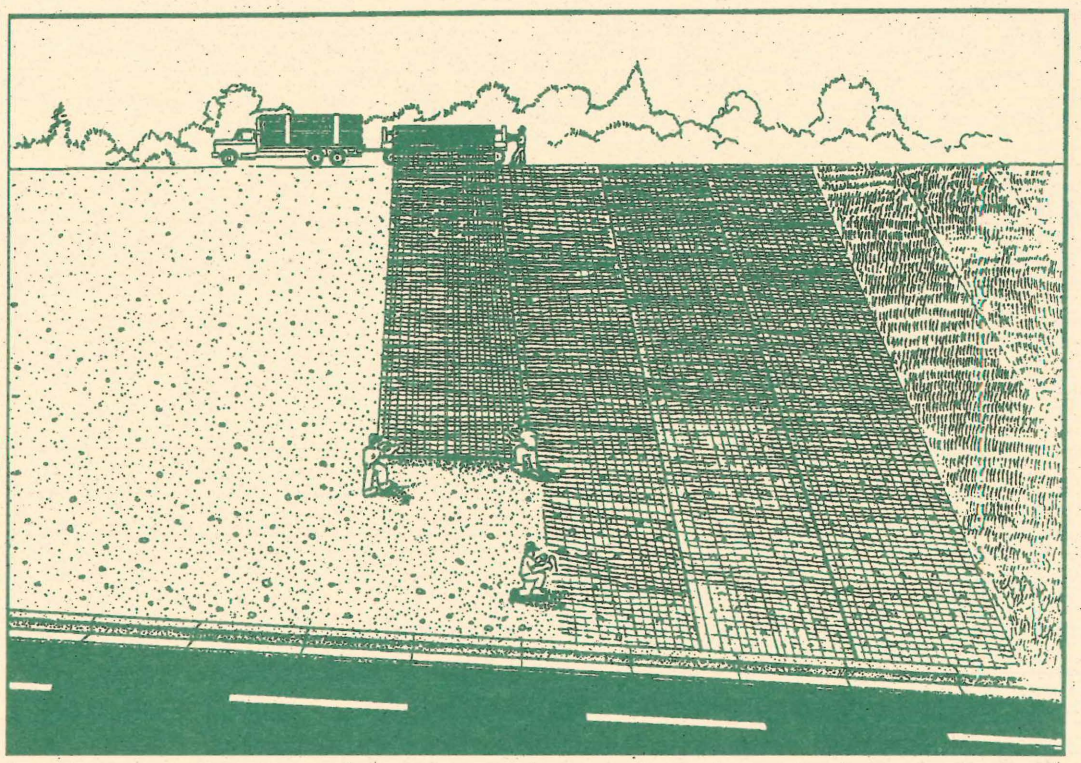


Figure 4

A flexible, woven geotextile erosion control mesh can be installed on the soil surface to hold seeds and soil in place on slopes until vegetation is established. These biodegradable materials protect the soil surface from water and wind erosion while offering partial shading and heat storage to accelerate vegetative development.

Figure courtesy of Synthetic Industries, 4019 Industry Drive, Chattanooga, Tennessee, U.S.A. 37416

materials such as plastic or carpeting, or they may be organic, consisting of leaves, seaweed, straw or sawdust. Although inorganic mulches have the advantage of warming the soil, organic mulches are more appropriate for revegetation work.

4.3.2 Uses of Mulch

Despite the potential benefits of mulch, a good catch can be established in most parts of the Yukon without the use of a mulch (97). Mulch will serve to minimize soil loss from water and wind erosion, enhance seed germination, and assist in retention of seed in place (40,41). Also, soil moisture will be conserved and surface soil temperatures will fluctuate less with the addition of a mulch.

On less favourable sites, the addition of a mulch is important, and can be critical to the success of the revegetation program.

Sites which benefit from the use of mulch are those in xeric regions which have either low moisture retention capacity or low precipitation during the growing season (96,97), nearly all steep or unstable slopes (109) and sections of the subalpine or alpine (12). Most of the south-central Yukon addressed in these guide-lines has sites which fall into one or more of these categories.

All slopes greater than 27 degrees (2:1) should be mulched. Slopes exceeding 18 degrees (3:1) which have a southern aspect should also be mulched as moisture retention is significantly lower on south facing slopes (5). Other slopes should be assessed on a site-specific basis.



If the reclamation program is planned prior to the initiation of disturbance, then a useful mulch can be obtained by stockpiling and subsequently replacing the organic layer removed in construction. This procedure also conserves the nutrients concentrated in the surface soil layers. If this is not done, then the optimal alternative is the use of hay or straw. These mulches can be applied with a straw blower after seeding and fertilization, at an approximate rate of 3000kg/ha (12,109). The mulch can be held in place with any of several commercially available organic tackifiers (40,41).



Figure 5

Immediately after seeding, hay (e.g. from grass grown locally) is applied with a straw blower and sprayed over with an organic tack mulch. This process enhances germination through improved moisture and soil retention.

Photo courtesy of Central Fiber Corporation, 4814 Fiber Lane, Wellsville, Kansas U.S.A. 66092

A less desirable, but frequently more practical approach, is the inclusion of the mulch material in the slurry of the hydroseeder. In this instance the mulch consists of wood cellulose fibre. Numerous suitable products are on the market, including the Weyerhauser and Conwed hydromulches (40,41).

4.4 Time of Seeding

The optimal time for seeding will vary, depending upon the time of termination of the disturbance. In non-xeric regions, the preferred time of seeding is early spring, but if construction is completed in late fall, then fall seeding can be employed to gain the benefits of snow melt in the spring (99). Similarly, in xeric regions which are to be mulched (see 4.3), early spring or fall seeding can be used.

In xeric regions which will not be mulched, snow seeding is the method of choice. The amount of snow cover, at the time of seeding, should not exceed 10 cm as germination can be greatly reduced with higher levels of snow (96). If this is not convenient, then spring or fall seeding is recommended; however, considerable touch-up seeding may be required in the future.

Summer seeding should be avoided except in high profile areas and sites of high erosion potential, which require immediate treatment. Such areas can be seeded in summer but will often need follow-up seeding the next spring.

4.5 Methods of Seeding

Successful revegetation may require the use of a variety of seeding methods, depending upon the terrain and amount of area to be seeded. Seeds are planted either by drill seeding or by broadcast seeding.

Different types of broadcast seeding (including aerial seeding, hydroseeding and ground cyclone seeding) are generally the

most practical methods for northern revegetation. Broadcast seeding is the scattering of seed onto the soil surface. The seed may or may not be covered in a subsequent operation.

Drill seeding involves the dropping of seed from a seeder into holes or furrows and then covering the seed with soil.

4.5.1 Broadcast Seeding

4.5.1.1 Aerial Seeding

For lengthy linear projects, such as pipeline or powerline seeding, where access is difficult, aerial seeding is the method of choice. Either helicopters or fixed wing aircraft can be used if proper landing and loading sites are available (35). This is less of a problem if the more costly helicopters are used. Other constraints to aerial seeding include inclement flying weather and crosswinds exceeding five miles per hour. The latter hamper accurate seed placement (35). Also, caution should be taken with aerial seeding to avoid disturbance to wildlife during critical periods in their life cycle. Wildlife biologists or other locally experienced personnel should be consulted if aerial seeding is contemplated.

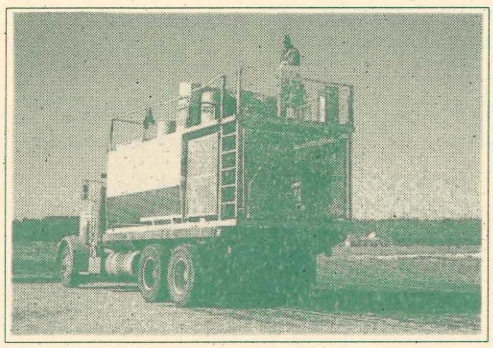


Figure 6

Seed, fertilizer, and mulch may be applied with a hydroseeder in one operation.

Photo courtesy of Granite Seed, 1697 West 2100 North, P.O. Box 177, Lehi, Utah, U.S.A. 84043

4.5.1.2 Hydroseeding

Hydroseeding consists of the application of seed, fertilizer and soil amendments, such as a mulch, in one operation. The tank containing the slurry is mounted on either a trailer or truck frame. From this base, it is possible to cover distances of up to 60 metres. The operator controls spray pressure, volume and direction. Hydroseeders can be operated when stationary or moving (68). For highway seeding, the use of a hydroseeder is the optimal method. Hydroseeding can also be useful on large mine sites. The major drawbacks to hydroseeding are the cost, the need for large quantities of water and the need for ground access to the site.

4.5.1.3 Cyclone Seeding

Cyclone seeding consists of broadcasting seed and fertilizer from rotary spreaders. The spreaders may be mounted on all-terrain vehicles, tractors or other vehicles, or may be hand operated for spot treatment (68). In the latter case it is preferable to cover the area twice - first with the fertilizer and then with the seed. Mixing the seed and fertilizer into the seeder may often be successful but differences in weight can lead to a spotty catch which would require follow-up work once this became apparent.

In non-linear projects, such as mine reclamation or revegetation of smaller disturbed areas such as borrow pits, the choice of methodology is largely dependent upon equipment access and convenience. For large mine operations a hydroseeder is the most practical implement but vehicle



Figure 7

A packstrap style cyclone seeder may be used for manually seeding smaller sites which are inaccessible to a hydroseeder.

Photo courtesy of Granite Seed, 1697 West 2100 North, P.O. Box 177, Lehi, Utah, U.S.A. 84043

mounted cyclone seeders may also be utilized. For smaller sites, such as borrow pits which are inaccessible to a hydroseeder, manual cyclone seeding is the most practical method (104). Manual cyclone seeding can also be used around campgrounds, subdivisions or other urban projects. The major limitation to cyclone seeding is the lack of precision in seed placement.

4.5.1.4 Slope Seeding

Slopes which have a high erodibility potential must be treated as a separate issue. If not tackled correctly the first time, they will require repeated follow-up work. After physical slope stabilization and surface preparation have been completed, nearly all major slopes will require the application of a mulch to retain the seed in place and improve germination. All slopes exceeding 27 degrees (2:1) should receive a mulch. Slopes having a southern aspect, which exceed 18 degrees (3:1), should also be mulched to aid in moisture retention. If machine access is possible, hydroseeding is the method of choice. This method minimizes foot traffic and potential destabilization of the slope. However, if the area is too confined to allow hydroseeder access, then ground cyclone seeding must be used and the mulch applied after the seed and fertilizer are in place.

Establishment of permanent ground cover on steep slopes is often the major difficulty in reclamation. All aspects of the reclamation process, including method of seeding, must be assessed on a site-specific basis.

4.5.2 Drill Seeding

Drill seeding is the optimal method of seeding where feasible. Advantages of drill seeding include covering the seed to a correct depth, more uniform distribution of seed and better control of the seeding rate. Also, the higher germination rate and seedling emergence associated with drill seeding allow for lower seeding rates. Slightly modified commercially available grain drills can be used for seeding on relatively smooth, brush-free sites (42). Rangeland drill seeders are better adapted for rough terrain having rocky and hard soils, but heavy brush stems will cause damage and should be removed prior to seeding (1). Other equipment, such as the cultipacker-seeder or Brillion drill, can be used on level areas where compaction is necessary (75).

Despite the benefits, current applications of drill seeding in the Yukon are limited to forage crop seeding. Practical difficulties minimize the usefulness of drill seeding in northern reclamation. In particular, the rough terrain makes even the sturdiest of drill seeders inadequate for northern reclamation. If large-scale mine reclamation on level, rock-free land is undertaken, then the use of drill seeding will be appropriate.

4.6 Rate of Seeding

Two critical factors to consider in determining the seeding rate required for successful revegetation are method of seeding and the percentage of live seed of each selection or variety in the seed mixture.

The seed recommendations in this manual are written for broadcast seeding programs, which include hydroseeding. If drill seeding methods are used, the seed quantities should be reduced by one half.

Secondly, the seed quantities recommended in this manual are based on 90 to 95 percent live seed. The percentage of live seed takes into account both the percent germination and the percent purity of the seed, information which is available from the seed supplier. To calculate the percentage of live seed, multiply the percent germination by the percent purity. The quantity of seed to be applied may have to be adjusted if the percent live seed obtained varies significantly from that assumed in the seed recommendations.

In the seed mixture tables, it will be noted that the total weight (i.e. kilograms per hectare) of native seed recommended is always less than the total weight of agronomic seed. This is because a greater quantity of agronomic seed is required to ensure an adequate catch, compared to native seed, which has a higher probability of long-term success in northern environments.

4. 7 Fertilization

4.7.1 Nutrient Testing

4.7.1.1 General Considerations

It is strongly recommended that soil nutrient testing be incorporated into any revegetation methodology.

Nutrient testing is the only way to insure that the fertilizer applied is neither more nor less than is required on the site. Excessive fertilizer application can be detrimental to plant growth and may pollute nearby water sources. Nutrient testing is also required if a custom seed formulation is desired. Knowledge of the available nutrients increases the options available to the revegetation plan.

There are some disturbed sites (such as tailings piles at abandoned mines) where soil nutrient testing is absolutely prerequisite to a successful revegetation program. These sites may be contaminated with toxic substances in addition to exhibiting deficiencies in major and micro soil nutrients.

Soil testing is a chemical method for estimating the nutrient-supplying power of the soil (86). The soil test gives information on the quantity available of the major plant nutrients. Primary nutrients are nitrogen (N), phosphorus (P), potassium (K) and sulphur (S). Micronutrient testing is also available, if desired. Soil test results indicate the amount of nutrient available in parts per million or as a class estimate such as very low, low, moderate, high and very high.

The presence of nutrients in the soil is only one part of the fertility equation. Other factors include the variation in plant nutrient requirements and the rate of nutrient uptake by specific plant species. The fertilizer recommendation, therefore, must match the soil nutrient availability with the needs of the plants used in the program.



4.7.1.2 Soil Sampling Procedures

The objective of soil testing is to obtain a value for the plant-available nutrients present in the soil. This determines the amount of nutrient needed to supplement the supply in the soil (86). The sample obtained must be an accurate estimate or representative of the overall soil fertility conditions in the area tested.

To ensure representativeness the sample must be taken from a relatively homogeneous area and the sample points within this area must be random (Figure 8c). This stratified random technique partitions the area to be sampled according to important soil characteristics such as drainage, texture, slope and, in agricultural situations, cropping history.

In the revegetation situation, the plant communities growing on the area to be seeded can be considered a rough analog to cropping history. If you are using the plant community seed recommendations, soil testing for nutrients should also be on a plant community basis. If your revegetation project is a linear right of way where plant communities are not the basis of your revegetation strategy, sampling areas should be developed based on homogeneous soil characteristics.

Approximately one dozen samples in the 0-15 cm. range and the 16-30 cm. range should be taken (total of 24 samples). Samples must be taken from every part of the sampling unit and all the samples from each depth range should be combined into one sample for submission to the soil testing laboratory. The total weight of soil sample required by the lab is 0.5 kilogram.

Only a small amount of soil is required from each sample point. A soil probe (such as the one illustrated in Figure 8a), is a very economical and efficient soil sampler for finer textured soils. Coarse textured or stoney soils require sampling by shovel (Figure 8b). Place a wedge of soil on the shovel that can be separated into 0-15 and 16-30 cm. sub-samples. This procedure is not precise, but, if care is taken, a representative sample can be obtained.

4.7.2 Fertilizer Formulation

At the present time, a myriad of fertilizer recommendations is available for northern reclamation. All have some merit and will enhance the nutrient base available for seedlings. However, none published to date are designed specifically for the Yukon. Calibration of plant response to incremental increases of the various nutrients has not been undertaken in the Yukon.

Optimal results in revegetation trials along the Alaska highway were obtained with a mixture of triple superphosphate and urea (96,97). Good results were also obtained along the Dempster Highway with 16-20-0 commercial fertilizer (98,100). If a potassium deficiency is indicated through soil analysis, then potassium, in the form of potassium sulphate, should be added to the above fertilizers. If rapid greening is required for high profile areas, then ammonium nitrate may be added. This is optional and has not been included in any specific recommendation. Saline areas will benefit from the addition of ammonium sulphate.

If the fertilizer recommendations in the manual are adopted without site specific soil analyses, the user should he cautioned that the recommendations are based on some overall assumptions regarding the status of major and micro nutrients on a

Figure 8a: Soil Probe

A soil probe is an efficient and economical soil sampler for finer textured soils.

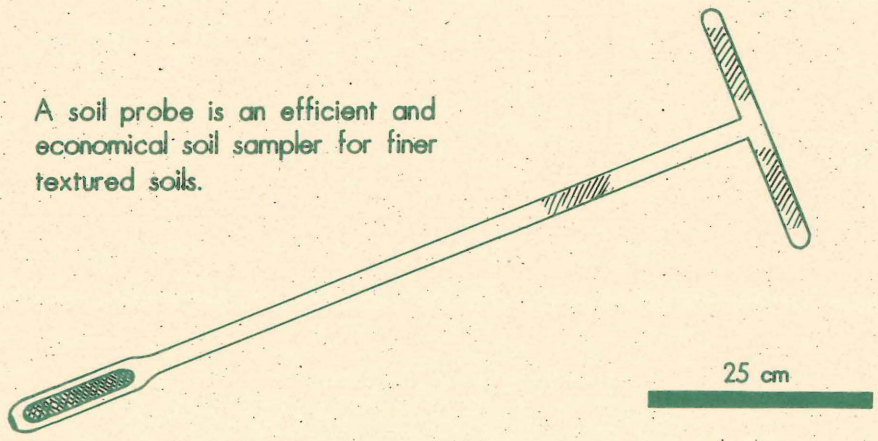
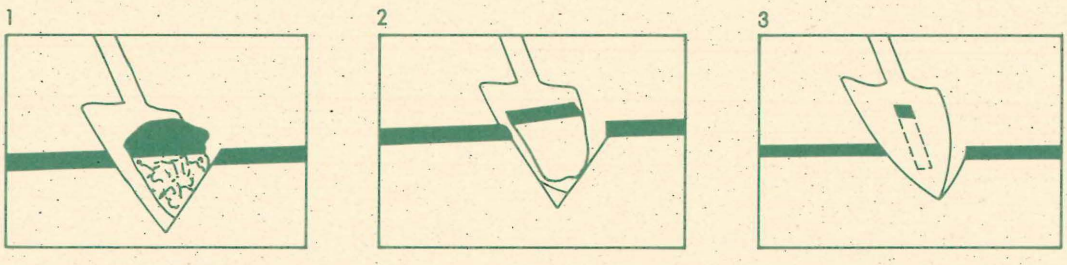


Figure 8b : Soil Sampling with a Shovel



– dig shovel full of soil and set to the side

– take 2.5cm slice with shovel

– use knife to cut a 2.5cm core

Figure 8c : Distribution of Sample Points

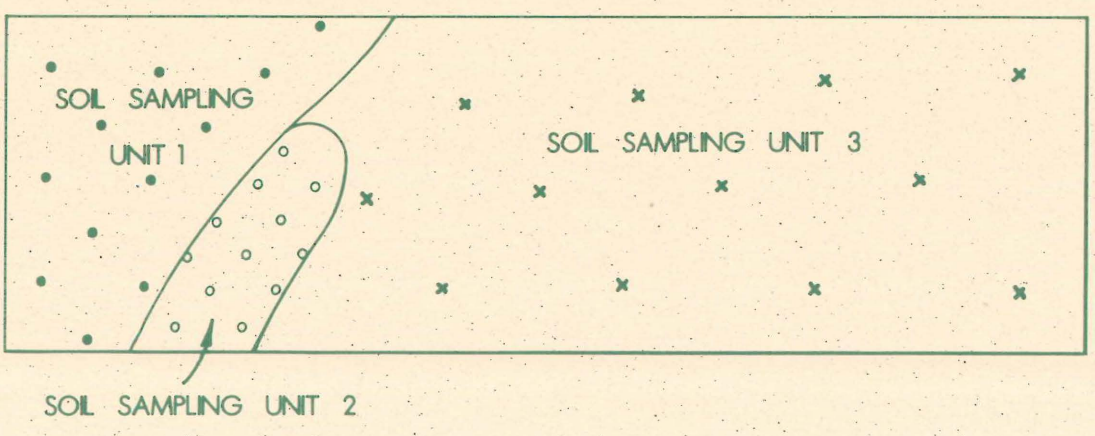


Figure 8 : Soil sampling tools and techniques for nutrient testing.

Yukon-wide basis. Of the major nutrients, it is assumed that the soil nutrient status of nitrogen and phosphorus is low to very low, whereas potassium is usually adequate.

The micronutrient status is generally adequate throughout the territory and further additions are not necessary. However, occasionally there may be sites where micronutrients (such as boron or zinc) are marginal or deficient and successful seed establishment is inhibited (K.Bisset, pers.comm.).

The recommended fertilizer application rate is based on the average nutrient status of the top 30 cm. of soil under the described vegetation communities. Typical soil nutrient values are presented with the site characteristics which accompany each vegetation community description.

The recommendation may be considered accurate only if the top 30 cm. of soil has been preserved during the construction phase of the project. If this top soil has been removed, then the actual nutrients available are lower than was assumed in the formulation of the rate of fertilizer application recommended. However, the application rates given are high to compensate for variability in nutrient status and, in some cases, may be higher than is required for optimal growth.

It is most desirable to check the nutrient status of the soil for a specific site before using the fertilizer rates recommended for the seed mixtures. In many instances, site specific nutrient sampling will save in total fertilizer costs, as well as increasing the likelihood for success of the revegetation program.

The fertilizer recommendations include a listing of the nutrient requirement for each vegetation community or landscape application. This is accompanied by one or more examples of commercial fertilizers which will approximate the nutrient requirement.

The fertilizer application is intended to be a one-time application, at the time of seeding. Occasionally, supplemental fertilizer applications may be anticipated due to soil conditions; these have been noted in the tables.

Appendix F includes a comprehensive list of commercial fertilizers available in western Canada, and their characteristics. Appendix G indicates how to calculate the rate of fertilizer required to meet the nutrient requirement.

SECTION TWO - REGIONAL SEED SPECIFICATIONS

1.0 INTRODUCTION

1.1 Delineation of Regions

The recommendations presented in this manual are limited to those areas of the Yukon where revegetation research data is available. This data was obtained through environmental studies conducted along proposed gas pipeline corridors in the late 1970's and early 1980's. These corridors paralleled the Alaska Highway, (from Watson Lake to Beaver Creek), the Klondike Highway (from Whitehorse to Dawson City) and the Dempster Highway (from Dawson City to Inuvik).

The research included studies of natural plant communities, soil nutrient status of disturbed and natural sites and revegetation trials, conducted over an eight year period (78,79,80,81,82). The trials involved various site preparations, fertilizer applications and numerous varieties of agronomic and native plant species.

The first edition of this manual includes recommendations for four regions, encompassing the southern Yukon from the B.C.-Yukon border as far north as Carmacks and from Watson Lake to Beaver Creek (Figure 5). These regions are based on similarities in climatic and physiographic characteristics (70).

The four regions addressed are as follows:

Region 1 - South-Central Yukon

Region 2 - South-East Yukon

Region 3 - South-West Yukon

Region 4 - Pelly/Cassiar Mountains

1.2 Generalizing Existing Data to Other Areas

It is possible, with some caution, to extrapolate the guidelines in this manual to adjacent areas of the central and eastern Yukon. The Dawson City and Stewart River area exhibits climatic, physiographic, and vegetation similarities to Region 3. This region, which is situated in the western Yukon from Kluane Lake to the Alaska boundary, has a very similar climate, particularly in the Beaver Creek area (106).

The La Biche River area is similar in terms of climate and physiography to Region 2, directly to the west and it may be reasonable to extrapolate formulations for seed and fertilizer.

It must be emphasized, however, that there is no substitute for site specific investigations. Extrapolations beyond these suggested regions are not recommended.





Figure 9 : Location of Regions

2.0 REGION 1: SOUTH-CENTRAL YUKON

Revegetation Region 1, the south-central Yukon, encompasses the upper Yukon River drainage basin. It extends from the Teslin River in the east to Kluane Lake in the west, and from the B.C./Yukon border in the south to Minto in the north, as illustrated in Figure 6.

2.1 Climate

The climate of the south-central Yukon is characterized by long, cold winters and short, warm summers. Lack of precipitation can be a major barrier to successful revegetation. The four westerly population centres of Haines Junction, Carmacks, Whitehorse and Carcross have annual precipitation ranging from 225 to 285mm. This general lack of precipitation is compounded by the lack of rainfall during the growing season, specifically in spring (May and June). Only in the eastern part of the region, from Johnson's Crossing to Teslin, does precipitation exceed 300mm per year (70).

Temperature is not a barrier to successful revegetation. Mean annual temperatures vary from -1 to -5C, depending upon location, but mean temperatures during the growing season are +9 to +11C (70). Snow accumulation and snow mold damage to vegetation may be a problem during some years.

2.2 Landforms and Soils

The south-central Yukon consists of mountainous terrain with steep to rolling foothills cut by broad, glacially carved valleys. These valleys are occupied by large rivers and lakes.

Higher elevations along the valley sides are often mantled by sandy to loamy textured glacial moraines. Deposits on valley bottoms are typically glaciolacustrine in origin, consisting of deep clay and silt accumulations. Sandy and gravelly glaciofluvial landforms are not confined to a particular elevation. They occur on top of and within both the morainal and glaciolacustrine deposits. Fluvial deposits are found along the river courses and, due to the regional trend toward finer textured materials, tend toward the finer end of the soil texture spectrum (19,43,70).

Soils are variable throughout the region. Texture can range from silty clay, to gravel, to sand (e.g. the dunes found in the vicinity of Carcross and Whitehorse; 19,43).

Soil pH generally ranges from 6.5 to 7.5, with an alkaline trend found throughout the region. Electrical conductivity is moderate but saline areas do occur. Calcium carbonate and organic matter content levels are generally low to moderate. Potassium and sulphur levels are usually adequate for revegetation purposes but some locations may be deficient in either of these plant nutrients. Nitrogen and phosphorus levels are typically very low and insufficient for successful revegetation (94).



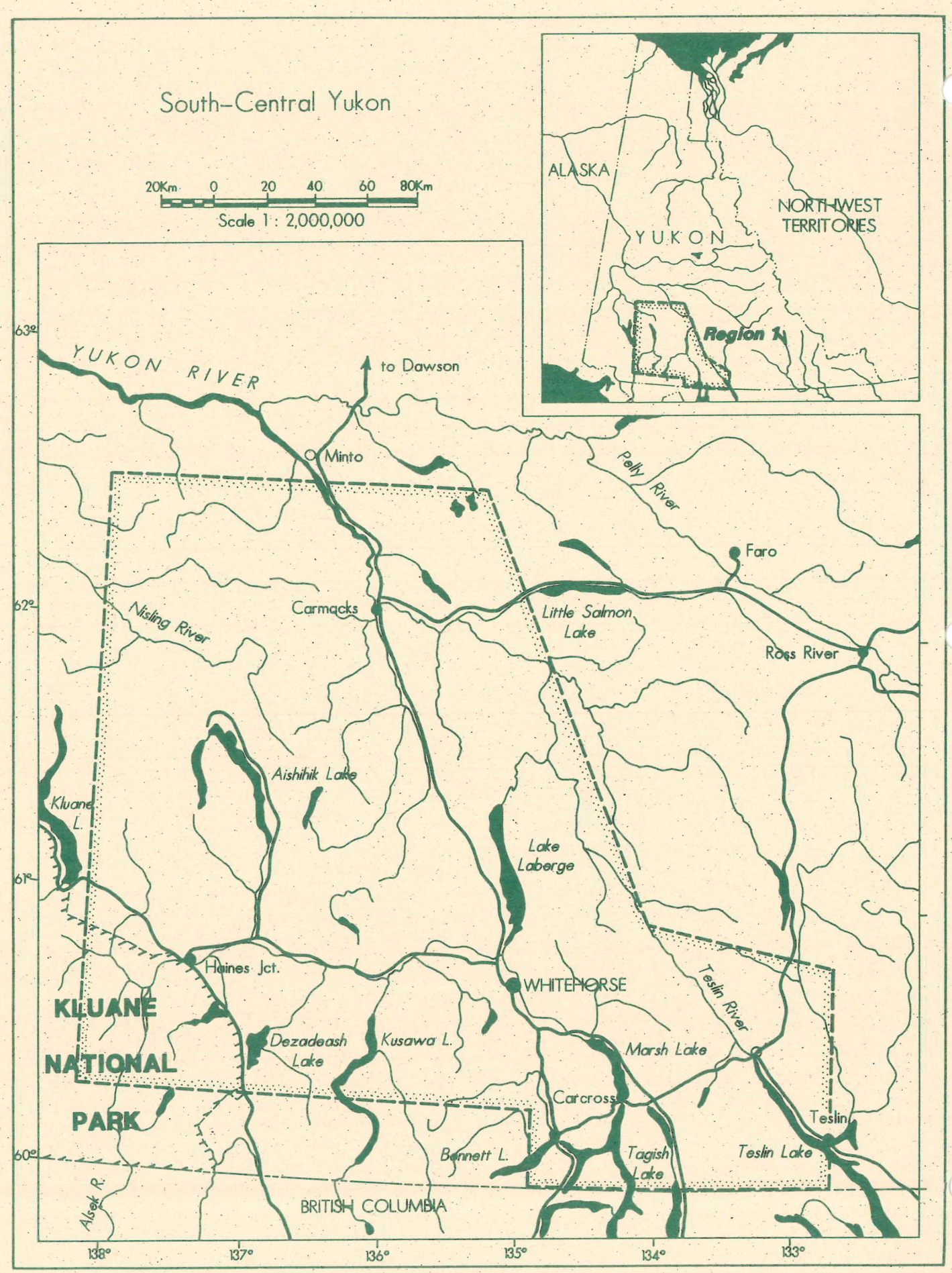


Figure 10 : REGION 1 – South-Central Yukon

2.3 Vegetation

This region of the Yukon is in the central Yukon section of the boreal forest (26,77). It is primarily situated in the Lake Laberge Ecoregion but includes the southern parts of the Ruby and Dawson Range Ecoregions (70). Canopy cover includes several forest types including white spruce *(Picea glauca)*, lodgepole pine *(Pinus contorta)*, black spruce *(Picea mariana)*, mixed coniferous, and mixed coniferous and deciduous. At higher elevations, alpine fir *(Abies lasiocarpa)* occurs (70).

Species such as rose *(Rosa acicularis)*, willow *(Salix* spp.), and soapberry *(Shepherdia canadensis)* are common in the shrub layer. Shrub birch *(Betula glandulosa)* is often dominant on sub-alpine sites. Kinnikinnick *(Arctostaphylos uva-ursi)* and lowbush cranberry *(Vaccinium vitis-idaea)* are dwarf shrubs which commonly comprise the groundcover (70, 93).

Numerous species of grass occur throughout this region. Among the most common are glaucous bluegrass *(Poa glauca)*, three wheatgrasses *(Agropyron pauciflorum, A. violaceum* and *A. yukonense)* and tufted hairgrass *(Deschampsia caespitosa)*. Fescues such as *(Festuca altaica, F. ovina, F. rubra* and *F. saximontana)* occur frequently along with fowl bluegrass *(Poa palustris)* and two reedgrasses *(Calamagrostis canadensis* and *C. purpurascens)*. More limited in their distribution are various alkaligrasses *(Puccinellia* spp.), spike trisetum *(Trisetum spicatum)*, ticklegrass *(Agrostis scabra)* and sweetgrass *(Hierochloë odorata)* (36, 93).

These grasses and common native legumes have potential for use in northern revegetation. The use of native legumes should be encouraged because of their association with *(Rhizobium* sp.) bacteria, which allows them to convert nitrogen to a useable form (39). The amount of nitrogen fixed by native legumes is relatively small when compared to that from agronomic legumes but can still make a significant contribution in the nutrient-poor soils of the north (37, 47). Legumes found in this region include arctic lupine *(Lupinus arcticus)*, Yukon lupine *(Lupinus Kuschei)*, two hedysarums *(Hedysarum alpinum* and *H. Mackenzii)*, various locoweeds *(Oxytropis* spp.) and milk vetches *(Astragalus* spp.) (36, 93).

2.4 Plant Community Based Seed Mixtures

The natural vegetation cover growing on undisturbed sites is generally a good indication of the underlying soil properties, including texture, drainage and pH. The relationship between soil characteristics and plant communities can be used as a guide for revegetation of adjacent disturbed areas if the surface soil horizons have not been removed or destroyed.

It is preferable to conduct analyses of soil samples from the actual revegetation site to use in the formulation of appropriate seed mixtures and fertilizer, especially to determine the availability of nutrients such as nitrogen, potassium and phosphorus. In the absence of site-specific soil analysis data, the soil-vegetation community data provided in this section may be used as a guide.



Figure 7 illustrates in cross-section the plant community and landform relationships

common to the region and will be useful in recognizing the community types to be revegetated.

The plant communities in the tables following are named according to canopy cover. These communities are a generalization of the natural vegetation diversity of the region. Vegetation stands may appear slightly different than the plant communities that are described here, due to vegetation succession, or transition zones between distinct vegetation types.

To help the reader identify the different plant communities, a brief description of the vegetation composition is presented, followed by a listing of the characteristic species (i.e. diagnostic species which are typically present) and associated species (i.e. species which are commonly, but not always present).

Tables 2-15 are paired tables of complementary information prepared for each of seven major plant communities occurring in the region. The first table in each pair lists pertinent site characteristics and vegetation cover associated with each community; the second table lists recommended seed mixtures and fertilizer application appropriate for revegetation, based on present and future seed availability.

Revegetation studies were conducted in the region in conjunction with pipeline proposals (94). The seed and fertilizer recommendations for disturbed sites presented in the tables following are based on data collected through studies of soil-plant community relationships and revegetation trials.

