



British Columbia Rangeland Seeding Manual



Canada

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British Columbia

British Columbia
Rangeland Seeding Manual

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Many individuals made contributions to this manual. A project steering committee comprised of Percy Folkard, Francis Njenga, Liza Zabek, Reg Newman, Rick Tucker, Doug Fraser, Lavona Liggins, Crystal Wheeler, Judy Millar, and Julie Robinson provided overall guidance, photographs, and technical and copy reviews. Charles Burnett and Geomemes helped with information organization, and a demonstration version of a web-based content management system for the manual. We thank Percy Folkard for compiling photographs and illustrations, the glossary and the index of this manual; Paul Nystedt for publishing advice and Nancy Portman for a thorough final copy edit.

Range Officers, Agrologists, and specialists throughout the province offered valuable information and insights on the practice of rangeland seeding. David Wong, Alberta Agriculture and Rural Development, assisted with seed industry and export information. Seed industry and forage specialists from other provinces in western Canada also gave freely of their time and knowledge. Faron Anslow at the Pacific Climate Impacts Consortium helped with access to climate data. Alf Bawtree and Brent Olsen each deserve special thanks for the time they spent in the field sharing their knowledge of historic seeding efforts in the Kamloops area. Glenn Hogberg and Gary Scorgie provided information on pasture seeding options for developing the cost-benefit analysis example.

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Library and Archives Canada Cataloguing in Publication

Dobb, Allen, 1961- British Columbia rangeland seeding manual [electronic resource] / Allen Dobb and Sandra Burton.

Includes bibliographical references and an index.
Electronic monograph in PDF format. Issued also in print form.
ISBN 978-0-7726-6643-7

1. Rangelands--Revegetation--British Columbia. 2. Range management--British Columbia. I. Burton, Sandra Lee, 1954- II. British Columbia. Ministry of Agriculture III. Title.

SB193.55 D62 2013 633.2'0209711 C2013-980005-0

Citation

Dobb, A., S. Burton. 2013. Rangeland Seeding Manual for British Columbia, B.C. Min. Agri., Sust. Agri. Mgmt. Br., Abbotsford, B.C.

Prepared for

B.C. Ministry of Agriculture
Sustainable Agriculture Management Branch
1767 Angus Campbell Road, Abbotsford, B.C., V3G 2M3

This project is supported by Growing Forward, a federal-provincial-territorial agreement.

Published by

Ministry of Agriculture
BO Box 9120 STN PROV GOVT, Victoria, B.C., V8W 9B4

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B.C. Ministry of Agriculture
http://www.gov.bc.ca/agri/
888-221-7141

Table of Contents

6 TABLES

6 FIGURES

8 LIMITATIONS

9 CHAPTER 1. INTRODUCTION

9 Background
10 Management Contexts
11 Rangeland Seeding Objectives
11 Potential Natural Community and Plant Succession
12 The Three R's: Rehabilitation, Reclamation, and Restoration
13 The Seeding Decision
14 How to use the manual
14 Chapter 1 Notes

15 CHAPTER 2. SITUATION ANALYSIS

16 Land Status
16 Legislation
20 Ecological
20 Social
20 Economic
22 Chapter 2 Notes

23 CHAPTER 3. MANAGEMENT CONTEXTS

24 FOREST LAND GRAZING AND SILVOPASTURE

24 Active Forestry Areas
25 Seeding for Forestry Objectives
26 Seeding and Rodents
26 Seeding Legumes for Soil Improvement
26 Livestock Grazing and Tree Interactions
28 Seeding for Forage Objectives
28 Silvicultural Site Preparation
30 Increasing Forage Production – Quantity and Quality
30 Temporary Landings, Skid Trails, and Burn piles
32 Silvopasture

34 PASTURE

35 Pasture Establishment
36 Pasture Rejuvenation
38 Intensively Managed Grazing
38 Fertilization
39 Over-seeding and Direct Seeding
40 Herbicide Control
41 Fire
41 Mechanical Disturbance
42 Winter Pasture Feeding

44 GRASSLAND RESTORATION

44 Historic Grassland Rehabilitation
45 Why Grassland Restoration?
46 Seeding and Restoration
47 Disturbances and Restoration
48 Past Rehabilitation Efforts: The Time Horizon
49 Invasive Plants
49 Native Seed Sources
50 Restoration Gene Pool Concept