A number of appendices are included in this manual which provide additional information on soil properties, characteristics of revegetation species, seed suppliers, fertilizer characteristics and calculation of application rates.

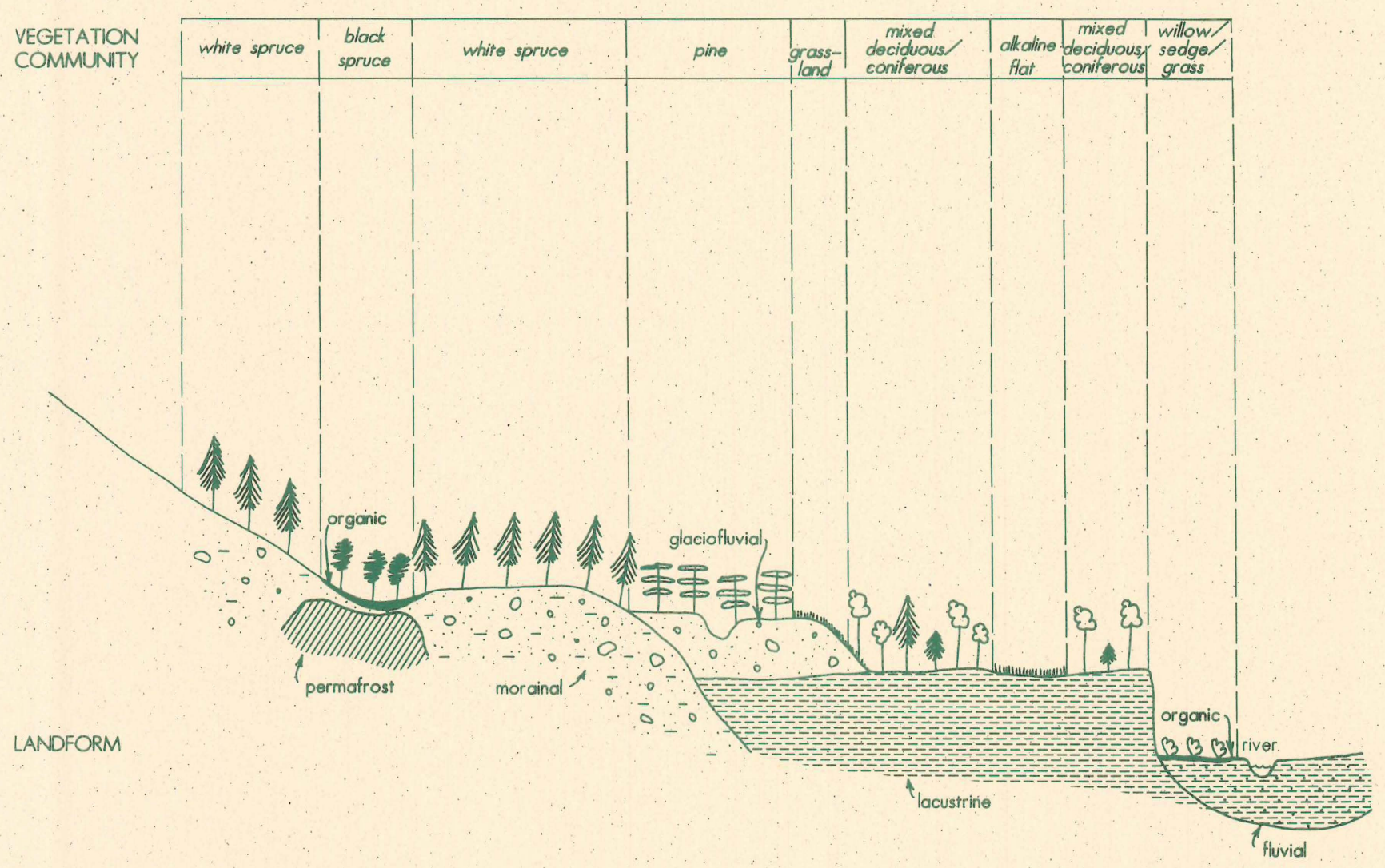


Figure 11 : Vegetation and Landform Relationships
REGION 1 – South-Central Yukon

Table 2: Site characteristics of alkaligrass-foxtail barley *(Puccinellia-Hordeum)* communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	glaciolacustrine and fluvial
Modifier(s):	level to depressional
Drainage:	poor to imperfect
Soil: Texture (top 30 cm):	silty loam to clay (ML to CL)#
(> 30 cm):	clay (ML,CL)
Other Soil Properties (top 30 cm):	
pH:	strongly alkaline (8.0-9.1)
$CaCO_3$:	high
Organic Matter:	moderate to low
Available Nutrients:	N - high to extremely high P - low K - high S - high

Soils similar to these may prove difficult to revegetate. Many of these alkaline sites will also be saline. High levels of phosphorus will be required. Alkali tolerant grasses will be required in the basic seed mixture. Some site-specific seeding or planting may be required to correct failures from the initial seeding. Revegetation of sites with comparable soil conditions must be considered a problem in the southern Yukon.

Vegetation Community Description: A halophytic graminoid community, dominated by alkaligrass and foxtail barley, which occurs in small depressions common throughout the Takhini Valley; forbs are sparse, but often exhibit similar tolerance toward saline and alkaline conditions. Species are typically arranged in concentric circles, a reflection of the ecological gradient.

Characteristic Species: alkaligrass (*Puccinellia* spp.), foxtail barley (*Hordeum jubatum*)

Associated Species: tufted hairgrass (*Deschampsia caespitosa*), arctic rush (*Juncus arcticus*), ticklegrass (*Argrostis scabra*), silverweed (*Potentilla diversifolia*), yarrow (*Achillea borealis*)

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 3: Seed mixture and fertilizer specifications for alkaligrass-foxtail *(Puccinellia-Hordeum)*

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Crested wheatgrass *Agropyron cristatum*	SUMMIT	2	Northern fescue *Festuca saximontana*	3
Streambank wheatgrass *Agropyron riparium*	SODAR	6	Yukon wheatgrass *Agropyron yukonense*	2
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	10	Violet wheatgrass *Agropyron violaceum*	5
Sheep fescue *Festuca ovina*	COMMON	8	Sheep fescue *Festuca ovina*	3
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	4	Yellow locoweed *Oxytropis campestris*	1
Big bluegrass *Poa ampla*	SHERMAN	6	Big bluegrass *Poa ampla*	2
			Alkaligrass *Puccinellia* sp.	2
Glaucous bluegrass *Poa glauca*	TUNDRA+	2	Glaucous bluegrass *Poa glauca*	2
Total		38		20

FERTILIZER:

Nutrient requirement: Nitrogen (50kg N/ha) + Phosphate (200kg P_2O_5/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 400kg/ha 11-51-0



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 4: Site characteristics of sage/grass *(Artemisia/Calamagrostis-Festuca)* communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	colluvial, glaciofluvial, glaciolacustrine, morainal
Modifier(s):	gentle to steep slopes with southerly aspects
Drainage:	well to rapid
Soil: Texture (top 30 cm):	loam to sand (SM)#
(> 30 cm):	clay to gravelly sand (CL to GW)
Other Soil Properties (top 30 cm):	
pH:	mildly alkaline (7.3-8.0)
$CaCO_3$:	low to high
Organic Matter:	moderate to high
Available Nutrients:	N - moderate to high P - moderate to high K - moderate to high S - moderate to high

Such soils provide very good growth media for development of vigorous grass. The basic seed mixture should include some species successful on alkaline soils. No major problems should arise in restoration of a grass-legume ground cover unless precipitation in the year of establishment is inadequate.

Vegetation Community Description: Groundcover dominated by grass, with sage diagnostic among a diverse array of forbs; low, scattered aspen trees are common. Establishes under xeric conditions on steep, south-facing slopes.

Characteristic Species: sage *(Artemisia frigida)*, purple reedgrass *(Calamagrostis purpurascens)*, altai fescue *(Festuca altaica)*, three-toothed saxifrage *(Saxifraga tricuspidata)*

Associated Species: aspen *(Populus tremuloides)*, common juniper *(Juniper communis)*, kinnikinnick *(Arctostaphylos uva-ursi)*, Jacob's ladder *(Polemonium pulcherrimum)*, crocus *(Pulsatilla patens)*, stonecrop *(Sedum lanceolatum)*, wheatgrass *(Agropyron* sp.*)*

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 5: Seed mixture and fertilizer specifications for sage/grass *(Artemisia/Calamagrostis-Festuca)* community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Streambank wheatgrass *Agropyron riparium*	SODAR	8	Yukon wheatgrass *Agropyron yukonense*	2
			Northern fescue *Festuca saximontana*	4
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	10	Violet wheatgrass *Agropyron violaceum*	4
Sheep fescue *Festuca ovina*	COMMON	6	Sheep fescue *Festuca ovina*	2
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	4	Mackenzie's hedysarum *Hedysarum Mackenzii*	1
			Yellow locoweed *Oxytropis campestris*	1
Glaucous bluegrass *Poa glauca*	TUNDRA+	4	Glaucous bluegrass *Poa glauca*	4
Total		32		18

FERTILIZER:

Nutrient requirement: Nitrogen (80kg N/ha) + Phosphate (80kg $P_2 0_5$/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 350kg/ha 23-23-0 or 250kg/ha 16-20-0



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 6: Site characteristics of willow/sedge *(Salix/Carex)* communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	fluvial
Modifier(s):	level, depressional, undulating
Drainage:	imperfect to poor; flooding possible
Soil: Texture (top 30 cm):	moderately decomposed organics and/or clay to sandy loam (PT and/or SM, ML,CL)#
(> 30 cm):	clay to sand (SP to CL)
Other Soil Properties (top 30 cm):	
pH:	slightly alkaline to neutral (6.4-7.6)
$CaCO_3$:	very low
Organic Matter:	high
Available Nutrients:	N - moderate P - moderate K - moderate S - high

Soils underlying these communities will support vigorous grass cover with only minimal nitrogen and phosphorus application. The basic seed mixture must contain species which are adapted to organic soils. No major problems are foreseeen in revegetation of these soils.

Vegetation Community Description: Moderate to dense overstory of willow; groundcover dominated by sedge and moss; grass and horsetail common; forbs diverse and scant; sphagnum often present. Riparian vegetation established along lake margins and creek drainages.

Characteristic Species: willow *(Salix* spp.), water sedge *(Carex aquatilis)*, moss (bryophyte spp.)

Associated Species: shrub birch *(Betula glandulosa)*, shrubby cinquefoil *(Potentilla fruticosa)*, nagoonberry *(Rubus acaulis)*, sedge *(Carex* spp.), grass (Gramineae spp.), horsetail *(Equisetum* spp.), coltsfoot *(Petasites frigidus)*, bluebell *(Mertensia paniculata)*, sphagnum moss *(Sphagnum)*

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 7: Seed mixture and fertilizer specifications for willow/sedge *(Salix/Carex)* community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Meadow foxtail *Alopecurus pratensis*	COMMON	10	Meadow foxtail *Alopecurus pratensis*	3
Tufted hairgrass *Deschampsia caespitosa*	NORTRAN+	8	Tufted hairgrass *Deschampsia caespitosa*	4
Reed canarygrass *Phalaris arundinacea*	FRONTIER	8	Bluejoint reedgrass *Calamagrostis canadensis*	1
Timothy *Phleum pratense*	ENGMO	6	Fowl bluegrass *Poa palustris*	8
Total		32		16

FERTILIZER:

Nutrient requirement: Nitrogen (50kg N/ha) + Phosphate (100kg P_2O_5/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 300kg/ha 17-34-0



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 8: Site characteristics of lodgepole pine *(Pinus contorta)* communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	glaciofluvial, fluvial, morainal
Modifier(s):	level terraces
Drainage:	well to rapid
Soil: Texture (top 30 cm):	sandy loam to loamy sand (SM)#
(> 30 cm):	sandy loam to gravelly sand (SM to GW)
Other Soil Properties (top 30 cm):	
pH:	very strongly to slightly acid (5.3-6.3)
$CaCO_3$:	low
Organic Matter:	low
Available Nutrients:	N - very low P - very low K - very low S - very low

Soils similar to these are realistically capable of only supporting a short, sparse grass cover. A complete fertilization program will be necessary. If this is done then revegetation is possible, but areas such as these may require reseeding if precipitation is limited in the year of establishment.

Vegetation Community Description: Lodgepole pine dominates an open tree canopy which often includes white spruce and aspen; tall shrub understory sparse or absent; low shrubs include soapberry and rose; kinnikinnick is a diagnostic and dominant groundshrub; grass, forbs and lichen are common but sparse. Develops on well-drained sites.

Characteristic Species: lodgepole pine *(Pinus contorta)*, kinnikinnick *(Arctostaphylos uva-ursi)*, lowbush cranberry *(Vaccinium vitis-idaea)*

Associated Species: white spruce *(Picea glauca)*, aspen *(Populus tremuloides)*, soapberry *(Shepherdia canadensis)*, willow *(Salix* spp.), rose *(Rosa acicularis)*, altai fescue *(Festuca altaica)*, arctic lupine *(Lupinus arcticus)*, fireweed *(Epilobium angustifolium)*

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 9: Seed mixture and fertilizer specifications for lodgepole pine *(Pinus contorta)* community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Streambank wheatgrass *Agropyron riparium*	SODAR	6	Yukon wheatgrass *Agropyron yukonense*	3
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	6	Violet wheatgrass *Agropyron violaceum*	6
Creeping red fescue *Festuca rubra*	BOREAL	2		
Sheep fescue *Festuca ovina*	COMMON	8	Northern fescue *Festuca saximontana*	4
Alfalfa *Medicago sp.*	DRYLANDER or RAMBLER	4	Arctic lupine *Lupinus arcticus*	1
			Yellow locoweed *Oxytropis campestris*	1
Canada bluegrass *Poa compressa*	CANON	6	Glaucous bluegrass *Poa glauca*	3
Total		32		18

FERTILIZER:

Nutrient requirement: Nitrogen (100kg N/ha) + Phosphate (120kg $P_2 0_5$/ha) + Potash (80kg $K_2 0$/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 300kg/ha 28-28-0 + 150kg/ha 0-0-60



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 10: Site characteristics of black spruce *(Picea mariana)* communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	lacustrine, morainal, fluvial
Modifier(s):	depressions, lower slopes
Drainage:	poor to moderately well
Soil: Texture (top 30 cm):	fibric to mesic peat (PT)#
(> 30 cm):	clay loam to gravelly sand (CL to GW)
Other Soil Properties (top 30 cm):	
pH:	slightly acid to acid (6.0-6.7)
$CaCO_3$:	very low
Organic Matter:	very high
Available Nutrients:	N - low P - very low K - low S - low

Such soils will require high rates of nitrogen and phosphorus fertilization at the time of seeding. Potassium may be required, depending upon the site. Species in the basic seed mixture must be adapted to organic soils. No serious problems are foreseen in revegetation of soils in these communities if the initial fertilization is adequate.

Vegetation Community Description: Black spruce diagnostic and dominant in a sparse tree and shrub understory; shrub birch, willow, Labrador tea and other low and prostrate ericaceous species commonly present; extensive moss groundcover often includes sphagnum.

Characteristic Species: black spruce *(Picea mariana)*, willow *(Salix* spp.*)*, shrub birch *(Betula glandulosa)*, labrador tea *(Ledum groenlandicum)*,feathermoss (bryophyte spp.)

Associated Species: shrubby cinquefoil *(Potentilla fruticosa)*, bog blueberry *(Vaccinium uliginosum)*, mossberry *(Empetrum nigrum)*, northern bearberry *(Arctostaphylos rubra)*, cloudberry *(Rubus chamaemorus)*, lousewort *(Pedicularis* spp.*)*

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 11: Seed mixture and fertilizer specifications for black spruce *(Picea mariana)* community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Meadow foxtail *Alopecurus pratensis*	COMMON	8	Meadow foxtail *Alopecurus pratensis*	5
Tufted hairgrass *Deschampsia caespitosa*	NORTRAN+	8	Tufted hairgrass *Deschampsia caespitosa*	4
Reed canarygrass *Phalaris arundinacea*	FRONTIER	8	Polargrass *Arctagrostis latifolia*	1
			Bluejoint reedgrass *Calamagrostis canadensis*	1
Timothy *Phleum pratense*	ENGMO	6	Altai fescue *Festuca altaica*	6
Total		30		17

FERTILIZER:

Nutrient requirement: Nitrogen (80kg N/ha) + Phosphate (80kg $P_2 0_5$/ha) + Potash (60kg $K_2 0$/ha)

Example of commercial fertilizers which approximate the nutrient requirement:
400kg/ha 16-20-0 + Potassium sulphate (60kg $K_2 0$/ha) or
500kg/ha 16-16-16 (3)**



** ( ) indicates percent Sulphur

* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 12: Site characteristics of white spruce *(Picea glauca)* communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	glaciolacustrine, morainal, fluvial
Modifier(s):	
Drainage:	moderately well to well
Soil: Texture (top 30 cm):	clay loam to sandy loam (ML, SM)#
(> 30 cm):	clay to gravelly sandy loam (CL, ML, SM, GW)
Other Soil Properties (top 30 cm):	
pH:	neutral to strongly alkaline (6.6-8.7)
$CaCO_3$:	varies from low to high
Organic Matter:	moderate to low
Available Nutrients:	N - low to very high P - very low K - high S - low to high

These soils may be difficult to revegetate if the alkalinity arises from sodium salts. A dry season may severely delay germination. The basic seed mixture must contain alkali tolerant species. Fall seeding may be required to enhance germination and early development.

Vegetation Community Description: White spruce dominant species in tree canopy, though pine and aspen are frequently present; shrub understory includes willow, soapberry and rose; on moister sites, groundcover is dominated by lowbush cranberry, horsetail, moss and forbs; kinnikinnick, twinflower and fescue dominate drier sites.

Characteristic Species: white spruce *(Picea glauca)*, kinnikinnick *(Arctostaphylos uva-ursi)*

Associated Species: aspen *(Populus tremuloides)*, lodgepole pine *(Pinus contorta)*, rose *(Rosa acicularis)*, soapberry *(Shepherdia canadensis)*, lowbush cranberry *(Vaccinium vitis-idaea)*, twinflower *(Linnaea borealis)*, horsetail *(Equisetum* spp.*)*, fescue *(Festuca altaica)*, bluebell *(Mertensia paniculata)*, feathermoss *(Hylocomium splendens, Pleurozium schreberi)*

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 13: Seed mixture and fertilizer specifications for white spruce *(Picea glauca)* community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Streambank wheatgrass *Agropyron riparium*	SODAR	6	Yukon wheatgrass *Agropyron yukonense*	5
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	8	Violet wheatgrass *Agropyron violaceum*	5
Creeping red fescue *Festuca rubra*	BOREAL	2		
Sheep fescue *Festuca ovina*	COMMON	4	Northern fescue *Festuca saximontana*	2
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	2	Yellow locoweed *Oxytropis campestris*	1
Fowl bluegrass *Poa palustris*	COMMON	4	Glaucous bluegrass *Poa glauca*	2
Kentucky bluegrass *Poa pratensis*	COMMON	2	Sweetgrass *Hierochlöe odorata*	1
Alsike clover *Trifolium hybridum*	TETRA	2	Arctic lupine *Lupinus arcticus*	2
Total		30		18

FERTILIZER:

Nutrient requirement: Nitrogen (50-100kg N/ha) + Phosphate (100kg P_2O_5/ha)

Examples of commercial fertilizers which approximate the nutrient requirement:
350kg/ha 17-34-0 - hits low range of N specification or
450kg/ha 23-23-0: - hits high range of N specification



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 14: Site characteristics of mixed deciduous/ coniferous tree communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	lacustrine, morainal, fluvial
Modifier(s):	fine to medium textured
Drainage:	imperfect to well
Soil: Texture (top 30 cm):	clay to gravelly sandy loam (ML,SM,SP)#
(> 30 cm):	clay to gravelly sandly loam (ML,SM,SP)
Other Soil Properties (top 30 cm):	
pH:	neutral to slightly alkaline (6.5-7.4)
$CaCO_3$:	low to moderate
Organic Matter:	low
Available Nutrients:	N - low P - high K - moderate S - low

Soils such as these are well adapted for the growth of grass cover. Only nitrogen, applied at the time of seeding, is required for successful revegetation. No serious problems are anticipated in revegetation of these soils.

Vegetation Community Description: This community is successional after fire. The canopy is usually dominated by pine and aspen, with willow common throughout the understory; white spruce appears in the low shrub layer later in succession, and eventually dominates most stands which reach maturity on these sites.

Characteristic Species: lodgepole pine *(Pinus contorta)*, aspen *(Populus tremuloides)*, willow *(Salix* spp.*)*

Associated Species: white spruce *(Picea glauca)*, balsam poplar *(Populus balsamifera)*, highbush cranberry *(Viburnum edule)*, rose *(Rosa acicularis)*, soapberry *(Shepherdia canadensis)*, kinnikinnick *(Arctostaphylos uva-ursi)*, lowbush cranberry *(Vaccinium vitis-idaea)*, twinflower *(Linnaea borealis)*, altai fescue *(Festuca altaica)*, reedgrass *(Calamagrostis* spp.*)*, wheatgrass *(Agropyron* spp.*)*

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 15: Seed mixture and fertilizer specifications for mixed deciduous/coniferous tree community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Streambank wheatgrass *Agropyron riparium*	SODAR	6	Yukon wheatgrass *Agropyron yukonense*	2
			Northern fescue *Festuca saximontana*	2
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	6	Violet wheatgrass *Agropyron violaceum*	6
Creeping red fescue *Festuca rubra*	BOREAL	4		
Sheep fescue *Festuca ovina*	COMMON	4	Sheep fescue *Festuca ovina*	2
Fowl bluegrass *Poa palustris*	COMMON	6	Glaucous bluegrass *Poa glauca*	2
Kentucky bluegrass *Poa pratensis*	COMMON	2	Sweetgrass *Hierochlöe odorata*	1
Alsike clover *Trifolium hybridum*	TETRA	2	Arctic lupine *Lupinus arcticus*	2
Total		30		17

FERTILIZER:

Nutrient requirement: Nitrogen (80kg N/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 250kg/ha 34-0-0



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

2.5 Seed Mixtures For High Elevation Sites

Successful revegetation of high elevation sites requires the use of specialized seed mixtures (13). Soil conditions can vary tremendously, but the severe climatic conditions override all other aspects of seed mixture formulation. Major climatic factors which cause revegetation problems are low summer temperatures, high solar radiation, high winds, a short growing season, and often, a precipitation shortage during the growing season (11,12). Evidence throughout North America indicates that varieties developed for moderate climatic regions have little long-term success and frequently decrease in vigor or die out within three years on alpine sites (13,85).

The Agronomic Selections recommended in Tables 16-17, include some northern varieties (34,59,60,64) developed in Alaska. These varieties are expensive, but are more likely to survive than varieties developed for use in less severe environments. If alpine or subalpine revegetation in the southern Yukon is required before the Yukon native seed selections are commercially available, the Alaskan varieties are the optimal choices for inclusion in the seed mixture.

In the following tables, alpine environments are considered to occur above treeline, and subalpine environments occur at treeline and below.

Table 16: Seed mixture and fertilizer specifications for subalpine environments

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Streambank wheatgrass *Agropyron riparium*	SODAR	6	Yukon wheatgrass *Agropyron yukonense*	1
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	4	Violet wheatgrass *Agropyron violaceum*	4
Creeping red fescue *Festuca rubra*	ARCTARED+	4		
Tufted hairgrass *Deschampsia caespitosa*	NORTRAN+	4	Tufted hairgrass *Deschampsia caespitosa*	3
Sheep fescue *Festuca ovina*	COMMON	4	Northern fescue *Festuca saximontana*	2
			Ticklegrass *Agrostis scabra*	1
Alfalfa *Medicago falcata*	ANIK	4	Arctic lupine *Lupinus arcticus*	1
			Yellow locoweed *Oxytropis campestris*	1
Glaucous bluegrass *Poa glauca*	TUNDRA+	6	Glaucous bluegrass *Poa glauca*	4
Total		32		17

FERTILIZER:

Nutrient Requirement**: Nitrogen (50kg N/ha) + Phosphate (80kg $P_2 0_5$/ha)

Example of a commercial fertilizer which approximates the nutrient requirement:
250kg/ha 17-34-0



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 17: Seed mixture and fertilizer specifications for alpine environments

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Meadow foxtail *Alopecurus pratensis*	COMMON	6	Mountain timothy *Phleum commutatum*	3
Polargrass *Arctagrostis latifolia*	ALYESKA+	2	Polargrass *Arctagrostis latifolia*	1
Tufted hairgrass *Deschampsia caespitosa*	NORTRAN+	4	Tufted hairgrass *Deschampsia caespitosa*	2
			Ticklegrass *Agrostis scabra*	1
Sheep fescue *Festuca ovina*	COMMON	4	Northern fescue *Festuca ovina*	2
Creeping red fescue *Festuca rubra*	ARCTARED+	4	Violet wheatgrass *Agropyron violaceum*	3
Alpine bluegrass *Poa alpina*	COMMON	4	Alpine bluegrass *Poa alpina*	2
Glaucous bluegrass *Poa glauca*	TUNDRA+	6	Glaucous bluegrass *Poa glauca*	4
Total		30		18

FERTILIZER:

Nutrient Requirement**: Nitrogen (50kg N/ha) + Phosphate (80kg $P_2 0_5$/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 250kg/ha 17-34-0

** On sandy soil, Potash, at the rate of 50kg $K_2 0$/ha, may be required

* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

2.6 Seed Mixtures For Linear Developments

The seed mixtures in Tables 18-21 are designed for use on projects which encompass a long but narrow stretch of land which needs revegetation, such as highway right-of-ways and pipeline or utility corridors.

Seed mixtures for lengthy linear projects must be of a more comprehensive nature than those formulated for projects which are confined to one or two relatively homogeneous environments. Soils and climate will vary to some degree on such projects. Precise locations of changes in either soil or climate will not be demarcated even if the general soil types and ecoregion climatic conditions are known. It is improbable that sufficient soil sampling will be done for definitive knowledge of the soils underlying each plant community and every part of the disturbed site. Also, it is not feasible, from a logistics point of view, to constantly change the seed mixture every few kilometers during a revegetation operation (such as hydroseeding) to account for minor shifts in growing conditions.

Seed mixtures must contain sufficient species diversity to accommodate all major environments which may be encountered in the revegetation project. The mixtures in Tables 18-21 include a greater number of species than the mixtures for more homogeneous or precisely defined disturbed sites. Consequently, the total weight of seed per hectare is higher. Although every seed selection is not required at all locations en route, a complete range of species is necessary for overall success.



Table 18: Seed mixture and fertilizer specifications for linear project seeding from Whitehorse to Teslin

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Streambank wheatgrass *Agropyron riparium*	SODAR	4	Yukon wheatgrass *Agropyron yukonense*	2
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	8	Violet wheatgrass *Agropyron violaceum*	8
Smooth brome *Bromus inermis*	CARLTON	4		
Creeping red fescue *Festuca rubra*	BOREAL	6	Northern fescue *Festuca saximontana*	4
Sheep fescue *Festuca ovina*	COMMON	8	Sheep fescue *Festuca ovina*	3
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	4	Yellow locoweed *Oxytropis campestris*	1
Canada bluegrass *Poa compressa*	CANON	2	Glaucous bluegrass *Poa glauca*	2
Fowl bluegrass *Poa palustris*	COMMON	2	Fowl bluegrass *Poa palustris*	1
Alsike clover *Trifolium hybridum*	TETRA	2	Arctic lupine *Lupinus arcticus*	3
Total		40		24

FERTILIZER:

Nutrient requirement: Nitrogen (100kg N/ha) + Phosphate (120kg $P_2 0_5$/ha) + Potash (60kg $K_2 0$/ha)

Examples of commercial fertilizers which approximate the nutrient requirement:
400 kg/ha 16-20-0 + Potash (60kg $K_2 0$/ha) or
400kg/ha 28-28-0 + 100kg/ha 0-0-60

* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 19: Seed mixture and fertilizer specifications for linear project seeding from Whitehorse to Haines Junction

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Streambank wheatgrass *Agropyron riparium*	SODAR	4	Yukon wheatgrass *Agropyron yukonense*	2
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	8	Violet wheatgrass *Agropyron violaceum*	8
Creeping red fescue *Festuca rubra*	BOREAL	6	Northern fescue *Festuca saximontana*	3
Sheep fescue Festuca ovina	COMMON	8	Sheep fescue *Festuca ovina*	3
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	6	Yellow locoweed *Oxytropis campestris*	2
			Showy locoweed *Oxytropis splendens*	1
			Arctic lupine *Lupinus arcticus*	1
Big bluegrass *Poa ampla*	SHERMAN	4	Big bluegrass *Poa ampla*	1
Canada bluegrass *Poa compressa*	CANON	4	Glaucous bluegrass *Poa glauca*	3
Total		40		24

FERTILIZER:

Nutrient requirement: Nitrogen (100kg N/ha) + Phosphate (120kg P_2O_5/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 400kg/ha 28-28-0

* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.



Table 20: Seed mixture and fertilizer specifications for linear project seeding from Haines Junction to Kluane Lake

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Streambank wheatgrass *Agropyron riparium*	SODAR	4	Yukon wheatgrass *Agropyron yukonense*	2
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	8	Violet wheatgrass *Agropyron violaceum*	8
Creeping red fescue *Festuca rubra*	BOREAL	6	Northern fescue *Festuca saximontana*	3
Sheep fescue *Festuca ovina*	COMMON	8	Sheep fescue *Festuca ovina*	3
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	6	Yellow locoweed *Oxytropis campestris*	2
			Showy locoweed *Oxytropis splendens*	1
			Arctic lupine *Lupinus arcticus*	1
Big bluegrass *Poa ampla*	SHERMAN	2	Big bluegrass *Poa ampla*	1
Canada bluegrass *Poa compressa*	CANON	6	Glaucous bluegrass *Poa glauca*	3
Total		40		24

FERTILIZER:

Nutrient requirement: Nitrogen (100kg N/ha) + Phosphate (120kg P_2O_5/ha) + Potash (60kg K_2O/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 400kg/ha 28-28-0 + 100kg/ha 0-0-60

* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 21: Seed mixture and fertilizer specifications for linear project seeding from Whitehorse to McCabe Creek

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Streambank wheatgrass *Agropyron riparium*	SODAR	5	Yukon wheatgrass *Agropyron yukonense*	3
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	8	Violet wheatgrass *Agropyron violaceum*	8
Creeping red fescue *Festuca rubra*	BOREAL	8	Northern fescue *Festuca saximontana*	3
Sheep fescue *Festuca ovina*	COMMON	9	Sheep fescue *Festuca ovina*	3
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	6	Yellow locoweed *Oxytropis campestris*	1
			Showy locoweed *Oxytropis splendens*	1
			Artic lupine *Lupinus arcticus*	2
Canada bluegrass *Poa compressa*	CANON	4	Glaucous bluegrass *Poa glauca*	3
Total		40		24

FERTILIZER:

Nutrient requirement: Nitrogen (100kg N/ha) + Phosphate (120kg $P_2 0_5$/ha) + Potash (100kg $K_2 0$/ha)

Example of a commercial fertilizer which approximates the nutrient requirement:
400kg/ha 28-28-0

* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.



2.7 Specific Problem Seed Mixtures

2.7.1 Highway Cut Slope Seed Mixtures

Highway cut slopes present one of the more difficult problems in northern reclamation. Initial instability must be corrected through physical techniques prior to the application of seed, fertilizer and mulch (89). The seed then applied is expected to germinate and produce vegetative cover on subsoil which can vary tremendously in physical and chemical properties, even on a small slope. For optimal results, site-specific soil sampling of the growth medium is essential, but, if not possible, then the mixtures indicated in Tables 22-23 can be used as guidelines for revegetation of sand or gravel and silty-clay cut slopes, respectively.

2.7.2 Saline Soil Seed Mixture

Saline soils occur only in a few areas in southern Yukon Territory. If revegetation of these areas is deemed critical, the mixtures in Table 24 can be used as guidelines. However, it must be remembered that until northern selections of alkaligrass *(Puccinellia* spp.) are developed, there is not a truly satisfactory saline soil seed mixture available.

2.7.3 Sandy Soil Seed Mixture

The mixtures in Table 25 are designed for revegetation of sand dunes, such as those found near Carcross and Whitehorse.

Table 22: Seed mixture and fertilizer specifications for sand or gravel cut slopes

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Streambank wheatgrass *Agropyron riparium*	SODAR	6	Yukon wheatgrass *Agropyron yukonense*	4
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	8	Violet wheatgrass *Agropyron violaceum*	6
Sheep fescue *Festuca ovina*	COMMON	8	Northern fescue *Festuca saximontana*	5
Creeping red fescue *Festuca rubra*	BOREAL	6	Glaucous bluegrass *Poa glauca*	3
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	2	Yellow locoweed *Oxytropis campestris*	1
Total		30		19

FERTILIZER:

Nutrient requirement: Nitrogen (120kg N/ha) + Phosphate (120kg $P_2 0_5$/ha) + Potash (100kg $K_2 0$/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 480kg/ha 28-28-0 + 150kg/ha 0-0-60



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 23: Seed mixture and fertilizer specifications for silty-clay cut slopes

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Streambank wheatgrass *Agropyron riparium*	SODAR	8	Yukon wheatgrass *Agropyron yukonense*	6
Crested wheatgrass *Agropyron cristatum*	SUMMIT	5	Violet wheatgrass *Agropyron violaceum*	4
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	3		
Sheep fescue *Festuca ovina*	COMMON	6	Sheep fescue *Festuca ovina*	4
Creeping red fescue *Festuca rubra*	BOREAL	6	Glaucous bluegrass *Poa gluaca*	4
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	2	Showy locoweed *Oxytropis campestris*	1
Total		30		19

FERTILIZER:

Nutrient requirement: Nitrogen (100kg N/ha) + Phosphate (80kg P_2O_5/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 350kg/ha 23-23-0

* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 24: Seed mixture and fertilizer specifications for saline soils

AGRONOMIC SELECTIONS **			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Tall wheatgrass *Agropyron elongatum*	ORBIT	10	Violet wheatgrass *Agropyron violaceum*	4
Slender wheatgrass *Agropyron pauciflorum*	REVENUE	5	Bearded wheatgrass *Agropyron subsecundum*	2
Sheep fescue *Festuca ovina*	COMMON	5	Northern fescue *Festuca saximontana*	4
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	1	Yellow locoweed *Oxytropis campestris*	1
Big bluegrass *Poa ampla*	SHERMAN	5	Big bluegrass *Poa ampla* Northern bluegrass *Poa alpigena*	3 2
Alkaligrass *Puccinellia* sp.	COMMON	5	Alkaligrass *Puccinellia* sp.	4
Total		31		20

FERTILIZER:

Nutrient requirement: Nitrogen (150kg N/ha) + Phosphate (100kg P_2O_5/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 450kg/ha 34-18 0



** There is no completely satisfactory saline soil mixture available at present. The mixture indicated has some chance of success.

* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 25: Seed mixture and fertilizer specifications for sandy soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Crested wheatgrass *Agropyron cristatum*	SUMMIT	7	Crested wheatgrass *Agropyron cristatum*	5
Streambank wheatgrass *Agropyron riparium*	SODAR	7	Violet wheatgrass *Agropyron violaceum*	3
Sheep fescue *Festuca ovina*	COMMON	6	Northern fescue *Festuca saximontana*	3
Canada bluegrass *Poa compressa*	CANON	4	Northern brome *Bromus Pumpellianus*	2
Glaucous bluegrass *Poa glauca*	TUNDRA+	2	Glaucous bluegrass *Poa glauca*	2
Alkaligrass *Puccinellia* sp.	COMMON	4	Alkaligrass *Puccinellia* sp.	2
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	2	Yukon lupine *Lupinus Kuschei* Yellow locoweed *Oxytropis campestris*	2 2
Total		32		21

FERTILIZER:

Nutrient requirement: Nitrogen (00kg N/ha) + Phosphate (120kg $P_2 0_5$/ha) + Potash (l00kg $K_2 0$/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 500kg/ha 16-20-0 + l00kg/ha 0-0-60

* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

3.0 REGION 2: SOUTH-EAST YUKON

Revegetation Region 2, the south-east Yukon, encompasses the Liard River drainage basin, in the vicinity of Watson Lake (Figure 8). It extends north from the B.C.-Yukon border to Tuchitua, and from Tootsee River near Rancheria eastward to Toobally Lakes.

3.1 Climate

Precipitation is adequate for successful revegetation in this region, ranging from 400 to 600 mm annually. Watson Lake, the major population centre, receives an average annual precipitation of 430 mm. Precipitation during the growing season is sufficient for successful revegetation, as Watson Lake receives an average of 147 mm of rain from June to August.

Temperature is not an impediment to successful revegetation as mean annual temperatures are between -3 to -4^0 C, while mean temperature during the growing season is +11 C at Watson Lake (70). Accumulation of snow may induce snow mold damage to vegetation in some years (95,96).

3.2 Landforms and Soils

This region consists of level to rolling morainal and glaciofluvial uplands dissected by major rivers (the Liard, Frances, Meister, and Rancheria) with associated floodplains and terraces. Morainal deposits are mainly gravelly sandy loam though siltier textures are found north and east of the Liard River. The glaciofluvial deposits are sandy and gravelly, as are the higher alluvial terraces. Silty and sandy deposits occur on the floodplains (43,76).

Soils vary throughout this region. Sandy soils are most prevalent, but some loam and silty loam pockets occur. Permafrost is associated with poorly drained black spruce *(Picea mariana)* sites where peat surface horizons and organic soils are common (76). Relevant soil characteristics can be summarized as follows:

Soil pH covers a broad range from highly acidic soils with a pH of 4.0 to alkaline soils with a pH as high as 8.1. Although acidic soils predominate, some floodplain soils are neutral to alkaline. The acidic soils are frequently associated with stands of lodgepole pine. Electrical conductivity is very low with minimal salinity problems. Calcium carbonate (CaCO3) levels are usually low and organic matter content varies widely, ranging from 0.0% to over 50.0%.

Potassium levels are high while sulphur content is usually adequate for revegetation. Phosphorus levels vary considerably, but are often insufficient for successful revegetation. Nitrogen levels are invariably low, with supplemental nitrogen a consistent requirement for a successful revegetation program (94). The variation in the quantity of available nutrients in soils of this region dictates a requirement for soil analysis, if at all possible, prior to planning a revegetation program for sites in this region.



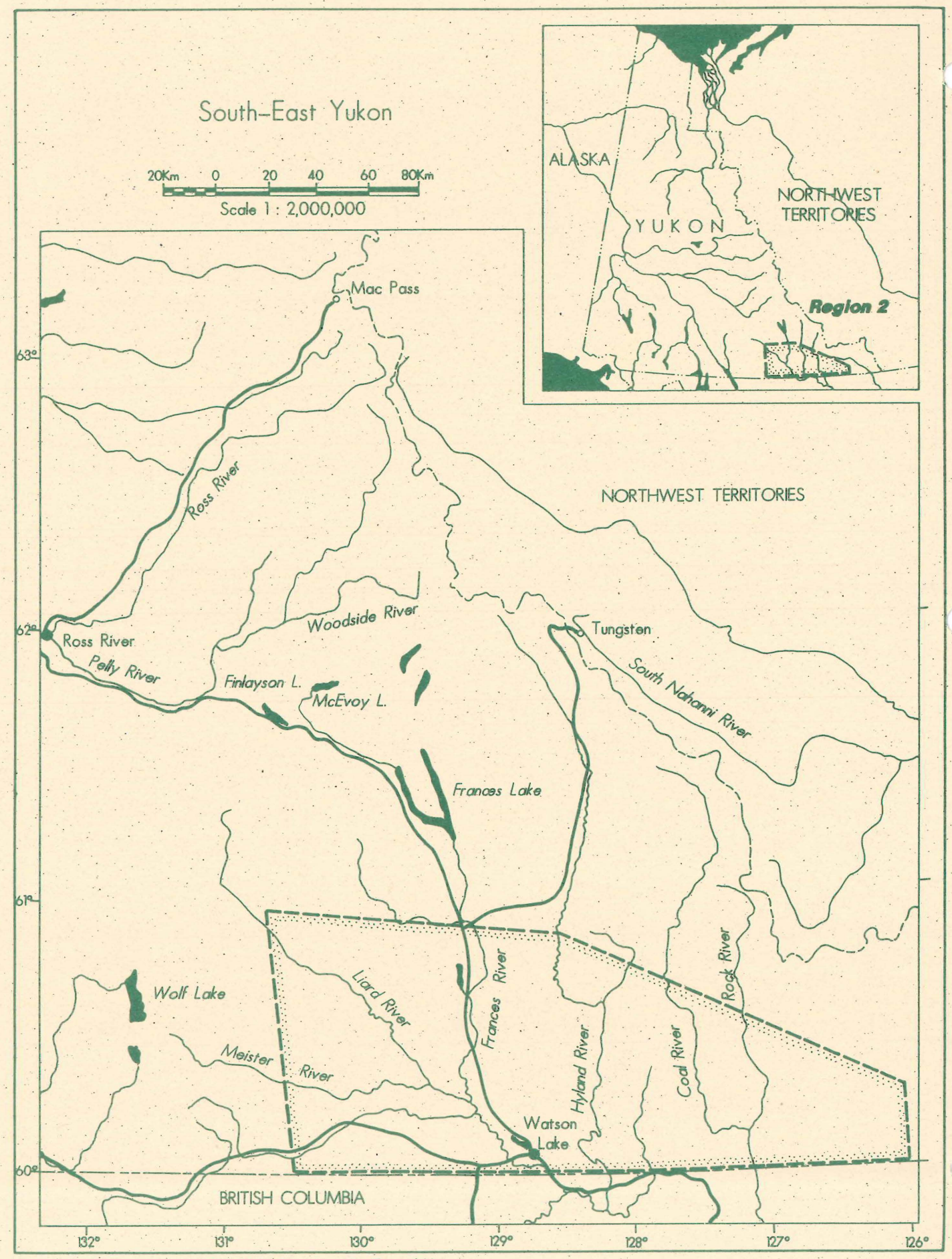


Figure 12 : REGION 2 – South-East Yukon

3.3 Vegetation

The South-East Yukon Region includes parts of the Upper Liard and Eastern Yukon sections of the boreal forest region of Canada (26,77). It encompasses portions of the Liard River Ecoregion of the Yukon (70).

Canopy cover varies, largely influenced by site elevation. At lower elevations, the climax vegetation is often white spruce *(Picea glauca)*, black spruce *(Picea mariana)*, or a mixture of both species. Lodgepole pine *(Pinus contorta)* is also very common, usually established on sites with a recent fire history. Aspen *(Populus tremuloides)* dominates south-facing slopes while mixed stands of balsam poplar *(Populus balsamifera)* and white spruce *(Picea glauca)* occur on recent floodplains. On poorly drained sites, black spruce is frequently interspersed with larch *(Larix laricina)*. Paper birch *(Betula papyrifera)* also occurs on moist sites throughout the region, but is less common.

In the understory at lower elevations, willow *(Salix* spp.*)*, alder *(Alnus* spp.*)*, rose *(Rosa acicularis)* and Labrador tea *(Ledum groenlandicum)* are typical. Shrubs such as juniper *(Juniperus* spp.*)*, soapberry *(Shepherdia canadensis)*, Canada gooseberry *(Ribes oxyacanthoides)* and raspberry *(Rubus idaeus)* also occur. The dwarf shrub layer is dominated by kinnikinnick *(Arctostaphylos uva-ursi)*, mossberry *(Empetrum nigrum)* and lowbush cranberry *(Vaccinium vitis-idaea)* (70,93). Shrub birch *(Betula glandulosa)* is prevalent in the subalpine.

The grass flora is diverse. Bluejoint reedgrass *(Calamagrostis canadensis)* is prominent in moist, semi-shaded areas. A northern fescue *(Festuca altaica)* is dominant on drier hillsides while fowl bluegrass *(Poa palustris)* is the most prevalent grass on moist, open areas. Slender wheatgrass *(Agropyron pauciflorum)*, bearded wheatgrass *(A. subsecundum)* and violet wheatgrass *(A. violaceum)* are often the primary invaders on disturbed areas. Other prominent grasses found throughout the region include glaucous bluegrass *(Poa glauca)*, ticklegrass *(Agrostis scabra)* and a native sheep fescue *(Festuca ovina)*.

The eastern portion of this region also supports some growth of naturalized species such as smooth brome *(Bromus inermis)* and timothy *(Phleum pratense)*, and both native and introduced species of red fescue *(Festuca rubra)* (36,93).

Legumes are not a prominent component of the flora; arctic lupine *(Lupinus arcticus)* and elegant milk vetch *(Astragalus eucosmus)* are the most common of the native legumes. Others of less frequent occurrence include various species of locoweed *(Oxytropis* spp.*)*, bear root *(Hedysarum* spp.*)* and other species of milk vetch *(Astragalus* spp.*)*. An introduced legume, alsike clover *(Trifolium hybridum)*, occurs on moist roadside ditches.

3.4 Plant Community Based Seed Mixtures

The natural vegetation cover growing on undisturbed sites is generally a good indication of the underlying soil properties, including texture, drainage and pH. The relationship between soil characteristics and plant communities can be used as a guide for revegetation of adjacent disturbed areas if the surface soil horizons



have not been removed or destroyed. It is preferable to conduct analyses of soil samples from the actual revegetation site to use in the formulation of appropriate seed mixtures and fertilizer, especially to determine the availability of nutrients such as nitrogen, potassium and phosphorus. In the absence of site-specific soil analysis data, the soil-vegetation community data provided in this section may be used as a guide.

Figure 9 illustrates in cross section the plant community and landform relationships common to the region and will be useful in recognizing the community types to be revegetated.

The plant communities in the tables following are named according to canopy cover. These communities are a generalization of the natural vegetation diversity of the region. Vegetation stands may appear slightly different than the plant communities that are described here, due to vegetation succession, or transition zones between distinct vegetation types.

To help the reader identify the different plant communities, a brief description of the vegetation composition is presented, followed by a listing of the characteristic species (i.e. diagnostic species which are typically present) and associated species (i.e. species which are commonly, but not always present).

Tables 26-41 are paired tables of complementary information prepared for each of eight major plant communities occurring in the region. The first table in each pair lists pertinent site characteristics and vegetation cover associated with each community; the second table lists recommended seed mixtures and fertilizer application appropriate for revegetation, based on present and future seed availability.

Revegetation studies were conducted in the region in conjunction with pipeline proposals (94). The seed and fertilizer recommendations for disturbed sites presented in the tables following are based on data collected through studies of soil-plant community relationships and revegetation trials.

A number of appendices are included in this manual which provide additional information on soil properties, characteristics of revegetation species, seed suppliers, fertilizer characteristics and calculation of application rates.

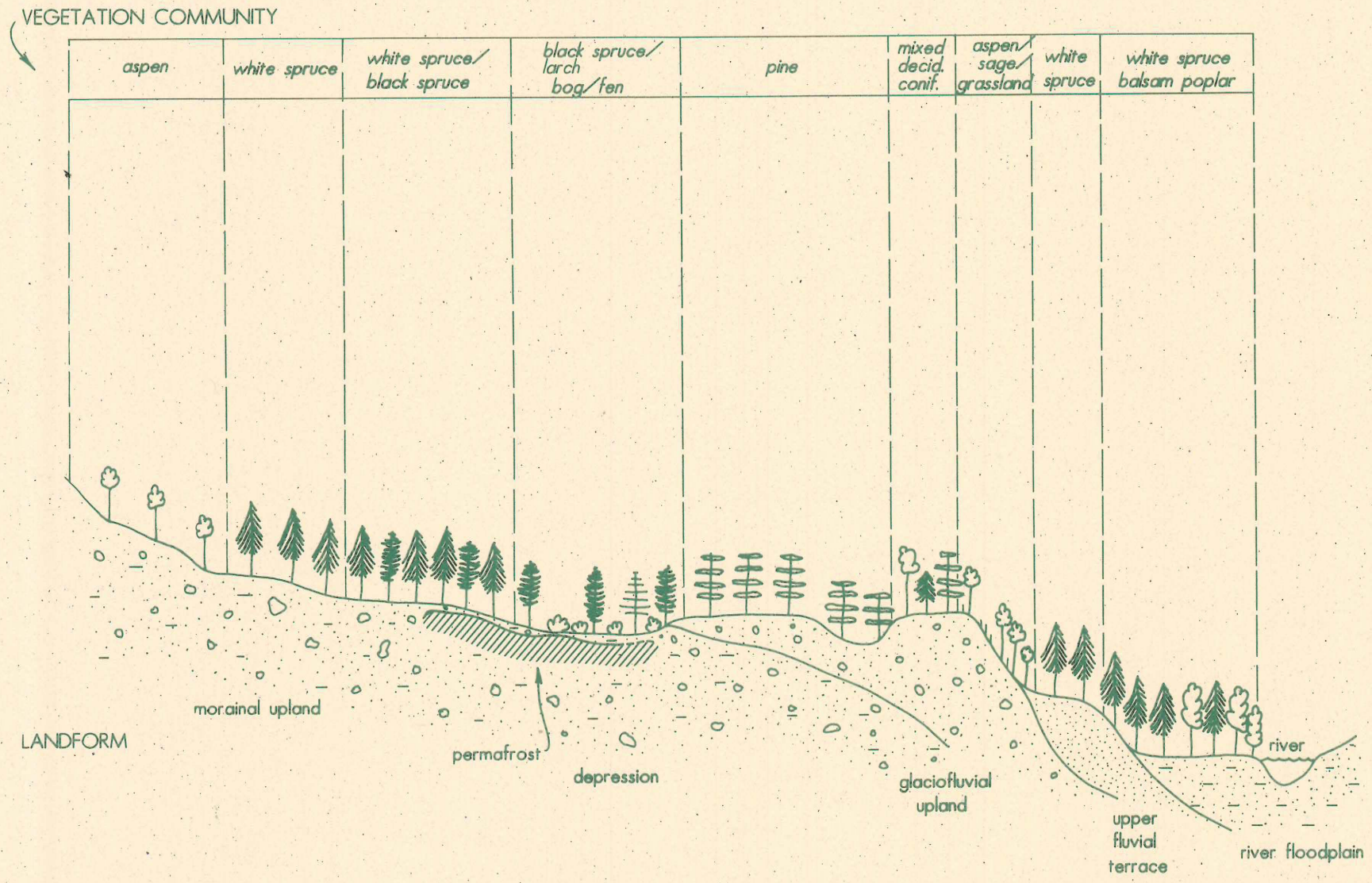


Figure 13 : Vegetation and Landform Relationships
REGION 2 – South-East Yukon

Table 26: Site characteristics of lodgepole pine *(Pinus contorta)* communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	glaciofluvial, morainal, high alluvial terraces
Modifier(s):	level to rolling
Drainage:	well to rapid
Soil: Texture (top 30 cm):	loam to sand (ML,SM,SP)#
(> 30 cm):	loam to gravelly sand (SM,GW,GM)
Other Soil Properties (top 30 cm):	
pH:	medium acid to strongly acid (6.0-5.1)
$CaCO_3$:	very low
Organic Matter:	very low
Available Nutrients:	N - very low P - very low K - low S - low

Sites which have soil parameters similar to the above will prove very difficult to revegetate. As indicated in Table 27, a complete fertilizer will be required at the time of seeding and follow-up fertilization will be necessary for one or more subsequent years. Fall or snow seeding may be superior to spring seeding on such sites, due to the low moisture-holding capacity associated with the coarse-grained soils.

Vegetation Community Description: Lodgepole pine dominates an open tree canopy which often includes white spruce and aspen; tall shrub understory sparse or absent; low shrubs include soapberry and rose; kinnikinnick is a diagnostic and dominant groundshrub; grass, forbs and lichen are common but sparse. This community commonly establishes following fire and is eventually succeeded by white spruce, which appears in the shrub understory.

Characteristic Species: lodgepole pine *(Pinus contorta)*, kinnikinnick *(Arctostaphylos uva-ursi)*, lowbush cranberry *(Vaccinium vitis-idaea)*

Associated Species: white spruce *(Picea glauca)*, aspen *(Populus tremuloides)*, soapberry *(Shepherdia canadensis)*, willow *(Salix* spp.*)*, wild rose *(Rosa acicularis)*, altai fescue *(Festuca altaica)*, arctic lupine *(Lupinus arcticus)*, fireweed *(Epilobium angustifolium)*

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 27: Seed mixture and fertilizer specifications for lodgepole pine *(Pinus contorta)* community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Streambank wheatgrass *Agropyron riparium*	SODAR	5	Yukon wheatgrass *Agropyron yukonense*	2
			Northern fescue *Festuca saximontana*	3
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	11	Violet wheatgrass *Agropyron violaceum*	6
Sheep fescue *Festuca ovina*	COMMON	8	Sheep fescue *Festuca ovina*	5
Creeping red fescue *Festuca rubra*	BOREAL	4	Glaucous bluegrass *Poa glauca*	2
Fowl bluegrass *Poa palustris*	COMMON	6	Fowl bluegrass *Poa palustris*	4
Alsike clover *Trifolium hybridum*	TETRA	4	Mackenzie's hedysarum *Hedysarum Mackenzii*	2
Total		38		24

FERTILIZER:

Nutrient requirement: Nitrogen (150kg N/ha)+ Phosphate (200kg $P_2 0_5$/ha) + Potash (100kg $K_2 0$/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 400 kg/ha 34-0-0 + 400 kg/ha 0-45-0 + 150 kg/ha 0-0-60

Second year: Nitrogen (75kg N/ha) eq. (200kg/ha 34-0-0)

Third year (if necessary): Nitrogen (75kg N/ha) eq. (200kg/ha 34-0-0)



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 28: Site characteristics of white spruce *(Picea glauca)* communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	morainal, fluvial
Modifier(s):	level to rolling
Drainage:	moderately well to well
Soil: Texture (top 30 cm):	silty loam to gravelly sandy loam (ML,SM,GM)#
(> 30 cm):	gravelly sandy loam (SM,GM)
Other Soil Properties (top 30 cm):	
pH:	slightly acid to neutral (6.1-7.3)
$CaCO_3$:	low
Organic Matter:	low
Available Nutrients:	N - low P - low to moderate K - moderate S - low

Soils such as these are reasonably well suited for the growth of grasses. Nitrogen and phosphorus will be required at the time of seeding.

Vegetation Community Description: White spruce dominant in tree canopy, though mature balsam poplar and aspen are frequently present; shrub understory includes willow, alder, highbush cranberry, Labrador tea, and rose; groundcover dominated by moss, lowbush cranberry, and horsetail; forbs diverse. This community represents a climax vegetation stage.

Characteristic Species: white spruce *(Picea glauca)*, willow *(Salix* spp.*)*

Associated Species: balsam poplar *(Populus balsamifera)*, aspen *(Populus tremuloides)*, hoary alder *(Alnus incana)*, rose *(Rosa acicularis)*, highbush cranberry *(Viburnum edule)*, soapberry *(Shepherdia canadensis)*, Labrador tea *(Ledum groenlandicum)*, lowbush cranberry *(Vaccinium vitis-idea)*, twinflower *(Linnaea borealis)*, horsetail *(Equisetum* spp.*)*, bluebell *(Mertensia paniculata)*, bunchberry *(Cornus canadensis)*, feathermoss *(Hylocomium splendens, Pleurozium schreberi)*

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 29: Seed mixture and fertilizer specifications for white spruce *(Picea glauca)* community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Streambank wheatgrass *Agropyron riparium*	SODAR	8	Yukon wheatgrass *Agropyron yukonense*	4
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	8	Violet wheatgrass *Agropyron violaceum*	4
Sheep fescue *Festuca ovina*	COMMON	6	Sheep fescue *Festuca ovina*	3
Creeping red fescue *Festuca rubra*	BOREAL	4	Glaucous bluegrass *Poa glauca*	2
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	2	Showy locoweed *Oxytropis splendens*	1
Fowl bluegrass *Poa palustris*	COMMON	6	Fowl bluegrass *Poa palustris*	5
Kentucky bluegrass *Poa pratensis*	NUGGET	2	Kentucky bluegrass *Poa pratensis*	1
Alsike clover *Trifolium hybridum*	AURORA	2	Arctic lupine *Lupinus arcticus*	1
Total		38		21

FERTILIZER:

Nutrient requirement: Nitrogen (75kg N/ha)+ Phosphate (75kg $P_2 0_5$/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 300 kg/ha 23-23-0



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 30: Site characteristics of mixed deciduous/ coniferous tree communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	morainal and fluvial
Modifier(s):	uplands
Drainage:	moderately well to well
Soil: Texture (top 30 cm):	silty loam (SM)#
(> 30 cm):	gravelly loamy sand to silt loam (GP,SP,SM)#
Other Soil Properties (top 30 cm):	
pH:	slightly acid to neutral (6.1-7.3)
$CaCO_3$:	moderate
Organic Matter:	medium
Available Nutrients:	N - low P - moderate K - high S - moderate

Soils such as these are excellent for the establishment of a grass cover. No major problems are anticipated and only nitrogen is required at the time of seeding.

Vegetation Community Description: This is an early seral community which commonly establishes following fire disturbance. Pine, aspen and paper birch dominate the canopy, with willow occurring throughout the understory. Later in succession, white and black spruce appear in the low shrub layer and eventually dominate most of these sites.

Characteristic Species: lodgepole pine *(Pinus contorta)*, aspen *(Populus tremuloides)*, paper birch *(Betula papyrifera)*, willow *(Salix* spp.*)*

Associated Species: white spruce *(Picea glauca)*, black spruce *(Picea mariana)*, highbush cranberry *(Viburnum edule)*, rose *(Rosa acicularis)*, soapberry *(Shepherdia canadensis)*, lowbush cranberry *(Vaccinium vitis-idaea)*, twinflower *(Linnaea borealis)*, fireweed *(Epilobium angustifolium)*, bunchberry *(Cornus canadensis)*, arctic lupine *(Lupinus arcticus)*, feathermoss *(Hylocomium splendens, Pleurozium schreberi)*

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 31: Seed mixture and fertilizer specifications for mixed deciduous/coniferous tree community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Streambank wheatgrass *Agropyron riparium*	SODAR	6	Yukon wheatgrass *Agropyron yukonénse*	3
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	8	Violet wheatgrass *Agropyron violaceum*	4
Creeping red fescue *Festuca rubra*	BOREAL	7	Northern fescue *Festuca saximontana*	1
			Glaucous bluegrass *Poa glauca*	3
Kentucky bluegrass *Poa pratensis*	NUGGET	6	Kentucky bluegrass *Poa pratensis*	3
Fowl bluegrass *Poa palustris*	COMMON	5	Fowl bluegrass *Poa palustris*	5
Timothy *Phleum pratense*	CLIMAX	3		
Alsike clover *Trifolium hybridum*	TETRA	3	Mackenzie's hedysarum *Hedysarum Mackenzii*	3
Total		38		22

FERTILIZER:

Nutrient requirement: Nitrogen (75kg N/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 225 kg/ha 34-0-0

YUKON ENERGY, MINES & RESOURCES LIBRARY
P.O. Box 2703
Whitehorse, Yukon Y1A 2C6



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 32: Site characteristics of white spruce/black spruce *(Picea glauca/Picea mariana)* communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	morainal
Modifier(s):	may be underlain by permafrost
Drainage:	imperfect to poor
Soil: Texture (top 30 cm):	mesic peat to sandy loam (PT, ML, SM)#
(> 30 cm):	silty loam to gravelly loamy sand (SM, SC, GW)
Other Soil Properties (top 30 cm):	
pH:	slightly acid to neutral (6.1-7.3)
$CaCO_3$:	low
Organic Matter:	high
Available Nutrients:	N - moderate to high P - low K - low S - low

Ground cover establishment can be difficult during periods of high precipitation. Species which are both acid and moisture tolerant should be used in the revegetation seed mixture.

Vegetation Community Description: Open tree canopy dominated by white and black spruce; Labrador tea and other low ericaceous shrubs are abundant in the understory; continuous moss groundcover; sphagnum often present; forbs scant.

Characteristic Species: white spruce *(Picea glauca)*, black spruce *(Picea mariana)*, feathermoss *(Pleurozium schreberi, Hylocomium splendens)*

Associated Species: labrador tea *(Ledum groenlandicum)*, willow *(Salix* spp.*)*, rose *(Rosa acicularis)*, bog blueberry *(Vaccinimum uliginosum)*, bearberry *(Arctostaphylos rubra)*, mossberry *(Empetrum nigrum)*, lowbush cranberry *(Vaccinium vitis-idaea)*, cloudberry *(Rubus chamaemorus* spp.*)*, sphagnum *(Sphagnum* spp.*)*, reindeer lichen *(Cladina* spp.*)*

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 33: Seed mixture and fertilizer specifications for white spruce/black spruce *(Picea glauca/Picea mariana)* community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Red top *Agrostis gigantea*	COMMON	2	Ticklegrass *Agrostis scabra*	1
Meadow foxtail *Alopecurus pratensis*	COMMON	8	Meadow foxtail *Alopecurus pratensis*	4
Reed canarygrass *Phalaris arundinacea*	FRONTIER	5	Altai fescue *Festuca altaica*	1
Timothy *Phleum pratense*	CLIMAX	9	Violet wheatgrass *Agropyron violaceum*	5
Fowl bluegrass *Poa palustris*	COMMON	6	Fowl bluegrass *Poa palustris*	4
Alsike clover *Trifolium hybridum*	TETRA	3	Bear root *Hedysarum alpinum*	3
Total		33		18

FERTILIZER:

Nutrient requirement: Nitrogen (50kg N/ha)+ Phosphate (100kg P_2O_5/ha) + Potash (50kg K_2O/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 250 kg/ha 18-46-0 + 100 kg/ha 0-0-60



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 34: Site characteristics of black spruce/larch *(Picea mariana/Larix laricina)* communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	bogs and fens; organic overlying morainal or fluvial
Modifier(s):	depressional areas, lower slopes
Drainage:	poor to very poor; (bogs frozen, fens not frozen)
Soil: Texture (top 30 cm):	fibric to mesic peat to silt loam (PT, ML, SM)#
(> 30 cm):	silty loam to loamy sand (ML, SM)
Other Soil Properties (top 30 cm):	
pH:	slightly acid to strongly acid (6.5-5.1)
$CaCO_3$:	low
Organic Matter:	high
Available Nutrients:	N - low P - low K - low S - low

Acid tolerant species which are adapted to wet conditions must be used in the revegetation mixture for such sites. Spot reseeding may be required in subsequent years.

Vegetation Community Description: Black spruce and larch diagnostic and co-dominant in a sparse tree and shrub understory; shrub birch, willow, Labrador tea and other low ericaceous species commonly present; extensive moss groundcover often includes sphagnum.

Characteristic Species: black spruce *(Picea mariana)*, larch *(Larix laricina)*, willow *(Salix* spp.*)*, bogmoss *(bryophyte* spp.*)*

Associated Species: shrub birch *(Betula glandulosa)*, shrubby cinquefoil *(Potentilla fruticosa)*, mossberry *(Empetrum nigrum)*, bog cranberry *(Oxycoccus microcarpus)*, northern bearberry *(Arctostaphylos rubra)*, cloudberry *(Rubus chamaemorus)*, sphagnum *(Sphagnum* spp.*)*, reindeer lichen *(Cladina* spp.*)*

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 35: Seed mixture and fertilizer specifications for black spruce/larch *(Picea mariana/Larix laricina)* community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Red top *Agrostis gigantea*	COMMON	4	Ticklegrass *Agrostis scabra*	2
Meadow foxtail *Alopecurus pratensis*	COMMON	8	Tufted hairgrass *Deschampsia caespitosa*	3
Reed canarygrass *Phalaris arundinacea*	FRONTIER	8	Polargrass *Arctagrostis latifolia*	3
Timothy *Phleum pratense*	CLIMAX	8	Violet wheatgrass *Agropyron violaceum*	7
Fowl bluegrass *Poa palustris*	COMMON	4	Fowl bluegrass *Poa palustris*	2
Alsike clover *Trifolium hybridum*	TETRA	3	Bear root *Hedysarum alpinum*	2
Total		35		19

FERTILIZER:

Nutrient requirement: Nitrogen (100kg N/ha) + Phosphate (200kg $P_2 0_5$/ha) + Potash (150kg $K_2 0$/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 300 kg/ha 34-0-0 + 400 kg/ha 0-45-0 + 225 kg/ha 0-0-60



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 36: Site characteristics of white spruce/balsam poplar *(Picea glauca/Populus balsamifera)* communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	fluvial floodplains and low terraces
Modifier(s):	
Drainage:	moderately well to imperfect
Soil: Texture (top 30 cm):	loamy sand to loam (SP, SM)#
(> 30 cm):	gravelly loamy sand to clay loam (ML, GM)
Other Soil Properties (top 30 cm):	
pH:	neutral to mildly alkaline (6.6-7.8)
$CaCO_3$:	medium
Organic Matter:	low
Available Nutrients:	N - low P - moderate K - high S - moderate

Sites having the above characteristics are easy to revegetate and a luxurious, robust ground cover should result. Seeding should be avoided during periods of potential flooding.

Vegetation Community Description: Open tree canopy is dominated by white spruce; mature balsam poplar co-dominate the stand; shrub assemblages variable and diverse, including willow, alder, highbush cranberry and red-osier dogwood; horsetail is prominent, and other forbs may be abundant and diverse; moss and lichen are frequently lacking due to frequent flooding and deposition.

Characteristic Species: white spruce *(Picea glauca)*, balsam poplar *(Populus balsamifera)*, rose *(Rosa acicularis)*

Associated Species: alder *(Alnus incana)*, willow *(Salix* spp.*)*, red-osier dogwood *(Cornus stolonifera)*, highbush cranberry *(Viburnum edule)*, northern red currant *(Ribes triste)*, soapberry *(Sheperdia canadensis)*, twinflower *(Linnaea borealis)*, horsetail *(Equisetum* spp.*)*, fireweed *(Epilobium angustifolium)*, strawberry *(Fragaria virginianum)*, toadflax *(Geocaulon lividum)*, bluebell *(Mertensia paniculata)*

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 37: Seed mixture and fertilizer specifications for white spruce/balsam poplar *(Picea glauca/Populus balsamifera)* community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Red top *Agrostis gigantea*	COMMON	4	Red top *Agrostis gigantea*	2
Meadow foxtail *Alopecurus pratensis*	COMMON	8	Tufted hairgrass *Deschampsia caespitosa*	3
Creeping red fescue *Festuca rubra*	BOREAL	6	Glaucous bluegrass *Poa glauca*	2
Reed canarygrass *Phalaris arundinacea*	FRONTIER	5	Bluejoint reedgrass *Calamagrostis canadensis*	1
Timothy *Phleum pratense*	CLIMAX	8	Violet wheatgrass *Agropyron violaceum*	8
Fowl bluegrass *Poa palustris*	COMMON	3	Fowl bluegrass *Poa palustris*	2
Alsike clover *Trifolium hybridum*	AURORA	4	Bear root *Hedysarum alpinum* Mackenzie's hedysarum *Hedysarum Mackenzii*	1 1
Total		38		20

FERTILIZER:

Nutrient requirement: Nitrogen (75 kg N/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 200 kg/ha 34-0-0



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 38: Site characteristics of aspen/soapberry *(Populus tremuloides/Sheperdia)* communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	morainal and glaciofluvial
Modifier(s):	level to moderately steep south-facing slopes
Drainage:	well
Soil: Texture (top 30 cm):	silty loam to sandy loam (SM, SP)#
(> 30 cm):	gravelly sandy loam to loamy sand (GP, GM, SP)
Other Soil Properties (top 30 cm):	
pH:	neutral to mildly alkaline (6.6-7.8)
$CaCO_3$:	moderate
Organic Matter:	low
Available Nutrients:	N - low P - moderate K - high S - moderate

Vegetation Community Description: Aspen dominates the tree canopy and is regenerating in the understory; soapberry and numerous low shrubs are present; kinnikinnick and fescue dominate the groundcover; forbs are diverse; lichen and moss are scant.