52 ECOSYSTEM RESTORATION

53 Forest Encroachment into Grasslands
53 Ecosystem Restoration Objectives
54 Ecosystem Restoration and Seeding
55 Disturbance Associated with Restoration Treatments

58 POST - WILDFIRE REHABILITATION

58 Large Fires and Fire Statistics Summary 2000–2009
59 Wildfire Rehabilitation Objectives and Seeding
59 Surface Erosion Control
60 Invasive Plant Suppression
62 Forage Enhancement
63 Forage Quantity and Quality
63 Animal Distribution
64 Fire Rehabilitation in Protected Areas and Special Management Zones

66 SITE REHABILITATION

66 Site Rehabilitation Seeding Objectives
66 The Importance of Site Rehabilitation
67 Role of Seeding in Site Rehabilitation
68 Soil and Site Preparation
68 Temporary Sites and Access Structures
70 Pipeline, Transmission Line
70 Topsoil is the key
70 Permanent Sites and Access Structures
72 Resource Roads
74 Chapter 3 Notes

79 CHAPTER 4. SITE AND OBJECTIVE ANALYSIS

80 Note on Species Selection, Adaptation, and Timelines
80 Region or BEC Zone in Region
81 Precipitation Zone
81 Precipitation and Climate Change
81 Site Analysis
82 BEC Information Online
83 Assessment of Vegetation and Potential Natural Community
83 Sources of information to assist with Vegetation Assessments
85 Invasive Plant Assessment
85 BC Invasive Plant Information online
86 Soil Assessment Keys and Information
86 Soil Test or Assessment
86 Terrain Assessment - Slope, Erosion Hazards, Microsite, Riparian Area Identification
87 Seedbed or Disturbance Assessment
92 Scale Analysis
92 Treatment Areas
93 Treatment Area Shape
93 Objective Analysis
94 Forage Enhancement
94 Invasive Plant Suppression
96 Erosion Control
96 Soil Improvement
96 Extending the Grazing Season
96 Native Plant Community
97 Hard Fescue Persistence
98 Vegetation Control
98 Sociocultural and/or Aesthetic
99 Chapter 4 Notes

101 CHAPTER 5. REGIONAL SPECIES FILTERS

102 Bulkley – Nechako
104 Cariboo – Fraser-Fort George
106 Kootenay
108 Northeast – Peace-Liard
110 Thompson – Okanagan

117 CHAPTER 6. SEEDLING AND STAND ESTABLISHMENT

119 Seed-to-Soil Contact
120 Seeding Methods
122 Broadcast Seeding Methods
123 Drilled or Direct Seeding Methods
124 Specialized Seeding Methods
124 Timing of Seeding
125 Seed Depth
127 Mixtures and Calculations
128 Inoculants for Legumes
129 Seeding Rates and Calibration
129 Pure Live Seed and Desired Plant Density
130 Seed Weights
131 Calibration
133 Pre-germination Issues
134 Seedling Establishment
134 Stand Establishment
134 Weed Control
135 Soil Fertility
136 Grazing
137 Mechanical Treatments
138 Chapter 6 Notes

140 CHAPTER 7. SOURCING SEED

140 Purchasing Seed
140 When sourcing and buying seed
141 Canadian Seed Grades, Standards, and Seed Tags
141 Pedigreed Seed
142 Examples of Pedigreed Seed Classes
142 Common Seed
145 Important Information
145 Seed Analysis Certificate for Mechanical Purity and Germination
147 Native species and the *Canada Seeds Act*, *Seeds Regulation*
148 U.S. Standards
148 Native Seed and Native Seed Production
150 Cultivars, Ecovars, and Wild Collections
150 Seed Producing Areas and the U.S. Pacific Northwest
152 Seed Producing Areas in Canada
153 Western Canada Forage Seed Collaboration
153 Peace River Region of British Columbia and Alberta
155 Saskatchewan
156 Manitoba
156 Willamette Valley, Oregon
156 Other Areas in the U.S. Pacific Northwest
157 Seed Companies in Western Canada
158 Forage Seed Associations
159 Chapter 7 Notes

160 CHAPTER 8. SPECIES SUMMARIES

162 AGRONOMIC GRASSES
162 Canada Bluegrass
164 Kentucky Bluegrass
166 Hybrid Bromegrass
168 Meadow Bromegrass
170 Smooth Bromegrass
172 Chewings Red Fescue
174 Creeping Red Fescue