Characteristic Species: aspen *(Populus tremuloides)*, soapberry *(Sheperdia canadensis)*

Associated Species: white spruce *(Picea glauca)*, lodgepole pine *(Pinus contorta)*, willow *(Salix* spp.*)*, rose *(Rosa acicularis)*, highbush cranberry *(Viburnum edule)*, lowbush cranberry *(Vaccinium vitis-idaea)*, Jacob's ladder *(Polemonium pulcherrimum)*

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Tables 39: Seed mixture and fertilizer specifications for aspen/soapberry *(Populus tremuloides/Sheperdia)* community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Streambank wheatgrass *Agropyron riparium*	SODAR	10	Northern fescue *Festuca saximontana*	3
			Yukon wheatgrass *Agropyron yukonense*	2
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	10	Violet wheatgrass *Agropyron violaceum*	5
Sheep fescue *Festuca ovina*	COMMON	4	Sheep fescue *Festuca ovina*	2
Creeping red fescue *Festuca rubra*	BOREAL	6	Glaucous bluegrass *Poa glauca*	3
Kentucky bluegrass *Poa pratensis*	NUGGET	4	Kentucky bluegrass *Poa pratensis*	2
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	4	Arctic lupine *Lupinus arcticus*	2
			Yellow locoweed *Oxytropis campestris*	1
Total		38		20

FERTILIZER:

Nutrient requirement: Nitrogen (100kg N/ha) + Phosphate (100kg P_2O_5/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 200 kg/ha 23-23-0



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 40: Site characteristics of aspen/kinnikinnick *(Populus tremuloides/Arctostaphylos)* communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	variable
Modifier(s):	moderate to steep south facing slopes
Drainage:	well to rapid
Soil: Texture (top 30 cm):	loam to gravelly loamy sand (ML to GW)#
(> 30 cm):	clay loam to gravelly loamy sand (DL to GW)
Other Soil Properties (top 30 cm):	
pH:	slightly alkaline to strongly alkaline (7.4->8.5)
$CaCO_3$:	high
Organic Matter:	medium
Available Nutrients:	N - moderate P - high K - high S - moderate

Vegetation Community Description: Aspen dominates the sparse tree canopy and is regenerating in the shrub understory. Common low shrubs include soapberry, rose and juniper. Kinnikinnick and grass dominate the groundcover. This vegetation represents the climax community on the steep slopes where it occurs.

Characteristic Species: aspen *(Populus tremuloides)*, kinnikinnick *(Arctostaphylos uva-ursi)*

Associated Species: soapberry *(Sheperdia canadensis)*, rose *(Rosa acicularis)*, common juniper *(Juniperus communis)*, altai fescue *(Festuca altaica)*, sage *(Artemisia spp.)*, prickly saxifrage *(Saxifraga tricuspidata)*, death camas *(Zygadenus elegans)*, crocus *(Pulsatilla patens)*

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 41: Seed mixture and fertilizer specifications for aspen/kinnikinnick *(Populus tremuloides/Arctostaphylos)* community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Streambank wheatgrass *Agropyron riparium*	SODAR	8	Yukon wheatgrass *Agropyron yukonense*	4
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	8	Violet wheatgrass *Agropyron violaceum*	4
Sheep fescue *Festuca ovina*	COMMON	8	Northern fescue *Festuca saximontana*	4
Creeping red fescue *Festuca rubra*	BOREAL	5	Glaucous bluegrass *Poa glauca*	2
Kentucky bluegrass *Poa pratensis*	NUGGET	4	Kentucky bluegrass *Poa pratensis*	2
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	5	Showy locoweed *Oxytropis splendens* Yellow locoweed *Oxytropis campestris*	2 2
Total		38		20

FERTILIZER:

Nutrient requirement: Nitrogen (100kg N/ha) + Phosphate (50kg P_2O_5/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 300 kg/ha 34-18-0



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

3.5 Linear Development Seed Mixtures

The seed mixtures in Tables 42-43 are designed for use on projects which encompass a long but narrow stretch of land which needs revegetation. At present, this refers primarily to the reseeding of roadsides, but if pipeline or powerline development were to occur, the mixtures would also be applicable.

Seed mixtures for lengthy linear projects must be of a more comprehensive nature than those for projects which are confined to one or two relatively homogeneous microenvironments. Soils and climate will vary to some degree on linear projects. Precise locations of changes in either soil or climate will not be demarcated even if the general soil types and ecoregion climatic conditions are known. It is improbable that sufficient soil sampling will be done for definitive knowledge of the solid underlying each plant community and every part of the disturbed site. Also, it is not feasible, from a logistical point of view, to constantly change the seed mixture every few kilometers to account for minor shifts in growing conditions.

Seed mixtures must contain sufficient diversity in species to allow for all major microenvironments which may be encountered in the revegetation process. The mixtures in Tables 42-43 contain more species than the mixtures for precisely defined disturbed sites, and total weight of seed per hectare is higher. Each selection is not applicable at all locations but is useful for overall success.

Table 42: Seed mixture and fertilizer specifications for linear project seeding from Rancheria to Upper Liard

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Meadow foxtail *Alopecurus pratensis*	COMMON	6	Meadow foxtail *Alopecurus pratensis*	3
Tufted hairgrass *Deschampsia caespitosa*	NORTRAN+	4	Tufted hairgrass *Deschampsia caespitosa*	2
Sheep fescue *Festuca ovina*	COMMON	6	Sheep fescue *Festuca ovina*	3
Creeping red fescue *Festuca rubra*	ARCTARED+	6	Alpine bluegrass *Poa alpina*	3
Timothy *Phleum pratense*	ENGMO	8	Violet wheatgrass *Agropyron violaceum*	5
Canada bluegrass *Poa compressa*	CANON	3	Canada bluegrass *Poa compressa*	2
Glaucous bluegrass *Poa glauca*	TUNDRA+	5	Glaucous bluegrass *Poa glauca*	4
Alsike cover *Trifolium hybridum*	TETRA	3	Mackenzie's hedysarum *Hedysarum Mackenzii*	2
Total		41		24

FERTILIZER:

Nutrient requirement: Nitrogen (75kg N/ha) + Phosphate (100kg P_2O_5/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 500 kg/ha 16-20-0



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 43: Seed mixture and fertilizer specifications for linear project seeding in the greater Watson Lake region

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Red top *Agrostis gigantea*	COMMON	4	Red top *Agrostis gigantea*	2
Meadow foxtail *Alopecurus pratensis*	COMMON	6	Meadow foxtail *Alopecurus pratensis*	3
Smooth brome *Bromus inermis*	CARLTON	8	Violet wheatgrass *Agropyron violaceum*	5
Sheep fescue *Festuca ovina*	COMMON	4	Sheep fescue *Festuca ovina*	2
Creeping red fescue *Festuca rubra*	BOREAL	3	Tufted hairgrass *Deschampsia caespitosa*	2
Fowl bluegrass *Poa palustris*	COMMON	6	Glaucous bluegrass *Poa glauca*	3
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	3	Mackenzie's hedysarum *Hedysarum Mackenzii*	2
Alsike clover *Trifolium hybridum*	TETRA	3	Arctic lupine *Lupinus arcticus*	2
Total		37		21

FERTILIZER:

Nutrient requirement: Nitrogen (100kg N/ha) + Phosphate (120kg P_2O_5/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 250 kg/ha 34-0-0 + 300 kg/ha 0-45-0

* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

3.6 Specific Problem Seed Mixtures

3.6.1 Highway Cut Slope Seed Mixtures

Highway cut slopes present one of the more difficult challenges in northern reclamation. Initial instability must be corrected through physical techniques prior to the application of seed, fertilizer and mulch (89). The seed then applied is expected to germinate and produce vegetative cover on subsoil which can vary tremendously in physical and chemical properties, even on a small slope. For optimal results, site-specific soil sampling of the growth medium is essential, but if this is not possible, then the mixtures indicated in Tables 44-46 can be used as guidelines for revegetation of sandy, gravelly and silty-clay slopes respectively.

3.6.2 Saline Soil Seed Mixture

Saline soils occur only sporadically in this region of the Yukon. If revegetation of such areas is deemed essential, the mixtures in Table 47 can be used as guidelines. However, it must be remembered that until northern selections which have proven themselves salt-tolerant are developed, and become commercially available, there is not a truly satisfactory saline soil mixture for the north.

3.6.3 Sandy Soil Mixture

The mixtures found in Table 48 are designed for revegetation of sites proximal to sand dunes or other sites having a very high content of sand. These sites will be encountered only rarely in this region of the Yukon.



Table 44: Seed mixture and fertilizer specifications for sandy cut slopes

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Streambank wheatgrass *Agropyron riparium*	SODAR	7	Violet wheatgrass *Agropyron violaceum*	4
			Yukon wheatgrass *Agropyron yukonense*	2
Sheep fescue *Festuca ovina*	COMMON	5	Sheep fescue *Festuca ovina*	3
Creeping red fescue *Festuca rubra*	BOREAL	6	Glaucous bluegrass *Poa glauca*	4
Canada bluegrass *Poa compressa*	CANON	4	Canada bluegrass *Poa compressa*	3
Fowl bluegrass *Poa palustris*	COMMON	6	Northern fescue *Festuca saximontana*	2
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	2	Yellow locoweed *Oxytropis campestris*	2
Total		30		20

FERTILIZER:

Nutrient requirement: Nitrogen (120kg N/ha) + Phosphate (120kg $P_2 0_5$/ha) + Potash (100kg $K_2 0$/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 250 kg/ha 28-28-0 + 150 kg/ha 0-60-0

* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 45: Seed mixture and fertilizer specifications for gravel cut slopes

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Smooth brome *Bromus inermis*	CARLTON	8	Violet wheatgrass *Agropyron violaceum*	6
Sheep fescue *Festuca ovina*	COMMON	6	Sheep fescue *Festuca ovina*	4
			Northern fescue *Festuca saximontana*	2
Creeping red fescue *Festuca rubra*	BOREAL	6	Glaucous bluegrass *Poa glauca*	4
Canada bluegrass *Poa compressa*	CANON	4	Canada bluegrass *Poa compressa*	2
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	2	Yellow locoweed *Oxytropis campestris*	2
Total		26		20

FERTILIZER:

Nutrient requirement: Nitrogen (120kg N/ha) + Phosphate (120kg P_2O_5/ha) + Potash (100kg K_2O/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 425 kg/ha 28-28-0 + 175 kg/ha 0-0-60



* Native Seed Selections should be substituted, at the rates indicated; for the Agronomic Selections adjacent to them in the above table.

Table 46: Seed mixture and fertilizer specifications for silty-clay cut slopes

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Crested wheatgrass *Agropyron cristatum*	SUMMIT	8	Violet wheatgrass *Agropyron violaceum*	5
Streambank wheatgrass *Agropyron riparium*	SODAR	8	Yukon wheatgrass *Agropyron yukonense*	3
			Northern fescue *Festuca saximontana*	2
Sheep fescue *Festuca ovina*	COMMON	6	Sheep fescue *Festuca ovina*	4
Creeping red fesuce *Festuca rubra*	BOREAL	4	Glaucous bluegrass *Poa glauca*	3
Kentucky bluegrass *Poa pratensis*	COMMON	3	Kentucky bluegrass *Poa pratensis*	1
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	2	Yellow locoweed *Oxytropis campestris*	2
Total		31		20

FERTILIZER:

Nutrient requirement: Nitrogen (100kg N/ha) + Phosphate (80kg P_2O_5/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 350 kg/ha 23-23-0

* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 47: Seed mixture and fertilizer specifications for saline soils

AGRONOMIC SELECTIONS **			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Crested wheatgrass *Agropyron cristatum*	SUMMIT	8	Violet wheatgrass *Agropyron violaceum*	5
Streambank wheatgrass *Agropyron riparium*	SODAR	8	Bearded wheatgrass *Agropyron subsecundum*	3
			Alkaligrass *Puccinellia* sp.	2
Sheep fescue *Festuca ovina*	COMMON	6	Northern fescue *Festuca saximontana*	4
Creeping red fescue *Festuca rubra*	BOREAL	4	Glaucous bluegrass *Poa glauca*	3
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	2	Yellow locoweed *Oxytropis campestris*	2
Kentucky bluegrass *Poa pratensis*	COMMON	3	Northern bluegrass *Poa alpigena*	1
Total		31		20

FERTILIZER:

Nutrient requirement: Nitrogen (150kg N/ha) + Phosphate (100kg P_2O_5/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 350 kg/ha 34-0-0 + 200 kg/ha 0-45-0



** There is no completely satisfactory saline soil mixture available at present. The mixture indicated has some chance of success.

* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 48: Seed mixture and fertilizer specifications for sandy soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Crested wheatgrass *Agropyron cristatum*	SUMMIT	7	Crested wheatgrass *Agropyron cristatum*	5
Streambank wheatgrass *Agropyron riparium*	SODAR	7	Violet wheatgrass *Agropyron violaceum*	3
Sheep fescue *Festuca ovina*	COMMON	6	Northern fescue *Festuca saximontana*	3
Canada bluegrass *Poa compressa*	CANON	4	Northern brome *Bromus Pumpellianus*	2
Glaucous bluegrass *Poa glauca*	TUNDRA+	2	Glaucous bluegrass *Poa glauca*	2
Alkaligrass *Puccinellia* sp.	COMMON	2	Alkaligrass *Puccinellia* sp.	2
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	2	Yukon lupine *Lupinus Kuschei*	2
			Yellow locoweed *Oxytropis campestris*	2
Total		30		21

FERTILIZER:

Nutrient requirement: Nitrogen (100kg N/ha) + Phosphate (120kg P_2O_5/ha) + Potash (100kg K_2O/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 400 kg/ha 28-28-0 + 175 kg/ha 0-0-60

* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

4.0 REGION 3: SOUTH-WEST YUKON

Revegetation Region 3, is situated in the south-west corner of the Yukon. It extends west from Kluane Lake to the Alaska border and north from the Yukon/B.C. border to the Nisling River, encompassing the area south of the Dawson Range. Revegetation Region 3 is depicted in Figure 10.

4.1 Climate

In this region, a shortage of precipitation is not a barrier to successful revegetation, as precipitation increases toward the west. The two major centres of Burwash Landing and Beaver Creek receive annual precipitation of 283mm and 412mm, respectively. From May to September, Burwash receives 144mm and Beaver Creek 229mm of precipitation (70), which is adequate for revegetation purposes.

4.2 Landforms and Soils

Region 3 includes the high rugged St. Elias Mountains and Kluane Ranges, and part of the Coast Mountains, the Shakwak valley and the Klondike and Kluane plateaus. Most of the area (up to 900 metres elevation in the north and 1800 metres in the south) has been glaciated. Steep colluvial slopes lie above the glacial limits. In the south of the region, alluvial fans skirt the slopes (70, 74).

Permafrost is widespread except under large lakes and rivers. Soils with organic surface horizons are very prominent, occurring mainly under black spruce and sedge communities. Soil texture is primarily loam and sandy loam. Clay soils, although present, are not common in this region. Relevant soil characteristics are summarized below.

Soil pH varies from 5.4 to 8.0. However, the majority of soils in this region have near-neutral pH values between 6.1 and 7.3. Grassland communities (rare in this region) are the major exceptions, as these are usually alkaline with pH values approaching 8.0. Electrical conductivity and salinity problems are minimal, while CaCO3 levels are extremely low, except under grassland communities. Surface organic matter levels are often high, especially in poorly drained permafrost.

Potassium and sulphur levels range from moderate to high. Only in isolated cases is supplemental potassium or sulphur required for successful revegetation. In contrast, phosphorus and nitrogen levels are consistently low; if soil sampling on a specific project site is not possible, then these nutrients should be supplied in the revegetation program.



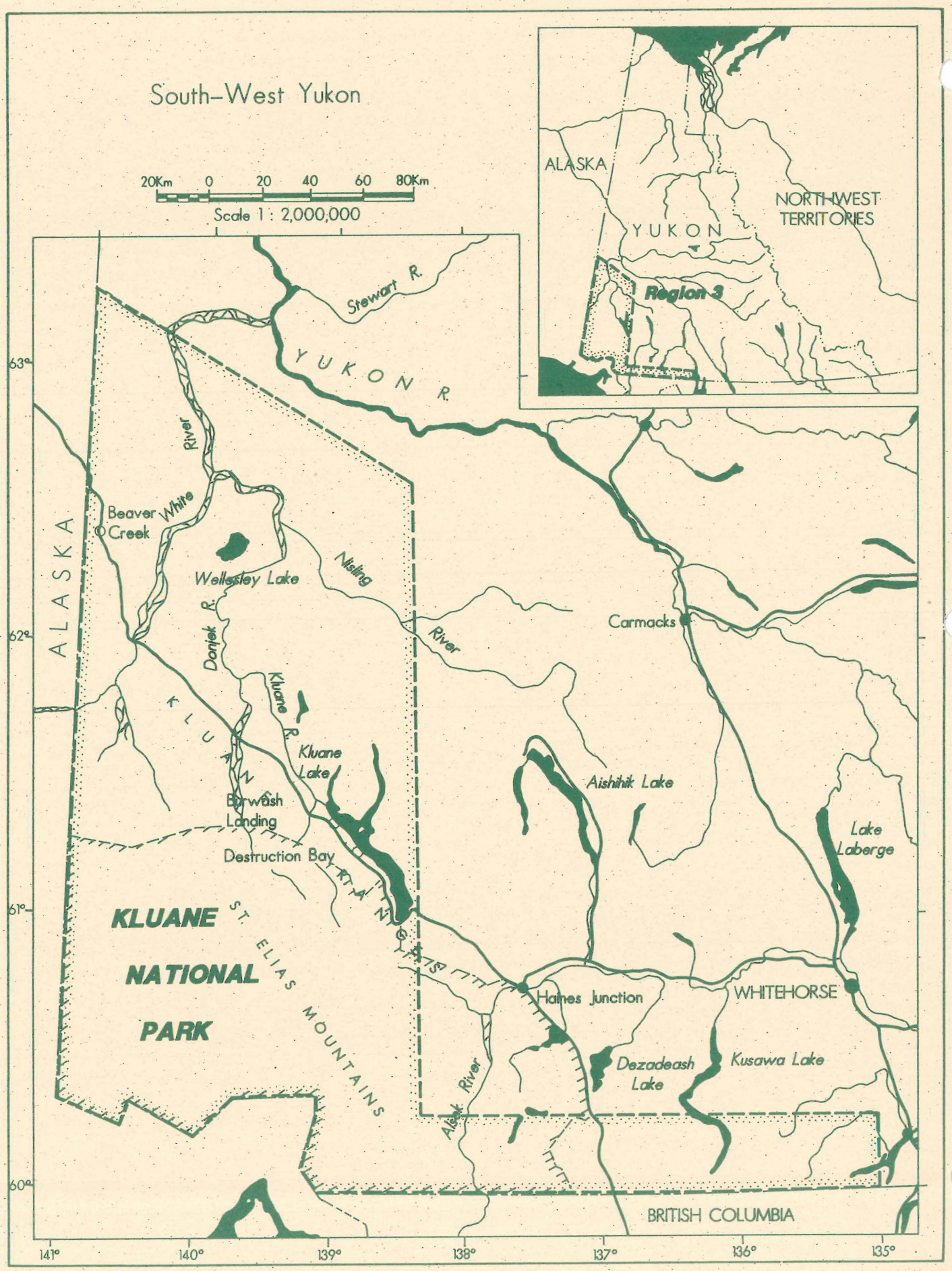


Figure 14 : REGION 3 - South-West Yukon

4.3 Vegetation

The northern portion of Revegetation Region 3 is included in the Kluane section of the boreal forest region of the Canada (26, 77) while the southern portion (the mountains comprising Kluane Park) has been classified as tundra (77). Region 3 includes the Wellesley Lake and St. Elias Mountains Ecoregions and the north-west section of the Ruby Range Ecoregion (70).

Canopy cover varies, depending upon the ecoregion. In the Ruby Range and Wellesley Lake Ecoregions, white spruce *(Picea glauca)* is common on better drained sites with warmer soils. In the northern part of the region, these warmer sites are confined to south-facing slopes and fluvial terraces. Black spruce *(Picea mariana)* is dominant on poorly drained sites. Aspen *(Populus tremuloides)* and balsam poplar *(Populus balsamifera)* are invaders which often establish after the occurrence of fires. Aspen prefer warm southerly aspects and well drained uplands while balsam poplar occur primarily on river terraces. Paper birch *(Betula papyrifera)* occurs on cooler aspects throughout the region but lodgepole pine *(Pinus contorta)* is very scarce (70).

In the understory, willow *(Salix* spp.*)*, Labrador tea *(Ledum groenlandicum)*, alder *(Alnus* spp.*)*, and shrub birch *(Betula glandulosa)* are very common. Other frequently occurring components of the shrub layer include bog blueberry *(Vaccinium uliginosum)*, shrubby cinquefoil *(Potentilla fruticosa)*, rose *(Rosa acicularis)*, soapberry *(Shepherdia canadensis)*, and mossberry *(Empetrum nigrum)*. Less common shrubs which are locally prevalent include silverberry *(Elaeagnus commutata)*, sage *(Artemisia frigida)* and lapland rosebay *(Rhododendron lapponicum)*. The dominant species of the dwarf shrub layer are lowbush cranberry *(Vaccinium vitis-idaea)* and northern bearberry *(Arctostaphylos rubra)* while yellow dryas *(Dryas Drummondii)* occurs on gravel bars (70, 93).

The grass flora is typically diverse, but four species are ubiquitous; violet wheatgrass *(Agropyron violaceum)* and glaucous bluegrass *(Poa glauca)* occur on drier sites, and polargrass *(Arctagrostis latifolia)* and bluejoint reedgrass *(Calamagrostis canadensis)*, are more abundant on mesic sites. Other common grasses include slender wheatgrass *(Agropyron pauciflorum)*, hairgrass *(Deschampsia caespitosa)*, a northern bluegrass *(Poa alpigena)* and a northern fescue *(Festuca altaica)*. Yukon wheatgrass *(Agropyron yukonense)* and purple reedgrass *(Calamagrostis purpurascens)* are locally abundant on drier sites while primary invaders of disturbed sites include ticklegrass *(Agrostis scabra)*, alkaligrass *(Puccinellia* spp.*)* and the weedy species, foxtail barley *(Hordeum jubatum)*. At higher elevations grasses include the common alpine species, alpine bluegrass *(Poa alpina)*, mountain timothy *(Phleum commutatum)* and spike trisetum *(Trisetum spicatum)* (93).

Legumes are not a major component of the flora. However, the common Yukon species, arctic lupine *(Lupinus arcticus)*, two hedysarums *(Hedysarum alpinum and H. Mackenzii)* and yellow locoweed *(Oxytropis campestris)*, are locally abundant. Also, three species of milk vetch, *(Astragalus agrestis, A. eucosmus and A. umbellatus)*, occur in isolated pockets, usually on disturbed sites (93).



4.4 Plant Community Based Seed Mixtures

The natural vegetation cover growing on undisturbed sites is generally a good indication of the underlying soil properties, including texture, drainage and pH. The relationship between soil characteristics and plant communities can be used as a guide for revegetation of adjacent disturbed areas if the surface soil horizons have not been removed or destroyed. It is preferable to conduct analyses of soil samples from the actual revegetation site to use in the formulation of appropriate seed mixtures and fertilizer, especially to determine the availability of nutrients such as nitrogen, potassium and phosphorus. In the absence of site-specific soil analysis data, the soil-vegetation community data provided in this section may be used as a guide.

Figure 11 illustrates in cross section the plant community and landform relationships common to the region and will be useful in recognizing the community types to be revegetated.

The plant communities in the tables following are named according to canopy cover. These communities are a generalization of the natural vegetation diversity of the region. Vegetation stands may appear slightly different than the plant communities that are described here, due to vegetation succession, or transition zones between distinct vegetation types.

To help the reader identify the different plant communities, a brief description of the vegetation composition is presented, followed by a listing of the characteristic species (i.e. diagnostic species which are typically present) and associated species (i.e. species which are commonly, but not always present).

Tables 49-66 are paired tables of complementary information prepared for each of nine major plant communities occurring in the region. The first table in each pair lists pertinent site characteristics and vegetation cover associated with each community; the second table lists recommended seed mixtures and fertilizer application appropriate for revegetation, based on present and future seed availability.

Revegetation studies were conducted in the region in conjunction with pipeline proposals (94). The seed and fertilizer recommendations for disturbed sites presented in the tables following are based on data collected through studies of soil-plant community relationships and revegetation trials.

A number of appendices are included in this manual to provide additional information on soil properties, characteristics of revegetation species, seed suppliers, fertilizer characteristics and calculation of application rates.

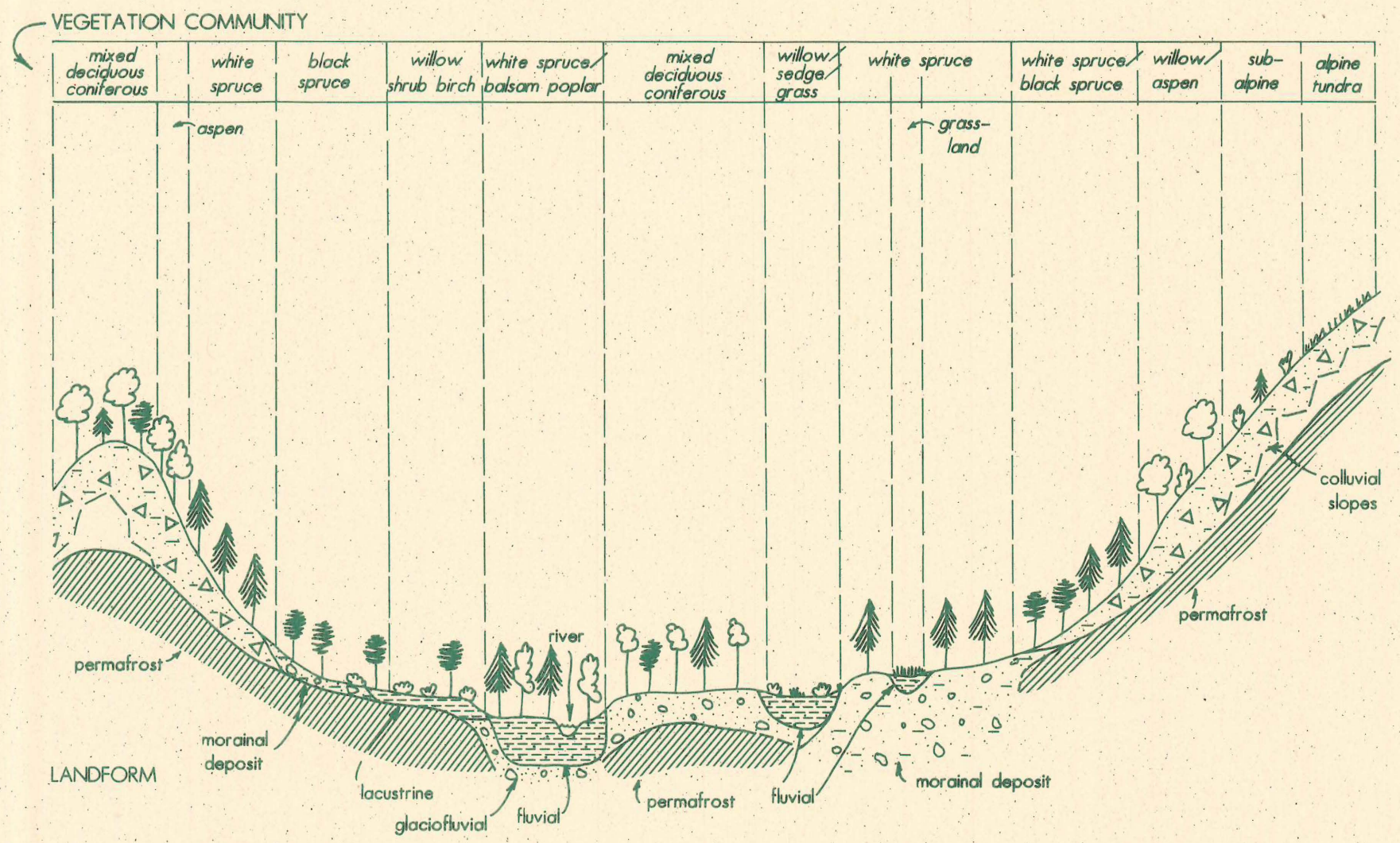


Figure 15 : Vegetation and Landform Relationships
REGION 3 – South--West Yukon

Table 49: Site characteristics of willow/shrub birch *(Salix/Betula glandulosa)* communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	aeolian veneer over morainal, glaciofluvial, fluvial
Modifier(s):	underlain by permafrost
Drainage:	poor to very poor; (permafrost present)
Soil: Texture (top 30 cm):	fibric peat to loam (PT, SM)#
(> 30 cm):	silty loam to gravelly sandy loam (ML to GW)
Other Soil Properties (top 30 cm):	
pH:	medium to slightly acid (5.6-6.5)
$CaCO_3$:	medium
Organic Matter:	moderate to high
Available Nutrients:	N - low P - low K - moderate S - moderate

Such soils can support reasonable ground cover after initial fertilization with nitrogen and phosphorus. Grasses adapted to organic soils should be included in the basic seed mixture. No serious problems are anticipated in revegetation of such soils.

Vegetation Community Description: Willow and shrub birch co-dominate in a well-developed shrub overstory. Low ericaceous shrubs and scattered conifers are common. Graminoids scant; variable moss and lichen groundcover.

Characteristic Species: willow *(Salix* spp.), shrub birch *(Betula glandulosa)*

Associated Species: black spruce *(Picea mariana)*, Labrador tea *(Ledum groenlandicum)*, shrubby cinquefoil *(Potentilla fruticosa)*, bog blueberry *(Vaccininum uliginosum)*, lowbush cranberry *(Vaccinium vitus-idaea)*, arctic bearberry *(Arctostaphylos rubra)*, cloudberry *(Rubus chamaemorus)*, sedge *(Carex* spp.), cottongrass *(Eriophorum* spp.), polargrass *(Arctagrostis latifolia)*, moss (bryophyte spp.), reindeer lichen *(Cladina* spp.)

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 50: Seed mixture and fertilizer specifications for willow/shrub birch *(Salix/Betula glandulosa)* community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	5	Violet wheatgrass *Agropyron violaceum*	4
Meadow foxtail *Alopecurus pratensis*	COMMON	8	Meadow foxtail *Alopecurus pratensis*	4
Tufted hairgrass *Deschampsia caespitosa*	NORTRAN+	5	Tufted hairgrass *Deschampsia caespitosa*	3
Reed canarygrass *Phalaris arundinacea*	FRONTIER	6	Bluejoint reedgrass *Calamagrostis canadensis*	1
Timothy *Phleum pratense*	ENGMO	8	Kentucky bluegrass *Poa pratensis*	6
Total		32		18

FERTILIZER:

Nutrient requirement: Nitrogen (50kg N/ha) + Phosphate (100kg P_2O_5/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 300 kg/ha 17-34-0



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 51: Site characteristics of black spruce/white spruce *(Picea mariana/Picea glauca)* communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	alluvial fans, moraines, colluvium
Modifier(s):	lower slopes
Drainage:	moderately well; (probably permafrost)
Soil: Texture (top 30 cm):	silty loam to sandy loam (ML, SC, SM)#
(> 30 cm):	silty loam to gravelly loamy sand (ML to GW)
Other Soil Properties (top 30 cm):	
pH:	neutral to slightly acid (6.1-7.3)
$CaCO_3$:	very low
Organic Matter:	high
Available Nutrients:	N - moderate P - low K - moderate S - moderate

Such soils can support good grass growth if adequate phosphate fertilizer is applied at the time of establishment. Grasses adapted to organic soils should be included in the basic seed mixture. No major problems are expected in revegetation of soils similar to these.

Vegetation Community Description: Open tree canopy dominated by white and black spruce; labrador tea and other low ericaceous shrubs are abundant in the understory; continuous moss groundcover; sphagnum often present; forbs scant.

Characteristic Species: white spruce *(Picea glauca)*, black spruce *(Picea mariana)*

Associated Species: labrador tea *(Ledum groenlandicum)*, willow *(Salix* spp.), rose *(Rosa acicularis)*, bog blueberry *(Vaccinium uliginosum)*, bearberry *(Arctostaphylos rubra)*, mossberry *(Empetrum nigrum)*, lowbush cranberry *(Vaccinium vitis-idaea)*, cloudberry *(Rubus chamaemorus)*, feathermoss *(Pleurozium schreberi, Hylocomium splendens)*, sphagnum *(Sphagnum* spp.); reindeer lichen *(Cladina* spp.)

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 52: Seed mixture and fertilizer specifications for black spruce/white spruce *(Picea mariana/Picea glauca)* community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	8	Slender wheatgrass *Agropyron pauciflorum*	6
Red top *Agrostis gigantea*	COMMON	5	Ticklegrass *Agrostis scabra*	3
Meadow foxtail *Alopecurus pratensis*	COMMON	5	Meadow foxtail *Alopecurus pratensis*	3
Reed canarygrass *Phalaris arundinacea*	FRONTIER	5	Polargrass *Arctagrostis latifolia*	2
Timothy *Phleum pratense*	CLIMAX	6	Violet wheatgrass *Agropyron violaceum*	5
Fowl bluegrass *Poa palustris*	COMMON	4	Fowl bluegrass *Poa palustris*	3
Alsike cover *Trifolium hybridum*	AURORA	3	Bear root *Hedysarum alpinum*	2
Total		36		24

FERTILIZER:

Nutrient requirement: Nitrogen (25kg N/ha) + Phosphate (200kg P_2O_5/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 75 kg/ha 34-0-0 + 400 kg/ha 0-45-0



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 53: Site characteristics of white spruce/balsam poplar *(Picea glauca/Populus balsamifera)* communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	floodplains of large creeks and rivers
Modifier(s):	
Drainage:	moderately well to rapid
Soil: Texture (top 30 cm):	sandy loam (SC, SM)#
(> 30 cm):	sandy loam (SM, SM)
Other Soil Properties (top 30 cm):	
pH:	medium to slightly acid (5.6-6.5)
$CaCO_3$:	very low
Organic Matter:	high
Available Nutrients:	N - low P - low K - low S - low

Such soils will require a complete fertilizer program at the time of seeding if they are to support a good grass growth. Grasses which prefer somewhat acid soil types should be predominant in the basic seed mixture. Under these circumstances, revegetation should not prove to be a major difficulty.

Vegetation Community Description: Open tree canopy is dominated by white spruce; mature balsam poplar co-dominate the stand; shrub assemblages variable and diverse, including willow, alder, highbush cranberry and red-osier dogwood; horsetail is prominent, and other forbs may be abundant and diverse; moss and lichen are often lacking due to frequent flooding and deposition.

Characteristic Species: white spruce *(Picea glauca)*, balsam poplar *(Populus balsamifera)*, rose *(Rosa acicularis)*

Associated Species: alder *(Alnus incana)*, willow *(Salix* spp.), red-osier dogwood *(Cornus stolonifera)*, highbush cranberry *(Viburnum edule)*, northern red currant *(Ribes triste)*, soapberry *(Sheperdia canadensis)*, twinflower *(Linnaea borealis)*, horsetail *(Equisetum* spp.), fireweed *(Epilobium angustifolium)*, strawberry *(Fragaria virginianum)*, toadflax *(Geocaulon lividum)*, bluebell *(Mertensia paniculata)*

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 54: Seed mixture and fertilizer specifications for white spruce/balsam poplar *(Picea glauca/Populus balsamifera)* community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Red top *Agrostis gigantea*	COMMON	4	Red top *Agrostis gigantea*	2
Meadow foxtail *Alopecurus pratensis*	COMMON	5	Tufted hairgrass *Deschampsia caespitosa*	3
Creeping red fescue *Festuca rubra*	BOREAL	6	Glaucous bluegrass *Poa glauca*	2
Reed canarygrass *Phalaris arundinacea*	FRONTIER	4	Bluejoint reedgrass *Calamagrostis canadensis*	1
Timothy *Phleum pratense*	CLIMAX	8	Violet wheatgrass *Agropyron violaceum*	8
Fowl bluegrass *Poa palustris*	COMMON	3	Fowl bluegrass *Poa palustris*	2
Alsike clover *Trifolium hybridum*	TETRA	4	Bear root *Hedysarum alpinum* Mackenzie's hedysarum *Hedysarum Mackenzii*	1 1
Total		34		20

FERTILIZER:

Nutrient requirement: Nitrogen (75kg N/ha) + Phosphate (200kg P_2O_5/ha) +Potash (l00kg K_2O/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 400 kg/ha 18-46-0 + 175 kg/ha 0-0-60



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 55: Site characteristics of black spruce communities *(Picea mariana)*

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	colluvial, morainal, fluvial
Modifier(s):	northerly aspects, lower slopes
Drainage:	poor to moderately well; (frequently permafrost)
Soil: Texture (top 30 cm):	fibric peat over loam to sand (PT, ML, SM)#
(> 30 cm):	silty loam to gravelly loamy sand (ML to GW)
Other Soil Properties (top 30 cm):	
pH:	neutral (6.5-6.7)
$CaCO_3$:	low
Organic Matter:	high
Available Nutrients:	N - low P - low K - moderate S - moderate

Such soils will support growth of excellent grass cover. They require an initial application of fertilizer, with the emphasis on phosphorus. The basic seed mixture should include some species adapted to organic soils. No major revegetation problems are foreseen with comparable soils.

Vegetation Community Description: Black spruce diagnostic and dominant in a sparse tree and shrub understory; shrub birch, willow, Labrador tea and other low and prostrate ericaceous species commonly present; extensive moss groundcover often includes sphagnum.

Characteristic Species: black spruce *(Picea mariana)*, willow *(Salix* spp.*)*, shrub birch *(Betula glandulosa)*, Labrador tea *(Ledum groenlandicum)*, feathermoss *(Hylocomium splendens, Pleurozium schreberi)*

Associated Species: shrubby cinquefoil *(Potentilla fruticosa)*, bog blueberry *(Vaccinium uliginosum)*, mossberry *(Empetrum nigrum)*, northern bearberry *(Arctostaphylos rubra)*, cloudberry *(Rubus chamaemorus)*, lousewort *(Pedicularis* spp.*)*, sphagnum *(Sphagnum* spp.*)*

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 56: Seed mixture and fertilizer specifications for black spruce *(Picea mariana)* community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Red top *Agrostis gigantea*	COMMON	3	Ticklegrass *Agrostis scabra*	2
Meadow foxtail *Alopecurus pratensis*	COMMON	8	Tufted hairgrass *Deschampsia caespitosa*	3
Reed canarygrass *Phalaris arundinacea*	FRONTIER	6	Polargrass *Arctagrostis latifolia*	3
Timothy *Phleum pratense*	CLIMAX	8	Violet wheatgrass *Agropyron violaceum*	8
Fowl bluegrass *Poa palustris*	COMMON	4	Fowl bluegrass *Poa palustris*	3
Alsike clover *Trifolium hybridum*	TETRA	3	Bear root *Hedysarum alpinum*	2
Total		32		21

FERTILIZER:

Nutrient requirement: Nitrogen (50kg N/ha) + Phosphate (200kg $P_2 0_5$ /ha) + Potash (50kg $K_2 0$/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 150 kg/ha 34-0-0 + 400 kg/ha 0-45-0 + 100 kg/ha 0-0-60



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 57: Site characteristics of white spruce *(Picea glauca)* communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	colluvial, alluvial fans, morainal
Modifier(s):	most slopes and rolling terrain
Drainage:	well to imperfect (may be frozen)
Soil: Texture (top 30 cm):	loam (ML to SP)#
(> 30 cm):	loam to gravelly sand (ML to GW)
Other Soil Properties (top 30 cm):	
pH:	slightly acid to neutral (6.1-7.3)
$CaCO_3$:	medium
Organic Matter:	variable (low to high)
Available Nutrients:	N - low to moderate P - very low K - moderate S - high

Such soils will support substantial grass growth if alkali tolerant grasses are included in the basic seed mixture. Phosphorus will be required at the time of planting but no serious revegetation problems are foreseen.

Vegetation Community Description: White spruce dominant in tree canopy, though balsam poplar and aspen are frequently present; shrub understory includes willow, alder, shrub birch and labrador tea; groundcover dominated by moss, lowbush cranberry and horsetail; forbs sparse and diverse. This community represents a climax vegetation stage.

Characteristic Species: white spruce *(Picea glauca)*, willow *(Salix* spp.*)*, feathermoss *(Hylocomium splendens, Pleurozium schreberi)*

Associated Species: aspen *(Populus tremuloides)*, alder *(Alnus* spp.*)*, shrub birch *(Betula glandulosa)*, soapberry *(Shepherdia canadensis)*, rose *(Rosa acicularis)*, mossberry *(Empetrum nigrum)*, northern bearberry *(Arctostaphylos rubra)*, lowbush cranberry *(Vaccinium vitis-idaea)*, wintergreen *(Pyrola* spp.*)*, horsetail *(Equisetum* spp.*)*, toadflax *(Geocaulon lividum)*

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 58: Seed mixture and fertilizer specifications for white spruce *(Picea glauca)* community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Streambank wheatgrass *Agropyron riparium*	SODAR	6	Yukon wheatgrass *Agropyron yukonense*	3
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	6	Violet wheatgrass *Agropyron violaceum*	4
Creeping red fescue *Festuca rubra*	BOREAL	8	Northern fescue *Festuca saximontana*	2
			Glaucous bluegrass *Poa glauca*	3
Kentucky bluegrass *Poa pratensis*	NUGGET	5	Kentucky bluegrass *Poa pratensis*	3
Fowl bluegrass *Poa palustris*	COMMON	5	Fowl bluegrass *Poa palustris*	4
Timothy *Phleum pratense*	CLIMAX	4		
Alsike clover *Trifolium hybridum*	AURORA	3	Mackenzie's hedysarum *Hedysarum Mackenzii*	2
Total		37		21

FERTILIZER:

Nutrient requirement: Nitrogen (25 kg N/ha) + Phosphate (250kg PO/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 300 kg/ha 11-55-0



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 59: Site characteristics of willow/sedge *(Salix/Carex)* communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	alluvial
Modifier(s):	drainage channels
Drainage:	poor to very poor
Soil: Texture (top 30 cm):	mesic peat (PT)#
(> 30 cm):	mesic peat to loam (PT, LM, SM)
Other Soil Properties (top 30 cm):	
pH:	mildly alkaline (7.4-7.8)
$CaCO_3$:	low
Organic Matter:	high
Available Nutrients:	N - low P - low K - high S - high

Soils similar to these will require a large application of both nitrogen and phosphorus at the time of establishment of grass in order to provide adequate available nutrients for early plant development. However, if fertilization is adequate, no major revegetation problems are foreseen.

Vegetation Community Description: moderate to dense overstory of willow; groundcover dominated by sedge and moss; grass and horsetail common; forbs diverse and scant; sphagnum often present. Riparian vegetation established along lake margins and creek drainages, which will regenerate if the present moisture regime persists.

Characteristic Species: willow *(Salix* spp.*)*, water sedge *(Carex aquatilis)*, moss (bryophyte spp.)

Associated Species: shrub birch *(Betula glandulosa)*, shrubby cinquefoil *(Potentilla fruticosa)*, nagoonberry *(Rubus acaulis)*, sedge *(Carex* spp.*)*, grass (Gramineae spp.), horsetail *(Equisetum* spp.*)*, coltsfoot *(Petasites frigidus)*, bluebell *(Mertensia paniculata)*

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 60: Seed mixture and fertilizer specifications for willow sedge *(Salix/Carex)* community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Meadow foxtail *Alopecurus pratensis*	COMMON	8	Meadow foxtail *Alopecurus pratensis*	5
Tufted hairgrass *Deschampsia caespitosa*	NORTRAN+	8	Tufted hairgrass *Deschampsia caespitosa*	4
Creeping red fescue *Festuca rubra*	BOREAL	4	Glaucous bluegrass *Poa glauca*	3
Reed canarygrass *Phalaris arundinacea*	FRONTIER	10	Bluejoint reedgrass *Calamagrostis canadensis*	3
Timothy *Phleum pratense*	ENGMO	6	Fowl bluegrass *Poa palustris*	5
Total		36		20

FERTILIZER:

Nutrient requirement: Nitrogen (50kg N/ha) + Phosphate (200kg $P_2 0_5$/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 400 kg/ha 11-55-0



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 61: Site characteristics of sage/grass *(Artemisia/Calamagrostis-Festuca)* communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	colluvial slopes over bedrock
Modifier(s):	steep south facing
Drainage:	rapid
Soil: Texture (top 30 cm):	loam to gravelly sand (SM to GW)#
(> 30 cm):	gravelly loam to gravelly sand (GW)
Other Soil Properties (top 30 cm):	
pH:	mildly alkaline: (7.4-7.8)
$CaCO_3$:	moderate to high
Organic Matter:	moderate
Available Nutrients:	N - high P - low K - high S - high

Soils such as these, which contain alkaline salts, may prove difficult to revegetate. Fertilization with phosphorus is required and alkali tolerant grasses must be included in the basic seed mixture. Some site-specific reseeding or planting may be required to remedy initial failures in the stand. Comparable soils are usually considered problems in revegetation.

Vegetation Community Description: Sage is diagnostic among a diverse array of drought-tolerant forbs; sparse low shrubs include juniper; groundcover dominated by grass. Establishes under xeric conditions on steep, south-facing slopes.

Characteristic species: sage *(Artemisia frigida)*, purple reedgrass *(Calamagrostis purpurascens)*, fescue *(Festuca* sp.*)*

Associated Species: kinnikinnick *(Arctostaphylos uva-ursi)*, crocus *(Pulsatilla patens)*, prickly saxifrage *(Saxifraga tricuspidata)*, Jacob's ladder *(Polemonium pulcherrimum)*, crocus *(Pulsatilla patens)*, death camas *(Zygadenus elegans)*, wheatgrass *(Agropyron* spp.*)*

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 62: Seed mixture and fertilizer specifications for grassland community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Streambank wheatgrass *Agrpyron riparium*	SODAR	8	Yukon wheatgrass *Agropyron yukonense*	2
			Northern fescue *Festuca saximontana*	4
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	8	Violet wheatgrass *Agropyron violaceum*	4
Sheep fescue *Festuca ovina*	COMMON	6	Sheep fescue *Festuca ovina*	2
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	5	Mackenzie's hedysarum *Hedysarum Mackenzii*	2
			Yellow locoweed *Oxytropis campestris*	2
Glaucous bluegrass *Poa glauca*	TUNDRA+	6	Glaucous bluegrass *Poa glauca*	4
Total		33		20

FERTILIZER:

Nutrient requirement: Nitrogen (25kg N/ha) + Phosphate (200kg PO/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 300 kg/ha 11-55-0



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 63: Site characteristics of willow/aspen *(Salix /Populus tremuloides)* communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	colluvial, morainal, alluvial
Modifier(s):	level to moderately sloping
Drainage:	moderately well to imperfect
Soil: Texture (top 30 cm):	silty loam to gravelly sandy loam (ML, SP, SM, GW)#
(> 30 cm):	silty loam to gravelly sandy loam (ML, SP, SM, GW)
Other Soil Properties (top 30 cm):	
pH:	slightly acid to neutral (6.1-7.3)
$CaCO_3$:	moderate
Organic Matter:	moderate
Available Nutrients:	N - moderate P - very low K - very high S - very high

This community commonly regenerates after fires. Soils such as these are excellent media for growing grasses. There is a serious deficiency of phosphorus, although nitrogen may occasionally be lacking. Many grass species will grow on such sites if moisture is adequate. No serious revegetation problems are foreseen on such sites.

Vegetation Community Description: This early successional community is common on disturbed sites following fire. The canopy is comprised of low tree willows and aspen. Pine and spruce typically invade these sites and frequently appear in the shrub understory. Willow, rose, Labrador tea and soapberry are usually present. The groundcover is comprised of variable amounts of lowbush cranberry, kinnikinnick and moss. Stands of white or black spruce may eventually develop on these sites.

Characteristic Species: willow *(Salix* spp.), aspen *(Populus tremuloides)*

Associated Species: white spruce *(Picea glauca)*, lodgepole pine *(Pinus contorta)*, rose *(Rosa acicularis)*, Labrador tea *(Ledum groenlandicum)*, soapberry *(Sheperdia canadensis)*, kinnikinnick *(Arctostophylos uva-ursi)*, northern bearberry *(Arctostaphylos rubra)*, lowbush cranberrry *(Vaccinium vitis-idaea)*, moss (bryophyte spp.)

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 64: Seed mixture and fertilizer specifications for willow/aspen *(Salix /Populus tremuloides)* community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Crested wheatgrass *Agropyron cristatum*	SUMMIT	4	Northern fescue *Festuca saximontana*	3
Streambank wheatgrass *Agropyron riparium*	SODAR	6	Yukon wheatgrass *Agropyron yukonense*	3
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	8	Violet wheatgrass *Agropyron violaceum*	4
Sheep fescue *Festuca ovina*	COMMON	6	Sheep fescue *Festuca ovina*	3
Big bluegrass *Poa ampla*	SHERMAN	5	Big bluegrass *Poa ampla* Alkaligrass *Puccinellia* sp.	2 1
Glaucous bluegrass *Poa glauca*	TUNDRA+	4	Glaucous bluegrass *Poa glauca*	3
Total		33		19

FERTILIZER:

Nutrient requirement: Nitrogen (25kg N/ha) + Phosphate (250kg $P_2 0_5$/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 75 kg/ha 34-0-0 + 400 kg/ha 0-45-0



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 65: Site characteristics of mixed deciduous/ coniferous tree communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	colluvial, morainal, glaciofluvial
Modifier(s):	slopes and rolling uplands
Drainage:	moderately well
Soil: Texture (top 30 cm):	sandy loam to loam (SM, ML)#
(> 30 cm):	loam to clay loam (ML, CL)
Other Soil Properties (top 30 cm):	
pH:	neutral (6.6-7.3)
$CaCO_3$:	medium
Organic Matter:	low
Available Nutrients:	N - low P - high K - low S - low

Soils such as these can support a robust growth of grasses. Only nitrogen, applied at the time of establishment, is required for the successful initiation of a grass stand. No serious problems are foreseen in revegetation.

Vegetation Community Description: This seral community typically establishes following fire. The tree canopy is dominated by aspen, willow and paper birch. Pine is absent except in the easternmost part of Region 3. White and black spruce eventually invade these sites and comprise the climax vegetation cover.

Characteristic Species: aspen *(Populus tremuloides)*, paper birch *(Betula papyrifera)*,willow *(Salix* spp.*)*

Associated Species: white spruce *(Picea glauca)*, black spruce *(Picea mariana)*, alder *(Alnus* spp.*)*, shrub birch *(Betula glandulosa)*, soapberry *(Shepherdia canadensis)*, rose *(Rosa acicularis)*, lowbush cranberry *(Vaccinium vitis-idaea)*, northern bearberry *(Arctostaphylos rubra)*, arctic lupine *(Lupinus arcticus)*, cottongrass *(Eriophorum angustifolium)*, dog ear lichen *(Peltigera* spp.*)*, feathermoss *(Hylocomium splendens, Pleurozium schreberi)*

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 66: Seed mixture and fertilizer specifications for mixed deciduous/coniferous tree community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Streambank wheatgrass *Agropyron riparium*	SODAR	8	Yukon wheatgrass *Agropyron yukonense*	3
			Northern fescue *Festuca saximontana*	2
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	6	Violet wheatgrass *Agropyron violaceum*	6
Creeping red fescue *Festuca rubra*	BOREAL	4		
Sheep fescue *Festuca ovina*	COMMON	5	Sheep fescue *Festuca ovina*	3
Fowl bluegrass *Poa palustris*	COMMON	3	Glaucous bluegrass *Poa glauca*	3
Kentucky bluegrass *Poa pratensis*	NUGGET	4	Sweetgrass *Hierochloë odorata*	1
Alsike clover *Trifolium hybridum*	TETRA	3	Arctic lupine *Lupinus arcticus*	2
Total		33		20

FERTILIZER:

Nutrient requirement: Nitrogen (50 kg N/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 150 kg/ha 34-0-0



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

4.5 Seed Mixtures for High Elevations

The southwest region of the Yukon includes a substantial amount of terrain in the alpine and subalpine. A vast majority of the St. Elias Mountains Ecoregion is above treeline and has been classified as tundra (77). Also, in the Ruby Range and Wellesley lake Ecoregions there is considerable high elevation territory.

Sites in these environments which require revegetation will be more difficult to successfully reclaim because of problems associated with low temperatures, high winds, high solar radiation and a possible shortage of precipitation during the growing season (11, 12). Varieties of grasses and legumes developed for use in more moderate environments have had little long-term success in the alpine (13, 85). Thus, it is necessary to utilize varieties developed for harsh northern regions or native selections adapted to the region.

The optimal agronomic varieties include those developed in Alaska (34, 59, 64) and northern Europe. However, after the development of indigenous Yukon species, the local selections are apt to be superior and less expensive. Tables 67 and 68 contain mixtures composed of currently available agronomic varieties and Yukon native selections useful for revegetation in the alpine and subalpine.

Table 67: Seed mixture and fertilizer specifications for subalpine environments

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Tufted hairgrass *Deschampsia caespitosa*	NORTRAN+	5	Tufted hairgrass *Deschampsia caespitosa*	2
Sheep fescue *Festuca ovina*	COMMON	6	Northern fescue *Festuca saximontana*	3
Creeping red fescue *Festuca rubra*	ARCTARED+	8	Alpine bluegrass *Poa alpina*	4
Timothy *Phleum pratense*	ENGMO	9	Violet wheatgrass *Agropyron violaceum*	6
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	4	Mackenzie's hedysarum *Hedysarum Mackenzii*	3
			Yellow locoweed *Oxytropis campestris*	1
Glaucous bluegrass *Poa glauca*	TUNDRA+	6	Glaucous bluegrass *Poa glauca*	4
Total		38		23

FERTILIZER:

Nutrient requirement: Nitrogen (75 kg N/ha) + Phosphate (200kg $P_2 0_5$/ha) + Potash (75kg $K_2 0$/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 400 kg/ha 18-46-0 + 125 kg/ha 0-0-60



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 68: Seed mixture and fertilizer specifications for alpine environments

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Meadow foxtail *Alopecurus pratensis*	COMMON	4	Polargrass *Arctagrostis latifolia*	2
Tufted hairgrass *Deschampsia caespitosa*	NORTRAN+	6	Tufted hairgrass *Deschampsia caespitosa*	3
Sheep fescue *Festuca ovina*	COMMON	8	Sheep fescue *Festuca ovina*	4
Creeping red fescue *Festuca rubra*	ARCTARED+	2	Tickleweed *Agrostis scabra*	1
Timothy *Phleum pratense*	ENGMO	6	Alpine bluegrass *Poa alpina*	4
			Mountain timothy *Phleum commutatum*	1
Glaucous bluegrass *Poa glauca*	TUNDRA+	8	Glaucous bluegrass *Poa glauca*	4
Total		34		19

FERTILIZER:

Nutrient requirement: Nitrogen (90kg N/ha) + Phosphate (100kg $P_2 0_5$/ha) + Potash (75kg $K_2 0$/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 400 kg/ha 23-23-0 + 125 kg/ha 0-0-60

* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

4.6 Seed Mixtures for Linear Developments

The seed mixtures in Tables 69 and 70 are designed for use on projects which encompass a long but narrow stretch of land which needs revegetation. At present, this refers primarily to the reseeding of roadsides, but if pipeline or powerline development were to occur, the mixtures would also be applicable.

Seed mixtures for lengthy linear projects must be of a more comprehensive nature then those for projects which are confined to one or two relatively homogeneous environments. Soils and climate will vary to some degree on such projects. Precise locations of changes in either soil or climate will not be demarcated even if the general soil types and ecoregion climatic conditions are known. It is improbable that sufficient soil sampling will be done for definitive knowledge of the soils underlying each plant community and every part of the disturbed site. Also, it is not feasible, from a logistical point of view, to constantly change the seed mixture every few kilometers to account for minor shifts in growing conditions.

Seed mixtures must contain sufficient diversity in species to allow for all major microenvironments which may be encountered in the revegetation process. The mixtures in Table 69 and 70 contain more species than the mixtures for precisely defined disturbed sites, and total weight of seed per hectare is higher.

Although every seed selection is not required at all locations en route, a complete range of species is necessary for overall success.



Table 69: Seed mixture and fertilizer specifications for linear project seeding from Kluane Lake to Pickhandle Lake

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Streambank wheatgrass *Agropyron riparium*	SODAR	8	Yukon wheatgrass *Agropyron yukonense* Northern fescue *Festuca saximontana*	3 3
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	8	Violet wheatgrass *Agropyron violaceum*	5
Sheep fescue *Festuca ovina*	COMMON	5	Sheep fescue *Festuca ovina*	3
Creeping red fescue *Festuca rubra*	BOREAL	6	Glaucous bluegrass *Poa glauca*	4
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	2	Mackenzie's hedysarum *Hedysarum Mackenzii*	1
Timothy *Phleum pratense*	ENGMO	6	Tufted hairgrass *Deschampsia caespitosa*	2
Canada bluegrass *Poa compressa*	CANON	3	Canada bluegrass *Poa compressa*	2
Alsike clover *Trifolium hybridum*	TETRA	2	Arctic lupine *Lupinus arcticus*	1
Total		40		24

FERTILIZER:

Nutrient requirement: Nitrogen (50kg N/ha) + Phosphate (200kg $P_2 0_5$/ha) + Potash (25kg $K_2 0$/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 425 kg/ha 11-48-0 + 50 kg/ha 0-0-60

* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 70: Seed mixture and fertilizer specifications for linear project seeding from Pickhandle Lake to the Alaska border

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	7	Violet wheatgrass *Agropyron violaceum*	5
Meadow foxtail *Alopecurus pratensis*	COMMON	5	Meadow foxtail *Alopecurus pratensis*	3
Tufted hairgrass *Deschampsia caespitosa*	NORTRAN+	4	Tufted hairgrass *Deschampsia caespitosa*	2
Creeping red fescue *Festuca rubra*	BOREAL	5	Sheep fescue *Festuca ovina*	3
Timothy *Phleum pratense*	ENGMO	6	Timothy *Phleum pratense*	3
Fowl bluegrass *Poa palustris*	COMMON	5	Fowl bluegrass *Poa palustris*	3
Kentucky bluegrass *Poa pratensis*	NUGGET	4	Polargrass *Arctagrostis latifolia*	2
Alsike clover *Trifolium hybridum*	TETRA	3	Bear root *Hedysarum alpinum*	2
Total		39		23

FERTILIZER:

Nutrient requirement: Nitrogen (40kg N/ha) + Phosphate (200kg $P_2 0_5$/ha) + Potash (40kg $K_2 0$/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 400 kg/ha 11-48-0 + 70 kg/ha 0-0-60



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

4.7 Specific Problem Seed Mixtures

4.7.1 Highway Cut Slope Seed Mixtures

Highway cut slopes present one of the more difficult problems in northern reclamation. Initial instability must be corrected through physical techniques prior to the application of seed, fertilizer, and mulch (89). The seed applied is expected to germinate and produce vegetative cover on subsoil which can vary tremendously in physical and chemical properties, even on a small slope. For optimal results, site-specific soil sampling of the growth medium is essential, but, if not possible, then the mixtures indicated in Tables 71 and 72 can be used as guidelines for revegetation of sand or gravel, and silty-clay cut slopes, respectively.

4.7.2 Saline Soil Seed Mixture

Saline soils occur only in isolated locations in this region and thus are a minimal problem. However, if encountered, and if revegetation of such sites is deemed essential, the mixtures in Table 73 can be used as guidelines. Nonetheless, the southern agronomic varieties in this table, which are commercially available, are unlikely to persist in the north. Until the salt-tolerant northern selections listed in Table 73 are developed, there is not a truly satisfactory saline soil seed mixture available for the Yukon.

4.7.3 Sandy Soil Mixture

The seed mixtures found in Table 74 are designed for revegetation of sites with high content of sand. However, in Revegetation Region 3, such sites are not common and will rarely need revegetation.

Table 71: Seed mixture and fertilizer specifications for sand and gravel cut slopes

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Streambank wheatgrass *Agropyron riparium*	SODAR	4	Violet wheatgrass *Agropyron violaceum*	6
Smooth brome *Bromus inermis*	CARLTON	4		
Meadow foxtail *Alopecurus pratensis*	COMMON	4	Yukon wheatgrass *Agropyron yukonense*	2
Sheep fescue *Festuca ovina*	COMMON	5	Sheep fescue *Festuca ovina*	3
Creeping red fescue *Festuca rubra*	BOREAL	8	Glaucous bluegrass *Poa glauca*	4
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	2	Yellow locoweed *Oxytropis campestris*	2
Canada bluegrass *Poa compressa*	CANON	4	Canada bluegrass *Poa compressa*	2
			Northern fescue *Festuca saximontana*	2
Total		31		21

FERTILIZER:

Nutrient requirement: Nitrogen (120kg N/ha) + Phosphate (120kg $P_2 0_5$/ha) + Potash (100kg $K_2 0$/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 400 kg/ha 23-23-0 + 130 kg/ha 0-0-60



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 72: Seed mixture and fertilizer specifications for silty-clay cut slopes

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Crested wheatgrass *Agropyron cristatum*	SUMMIT	6	Violet wheatgrass *Agropyron violaceum*	6
Meadow foxtail *Alopecurus pratensis*	COMMON	3		
Streambank wheatgrass *Agropyron riparium*	SODAR	6	Yukon wheatgrass *Agropyron yukonense*	2
			Northern fescue *Festuca saximontana*	2
Sheep fescue *Festuca ovina*	COMMON	6	Sheep fescue *Festuca ovina*	4
Creeping red fescue *Festuca rubra*	BOREAL	8	Glaucous bluegrass *Poa glauca*	4
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	2	Yellow locoweed *Oxytropis campestris*	2
Total		31		20

FERTILIZER:

Nutrient requirement: Nitrogen (100kg N/ha) + Phosphate (80kg P_2O_5/ha)

Example of a commercial fertilizer which approximates the recommended nutrient application: 400kg/ha 23-23-0

* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 73: Seed mixture and fertilizer specifications for saline soils

AGRONOMIC SELECTIONS **			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Tall wheatgrass *Agropyron elongatum*	ORBIT	8	Violet wheatgrass *Agropyron violaceum*	4
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	3	Bearded wheatgrass *Agropyron subsecundum*	2
Russian wild ryegrass *Elymus junceus*	SAWKI	5	Lymegrass *Elymus arenarius*	2
Sheep fescue *Festuca ovina*	COMMON	5	Northern fescue *Festuca saximontana*	4
Big bluegrass *Poa ampla*	SHERMAN	5	Big bluegrass *Poa ampla* Northern bluegrass *Poa alpigena*	3 2
Alkaligrass *Puccinellia* sp.	COMMON	5	Alkaligrass *Puccinellia* sp.	4
Total		31		21

FERTILIZER:

Nutrient requirement: Nitrogen (150kg N/ha) + Phosphate (100kg P_2O_5/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 400 kg/ha 34-18-0



** There is no completely satisfactory saline soil mixture available at present. The mixture indicated has some chance of success.

* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 74: Seed mixture and fertilizer specifications for sandy soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Crested wheatgrass *Agropyron cristatum*	SUMMIT	7	Crested wheatgrass *Agropyron cristatum*	4
Streambank wheatgrass *Agropyron riparium*	SODAR	6	Violet wheatgrass *Agropyron violaceum*	2
Sheep fescue *Festuca ovina*	COMMON	6	Northern fescue *Festuca saximontana*	3
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	3	Yukon lupine *Lupinus Kuschei*	2
			Yellow locoweed *Oxytropis campestris*	2
Canada bluegrass *Poa compressa*	CANON	4	Northern brome *Bromus Pumpellianus*	2
Glaucous bluegrass *Poa glauca*	TUNDRA+	2	Glaucous bluegrass *Poa glauca*	2
Alkaligrass *Puccinellia* sp.	COMMON	2	Alkaligrass *Puccinellia* sp.	2
Total		30		19

FERTILIZER:

Nutrient requirement: Nitrogen (100 kg N/ha) + Phosphate (120 kg $P_2 0_5$/ha) + Potash (100 kg $K_2 0$/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 400 kg/ha 28-28-0 + 175 kg/ha 0-0-60

* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

5.0 REGION 4: PELLY/ CASSIAR MOUNTAINS

Revegetation Region 4 is located in the southern Yukon, encompassing portions of the Pelly and Cassiar Mountain Ranges. It extends east from the Teslin River toward the Liard River, and from the Yukon/B.C. border north to Little Salmon Lake, illustrated in Figure 12.

Much of the terrain in this region is situated in alpine and subalpine environments. Characteristic features such as steep slopes and an abundance of micro-climates present difficult revegetation problems. Varieties of grasses and legumes developed for use in more moderate environments have had little long-term success in the alpine (13, 85). Consequently, it is necessary to use varieties developed for harsh northern regions or native selections adapted to the region.

5.1 Climate

The winter climate of the Pelly/Cassiar Mountains is moderated by the higher elevations, characteristic of the region. Mid-winter mild spells are frequent; conversely, the higher elevations make for relatively cool summers.

Moisture and temperature are not an impediment to successful revegetation in Region 4. Precipitation totals are relatively high, varying from 500-700mm. Approximately one half of this precipitation falls as rain. September and October are, on average, the wettest months of the year.

Mean growing season temperatures are approximately 8°C while the mean annual temperature is -3°C.

5.2 Landforms and Soils

This region is comprised of rugged mountain ranges varying in elevation from 1,000 to 2,000 meters. The region is characterized by steep, narrow valleys and small lakes and rivers. Glaciofluvial, morainal and localized lacustine deposits fill the valleys while deep morainal and colluvial materials mantle the mid and lower slopes. Scree and bedrock are present at higher elevations. Permafrost is widespread, especially on north facing slopes.

Due to the proximity and nature of the intrusive bedrock which predominates in the Pelly/Cassiar Mountains, soil texture is generally course ranging from sandy loam to sand and gravel. Some finer textures do occur on locally ponded lacustrine deposits. Organic deposits are common on valley floors and lower slopes associated with peat plateaus and black spruce bogs, and under sedge tussocks in seepage areas. Relevant soil characteristics are summarized below:

Soil pH is usually acidic ranging from 4.0 to 7.0. Electrical conductivity and $CaCO_3$ levels are low while organic matter content varies widely. Nutrient levels are generally low although sulphur content and sometimes potassium levels are sufficient for revegetation purposes. Substantial additions of nitrogen and phosphorus are usually required for successful revegetation.