176 Hard Fescue/ Sheep Fescue
178 Tall Fescue
180 Orchardgrass
182 Italian Ryegrass
184 Perennial Ryegrass
186 Redtop
188 Timothy
190 Crested Wheatgrass
192 Intermediate/ Pubescent Wheatgrass
194 Tall Wheatgrass
196 Dahurian Wildrye
198 Russian Wildrye

200 AGRONOMIC LEGUMES
200 Alfalfa
202 Birdsfoot Trefoil
204 Alsike Clover
206 Red Clover
208 White Clover
210 Sainfoin
212 Cicer Milkvetch
214 Common Vetch
216 Hairy Vetch

218 NATIVE GRASSES
218 Fringed Brome
220 Big Bluegrass
222 Fowl Bluegrass
224 Reed Canarygrass
226 Bluejoint Reedgrass
228 Pinegrass
230 Junegrass
232 Rocky Mountain/ Alpine Fescue
234 Idaho Fescue
236 Rough Fescue
238 Tufted Hairgrass
240 Bluebunch Wheatgrass
244 Slender Wheatgrass
246 Western Wheatgrass
248 Blue Wildrye
250 Canada Wildrye
252 Fuzzy-spiked Wildrye (Hairy Wildrye)

254 NATIVE LEGUMES
254 Creamy Peavine
256 American Vetch

258 APPENDICES

258 A. Economic Analysis
266 B. Soil Erosion Assessment Key – Climatic Precipitation Factors
269 C. Seeding Rate Calculations

272 GLOSSARY

279 INDEX

Tables

25 **Table 3.1**
Area seeded to forage species in B.C. forests, 1983–2008

82 **Table 4.1**
Predominant Biogeoclimatic Zones within British Columbia's interior range area and their geo-climatic ranges

84 **Table 4.2**
Pasture assessment tool

89 **Table 4.3**
Erosion hazard assessment tool

91 **Table 4.4**
Burn severity assessment tool

111 **Table 5.1**
Species summary ratings (species filters)

121 **Table 6.1**
Description of common seeding methods by appropriate project scale, resources required, advantages, limitations and concerns, and typical management context

121 **Table 6.2**
Inoculants for some common agronomic legumes

131 **Table 6.3**
Difference in seed mix compositions when expressed as % by weight versus % by seed count

143 **Table 7.1**
Canada Seeds Regulations, Grade Table (VIII) applicable to alfalfa, red clover, sweet clover, and cicer milkvetch

152 **Table 7.2**
Canadian acres in grass and legume seed crops

152 **Table 7.3**
Canadian export values for grass and legume seed crops

261 **Table A.1**
Summary of pasture seeding options for cost–benefit analysis example

262 **Table A.2**
Costs and benefits associated with pasture seeding options

262 **Table A.3**
Summary of present value costs, annual net revenues, present value of benefits over 15 years, and NPV for pasture development options

266 **Table B.1**
Cariboo forest region: Precipitation factors

266 **Table B.2**
Kamloops forest region: Precipitation factors

267 **Table B.3**
Nelson forest region: Precipitation factors

267 **Table B.4**
Prince George forest region: Precipitation factors

270 **Table C.1**
Suggested seedling density for forage seeding (plants/m^2)

270 **Table C.2**
Typical estimates of seedling establishment (% seedlings per pure live seed after one season)

Figures

10 **Figure 1.1** Active Crown range tenures and interior regions of British Columbia

12 **Figure 1.2** Rehabilitation, reclamation, and restoration goals in relation to ecosystem structure and function

13 **Figure 1.3** Four level rangeland seeding decision aid flow chart

15 **Figure 2.1** Situation analysis flow chart

23 **Figure 3.1** Management contest descriptions and index

28 **Figure 3.2** Management continuum in forest land grazing and silvopasture systems and potential opportunity for seeing applications

33 **Figure 3.3** Forest land grazing and silvopasture decision aid

43 **Figure 3.4** Pasture seeding decision aid

51 **Figure 3.5** Grassland restoration seeding decision aid

57 **Figure 3.6** Ecosystem restoration seeding decision aid

65 **Figure 3.7** Post-wildfire rehabilitation seeding decision aid

73 **Figure 3.8** Site rehabilitation seeding decision aid

79 **Figure 4.1** Site and objective analysis process flow chart

95 **Figure 4.2** Invasive plant risk evaluation tool

101 **Figure 5.1** Interior regions of British Columbia

102 **Figure 5.2(a)** Bulkley - Nechako Biogeoclimatic Zones

103 **Figure 5.2(b)** Bulkley - Nechako total annual precipitation (1961 - 1990 average)