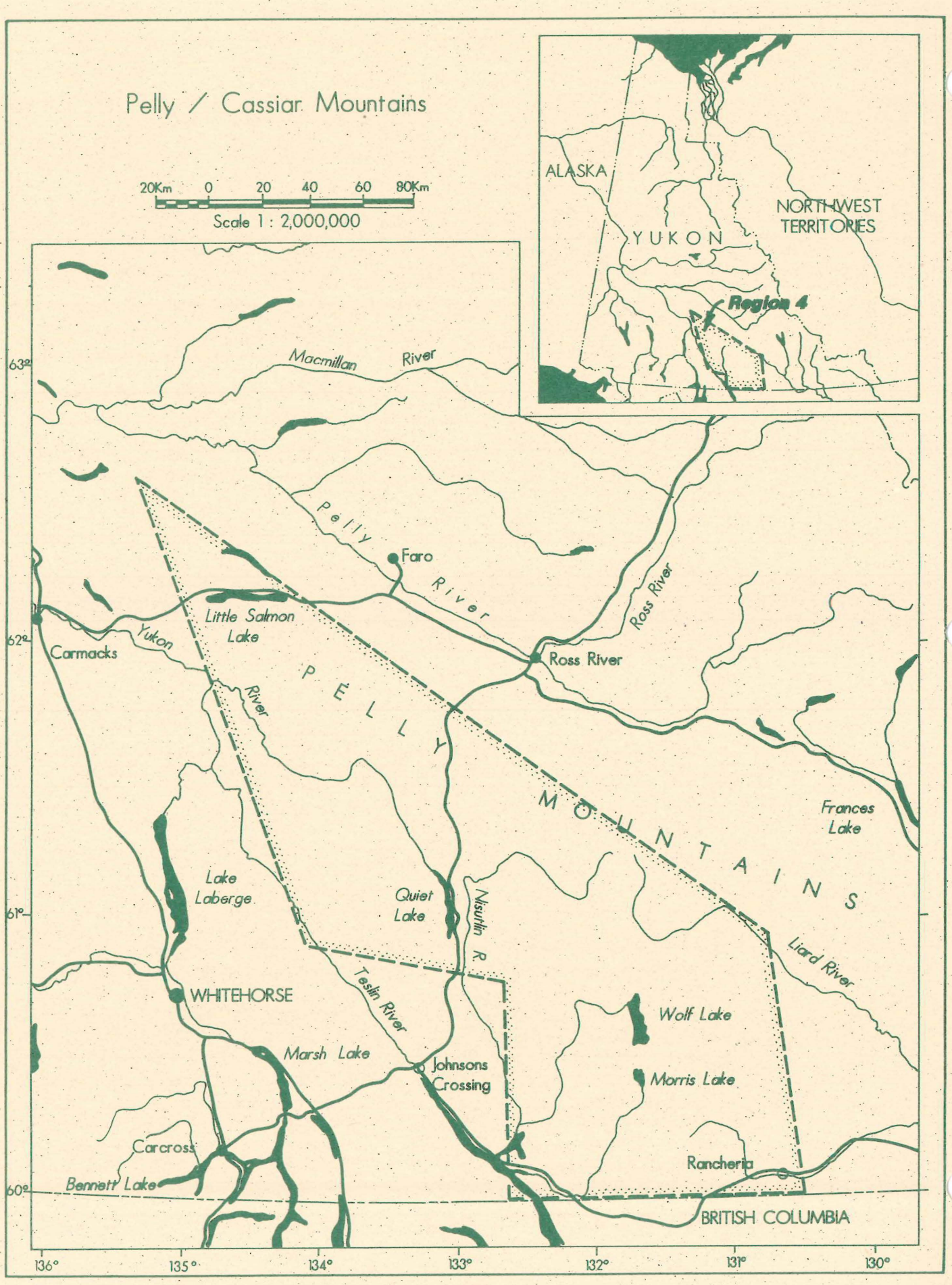


Figure 16 : REGION 4 – Pelly/Cassiar Mountains

5.3 Vegetation

White spruce *(Picea glauca)* and black spruce *(Picea mariana)* dominate the lower slopes in this region. On moist lower slopes, black spruce bog plateaus are common. Pine *(Pinus contorta)* is common after fire, while deciduous species *(Populus tremuloides, P. balsamifera)* are generally limited to lower elevations, usually associated with fluvial floodplains and lower terraces. At higher elevations, the tree canopy is less varied; alpine fir *(Abies lasiocarpa)* is the dominant species in the subalpine while various shrubs comprise the overstory vegetation in the alpine (70, 93). Shrub birch *(Betula glandulosa)* is also prevalent in subalpine areas.

In the understory at lower elevations, willow *(Salix* spp.*)*, alder *(Alnus* spp.*)*, rose *(Rosa acicularis)*, and Labrador tea *(Ledum groenlandicum)* are typical. Shrubs such as juniper *(Juniperus* spp.*)*, mossberry *(Empetrum nigrum)*, soapberry *(Sheperdia canadensis)*, Canada gooseberry *(Ribes oxycanthoides)* and raspberry *(Rubus idaeus)* also occur. The dwarf shrub layer is dominated by kinnikinnick *(Arctostaphylos uva-ursi)* and lowbush cranberry *(Vaccinium vitis-idaea)*. Shrub birch *(Betula glandulosa)* is prevalent in the subalpine.

The grass flora is diverse. Bluejoint reedgrass *(Calamagrostis canadensis)* is the prominent grass in moist, semi-shaded areas. A northern fescue *(Festuca altaica)* is dominant on drier hillsides while fowl bluegrass *(Poa palustris)* is the most prevalent grass on moist, open areas. Slender wheatgrass *(Agropyron pauciflorum)*, bearded wheatgrass *(A. subsecundum)* and violet wheatgrass *(A. Violaceum)* are often the primary invaders on disturbed areas.

Other prominent grasses found throughout the region include glaucous bluegrass *(Poa glauca)*, ticklegrass *(Agrostis scabra)* and a native fescue *(Festuca ovina)*. In alpine and subalpine locations, species such as alpine bluegrass *(Poa alpina)*, spike trisetum *(Trisetum spicatum)* and a northern fescue *(Festuca saximontana)*, occur frequently.

5.4 Plant Community Based Seed Mixtures

The natural vegetation cover growing on undisturbed sites is generally a good indication of the underlying soil properties, including texture, drainage and pH. The relationship between soil characteristics and plant communities can be used as a guide for revegetation of adjacent disturbed areas if the surface soil horizons have not been removed or destroyed. It is preferable to conduct analyses of soil samples from the actual revegetation site to use in the formulation of appropriate seed mixtures and fertilizer, especially to determine the availability of nutrients such as nitrogen, potassium and phosphorus. In the absence of site-specific soil analysis data, the soil-vegetation community data provided in this section may be used as a guide.

Figure 13 illustrates in cross section the plant community and landform relationships common to the region and will be useful in recognizing the community types to be revegetated.



The plant communities in the tables following are named according to canopy cover. These communities are a generalization of the natural vegetation diversity of the region. Vegetation stands may appear slightly different than the plant communities that are described here, due to vegetation succession, or transition zones between distinct vegetation types.

To help the reader identify the different plant communities, a brief description of the vegetation composition is presented, followed by a listing of the characteristic species (i.e. diagnostic species which are typically present) and associated species (i.e. species which are commonly, but not always present).

Tables 75-88 are paired tables of complementary information prepared for each of seven major plant communities occurring in the region. The first table in each pair lists pertinent site characteristics and vegetation cover associated with each community; the second table lists recommended seed mixtures and fertilizer application appropriate for revegetation, based on present and future seed availability.

Revegetation studies were conducted in the region in conjunction with pipeline proposals (94). The seed and fertilizer recommendations for disturbed sites presented in the tables following are based on data collected through studies of soil-plant community relationships and revegetation trials.

A number of appendices are included in this manual which provide additional information on soil properties, characteristics of revegetation species, seed suppliers, fertilizer characteristics and calculation of application rates.

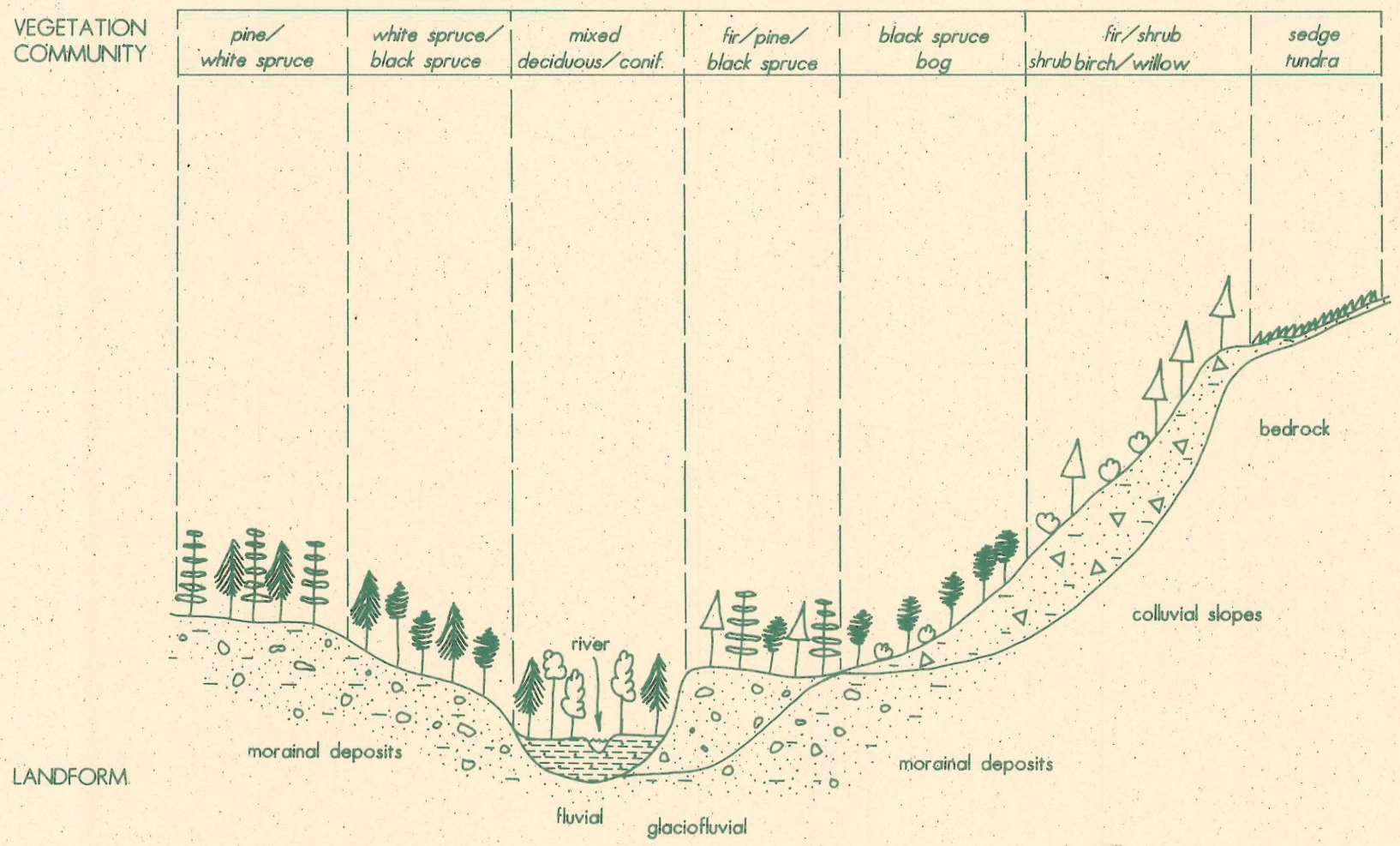


Figure 17: Vegetation and Landform Relationships
REGION 4 - Pelly / Cassiar Mountains

Table 75: Site characteristics of white spruce/lodgepole pine *(Picea glauca/Pinus contorta)* communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	glaciofluvial, fluvial terraces
Modifier(s):	level to gently sloping
Drainage:	well to rapid
Soil: Texture (top 30 cm):	sandy loam (SM)#
(> 30 cm):	sandy loam to gravelly sand (SM, GW)
Other Soil Properties (top 30 cm):	
pH:	slightly acid to neutral (6.1-7.3)
$CaCO_3$:	low
Organic Matter:	low
Available Nutrients:	N - low P - moderate K - moderate S - low

No serious difficulties exist in establishment of vegetation on such sites. However, in some years the optimal seeding time may be very short. Species which prefer slightly acidic soil should be used in the revegetation seed mixture.

Vegetation Community Description: Open tree canopy dominated by pine and white spruce. Shrub understory diverse and well developed, including rose and willow. Groundcover is mainly comprised of kinnikinnick, lowbush cranberry and twinflower. Grass and forbs are sparse. This is a successional vegetation type which establishes after fire.

Characteristic Species: white spruce *(Picea glauca)*, lodgepole pine *(Pinus contorta)*, willow *(Salix* spp.*)*

Associated Species: aspen *(Populus tremuloides)*, Labrador tea *(Ledum groenlandicum)*, rose *(Rosa acicularis)*, twinflower *(Linnaea borealis)*, lowbush cranberry *(Vaccinium vitis-idaea)*, altai fescue *(Festuca altaica)*, arctic lupine *(Lupinus arcticus)*, fireweed *(Epilobium angustifolium)*, moss (bryophyte spp.)

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 76: Seed mixture and fertilizer recommendations for white spruce/lodgepole pine *(Picea glauca/Pinus contorta)* community soil

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	8	Violet wheatgrass *Agropyron violaceum*	5
Red top *Agrostis gigantea*	COMMON	2	Ticklegrass *Agrostis scabra*	1
Meadow foxtail *Alopecurus pratensis*	COMMON	8	Meadow foxtail *Alopecurus pratensis*	4
Creeping red fescue *Festuca rubra*	ARCTARED+	6	Glaucous bluegrass *Poa glauca*	2
Timothy *Phleum pratense*	ENGMO	6	Fowl bluegrass *Poa palustris*	2
Canada bluegrass *Poa compressa*	CANON	4	Canada bluegrass *Poa compressa*	2
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	4	Bear root *Hedysarum alpinum* Yellow locoweed *Oxytropis campestris*	2 2
Total		38		20

FERTILIZER:

Nutrient requirement: Nitrogen (150kg N/ha) + Phosphate (50kg P_2O_5/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 400 kg/ha 34-18-0



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 77: Site characteristics of white spruce/black spruce *(Picea glauca/Picea mariana)* communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	morainal and colluvial
Modifier(s):	lower slopes
Drainage:	well to imperfect; permafrost commonly present
Soil: Texture (top 30 cm):	sandy loam (SM)#
(> 30 cm):	sandy loam (SM)#
Other Soil Properties (top 30 cm):	
pH:	slightly acid to mildly alkaline (6.1-7.8)
$CaCO_3$:	low
Organic Matter:	moderate
Available Nutrients:	N - moderate P - low K - low S - low

Such sites will support good grass growth once the cover has been successfully established. No major problems are foreseen on such sites.

Vegetation Community Description: Open tree canopy dominated by white and black spruce; Labrador tea and other low ericaceous shrubs are abundant in the understory; continuous moss groundcover; sphagnum often present; forbs scant.

Characteristic Species: white spruce *(Picea glauca)*, black spruce *(Picea mariana)*

Associated Species: labrador tea *(Ledum groenlandicum)*, willow *(Salix* spp.*)*, rose *(Rosa acicularis)*, bog blueberry *(Vaccinium uliginosum)*, bearberry *(Arctostaphylos rubra)*, mossberry *(Empetrum nigrum)*, lowbush cranberry *(Vaccinium vitis-idaea)*, cloudberry *(Rubus chamaemorus* spp.*)*, feathermoss *(Pleurozium schreberi, Hylocomium splendens)*, sphagnum *(Sphagnum* spp.*)*; reindeer lichen *(Cladina* spp.*)*

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 78: Seed mixture and fertilizer specifications for white spruce/black spruce *(Picea glauca/Picea mariana)* communities

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Red top *Agrostis gigantea*	COMMON	4	Ticklegrass *Agrostis scabra*	1
Meadow foxtail *Alopecurus pratensis*	COMMON	10	Tufted hairgrass *Deschampsia caespitosa*	5
Reed canarygrass *Phalaris arundinacea*	FRONTIER	5	Altai fescue *Festuca altaica*	2
Timothy *Phleum pratense*	ENGMO	10	Violet wheatgrass *Agropyron violaceum*	7
Fowl bluegrass *Poa palustris*	COMMON	5	Fowl bluegrass *Poa palustris*	3
Alsike clover *Trifolium hybridum*	TETRA	4	Bear root *Hedysarum alpinum*	2
Total		38		20

FERTILIZER:

Nutrient requirement: Nitrogen (100kg N/ha) + Phosphate (100kg P_2O_5/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 400 kg/ha 23-23-0



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 79: Site characteristics of mixed deciduous/ coniferous tree communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	morainal and fluvial
Modifier(s):	valleys (at lower elevations)
Drainage:	well to moderately well
Soil: Texture (top 30 cm):	silty loam to sandy loam (SM to SC)#
(> 30 cm):	silty loam to gravelly sandy loam (SC to GM)
Other Soil Properties (top 30 cm):	
pH:	neutral to mildly alkaline (6.6-7.8)
$CaCO_3$:	medium
Organic Matter:	medium
Available Nutrients:	N - low P - low K - moderate S - low

Establishment of a grass cover is relatively easy on such sites. However, dry periods after seedling emergence may reduce seedling survival. Fall seeding can be used on such sites.

Vegetation Community Description: This is an early seral community which establishes after fire. The canopy is dominated by pine, aspen and balsam poplar. Paper birch is common on wetter sites. Willow occurs throughout the understory. Later in succession, white and black spruce appear in the low shrub layer and eventually dominate most stands which reach maturity on these sites.

Characteristic Species: lodgepole pine *(Pinus contorta)*, aspen *(Populus tremuloides)*, balsam poplar *(Populus balsamifera)*, paper birch *(Betula papyrifera)*, willow *(Salix* spp.*)*

Associated Species: white spruce *(Picea glauca)*, black spruce *(Picea mariana)*, alder *(Alnus* spp.*)*, rose *(Rosa acicularis)*, kinnikinnick *(Arctostaphylos uva-ursi)*, lowbush cranberry *(Vaccinium vitis-idaea)*, bunchberry *(Cornus canadensis)*, feathermoss *(Hylocomium splendens, Pleurozium schreberi)*

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 80: Seed mixture and fertilizer specifications for mixed deciduous/coniferous tree community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Streambank wheatgrass *Agropyron riparium*	SODAR	8	Yukon wheatgrass *Agropyron yukonense*	2
			Northern fescue *Festuca saximontana*	2
Creeping red fescue *Festuca rubra*	ARCTARED+	10	Glaucous bluegrass *Poa glauca*	4
Timothy *Phleum pratense*	ENGMO	12	Violet wheatgrass *Agropyron violaceum*	6
Big bluegrass *Poa ampla*	SHERMAN	4	Big bluegrass *Poa ampla*	2
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	4	Arctic lupine *Lupinus arcticus*	2
			Yellow locoweed *Oxytropis campestris*	2
Total		38		20

FERTILIZER:

Nutrient requirement: Nitrogen (150kg N/ha) + Phosphate (100kg P_2O_5/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 400 kg/ha 34-0-0 + 200 kg/ha 0-45-0



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 81: Site characteristics of black spruce *(Picea mariana)* communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	morainal and colluvial
Modifier(s):	lower slopes, depressions
Drainage:	imperfect to poor
Soil: Texture (top 30 cm):	fibric peat, sandy loam (PT, SM)#
(> 30 cm):	sandy loam to loamy sand (SM, SP)
Other Soil Properties (top 30 cm):	
pH:	slightly acid to strongly acid (6.5-5.1)
$CaCO_3$:	low
Organic Matter:	high
Available Nutrients:	N - low P - low K - low S - low

Acid tolerant species which are adapted to wet conditions must be used in the revegetation mixture for such sites. Spot reseeding may be required in subsequent years.

Vegetation Community Description: black spruce diagnostic and dominant in a sparse tree and shrub understory; shrub birch, willow, Larbrador tea and other low ericaceous species commonly present; extensive moss groundcover often includes sphagnum.

Characteristic Species: black spruce *(Picea mariana)*, Labrador tea *(Ledum groenlandicum)*, feathermoss *(Hylocomium splendens, Pleurozium schreberi)*

Associated Species: willow *(Salix* spp.*)*, shrub birch *(Betula glandulosa)*, shrubby cinquefoil *(Potentilla fruticosa)*, mossberry *(Empetrum nigrum)*, bog cranberry *(Oxycoccus microcarpus)*, northern bearberry *(Arctostaphylos rubra)*, cloudberry *(Rubus chamaemorus)*, sphagnum *(Sphagnum* spp.*)*, reindeer lichen *(Cladina* spp.*)*

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 82: Seed mixture and fertilizer specifications for black spruce *(Picea mariana)* community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Red top *Agrostis gigantea*	COMMON	4	Ticklegrass *Deschampsia caespitosa*	2
Meadow foxtail *Alopecurus pratensis*	COMMON	8	Tufted hairgrass *Deschampsia caespitosa*	3
Reed canarygrass *Phalaris arundinacea*	FRONTIER	8	Polargrass *Arctagrostis latifolia*	3
Timothy *Phleum pratense*	CLIMAX	8	Violet wheatgrass *Agropyron violaceum*	7
Fowl bluegrass *Poa palustris*	COMMON	4	Fowl bluegrass *Poa palustris*	3
Alsike cover *Trifolium hybridum*	TETRA	3	Bear root *Hedysarum alpinum*	2
Total		35		20

FERTILIZER:

Nutrient requirement: Nitrogen (100kg N/ha) + Phosphate (200kg $P_2 0_5$/ha) + Potash (150kg $K_2 0$/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 300 kg/ha 34-0-0 + 400 kg/ha 0-45-0 + 225 kg/ha 0-0-60



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 83: Site characteristics of alpine fir *(Abies lasiocarpa)* communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	morainal, colluvial, glaciofluvial
Modifier(s):	over bedrock
Drainage:	moderate to well
Soil: Texture (top 30 cm):	sandy loam to loamy sand (SM, SP)#
(> 30 cm):	gravelly sandy loam over bedrock (GW)
Other Soil Properties (top 30 cm):	
pH:	slightly acid to mildly alkaline (6.1-7.8)
$CaCO_3$:	neutral
Organic Matter:	low
Available Nutrients:	N - low P - low K - low S - low

Sites such as these can prove difficult for the establishment of vegetation. High winds may cause desiccation, thereby making fall seeding appropriate in many instances. Spot reseeding may be required in subsequent years.

Vegetation Community Description: This community comprises the climax vegetation at higher elevations; alpine fir dominant throughout the canopy and shrub understory; low ericaceous shrubs common; herbs scant but diverse; moss layer extensive overlain by variable cover of lichen.

Characteristic Species: alpine fir *(Abies lasiocarpa)*; shrub birch *(Betula glandulosa)*; mossberry *(Empetrum nigrum)*; feathermoss (bryophyte spp.); reindeer lichen *(Cladina* spp., *Cetraria* spp.*)*

Associated Species: white spruce *(Picea glauca)*, willow *(Salix* spp.*)*, Labrador tea *(Ledum groenlandicum)*; spirea *(Spirea beauverdiana)*, bag blueberry *(Vaccinium uliginosum)*, lowbush cranberry *(Vaccinium vitis-idaea)*, arctic lupine *(Lupinus arcticus)*

#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 84: Seed mixture and fertilizer specifications for alpine fir *(Abies lasiocarpa)* community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Tufted hairgrass *Deschampsia caespitosa*	NORTRAN+	6	Tufted hairgrass *Deschampsia caespitosa*	2
Sheep fescue *Festuca ovina*	COMMON	6	Sheep fescue *Festuca ovina*	3
Creeping red fescue *Festuca rubra*	ARCTARED+	8	Alpine bluegrass *Poa alpina*	4
Timothy *Phleum pratense*	ENGMO	9	Violet wheatgrass *Agropyron violaceum*	5
Glaucous bluegrass *Poa glauca*	TUNDRA+	6	Glaucous bluegrass *Poa glauca*	4
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	4	Mackenzie's hedysarun *Hedysarum Mackenzii*	1
			Yellow locoweed *Oxytropis campestris*	1
Total		39		20

FERTILIZER:

Nutrient requirement: Nitrogen (100kg N/ha) + Phosphate (200kg P_2O_5/ha) + Potash (100kg K_2O/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 450 kg/ha 18-46-0 + 150 kg/ha 0-0-60



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

5.5 Seed Mixtures For High Elevations

The Big Salmon, Pelly, and Cassiar Mountains, which comprise Region 4, include considerable terrain in alpine and subalpine environments. Revegetation in these environments is more difficult because of problems associated with low temperatures, high winds, high solar radiation levels, and a possible shortage of precipitation during the growing season. Varieties of grasses and legumes developed for use in moderate environments have had little long-term success in the alpine (13, 85). Varieties developed for harsh northern regions or specially adapted native selections are necessary in this region.

Table 85: Site characteristics of alpine fir/shrub birch-willow *(Abies lasiocarpa/Betula glandulosa-Salix)* communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	colluvial, morainal
Modifier(s):	especially cooler aspects in the subalpine
Drainage:	moderate to well
Soil: Texture (top 30 cm):	silty loam to loamy sand (SC, SM)#
(> 30 cm):	loam to sandy loam (SC, SM)
Other Soil Properties (top 30 cm):	
pH:	slightly acid to neutral (6.1-7.3)
$CaCO_3$:	low
Organic Matter:	low
Available Nutrients:	N - low P - low K - low to moderate S - low

On these subalpine sites, the short frost-free growing season requires the use of species adapted to the subalpine climate. Fall seeding is often the most successful. Second year fertilization with additional nitrogen may be required.

Vegetation Community Description: A stable community, common at subalpine elevations; tree canopy of alpine fir varies in density; shrub understory is well-developed, dominated by shrub birch and willow; low ericaceous shrubs common over groundcover of moss and lichen.

Characteristic Species: alpine fir *(Abies lasiocarpa)*, shrub birch *(Betula glandulosa)*, willow *(Salix* spp.*)*, mossberry *(Empetrum nigrum)*, feathermoss *(Hylocomium splendens, Pleurozium schreberi)*, reindeer lichen *(Cladina* spp., *Cetraria* spp.*)*

Associated Species: white spruce *(Picea glauca)*, Labrador tea *(Ledum groenlandicum)*, spiraea *(Spiraea beauverdiana)*, blueberry *(Vaccinium uliginosum)*, lowbush cranberry *(Vaccinium vitis-idaea)*, arctic lupine *(Lupinus arcticus)*



#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 86: Seed mixture and fertilizer specifications for alpine fir *(Abies lasiocarpa)* communities

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Meadow foxtail *Alopecurus pratensis*	COMMON	8	Meadow foxtail *Alopecurus pratensis*	3
Tufted hairgrass *Deschampsia caespitosa*	NORTRAN+	4	Tufted hairgrass *Deschampsia caespitosa*	2
Sheep fescue *Festuca ovina*	COMMON	6	Sheep fescue *Festuca ovina*	3
Creeping red fescue *Festuca rubra*	ARCTARED+	8	Alpine bluegrass *Poa alpina* Glaucous bluegrass *Poa glauca*	2 3
Timothy *Phleum pratense*	ENGMO	8	Violet wheatgrass *Agropyron violaceum*	5
Alsike clover *Trifolium hybridum*	TETRA	4	Mackenzie's hedysarun *Hedysarum Mackenzii*	2
Total		38		20

FERTILIZER:

Nutrient requirement: Nitrogen (150kg N/ha) + Phosphate (150kg $P_2 0_5$/ha) + Potash (50kg $K_2 0$/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 500kg/ha 28-28-0 + 75 kg/ha 0-0-60

* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 87: Site characteristics of sedge/cottongrass *(Carex/Eriophorum)* communities

SITE CHARACTERISTICS	
Landform/Genetic Material(s):	colluvial, bedrock
Modifier(s):	alpine and subalpine
Drainage:	well to poor
Soil: Texture (top 30 cm):	mesic peat to loam (PT, ML, SL)#
(> 30 cm):	loam to gravelly sand (ML, SM, GW)
Other Soil Properties (top 30 cm):	
pH:	slightly acid to mildly alkaline (6.1-6.5)
$CaCO_3$:	low
Organic Matter:	high
Available Nutrients:	N - low P - low K - low S - low

The establishment of grass ground cover is very difficult on these high elevation sites. Only species adapted to wet, windy, cold conditions on organic soil will survive and provide permanent ground cover.

Vegetation Community Description: Graminoid vegetation dominated by sedge and grass, with scattered willows; forbs diverse, but scant; ericaceous groundshrubs and prostrate willows present; moss layer well developed.

Characteristic Species: sedge *(Carex* spp.*)*, cottongrass *(Eriophorum* spp.*)*, willow *(Salix* spp.*)* moss (bryophyte spp.)

Associated Species: holy grass *(Hierochloë odorata)*, bluegrass *(Poa* sp.*)*, wood rush *(Luzula* spp.*)*, netted willow *(Salix reticulata)*, skeleton willow *(Salix phlebophylla)*, lowbush cranberry *(Vaccinium vitis-idaea)*, bistort *(Polygonum bistorta)*, groundsel *(Senecio* spp.*)*, anemone *(Anemone* spp.*)* lousewort *(Pedicularis* spp.*)*



#Agronomic Soil Texture Class (Unified Soil Classification (USC))

Table 88: Seed mixture and fertilizer specifications for cottongrass/sedge *(Eriophorum/Carex)* community soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Meadow foxtail *Alopecurus pratensis*	COMMON	6	Polargrass *Arctagrostis latifolia*	3
Tufted hairgrass *Deschampsia caespitosa*	NORTRAN+	8	Tufted hairgrass *Deschampsia caespitosa*	4
Sheep fescue *Festuca ovina*	COMMON	8	Sheep fescue *Festuca ovina*	4
Glaucous bluegrass *Poa glauca*	TUNDRA+	8	Glaucous bluegrass *Poa glauca*	5
Fowl bluegrass *Poa palustris*	COMMON	8	Alpine bluegrass *Poa alpina*	4
Total		38		20

FERTILIZER:

Nutrient requirement: Nitrogen (100kg N/ha) + Phosphate (150kg $P_2 0_5$/ha) + Potash (50kg $K_2 0$/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 150 kg/ha 34-0-0 + 500 kg/ha 10-30-10

* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

5.6 Seed Mixtures for Linear Developments

The seed mixture in Table 89 is designed for use on projects which encompass a long but narrow stretch of land which needs revegetation. At present,this refers primarily to the reseeding of roadsides, but if pipeline or powerline development were to occur, the mixture would also be applicable.

Seed mixtures for lengthy linear projects must be of a more comprehensive nature than those for projects which are confined to one or two relatively homogeneous microenvironments. Soils and climate will vary to some degree on such projects. Precise locations of changes in either soil or climate will not be demarcated even if the general soil types and ecoregion climatic conditions are known. It is improbable that sufficient soil sampling will be done for definitive knowledge of the soils underlying each plant community and every part of the disturbed site. Also, it is not feasible, from a logistical point of view, to constantly change the seed mixture every few kilometers to account for minor shifts in growing conditions.

Seed mixtures must contain sufficient diversity in species to allow for all major microenvironments which may be encountered in the revegetation process. The mixtures in Table 89 contain more species than the mixtures for precisely defined disturbed sites, and total weight of seed per hectare is higher. Each selection is not applicable at all locations but is useful for overall success.



Table 89: Seed mixture and fertilizer specifications for linear project seeding from Johnson's Crossing to Rancheria

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Streambank wheatgrass *Agropyron riparium*	SODAR	8	Yukon wheatgrass *Agropyron yukonense*	1
			Northern fescue *Festuca saximontana*	3
Slender wheatgrass *Agropyron trachycaulum*	REVENUE	10	Violet wheatgrass *Agropyron violaceum*	5
Sheep fescue *Festuca ovina*	COMMON	6	Sheep fescue *Festuca ovina*	3
Creeping red fescue *Festuca rubra*	BOREAL	4	Glaucous bluegrass *Poa glauca*	2
Canada bluegrass *Poa compressa*	CANON	3	Canada bluegrass *Poa compressa*	2
Fowl bluegrass *Poa palustris*	COMMON	4	Fowl bluegrass *Poa palustris*	2
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	2	Yellow locoweed *Oxytropis campestris*	1
Alsike clover *Trifolium hybridum*	AURORA	2	Arctic lupine *Lupinus arcticus*	2
Total		39		21

FERTILIZER:

Nutrient requirement: Nitrogen (100kg N/ha) + Phosphate (120kg P_2O_5/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 400kg/ha 28-28-0

* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

5.7 Specific Problem Seed Mixtures

5.7.1 Highway Cut Slope Seed Mixtures

Highway cut slopes present one of the more difficult challenges in northern reclamation. Initial instability must be corrected through physical techniques prior to the application of seed, fertilizer, and mulch (89). The seed then applied is expected to germinate and produce vegetative cover on subsoil which can vary tremendously in physical and chemical properties, even on a small slope. For optimal results, site-specific soil sampling of the growth medium is essential, but if this is not possible, then the mixtures indicated in Tables 90-93 can be used as guidelines for revegetation of sandy, gravelly, and silty-clay slopes, respectively.

5.7.2 Sandy Soil Mixture

The mixtures found in Table 93 are designed for revegetation of sites proximal to sand dunes or other sites having a very high content of sand. These sites will be encountered only rarely in this region of the Yukon.