104 **Figure 5.3(a)** Cariboo - Fraser-Fort George Biogeoclimatic Zones

105 **Figure 5.3(b)** Cariboo - Fraser-Fort George total annual precipitation (1961 - 1990 average)

106 **Figure 5.4(a)** Kootenay Biogeoclimatic Zones

107 **Figure 5.4(b)** Kootenay total annual precipitation (1961 - 1990 average)

108 **Figure 5.5(a)** Northeast - Peace-Liard Biogeoclimatic Zones

109 **Figure 5.5(b)** Northeast- Peace-Liard total annual precipitation (1961 - 1990 average)

110 **Figure 5.6(a)** Thompson - Okanagan Biogeoclimatic Zones

111 **Figure 5.6(b)** Thompson - Okanagan total annual precipitation (1961 - 1990 average)

118 **Figure 6.1** Factors affecting seedling and stand establishment

144 **Figure 7.1(a)** Example of a pedigreed seed tag

144 **Figure 7.1(b)** Example of a ground cover mixture tag

147 **Figure 7.2** Example of a seed analysis certificate

151 **Figure 7.3** Ecoregions and major forage seed producing areas in Western Canada and the U.S. Pacific Northwest

Limitations

Information presented in the manual is based on an extensive literature review, supplemented with information gathered from land managers and workers in the field. Every effort was made to present up-to-date information on seeding applications in British Columbia. There are, however, significant gaps in this type of research in the province and when applicable some information is adapted from research and experience in adjoining jurisdictions. There is generally less related information available for high elevation northern zones, and therefore the manual is focused predominantly on the lower elevation zones of the northern and southern interior regions.

The information contained in this manual should not be considered prescriptive. Any seeding decision should be informed by a situation and site analysis to help establish objectives and determine whether those objectives can be realized given site conditions. A goal of this manual is to provide a framework to assist users with this process, and to identify some of the factors that may affect decision making. Information in the manual should be supplemented by professional expertise and informed local knowledge whenever possible.

With a focus on rangeland forage production systems, the manual does not directly address seeding applications that are part of large-scale industrial (mining, for example) or roadside reclamation projects. Nor is it able to consider various restoration applications (i.e., wetland, riparian, and high-elevation rangeland and alpine area restoration) that may involve a variety of revegetation techniques. There are, however, sections of the manual that workers in those fields may find useful.

Chapter 1. Introduction

Seeding of introduced and native plant species is a management practice that is typically applied to increase forage production and revegetate disturbed sites. Increasingly, seeding is being considered within a broader context of social, economic and ecological values (e.g., biodiversity and ecosystem integrity) especially when applied to Crown land. Appropriate seeding is determined in large part by the land management context and objectives. Seeding operations are also determined by available resources and the scale of individual projects. In some instances, legislation may guide a decision to seed.[1]
Seeding decisions made without adequate information or a thorough evaluation of costs and benefits often lead to seeding failure, with expected benefits not being realized and unexpected costs being incurred. The purpose of this manual is to help users make well-informed decisions about seeding rangeland in the province of British Columbia.

Background

Range in British Columbia encompasses a wide variety of landscapes, and includes both grasslands and forests. For this manual, range also includes native and improved dryland (non-irrigated) pasture. Both Crown range utilization and private land grazing for livestock production occur predominantly in the interior regions of the province, east of the Coastal Mountains. Guide outfitter use of Crown range, mostly for localized horse grazing, occurs in the northeast and northwest regions of the province, but also at the edges of more concentrated livestock production areas of the interior. Crown range tenures, private lands, and interior regions are shown in Figure 1.1.

This manual focuses on seeding in the rangeland forage production systems within the regions identified in Figure 1.1, and management contexts including ecosystem restoration, post-wildfire rehabilitation, and site rehabilitation. When possible, experience from previous seeding projects in British Columbia is presented to support recommendations made within specific management contexts.

This manual makes reference to Biogeoclimatic Ecosystem Classification (BEC). BEC is a system that identifies and classifies similar sites based on climate, soils, and vegetation, and is used throughout British Columbia as a common descriptive framework for resource management and research (see Table 4.1 for zone names and geo-climatic ranges).