Table 90: Seed mixture and fertilizer specifications for sandy cut slopes

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Streambank wheatgrass *Agropyron riparium*	SODAR	7	Violet wheatgrass *Agropyron violaceum* Yukon wheatgrass *Agropyron yukonense*	4 2
Sheep fescue *Festuca ovina*	COMMON	4	Sheep fescue *Festuca ovina*	3
Creeping red fescue *Festuca rubra*	BOREAL	6	Glaucous bluegrass *Poa glauca*	4
Canada bluegrass *Poa compressa*	CANON	4	Canada bluegrass *Poa compressa*	3
Fowl bluegrass *Poa palustris*	COMMON	6	Alpine bluegrass *Poa alpina*	2
Alfalfa *Medicago* sp.	DRYLANDER OR RAMBLER	2	Yellow locoweed *Oxytropis campestris*	2
Total		29		20

FERTILIZER;

Nutrient requirement: Nitrogen (120kg N/ha) + Phosphate (120kg $P_2 0_5$/ha) + Potash (100kg $K_2 0$/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 400 kg/ha 23-23-0 + 150 kg/ha 0-0-60

* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 91: Seed mixture and fertilizer specifications for gravel cut slopes

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Smooth brome *Bromus inermis*	CARLTON	8	Violet wheatgrass *Agropyron violaceum*	6
Sheep fescue *Festuca ovina*	COMMON	6	Sheep fescue *Festuca ovina*	4
Creepinq red fescue *Festuca rubra*	BOREAL	6	Glaucous bluegrass *Poa glauca*	4
Canada bluegrass *Poa compressa*	CANON	4	Canada bluegrass *Poa compressa*	4
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	2	Yellow locoweed *Oxytropis campestris*	2
Total		26		20

FERTILIZER:

Nutrient requirement: Nitrogen (120kg N/ha) + Phosphate (120kg $P_2 0_5$/ha) + Potash (100kg $K_2 0$/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 400 kg/ha 23-23-0 + 150 kg/ha 0-0-60



* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 92: Seed mixture and fertilizer specifications for silty-clay cut slopes

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Crested wheatgrass *Agropyron cristatum*	SUMMIT	8	Violet wheatgrass *Agropyron violaceum*	5
Streambank wheatgrass *Agropyron riparium*	SODAR	8	Yukon wheatgrass *Agropyron yukonense*	5
Sheep fescue *Festuca ovina*	COMMON	6	Sheep fescue *Festuca ovina*	4
Creeping red fescue *Festuca rubra*	BOREAL	4	Glaucous bluegrass *Poa glauca*	3
Kentucky bluegrass *Poa pratensis*	COMMON	3	Northern bluegrass *Poa alpigena*	1
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	2	Yellow locoweed *Oxytropis campestris*	2
Total		31		20

FERTILIZER:

Nutrient requirement: Nitrogen (100kg N/ha) + Phosphate (80kg P_2O_5/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 400 kg/ha 23-23-0

* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.

Table 93: Seed mixture and fertilizer specifications for sandy soils

AGRONOMIC SELECTIONS			NATIVE SELECTIONS*	
Species	**Variety**	**kg/ha**	**Species**	**kg/ha**
Crested wheatgrass *Agropyron cristatum*	SUMMIT	7	Crested wheatgrass *Agropyron cristatum*	5
Streambank wheatgrass *Agropyron riparium*	SODAR	7	Violet wheatgrass *Agropyron violaceum*	3
Sheep fescue *Festuca ovina*	COMMON	6	Sheep fescue *Festuca ovina*	3
Canada bluegrass *Poa compressa*	CANON	4	Northern brome *Bromus Pumpellianus*	2
Glaucous bluegrass *Poa glauca*	TUNDRA+	2	Glaucous bluegrass *Poa glauca*	2
Alkaligrass *Puccinellia* sp.	COMMON	2	Alkaligrass *Puccinellia* sp.	2
Alfalfa *Medicago* sp.	DRYLANDER or RAMBLER	2	Yukon lupine *Lupinus Kuschei*	2
			Yellow locoweed *Oxytropis campestris*	2
Total		30		21

FERTILIZER:

Nutrient requirement: Nitrogen (100kg N/ha) + Phosphate (120kg P_2O_5/ha) + Potash (100kg K_2O/ha)

Example of a commercial fertilizer which approximates the nutrient requirement: 400 kg/ha 28-28-0 + 150 kg/ha 0-0-60

* Native Seed Selections should be substituted, at the rates indicated, for the Agronomic Selections adjacent to them in the above table.



LITERATURE CITED

1. Bentley, J.R. 1967. Conversion of chaparrel areas to grassland. USDA Agriculture Handbook. 26pp.
2. Berg, W.A. 1978. Limitations in the use of soil tests on drastically disturbed lands. In Reclamation of Drastically Disturbed Lands. (F.W. Schaller and P. Sutton, Eds.). ASA, CSSA, SSSA. Madison, Wisconsin, USA. p 653-661.
3. Bidwell, R.G.S. 1974. Plant Physiology. Macmillan Publishing Co., Inc. New York. 643pp.
4. Billings, W.D. 1973. Arctic and alpine vegetations: similarities, differences, and susceptibility to disturbance. Bioscience, Vol. 23, p 699-704.
5. Billings, W.D. 1974. Arctic and alpine vegetation: plant adaptations to cold summer climates. In Arctic and Alpine Environments. (J.D. Ives and R.G. Barry, Eds.). London: Methuen and Co. Ltd. p 403-443.
6. Billings, W.D. and H.A. Mooney 1968. The ecology of arctic and alpine plants. Biological Review, Vol. 43, p 481-529.
7. Bliss, L.C. 1970. Oil and the ecology of the arctic. In Transactions of the Royal Society of Canada, Series IV Vol. III. p 361-372.
8. Bliss, L.C., and R.W. Wein 1972. Ecological problems associated with arctic oil and gas development. In Proceedings of the Canadian Pipeline Research Conference, National Research Council of Canada. p 65-77.
9. Box, T.W. 1978. The significance and responsibility of rehabilitating drastically disturbed land. In Reclamation of Drastically Disturbed Lands. (F.W. Schaller and P. Sutton, Eds.). ASA, CSSA, SSSA. Madison, Wisconsin, USA. p 1-10.
10. Brown, G. 1985. Results of revegetation experiments 1981-1985 MacMillan Pass, Yukon Territory. Prepared for Northern Affairs Program, Yukon. 42pp.
11. Brown, R.W., R.S. Johnston, B.Z. Richardson and E.E. Farmer 1976. Rehabilitation of alpine disturbances: Beartooth Plateau, Montana. In Proceedings of High Altitude Revegetation Workshop No. 2. (R.H. Zuck and L.F. Brown, Eds.). Information Series No. 21. Colorado State University, Fort Collins, Colorado. p 58-73.
12. Brown, R.W., R.S. Johnston and K. Van Cleve 1978. Rehabilitation problems in alpine and arctic regions. In Reclamation of Drastically Disturbed Lands. (F.W. Schaller and P. Sutton, Eds.). ASA, CSSA, SSSA. Madison, Wisconsin, USA. p 23-44.
13. Brown, R.W., R.S. Johnston and D.A. Johnson 1978. Rehabilitation of alpine tundra disturbances. Journal of Soil and Water Conservation, Vol. 33, p 154-160.
14. Chapin, F.S., III 1974a. Phosphate absorption capacity and acclimation potential in plants along a latitudinal gradient. Science, Vol. 183, p 521-523.
15. Chapin, F.S., III 1974b. Morphological and physiological mechanisms of temperature compensation in phosphate absorption along a latitudinal gradient. Ecology, Vol. 55, p 1180-1198.
16. Chapin, F.S., III and G.R. Shaver 1985. Individualistic growth response of tundra plant species to environmental manipulations in the field. Ecology, Vol. 66, p 564-576.
17. Cuany, R.L. 1974. Plant breeding and its role in supplying new plant materials. In Proceedings of a workshop on revegetation of high-altitude disturbed lands. Co-chairmen: W.A. Berg, J.A. Brown, R.L. Cuany. Information Series No. 10. Colorado State University, Fort Collins, Colorado. p 44-54.
18. Dabbs, D.L., W. Friesen and S. Mitchell 1974. Pipeline revegetation. Arctic Gas Biological Report Series, Vol. 2. 67pp.

19. Davies, D., C.E. Kennedy and K. McKenna 1983. Resource Inventory Southern Lakes. Yukon Renewable Resources, Government of Yukon, Whitehorse. 151 pp + appendices.

20. Dennis, J.G. and P.L. Johnson 1970. Shoot and rhizome-root standing crops of tundra vegetation at Barrow, Alaska. Arctic and Alpine Research, Vol. 2, p 253-266.

21. Dumanski, J. 1978. ed. The Canada Soil Information System. (Cansis) Manual for describing soils in the field. Land Resource Research Institute. Ottawa.

22. Dyrness, C.T. 1975. Grass-legume mixtures for erosion control along forest roads in western Oregon. Journal of Soil and Water Conservation, Vol. 30(4), p 169-173.

23. Fergus E.N. and R.C. Buckner 1973. The bluegrasses and redtop. In Forages: The Science of Grassland Agriculture, Third Edition. (M.E. Heath, D.S. Metcalfe and R.F. Barnes, Eds.). Iowa State University Press, Ames, Iowa. p 243-253.

24. Forest Resources 1987. Forest Cover Map: Y03-NI. Indian and Northern Affairs Canada. Whitehorse.

25. Hagg, R.W. 1974. Nutrient limitations to plant production in two tundra communities. Canadian Journal of Botany, Vol. 52, p 103-116.

26. Halliday, W.E.D. 1937. A forest classification for Canada. Forest Service - Bulletin 89. Ottawa. 50pp.

27. Hardy Associates (1978) Ltd. 1985. 1985 revegetation monitoring of the Interprovincial Pipe Line (NW) Ltd. Norman Wells to Zama Pipeline. Prepared for Interprovincial Pipe Line (NW) Ltd. 33pp + appendices.

28. Hardy BBT Ltd. 1986. 1986 revegetation monitoring of the Interprovincial Pipe Line (NW) Ltd. Norman Wells to Zama Pipeline. Prepared for Interprovincial Pipe Line (NW) Ltd. 32pp + appendices.

29. Heilman, P.E. 1968. Relationship of availability of phosphorus and cations to forest succession and bog formation in interior Alaska. Ecology, Vol. 49, p 331-336.

30. Hernanadez, H. 1973. Revegetation studies Norman Wells, Inuvik, and Tuktoyaktuk, N.W.T. and Prudhoe Bay, Alaska. In Interim Report No 3: Towards an Environmental Impact Assessment of the Portion of the Mackenzie Gas Pipeline from Alaska to Alberta. Appendix V - Revegetation. Prepared for the Canadian Environmental Protection Board. Sponsored by Canadian Arctic Gas Study Ltd. 127pp.

31. Hodder, R.L. 1979. Strip mine reclamation in USSR, West Germany and USA. In Ecology and Coal Resource Development, Vol. One (M.K. Wali, Ed.). Pergamon Press Inc. p 531-536.

32. Hodgson, H.J., R.L. Taylor, A.C. Wilton and L.J. Klebesadel 1971a. Registration of Nugget Kentucky bluegrass. Crop Science, Vol. 11, p 938.

33. Hodgson, H.J., A.C. Wilton, R.L. Taylor and L.J. Klebesadel 1971b. Registration of Polar bromegrass. Crop Science, Vol. 11, p 939.

34. Hodgson, H.J., R.L. Taylor, L.J. Klebesadel and A.C. Wilton 1978. Registration of Arctared fescue. Crop Science, Vol. 18, p 524.

35. Hubbard, G.E. 1980. Revegetation-restoration for the Trans-Alaska pipeline system. In Proceedings: High-Altitude Revegetation Workshop No. 4. (C.L. Jackson and M.A. Schuster, Eds.). Information Series No. 42. Colorado State University, Fort Collins, Colorado. p 113-125.

36. Hulten, E. 1968. Flora of Alaska and Neighbouring Territories: A Manual of the Vascular Plants. Stanford University Press, Stanford, California. 1008pp.

37. Irwin, D.L. 1945. Forty-seven years of experimental work with grasses and legumes in Alaska. Alaska Agr. Exp. Sta. Bull. 12. 48pp.

38. Isard, S.I. 1986. Factors influencing soil moisture and plant community distributions on Niwot ridge, Front range, Colorado, U.S.A. Arctic and Alpine Research, Vol. 18(1), p 83-96.

39. Johnson, D.A. and M.D. Rumbaugh 1986. Field nodulation and acetylene reduction activity of high altitude legumes in the western United States. Arctic and Alpine Research, Vol. 18(2), p 171-179.

40. Kay, B.L. 1976. Hydroseeding, straw and chemicals for erosion control. Agronomy Progress Report No. 77. University of California Agronomy, Davis, California. 14pp.

41. Kay, B.L. 1978. Mulch and chemical stabilizers for land reclamation in dry regions. In Reclamation of Drastically Disturbed Lands. (F.W. Schaller and P. Sutton, Eds.). ASA, CSSA, SSSA. Madison, Wisconsin, USA. p 467-482.

42. Kay, B.L. and J.E. Street 1961. Drilling wheatgrass into sprayed sagebrush in northeastern California. Journal of Range Management, Vol. 14, p 271-273.

43. Klassen, R.J., 1978. Surficial Geology of Southern Yukon. Geological Survey of Canada. Open File 539. Ottawa.

44. Klebesadel, L.J., C.I. Branton and J.J. Koranda 1962. Seed characteristics of bluejoint and techniques for threshing. Journal of Range Management, Vol. 15(4), p 227-229.

45. Klebesadel, L.J. 1969a. Agronomic characteristics of the little known northern grass, *Arctagrostis latifolia* var.*arundinacea* (Trin.) Griseb., and a proposed common name, tall arcticgrass. Agronomy Journal, Vol. 61, p 45-49.

46. Klebesadel, L.J. 1969b. Siberian wildrye *(Elymus sibiricus* L.): Agronomic characteristics of a potentially valuable forage and conservation grass for the north. Agronomy Journal, Vol. 61, p 855-859.

47. Klebesadel, L.J. 1971. Native Alaskan legumes studied. Agroborealis, Vol. 3(1), p 9-11.

48. Klebesadel, L.J. 1974. Sweet holygrass, a potentially valuable ally. Agroborealis, Vol. 6(1), p 17-20.

49. Klebesadel, L.J. 1984a. Far-north-adapted bluegrasses from areas with rigorous winter climate perform best in southcentral Alaska. Agroborealis, Vol. 16(1), p 37-42.

50. Klebesadel, L.J. 1984b. Native Alaskan pumpelly bromegrass: characteristics and potential for use. Agroborealis, Vol. 16(2), p 9-14.

51. Klebesadel, L.J. 1985. The critical importance of north-latitude adaptation for dependable winter survival of perennial plants in Alaska. Agroborealis, Vol. 17(1), p 17-20.

52. Klebesadel, L.J. 1986. Natural selection may modify introduced white clover towards superior winterhardiness. Agroborealis, Vol. 18(1), p 13-19.

53. Klebesadel, L.J. and D. Helm 1986. Food reserve storage, low-temperature injury, winter survival, and forage yields of timothy in subarctic Alaska as related to latitude-of-origin. Crop Science, Vol. 26(2), p 325-334.

54. Lawson, D.E. 1986. Response of permafrost terrain to disturbance: A synthesis of observations from northern Alaska, U.S.A. Arctic and Alpine Research, Vol. 18, p 1-17.

55. McCown, B.H. 1972. The influence of soil temperature on pH, growth, and survival in Alaska. In Proceedings of the Symposium on the Impact of Oil Resource Development on Northern Plant Communities. Occasional publications on northern life No. 1. Institute of Arctic Biology, University of Alaska, Fairbanks, Alaska. p 12-33.

56. McCown, B.H. 1973. Growth and survival of northern plants at low soil temperatures. USA CRREL Special Report 186. 13pp.

57. McKenna, K. unpub. Airphoto Interpretation of Forest Cover 1989-90. Greater Kluane Planning Area. Forest Resources. INAC. Whitehorse, Yukon.

58. Mitchell, W.W. 1972. Adaptation of species and varieties of grasses for potential use in Alaska. In Proceedings of the Symposium on the Impact of Oil Resource Development on Northern Plant Communities. Occasional publications on northern life No. 1. Institute of Arctic Biology, University of Alaska, Fairbanks, Alaska. p 2-6.

59. Mitchell, W.W. 1980a. Registration of Tundra bluegrass. Crop Science, Vol. 20(5), p 669.

60. Mitchell, W.W. 1980b. Registration of Alyeska polargrass. Crop Science, Vol. 20(5), p 671.

61. Mitchell, W.W. 1980c. Registration of Sourdough bluejoint reedgrass. Crop Science, Vol. 20(5), pp 671-672.

62. Mitchell, W.W. 1984. Findings on turfgrasses and their management. Agroborealis, Vol. 16(1), p 31-36.

63. Mitchell, W.W. 1985. Registration of Norcoast Bering hairgrass. Crop Science, Vol. 25(4), p 708-709.

64. Mitchell, W.W. 1986. Notice of release of Nortran tufted hairgrass. Agroborealis, Vol. 18(1), p 6-7.

65. Mitchell, W.W. and J.D. McKendrick 1975. Tundra rehabilitation research: Prudhoe Bay and Palmer Research Centre, 1973-74 Summary Report to Alyeska Pipeline Service Co., ARCO, Canadian Arctic Gas Study Ltd., Exxon, Shell Oil and Union Oil. Institute of Agricultural Science, University of Alaska, Fairbanks, Alaska. 84 pp.

66. National Academy of Sciences 1969. Eutrophication: Causes, Consequences, Correctives. National Academy of Sciences, Washington, D.C. 661pp.

67. National Academy of Sciences 1974. Rehabilitation Potential of Western Coal Lands. Ballinger Publishing Co., Cambridge, Mass. 198pp.

68. Native Plants Inc. 1980. Revegetation assessment for the proposed Alaska natural gas transportation system. Volume III Revegetation recommendations for ANGTS Prudhoe Bay to Delta Junction. Prepared for Fluor Northwest, Inc. Northwest Alaskan Pipeline Company. 162pp.

69. Nuttall, W.F., et al ed. 1985. Saskatchewan Fertilizer Practices. Agriculture Plant Industry Branch. AGDEX541

70. Oswald, E.T. and J.P. Senyk 1977. Ecoregions of Yukon Territory. Fisheries and Environment Canada, Canadian Forest Service. 115pp.

71. Oswald, E.T. 1981. Vegetation Classification East Kluane Planning Area. Pacific Forest Research Center, Environment Canada. Victoria, B.C.

72. Oswald, E.T. and B.N. Brown 1986. Forest Communities in Lake Laberge Ecoregion, Yukon Territory. Canadian Forestry Service. Pacific Forestry Center.BC-X-282. Victoria. 97 pp.

73. Pringle, W.L., C.R. Elliot and K.F. Degenhardt 1975. The effect of photoperiod and temperature on northern Canadian ecotypes of *Agropyron trachycaulum* var. *trachycaulum* (slender wheatgrass). Canadian Journal of Botany, Vol. 53(1), p 18-24.

74. Rampton, V.N. 1977. Surficial Geology and Geomorphology of Mirror Creek, Koidern, Congdon Creek, Generc River, Yukon Territory. Geologic Survey of Canada. Ottawa.

75. Range Seeding Equipment Committee 1965. Handbook of range seeding equipment. USDA and USDI. 64pp.

76. Rostad et al, 1977. Soil Survey and Land Evaluation of the Yukon Territory. Saskatchewan Institute of Pedology Publications S174. Saskatoon.

77. Rowe, J.S. 1972. Forest Regions of Canada. Department of the Environment, Canadian Forest Service. Publication No. 1300. 172pp.

78. Salisbury, F.B. and C.W. Ross 1978. Plant Physiology. Second Edition. Wadsworth Publishing Company, Inc. Belmont, California. 422pp.

79. Savile, D.B. 1972. Arctic adaptations in plants. Monograph No. 6, Research Branch, Canada Department of Agriculture. 81 pp.

80. Shaver, G.R. and F.S. Chapin, III 1980. Response to fertilization by various plant growth forms in an Alaskan tundra: nutrient accumulation and growth. Ecology, Vol. 61, p 662-675.

81. Shaver, G.R. and F.S. Chapin, III 1986. Effect of fertilizer on production and biomass of tussock tundra, Alaska, U.S.A. Arctic and Alpine Research, Vol. 18(3), p 261-268.

82. Smith, C.A.S. unpub. Field Notes and Lab Results 1987. Pelly-Cassiar Mountains. Agriculture Canada. Whitehorse.

83. Stanek, W. 1980. Vegetation Types and Environmental Factors Associated with Foothills Gas Pipeline Route, Yukon Territory. Forest Resources. INAC Whitehorse, Yukon.

84. Stanek, W. and L. Orloci 1987. Some Silvacultural Ecosystems in the Yukon. Canadian Forest Service. Pacific Forestry Center. Report BC-X-293. 56 pp.

85. Thirgood, J.V. and P.F. Ziemkiewicz 1978. Reclamation of coal surface-mined land in western Canada. In Reclamation of Drastically Disturbed Lands. (F.W. Schaller and P. Sutton, Eds.). ASA, CSSA and SSSA. Madison, Wisconsin, USA. p 537-552.

86. Tisdale, S.L. and W.L. Nelson 1975. Soil Fertility and Fertilizers, 3rd Edition. MacMillan, New York.

87. Tomasson, T. 1984. A grass from Alaska gives promising results in Icelandic trials. Agroborealis, Vol. 16(1), p 33-36.

88. Trowbridge, R., J. Pojar & T. Lewis 1983. Interim Classification of the Boreal White and Black Spruce Biogeoclimatic Zone in the Prince Rupert Forest Region. B.C. Ministry of Forests. Smithers, B.C.

89. United States Environmental Protection Agency 1975. Methods of Quickly Vegetating Soils of Low Productivity, Construction Activities. Office of Water Planning and Standards, Washington, D.C. 20460. 467pp.

90. Vaartnou, H. and C.R. Elliot 1969. Snowmolds in lawns and lawn grasses in northwest Canada, Plant Disease Reporter, Vol. 53(11), p 891-894.

91. Vaartnou & Sons Enterprises Ltd. 1977a. Native seed multiplication. A progress report on work accomplished in multiplying seed stock of native ecotypes useful for northern revegetation. Prepared for Foothills Pipe Lines Ltd. 20pp.

92. Vaartnou & Sons Enterprises Ltd. 1977b. Revegetation Research. 1976 Progress Report Sub-projects - VE 7.2, 7.3 and 7.4. Prepared for Alberta Oil Sands Environment Research Program. 206pp.

93. Vaartnou & Sons Enterprises Ltd. 1978. Pipeline revegetation research: grasses, legumes and shrubs adjacent to the Alaska highway of Yukon Territory. Prepared for Foothills Pipe Lines (Yukon) Ltd. 47pp.

94. Vaartnou & Sons Enterprises Ltd. 1979. Chemical and physical properties of some soils proximal to the Alaska highway, Yukon Territory. Prepared for Foothills Pipe Lines (Yukon) Ltd. 41pp + appendices.

95. Vaartnou, M. 1980. Pipeline revegetation research: Haines Junction test site progress report 1979. Prepared for Foothills Pipe Lines (Yukon) Ltd. 57pp.

96. Vaartnou, M. 1981. Pipeline revegetation research: Alaska highway test sites progress report 1980. Prepared for Foothills Pipe Lines (South Yukon) Ltd. 83pp + appendices.

97. Vaartnou, M. 1982a. Pipeline revegetation research: Alaska highway test sites progress report 1981. Prepared for Foothills Pipe Lines (Yukon) Ltd. 70pp + appendices.

98. Vaartnou, M. 1982b. Pipeline revegetation research: Dempster lateral test sites progress report 1981. Prepared for Foothills Pipe Lines Ltd. 64 pp and appendices.

99. Vaartnou, M. 1982c. Pipeline revegetation research northern B.C. test final report. Prepared for Foothills Pipe Lines Ltd. and Westcoast Transmission Ltd. 41pp.

100. Vaartnou, M. 1985. Dempster highway revegetation. Prepared for Department of Community and Transportation Services and Department of Renewable Resources, Yukon Territorial Government. 13lpp.

101. Vaartnou, M. 1987. The market potential and production costs of a Yukon native grass and legume seed industry. Prepared for the Canada/Yukon Economic Development Agreement. 45 pp.

102. Vaartnou, M. 1988. The potential of native populations of grasses in northern revegetation. In Northern Environmental Disturbances. (P. Kershaw, Ed.). Occasional Publication Number 24. Boreal Institute for Northern Studies, University of Alberta, Edmonton, Alberta. Original paper presented at the 25th Anniversary Conference of the Boreal Institute of the University of Alberta, Edmonton, Alberta; November 20-22, 1986.

103 Vaartnou, M. 1991. The northern grass and legume seed industry -Spring 1991. Prepared for Arctic Alpine Seed Co. Ltd., Whitehorse, Yukon. 24 pp.

104. Van Cleve, K. 1975. (unpub.) Recovery of disturbed tundra and taiga surfaces. Paper presented at the International Symposium on Recovery of Damaged Ecosystems, Virginia Polytechnic Institute.

105. Van Cleve, K. and J. Manthei 1972. Summary report of the tundra-taiga stabilization study. Submitted to Alyeska Pipeline Service Co. Institute of Arctic Biology, University of Alaska, Fairbanks, Alaska.

106. Wahl et al 1987. Climate of Yukon. Environment Canada. Atmospheric Environment Service. Climatological Studies No. 40. Ottawa.

107. Walker, D., R.S. Sadasiviak and J. Weijer 1977. The utilization and genetic improvement of native Alberta grasses from the eastern slopes of the Rocky Mountains. Department of Genetics, University of Alberta, Edmonton, Alberta. 52pp.

108. Weise, H. 1979. Reclamation after strip mining: a vital means in long-term development planning in the Rhenish lignite district. In Ecology and Coal Resource Development, Vol. One (M.K. Wali, Ed.). Pergamon Press Inc. p 476-479.

109. Wright, D.L., H.D. Perry and R.E. Blaser 1978. Persistent low maintenance vegetation for erosion control and aesthetics in highway corridors. In Reclamation of Drastically Disturbed Lands. (F.W. Schaller and P. Sutton, Eds.). SSA, CSSA, and SSSA, Madison, Wisconsin, USA. p 553-582.

110. Younkin, W.E. 1972. Revegetation studies of disturbances in the Mackenzie delta region. In Botanical Studies of Natural and Man Modified Habitats in the Eastern Mackenzie Delta Region and the Arctic Islands. (L.C. Bliss and R.W. Wein, Eds.). ALUR. p 175-229.

111. Younkin, W.E. 1973. Autecological studies of native species potentially useful for revegetation, Tuktoyaktuk, N.W.T. In Botanical Studies of Natural and Modified Habitats in the Mackenzie Valley, Eastern Mackenzie Delta Region, and the Arctic Islands. (L.C. Bliss, Ed.). ALUR 72-73-14. Report No. 73-43 p 45-76.

112. Younkin, W.E. 1976. Preliminary pipeline revegetation specifications for the Mackenzie valley region, N.W.T. In Revegetation Studies in the Northern Mackenzie Valley Region. (W.E. Younkin, Ed.). Prepared for Canadian Arctic Gas Study Ltd. Biological Report Series, Vol. 38. Chapter IV. 23pp.

113. Younkin, W.E. and W. Friesen 1976. Sans Sault revegetation trials. In Revegetation Studies in the Northern Mackenzie Valley Region. (W.E. Younkin, Ed.). Prepared for Canadian Arctic Gas Study Ltd. Biological Report Series, Vol. 38. Chapter II. 28pp.

114. Ziemkiewicz, P.F. 1979. Effects of fertilization on the nutrient and organic matter dynamics of reclaimed coal mined areas and native grasslands in southeastern British Columbia. PhD Thesis, University of British Columbia, Vancouver, British Columbia. 162pp.

APPENDIX A

Relevant Traits of Species Included in the Revegetation Seed Mixtures

Species	Bunch Growth Habit	Rhizomatous Growth Habit	Low Growth Habit	Fire Hazard
Agropyron cristatum	x			x
Agropyron elongatum	x			x
Agropyron pauciflorum	x			x
Agropyron riparium		x		
Agropyron subsecundum	x			
Agropyron trachycaulum	x			x
Agropyron violaceum	x			
Agropyron yukonense		x		
Agrostis scabra	x		x	
Alopecurus pratensis	x			x
Arctagrostis latifolia		x		x
Bromus inermis		x		x
Bromus Pumpellianus		x		
Calamagrostis canadensis		x		x
Deschampsia caespitosa	x			
Elymus arenarius		x		x
Elymus junceus	x			x
Festuca altaica	x			
Festuca ovina	x		x	
Festuca rubra		x		
Festuca saximontana	x		x	
Hedysarum alpinum	x			
Hedysarum Mackenzii	x			
Hierochloë alpina	x		x	
Hierochloë odorata		x	x	
Lupinus arcticus	x		x	
Lupinus Kuschei	x		x	
Medicago falcata		x		x
Medicago sp.		x		x
Oxytropis campestris	x		x	
Oxytropis splendens	x		x	
Phalaris arundinacea		x		x
Phleum commutatum	x		x	
Phleum pratense	x			x
Poa alpigena		x		
Poa alpina	x		x	
Poa ampla	x			
Poa compressa		x	x	
Poa glauca	x		x	
Poa palustris	x			
Poa pratensis		x		
Puccinellia sp.	x		x	
Trifolium hybridum	x		x	
Trisetum spicatum	x		x	

Appendix A (Cont'd)
Relevant Traits of Species Included in the Revegetation Seed Mixtures

Species	Extensive Cover Production	High Root-shoot Ratio	Strong Competitive Ability	Resistant to Northern Diseases
Agropyron cristatum				
Agropyron elongatum				
Agropyron pauciflorum		x		
Agropyron riparium	x		x	
Agropyron subsecundum				x
Agropyron trachycaulum		x		
Agropyron violaceum	x	x	x	x
Agropyron yukonense			x	x
Agrostis scabra				x
Alopecurus pratensis	x		x	
Arctagrostis latifolia				x
Bromus inermis	x			
Bromus Pumpellianus				x
Calamagrostis canadensis	x			x
Deschampsia caespitosa	x		x	x
Elymus arenarius	x		x	x
Elymus junceus	x			
Festuca altaica	x			x
Festuca ovina				x
Festuca rubra	x		x	x
Festuca saximontana				x
Hedysarum alpinum	x	x		x
Hedysarum Mackenzii				x
Hierochloe alpina				x
Hierochloe odorata		x	x	x
Lupinus arcticus				x
Lupinus Kuschei				x
Medicago falcata	x			x
Medicago sp.	x			
Oxytropis campestris				x
Oxytropis splendens				x
Phalaris arundinacea	x			
Phleum commutatum				x
Phleum pratense	x			
Poa alpigena			x	x
Poa alpina		x		x
Poa ampla		x		
Poa compressa	x	x		
Poa glauca		x	x	x
Poa palustris		x	x	x
Poa pratensis	x		x	
Puccinellia sp.				x
Trifolium hybridum	x		x	
Trisetum spicatum				

Appendix A (Cont'd)
Relevant Traits of Species Included in the Revegetation Seed Mixtures

Species	Rapid Emergence Growth	Early Spring Growth	Late Summer	Drought Tolerance
Agropyron cristatum	x	x		x
Agropyron elongatum			x	
Agropyron pauciflorum	x	x	x	
Agropyron riparium	x		x	
Agropyron subsecundum	x	x	x	x
Agropyron trachycaulum	x	x	x	
Agropyron violaceum	x	x	x	x
Agropyron yukonense			x	x
Agrostis scabra		x		
Alopecurus pratensis	x	x	x	
Arctagrostis latifolia			x	
Bromus inermis	x	x	x	
Bromus Pumpellianus				x
Calamagrostis canadensis		x	x	
Deschampsia caespitosa			x	
Elymus arenarius		x		
Elymus junceus				x
Festuca altaica			x	
Festuca ovina				x
Festuca rubra	x	x	x	
Festuca saximontana	x	x		x
Hedysarum alpinum				
Hedysarum Mackenzii				
Hierochloë alpina		x		
Hierochloë odorata				x
Lupinus arcticus				x
Lupinus Kuschei				x
Medicago falcata		x	x	
Medicago sp.	x	x		
Oxytropis campestris				x
Oxytropis splendens				x
Phalaris arundinacea		x		
Phleum commutatum				
Phleum pratense	x	x	x	
Poa alpigena		x	x	
Poa alpina				
Poa ampla			x	
Poa compressa		x		
Poa glauca		x		x
Poa palustris	x	x		
Poa pratensis		x	x	
Puccinellia sp.	x	x		x
Trifolium hybridum		x		
Trisetum spicatum				

Appendix A (Cont'd)
Relevant Traits of Species Included in the Revegetation Seed Mixtures

Species	Tolerant to Alkaline Soils	Tolerant to Acidic Soils	Tolerant to Saline SoilsSoils	Tolerant to Organic
Agropyron cristatum				
Agropyron elongatum	x		x	
Agropyron pauciflorum	x			
Agropyron riparium				
Agropyron subsecundum	x		x	
Agropyron trachycaulum	x			
Agropyron violaceum	x			
Agropyron yukonense	x			
Agrostis scabra		x		
Alopecurus pratensis		x		x
Arctagrostis latifolia				
Bromus inermis				
Bromus Pumpellianus				
Calamagrostis canadensis				x
Deschampsia caespitosa		x		
Elymus arenarius			x	
Elymus junceus	x		x	
Festuca altaica				x
Festuca ovina		x		
Festuca rubra				
Festuca saximontana	x			
Hedysarum alpinum				
Hedysarum Mackenzii				
Hierochloë alpina				
Hierochloë odorata				
Lupinus arcticus				
Lupinus Kuschei				
Medicago falcata	x			
Medicago sp.	x			
Oxytropis campestris	x			
Oxytropis splendens	x			
Phalaris arundinacea		x		x
Phleum commutatum				
Phleum pratense		x		x
Poa alpigena				
Poa alpina				
Poa ampla	x		x	
Poa compressa				
Poa glauca	x			
Poa palustris		x		
Poa pratensis				
Puccinellia sp.	x		x	
Trifolium hybridum		x		
Trisetum spicatum				

Appendix A (Cont'd)
Relevant Traits of Species Included in the Revegetation Seed Mixtures

Species	Low Nutrient Tolerance	Permafrost Tolerance	Wet Soil Tolerance	High Altitude Tolerance
Agropyron cristatum				
Agropyron elongatum				
Agropyron pauciflorum	x			
Agropyron riparium				
Agropyron subsecundum	x			
Agropyron trachycaulum				
Agropyron violaceum	x	x		x
Agropyron yukonense	x			
Agrostis scabra	x	x		x
Alopecurus pratensis		x	x	
Arctagrostis latifolia	x	x	x	
Bromus inermis				
Bromus Pumpellianus	x			
Calamagrostis canadensis	x	x	x	
Deschampsia caespitosa	x	x	x	x
Elymus arenarius	x	x	x	
Elymus junceus				
Festuca altaica	x	x		
Festuca ovina	x			x
Festuca rubra		x		x
Festuca saximontana	x	x		x
Hedysarum alpinum	x	x	x	
Hedysarum Mackenzii	x	x		
Hierochloë alpina	x	x		x
Hierochloë odorata	x			
Lupinus arcticus	x	x		
Lupinus Kuschei	x			
Medicago falcata				
Medicago sp.				
Oxytropis campestris	x			
Oxytropis splendens	x			
Phalaris arundinacea			x	
Phleum commutatum		x		x
Phleum pratense				
Poa alpigena	x	x		
Poa alpina	x	x		x
Poa ampla	x			
Poa compressa	x			
Poa glauca	x	x		x
Poa palustris	x	x	x	
Poa pratensis				
Puccinellia sp.	x	x		
Trifolium hybridum				
Trisetum spicatum	x	x		x

APPPENDIX B

Botanical and Common Names of Plant Species

BOTANICAL NAME*	COMMON NAME
Abies lasiocarpa (Hook.) Nutt.	Alpine fir
Agropyron cristatum (L.) Gaertn.	Crested wheatgrass
Agropyron elongatum (Host) Beauv.	Tall wheatgrass
Agropyron pauciflorum (Schwein.) Hitchc.	Slender wheatgrass
Agropyron riparium Scribn. & Smith	Streambank wheatgrass
Agropyron subsecundum (Link) Hitchc.	Bearded wheatgrass
Agropyron trachycaulum (Link) Malte	Slender wheatgrass
Agropyron violaceum (Hornem.) Lange	Violet wheatgrass
Agropyron yukonense Scribn. & Merr.	Yukon wheatgrass
Agrostis gigantea Roth	Red top
Agrostis scabra Willd.	Ticklegrass
Alnus crispa (Ait.) Pursh	Mountain alder
Alnus incana (L.) Moench	Hoary alder
Alopecurus pratensis L.	Meadow foxtail
Arctagrostis latifolia (R.Br.) Griseb.	Polargrass
Arctostaphylos rubra (Rehd. & Wilson) Fern.	Northern bearberry
Arctostaphylos uva-ursi (L.) Spreng.	Kinnikinnick
Artemisia frigida Willd.	Sage
Aster brachyactis Blake	Aster
Astragalus agrestis Dougl.	Field milk vetch
Astragalus alpinus L.	Alpine milk vetch
Astragalus americanus (Hook) M.E. Jones	American milk vetch
Astragalus eucosmus Robins.	Elegant milk vetch
Astragalus umbellatus Bunge	Tundra milk vetch
Aulacomnium palustre (Hedw.) Schwaegr.	Moss (wetland)
Betula glandulosa Michx.	Shrub birch
Betula papyrifera Marsh.	Paper birch
Bromus inermis Leyss.	Smooth brome
Bromus Pumpellianus Scribn.	Northern brome
Calamagrostis canadensis (Michx.) Beauv.	Bluejoint reedgrass
Calamagrostis purpurascens R. Br.	Purple reedgrass
Carex aquatilis Wahlenb.	Water sedge
Cetraria sp.	Lichen

BOTANICAL NAME*	COMMON NAME
Cladina sp.	Reindeer lichen
Cornus canadensis L.	Bunchberry
Cornus stolonifera Michx.	Red Osier Dogwood
Deschampsia caespitosa (L.) Beauv.	Tufted hairgrass
Dryas Drummondii Richards.	Yellow dryas
Dryas octopetala L.	Mountain avens
Dryas integrifolia M.Vahl	Mountain avens
Elaeagnus commutata Bernh.	Silverberry
Elymus arenarius L.	Lymegrass
Elymus innovatus Beal	Hairy wild ryegrass
Elymus junceus Fisch.	Russian wild rye grass
Empetrum nigrum L.	Mossberry
Epilobium angustifolium L.	Fireweed
Equisetum sp.	Horsetail
Eriophorum sp.	Cottongrass
Festuca altaica Trin.	Altai fescue
Festuca ovina L.	Sheep fescue
Festuca rubra L.	Creeping red fescue
Festuca saximontana Rydb.	Northern fescue
Hedysarum alpinum L.	Bear root
Hedysarum Mackenzii Richards	Mackenzie's hedysarum
Hierochloë alpina (SW.) Roem. & Schult.	Alpine sweetgrass
Hierochloë odorata (L.) Wahlenb.	Sweetgrass
Hordeum jubatum L.	Foxtail barley
Hylocomium splendens (Hedw.) B.S.G	Feathermoss
Juncus arcticus Willd.	Arctic rush
Juniperus communis L.	Ground juniper
Juniperus horizontalis Moench	Creeping juniper
Larix laricina (Du Roi) K.Koch	Larch/Tamarack
Ledum groenlandicum Oeder	Labrador tea
Linnaea borealis L.	Twinflower
Lupinus arcticus S.Wats.	Arctic lupine
Lupinus Kuschei Eastw.	Yukon lupine
Medicago falcata L.	Yellow lucerne
Medicago sativa L.	Alfalfa

Appendix B (Cont'd)
Botanical and Common Names of Plant Species

BOTANICAL NAME*	COMMON NAME
Medicago sp.	Alfalfa
Mertensia paniculata (Ait.) G.Don	Bluebell
Mnium spp.	Moss (wetland)
Oxycoccus microcarpus Turcz	Bog cranberry
Oxytropis campestris (L.) DC.	Yellow locoweed
Oxytropis Maydelliana Trautv.	Maydell's locoweed
Oxytropis splendens Dougl.	Showy locoweed
Oxytropis sp.	Locoweed
Peltigera sp.	Dog ear lichen
Petasites frigidus	Coltsfoot
Phalaris arundinacea L.	Reed canarygrass
Phleum commutatum Gandoger	Mountain timothy
Phleum pratense L.	Timothy
Picea glauca (Moench) Voss	White spruce
Picea mariana (Mill.) Britt.,Sterns&Pogg	Black spruce
Pinus contorta Dougl. ex Loud.	Lodgepole pine
Plantago canescens Adams	Plantain
Pleurozium schreberi (Brid.) Mitt.	Feathermoss
Poa alpigena (E.Fries) Lindm.	Northern bluegrass
Poa alpina L.	Alpine bluegrass
Poa ampla Merr.	Big bluegrass
Poa arctica R.Br.	Arctic bluegrass
Poa compressa L.	Canada bluegrass
Poa glauca M. Vahl	Glaucous Bluegrass
Poa palustris L.	Fowl bluegrass
Poa pratensis L.	Kentucky bluegrass
Polemonium pulcherrimum Hook.	Jacob's ladder
Populus balsamifera L.	Balsam poplar
Populus tremuloides Michx.	Aspen
Potentilla anserina L.	Silverweed
Potentilla fruticosa L.	Shrubby cinquefoil
Ptilium crista-castrensis (Hedw.) De Not.	Feathermoss
Puccinellia sp.	Alkaligrass
Pulsatilla patens (L.) Mill.	Crocus
Pyrola L. sp.	Wintergreen

BOTANICAL NAME*	COMMON NAME
Rhododendron lapponicum (L.) Wahlenb.	Lapland rosebay
Ribes oxycanthoides L.	Canada gooseberry
Ribes triste Pall.	Northern red currant
Rosa acicularis Lindl.	Rose
Rubus acaulis Michx.	Nagoonberry
Rubus chamaemorus L.	Cloudberry
Rubus idaeus L.	Raspberry
Salix glauca L.	Greyleaf willow
Salix myrtillifolia Anders.	Tall blueberry willow
Shepherdia canadensis (L.) Nutt.	Soapberry
Saxifraga tricuspidata Rottb.	Prickly saxifrage
Sphagnum sp.	Sphagnum moss
Tomenthypnum nitens (Hedw.) Loeske	Moss (wetland)
Trifolium hybridum L.	Alsike clover
Trisetum spicatum (L.) Richter	Spike trisetum
Vaccinium uliginosum L.	Bog blueberry
Vaccinium vitis-idaea L.	Lowbush cranberry
Viburnum edule (Michx.) Raf.	Highbush cranberry

* Botanical nomenclature follows Hulten, E. 1968. Flora of Alaska and Neighbouring Territories. Stanford University Press. 1008pp. and Vitt, D.H., J.E. Marsh and R.B. Bovey 1988. Mosses, Lichens and Ferns of Northwest North America. Lone Pine Publishing. 296pp.

APPENDIX C

Additional References

Alaska Rural Development Council 1977. A Revegetative Guide for Alaska. Rural Development Council Publication No.2. P-238. 74pp.

Brown, J., P.C. Miller, L.L. Tiezen and F.L. Bunnell 1980. An Arctic Ecosystem. The Coastal Tundra at Barrow, Alaska. Dowden, Hutchinson & Ross, Inc. 571pp.

Hardy BBT Ltd. 1987. Reclamation Guidelines for Northern Canada. Prepared for Land Resources, Northern Affairs Program, Indian and Northern Affairs, Canada, Ottawa. 40pp.

Heady, H.F. 1975. Rangeland Management. McGraw-Hill Book Company. 460pp.

Heath, M.E., D.S. Metcalfe and R.F. Barnes (Eds.) 1973. Forages - The Science of Grassland Agriculture - Third Edition. The Iowa State University Press, Ames, Iowa. 755pp.

Johnson, L. and K. Van Cleve 1976. Revegetation in arctic and subarctic North America. A literature review. CRREL Report 76-15. 32pp.

Lewis, W.M. Jr., J.F. Saunders,III, D.W. Crumpacker Sr. and C.M. Brendecke 1984. Eutrophication and Land Use. Lake Dillon, Colorado. Springer-verlag, New York, Berlin, Heidelberg., Tokyo. 202pp.

Maynard, D. 1979. Terrain capability for residential settlements: background report. B.C. Ministry of Environment, Resource Analysis Branch, Victoria 151pp.

Peterson, E.B. and N.M. Peterson (Eds.) 1977. Revegetation Information Applicable to Mining Sites in Northern Canada. Department of Indian Affairs and Northern Development. Ottawa.

Porsild, A.E. and W.J. Cody 1980. Vascular Plants of Continental Northwest Territories, Canada. National Museum of Natural Sciences, National Museums of Canada. Ottawa, Canada. 667pp.

Rieger, S. 1983. The Genesis and Classification of Cold Soils. Academic Press Inc. New York, New York. 230pp.

Schaller, F.W. and P. Sutton (Eds.). 1978. Reclamation of Drastically Disturbed Lands. ASA, CSSA, SSSA. Madison, Wisconsin. 742pp.

Smoliak, S., D. Penney, A.M. Harper and J.S. Horricks 1981. Alberta Forage Manual. Alberta Agriculture. 87pp.

Stoddart, L.A., A.D. Smith, and T.W. Box. 1975. Range Management - Third Edition. McGraw-Hill Book Company. 532pp.

Vallentine, J.F. 1971. Range Development and Improvement. Brigham Young University Press, Provo, Utah. 516pp.

Watson, L.E., R.W. Parker and D.F. Polster 1980. Manual of Plant Species Suitability for Reclamation in Alberta Vol. I and II. Alberta Land Conservation and Reclamation Council Report #RRTAC 80-5. 541pp.

Welsh, S.L. 1974. Anderson's Flora of Alaska and Adjacent Parts of Canada. Brigham Young University Press. Provo, Utah. 724pp.

APPENDIX D

Seed Suppliers of Western North America

ALBERTA

Aimers Seeds
Box 5810, Station A
Calgary,
Alberta T2P 2P5

Fosters Seed and Feed Ltd.
Box 210
Beaverlodge,
Alberta T0H 0C0

Hannas Seeds
Box 849
Lacombe,
Alberta T0C 1S0

Northrup King Seeds Ltd.
Box 20
Fort Saskatchewan,
Alberta

Otto Pick & Sons Seeds Ltd.
8918 - 18th Street
Edmonton,
Alberta T6P 1K0

Prairie Seeds Ltd
R.R. 1
South Edmonton,
Alberta T6H 4N6

United Grain Growers
Box 6030, Station C
Edmonton,
Alberta T5B 4K5

BRITISH COLUMBIA

Buckerfields Ltd.
33850 Industrial Avenue,
P.O. Box 1030
Abbotsford,
British Columbia V2S 5B5

Dawson Seed Company Ltd.
175 Harbour Avenue
North Vancouver,
British Columbia V7J 2E7

Richardson Seeds Ltd.
4055 McConnell Street
Burnaby,
British Columbia V5A 3A7

YUKON TERRITORY

Arctic Alpine Seed Co.
105 Granite Road
Whitehorse,
Yukon YlA 2V8

UNITED STATES

Alaska Plant Materials Centre
SR B. Box 7440
Palmer, Alaska,
U.S.A. 99645

Jacklin Seed Company
West 5300 Jacklin Avenue
Post Falls, Idaho, U.S.A. 83854

APPENDIX E

Soil Properties Class Ranges

pH Values and Class**	
pH values	**Class**
< 4.5	Extremely acid
4.6 - 5.0	Very strongly acid
5.1 - 5.5	Strongly acid
5.6 - 6.0	Medium acid
6.1 - 6.5	Slightly acid
6.6 - 7.3	Neutral
7.4 - 7.8	Mildly alkaline
7.9 - 8.4	Moderately alkaline
> 8.5	Strongly alkaline

Calcium carbonate ($CaCO_3$) equivalent**	
Percent	**Class**
1 - 5	low
6 - 15	moderate
> 16	high

Electrical Conductivity Classes*	
Approximate range (mmho/cm.)	**Class**
< 1	low
1 - 5	moderate
> 5	high

* derived from site data in Vaartnou (94)

** Dumanski, ed.(1978)

Appendix E (Cont'd)
Soil Properties Class Ranges

AVAILABLE NUTRIENTS

Nitrogen (N) values*	
Approximate range+	Class
0 - 3	low
3.1 - 5	moderate
> 5.1	high

Phosphorus (P) values*	
Approximate range+	Class
0 - 10	low
10.1 - 25	moderate
> 25	high

Potassium (K) values*	
Approximate range+	Class
< 75	low
76 - 150	moderate
> 150	high

Sulphur (S) values*	
Approximate range+	Class
0 - 7.5	low
7.6 - 15	moderate
> 15	high

Organic matter values	
Percent	Class
0 - 4	low
4.1 - 14	moderate
14.1 - 29	high
> 29	very high

* derived from site data in Vaartnou (94)

\+ parts per million

APPENDIX F:

The Major Nitrogen (N), Phosphorus (P), Potassium (K), and Sulphur (S) Fertilizers Available in Western Canada and Their Characteristics

NOTE: Do not mix urea and ammonium nitrate sources of N fertilizer

Name	Nutrient Percentage	Physical Properties	Comments
P and N P FERTILIZERS			
Monoammonium Phosphate	11-48-0 11-51-0 11-54-0	- Solid, granular, does not absorb moisture during storage, fairly resistant to breakdown during handling.	Most commonly used high analysis dry phosphorus source in western Canada.
Diammonium Phosphate	18-46-0	- Solid, granular (same as monoammonium phosphate)	P availability to plants is slightly less than monoammonium phosphate.
Monocalcium Phosphate (Triple Super Phosphate)	0-45-0	- Solid, granular (same as monoammonium phosphate)	P availability to plants is slightly less than monoammonium phosphate.
Ammonium Polyphosphate Solution	10-34-0	- Liquid, must be stored above -18°C to maintain liquid state.	A phosphate fertilizer available in many parts of western Canada.
Ammonium Phosphate Sulphate	16-20-0(14)*	- Solid, granular	Suitable for sulphur deficient soils, P availability same as monoammonium phosphate.
Ammonium Nitrate Phosphate	23-23-0 27-14-0 17-34-0 etc.	- Solid, granular; a mixture of 34-0-0 and 11-48-0	Suitable for N & P deficient soils. P availability same as monoammonium phosphate.
Urea Ammonium	28-28-0 34-18-0 etc.	- Solid, granular; a mixture of 46-0-0 and 11-55-0 fairly stable during storage and handling.	Suitable for N & P deficient soils. Nitrogen component can cause germination damage to seed at above recommended rates.
N AND N-S FERTILIZERS			
Anhydrous Ammonia	82-0-0	- Compressed gas - High affinity for water - Pungent odor	Must be placed at 10-15 cm (4-6 in) depth at least 5 days prior to seeding. Danger in handling. Best applied at below 10°C.

* Refers to percent of sulphur

Appendix F (Cont'd)

Name	Nutrient Percentage	Physical Properties	Comments
N AND N-S FERTILIZERS (continued...)			
Aqua Ammonia	20-0-0	- Ammonia dissolved in water - Low vapor pressure - Pungent odor	Must be placed at 10-15 cm (4-6 in) depth at least 5 days prior to seeding. Best applied at below 10°C.
Nitrogen Solution	28-0-0 to 32-0-0	- Solution - 50% N in fertilizer is urea and 50% is ammonium nitrate - 28-0-0 starts to salt out at liquid temperature of -18°C. Specific gravity 1.284 kg/litre. - 32-0-0 starts to salt out at liquid temperature of 0°C.	Apply prior to or after seeding. Uniform application.
Nitrogen Sulphur	20-0-0(5)*	- Solution - 75% of the N in the fertilizer is urea and 25% is ammonium sulphate.	Can be applied prior to or after seeding. Corrosive to certain metals.
Ammonium Nitrate	34-0-0	- Granular - prilled	Larger amount can be applied with the seed. Applied prior to or after seeding.
Urea Ammonium Sulphate	34-0-0(11)* 40-0-0(6)* 30-0-0(4)*	- Prilled, granular and crystalline solid particles. - 1:1 ratio of urea and ammonium sulphate. - Ammonium sulphate coated with urea	Applied prior to or after seeding. Contains sulphur.
Ammonium Sulphate	21-0-0(24)*	- Crystalline solid particles.	Applied prior to or after seeding. Care must be taken to get a uniform application. Contains sulphur and supplies sufficient sulphur for crops grown on sulphur deficient soils.

* Refers to percent of sulphur

Cont'd

Appendix F (Cont'd)

Name	Nutrient Percentage	Physical Properties	Comments
N AND N-S FERTILIZERS (continued...)			
Urea	46-0-0	- Granular and prilled solid particles.	Applied prior to seeding. Much less corrosive than other N fertilizers. Avoid mixing with ammonium-nitrate as attraction for moisture causes mixture to slush.
Urea Ammonium Sulphate	20-0-0(5)*	- When in solution crystallizes or salts out at -40°C. Specific gravity 1.24kg/litre	Larger amounts can be applied with the seed than pure urea. Applied prior to or after seeding.
N,P,K,S OR COMPLETE FERTILIZERS			
Potassium Chloride	0-0-60	- Pinkish colour - Hygroscopic - Soluble	Can be mixed with other fertilizers.
Elemental Sulphur	0-0-0-90S* to 0-0-0-99S*	- Can be blended with most dry fertilizers except ammonium nitrate.	Must be oxidized to sulphate before the plant can use it. Apply 1 year in advance of use by crop.
Thio Sul	12-0-0-26*	- Liquid - Odorless - Colourless - Specific Gravity 1.325 kg/litre - Can be mixed with all standard fertilizer liquids which are non-acid.	Non-corrosive. Used effectively in irrigation systems.
Gypsum	0-0-0-17*	- Solid - Insoluble	Also called land plaster. Can be applied at any time.
Complete	10-30-10(5)* 13-13-13 8-24-24(1)* 12-16-10(11)* 14-14-10(11)* 16-16-16(3)*		The properties of these fertilizers vary with the compounds used in their make-up.

* Refers to percent of sulphur

APPENDIX G:

Calculation of rate of fertilizer required to meet nutrient requirements.

To calculate the rate of fertilizer required to supply a particular rate of nutrient, multiply the rate of nutrient desired by 100 and divide by the percent of the nutrient present in the fertilizer.

Examples—Metric

1. Rate of N desired: 50 kg/hectare (ha)
   Using 34-0-0

   Rate of fertilizer required =
   $\frac{50 \times 100}{34}$ = 147 kg of 34-0-0 per ha.

2. Rate of $P_2 0_5$ (phosphate) desired: 25 kg/ha
   Using 11-55-0

   Rate of fertilizer required =
   $\frac{25 \times 100}{55}$ = 45 kg/ha of 11-55-0.
   45 kg/ha of 11-55-0 also would supply:
   $\frac{11 \times 45}{100}$ = 5 kg/ha of N.

3. Rate of K_2O desired: 10 kg/ha
   Using 10-30-10

   Rate of fertilizer required =
   $\frac{10 \times 100}{10}$ = 100 kg/ha.
   100 kg/ha of 10-30-10 also would supply
   $\frac{10 \times 100}{100}$ - 10 kg/ha of N.
   and $\frac{30 \times 100}{100}$ = 30 kg/ha of $P_2 0_5$ (phosphate).

APPENDIX H

Definition of Terms

Genetic Material

Alluvium

Materials transported and deposited by streams and rivers.

Bedrock

Unweathered rock at or below the earth's surface.

Colluvium

Massive to moderately well stratified, non-sorted to poorly sorted sediments, with any range of particle sizes from clay to boulders and blocks that have reached their present position by direct, gravity induced movement.

Eolian

Wind deposited sediment, generally consisting of medium to fine sand and coarse silt particle sizes, that is well sorted, poorly compacted, and may show internal structures such as cross-bedding or ripple laminae, or may be rounded and show signs of frosting.

Glaciofluvial

Fluvial or (alluvial) materials that show clear evidence of having been deposited either directly in front of, or in contact with, glacier ice.

Lacustrine

Sediment generally consisting of either stratified fine sand, silt, and clay deposited on a lake bed; or moderately well sorted and stratified sand and coarser materials that are beach and other near-shore sediments transported and deposited by wave action.

Morainal

Sediment generally consisting of well compacted material that is nonstratified and contains a heterogeneous mixture of particle sizes, from clay to boulders that has been transported beneath, beside, on, within, and in front of a glacier and not modified by an intermediate agent.

Organic

Materials resulting from vegetative growth, decay and accumulation in and around closed basins or on gentle slopes, where the rate of accumulation exceeds that of decay.

Peat

A substance consisting of partically carbonized vegetable material, chiefly mosses, found usually in bogs.

Soil Drainage *

Very rapidly drained

Water is removed from the soil very rapidly in relation to supply. Excess water flows downward very rapidly if underlying material is pervious. There may be very rapid subsurface flow during heavy rainfall provided there is a steep gradient. Soils have very low available water storage capacity (usually less than 2.5 cm) within the control section and are usually coarse textured, or shallow, or both. Water source is precipitation.

Rapidly Drained

Water is removed from the soil rapidly in relation to supply. Excess water flows downward if underlying material is pervious. Subsurface flow may occur on steep gradients during heavy rainfall. Soils have low available water storage capacity (2.5 - 4 cm) within the control section, and are usually coarse textured, or shallow, or both. Water source is precipitation.

Well Drained

Water is removed from the soil readily but not rapidly. Excess water flows downward readily into underlying pervious material or laterally as subsurface flow. Soils have intermediate available water storage capacity (4 - 5 cm) within the control section, and are generally intermediate in texture

and depth. Water source is precipitation. On slopes subsurface flow may occur for short durations but additions are equalled by losses.

Moderately well drained

Water is removed from the soil somewhat slowly in relation to supply. Excess water is removed somewhat slowly due to low perviousness, shallow water table, lack of gradient, or some combination of these. Soils have intermediate to high water storage capacity (5 - 6 cm) within the control section and are usually medium to fine textured. Precipitation is the dominant water source in medium to fine textured soils; precipitation and significant additions by subsurface flow are necessary in coarse textured soils.

Imperfectly drained

Water is removed from the soil sufficiently slowly in relation to supply to keep the soil wet for a significant part of the growing season. Excess water moves slowly downward if precipitation is the major supply. If subsurface water or groundwater, or both, is the main source, flow rate may vary but the soil remains wet for a significant part of the growing season. Precipitation is the main source if available water storage capacity is high; contribution by subsurface flow or groundwater flow, or both, increases as available water storage capacity decreases. Soils have a wide range in available water supply, texture, and depth and are gleyed phases of well drained subgroups.

Poorly drained

Water is removed so slowly in relation to supply that the soil remains wet for a comparatively large part of the time the soil is not frozen. Excess water is evident in the soil for a large part of the time. Subsurface flow or groundwater flow, or both in addition to precipitation are main water sources; there may also be a perched water table, with precipitation exceeding evapotranspiration. Soils have a wide range in available water storage capacity, texture, and depth, and are gleyed subgroups, Gleysols, and Organic soils.

Very Poorly Drained

Water is removed from the soils so slowly that the water table remains at or on the surface for the greater part of the time the soil is not frozen. Excess water is present in the soil for the greater part of the time. Groundwater flow and subsurface flow are major water sources. Precipitation is less important except where there is a perched water table with precipitation exceeding evapotranspiration. Soils have a wide range in available water storage capacity, Gleysolic or Organic.

* Source: Dumanski, ed. 1978

Soil Classes

Clay

Soil material that contains 40% or more clay, less than 45% sand, and less than 40% silt.

Silty clay

Soil material that contains 40% or more clay and 40% more silt.

Sandy clay

Soil material that contains 35% or more clay and 45% or more sand.

Silty clay loam

Soil material that contains 27-40% clay and less than 20% sand.

Clay loam

Soil material that contains 27-40% clay and 20-45% sand.

Sandy clay loam

Soil material that contains 20-35% clay, less than 28% silt, and 45% or more sand.

Silt

Soil material that contains 80% or more silt and less than 12% clay.

Silt loam

Soil material that contains 50% or more silt and 12-27% clay, or 50-80% silt and less than 12% clay.

Loam

Soil material that contains 7-27% clay, 28-50% silt, and less than 53% sand.

Soil Classes (cont'd)

Sandy loam

Soil material that contains either 20% clay or less, with the percentage of silt plus twice the percentage of clay exceeding 30, and 52% or more sand; or less than 7% clay, less than 50% silt, and 43-52% sand.

Loamy sand

Soil material that contains at the upper limit 85-90% sand, and the percentage of silt plus 1.5 times the percentage of clay is not less than 15; at the lower limit it contains not less than 70-85% sand, and the percentage of silt plus twice the percentage of clay does not exceed 30.

Fine sand

50% or more fine sand, or less than 25% very coarse, coarse, and medium sand and less than 50% very fine sand.

Sand (medium)

25% or more coarse, coarse, and medium sand, and less than 50% fine or fine sand.

Coarse sand

25% or more very coarse and coarse sand, and less than 50% any other one grade of sand.

Very coarse sand

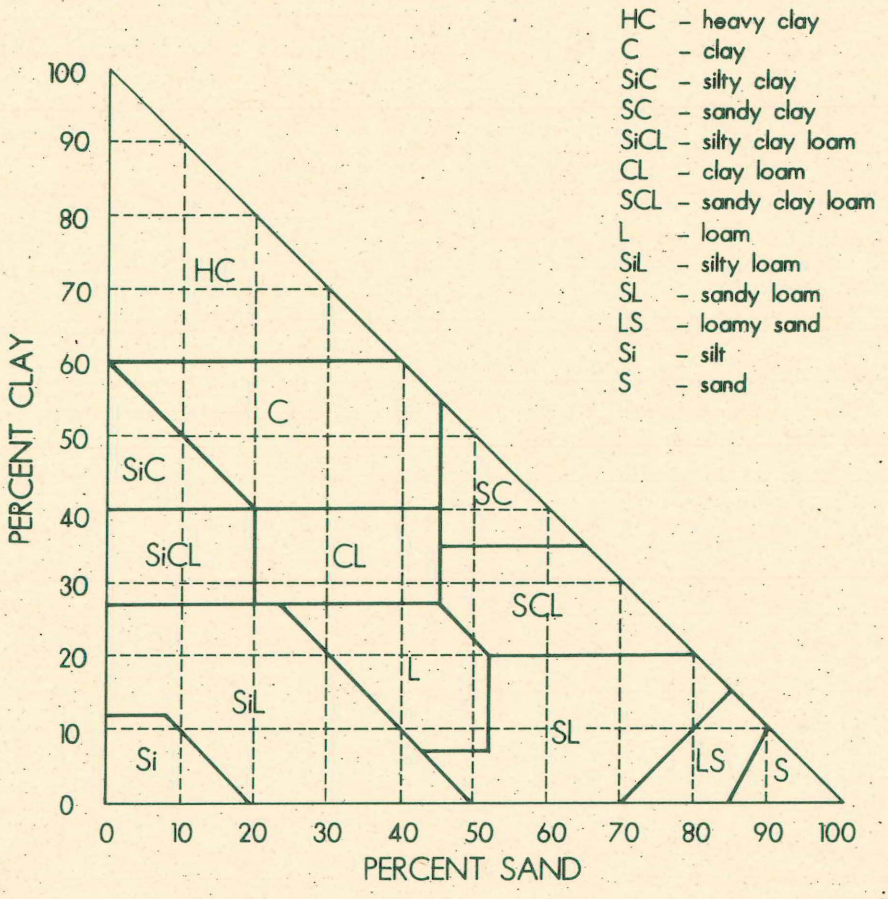
25% or more very coarse sand and less than 50% any other one grade of sand.

Other

Organic Matter

Refers to non-living organic material and the population of microscopic living organisms that is intimately associated with it.

AGRONOMIC SOIL TEXTURE CLASSES



Source : Dumanski, ed 1978

Figure 18 : Agronomic Soil Texture Classes

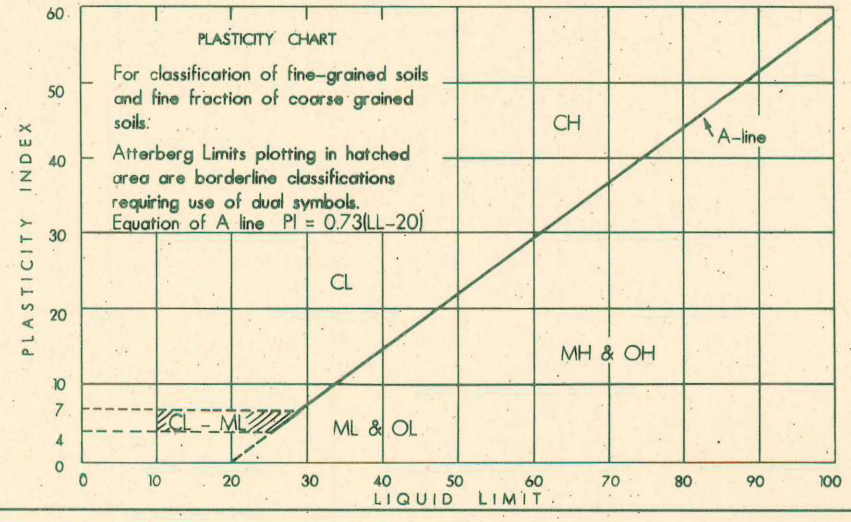
UNIFIED SOIL CLASSIFICATION (USC)

Major Divisions			Group Symbols	Typical Names	Classification Criteria
Coarse-Grained Soils More than 50% retained on No. 200 sieve*	Gravels 50% or more of coarse fraction retained on No. 4 sieve	Clean Gravels	GW	Well-graded gravels and gravel-sand mixtures, little or no fines	$C_U = D_{60}/D_{10}$ Greater than 4; $C_Z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines	Not meeting both criteria for GW
		Gravels with Fines	GM	Silty gravels, gravel-sand-silt mixtures	Atterbeg limits plot below "A" line or plasticity index less than 4
			GC	Clayey gravels, gravel-sand-clay mixtures	Atterberg limits plot above "A" line and plasticity index greater than 7
	Sands More than 50% of coarse fraction passes No. 4 sieve	Clean Sands	SW	Well-graded sands and gravelly sands, little or no fines	$C_U = D_{60}/D_{10}$ Greater than 6; $C_Z = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between 1 and 3
			SP	Poorly graded sands and gravelly sands, little or no fines	Not meeting both criteria for SW
		Sands with Fines	SM	Silty sands, sand-silt mixtures	Atterberg limits plot below "A" line or plasticity index less than 4
			SC	Clayey sands, sand-clay mixtures	Atterberg limits plot above "A" line and plasticity index greater than 7
Fine-Grained Soils 50% or more passes No. 200 sieve*	Silts and Clays Liquid Limit greater than 50%		ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands	
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays	
			OL	Organic silts and organic silty clays of low plasticity	
	Silts and Clays Liquid Limit greater than 50%		MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts	
			CH	Inorganic clays of high plasticity, fat clays	
			OH	Organic clays of medium to high plasticity	
Highly Organic Soils			PT	Peat, muck, and other highly organic soils	Visual-Manual Identification, see ASTM Designation D 2488.

Classification on basis of percentage of fines
Less than 5% pass No. 200 sieve GW, GP, SW, SP
More than 12% pass No. 200 sieve GM, GC, SM, SC
5% to 12% pass No. 200 sieve Borderline classification requiring use of dual symbols

Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols

Atterberg limits plotting in hatched are borderline classifications requiring use of dual symbols



* Based on the material passing the 3 in. (75 mm) sieve.

Figure 19 : Unified Soil Classification (USC)

Source : Maynard, D. 1979