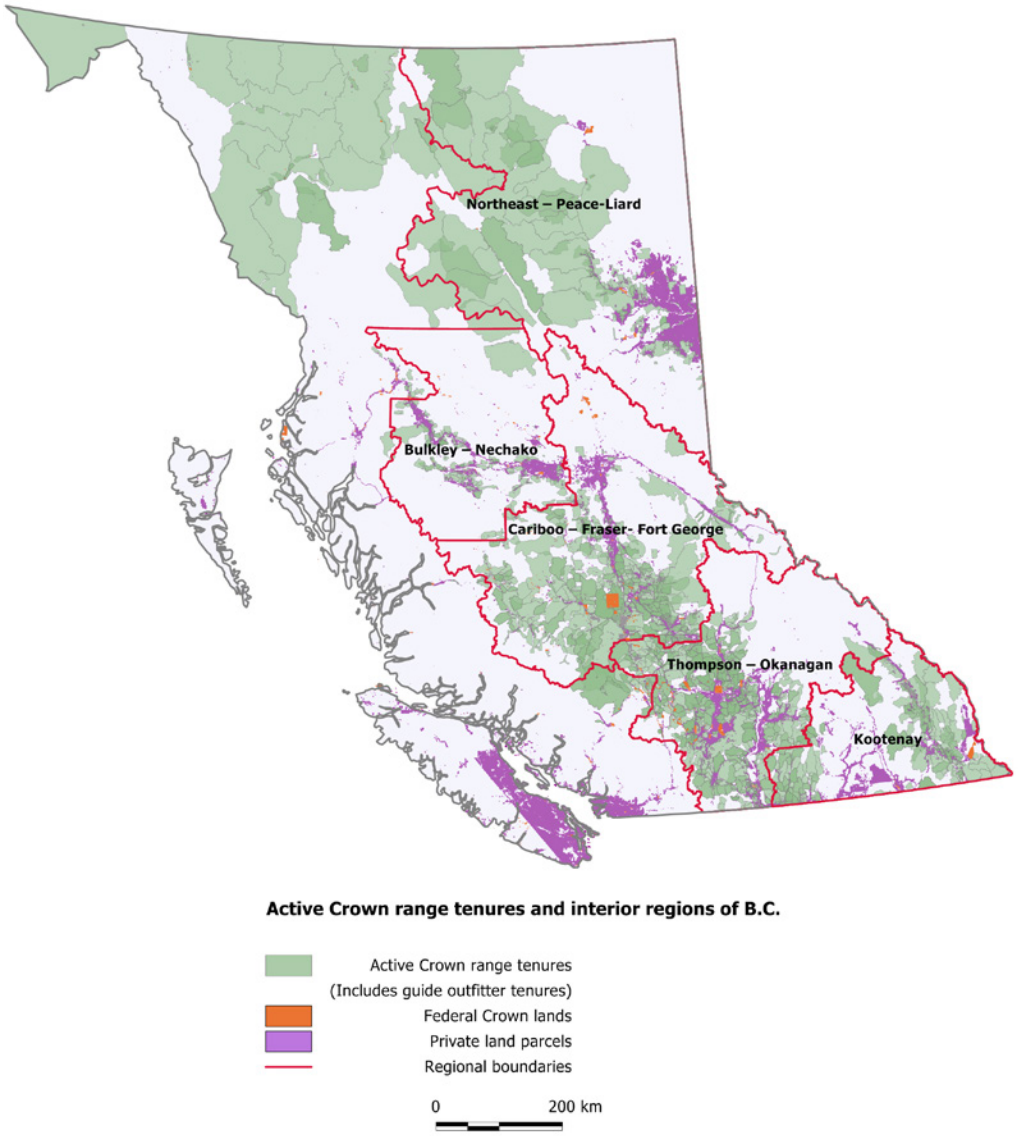


Figure 1.1 Active Crown range tenures and interior regions of British Columbia.

Source: Spatial data from the Province of British Columbia. Note: Extensive Crown range tenure areas represented in the northern regions of the province (i.e., the northwest), are used predominantly for localized horse grazing as part of guide outfitter operations.

Management Contexts

Seeding in British Columbia's rangelands occurs within several management or treatment contexts. A management context can be thought of as the setting, or the physical and institutional environment, in which seeding might be applied. It is defined by many factors, including land status, management goals, and site potential. Six management contexts have been identified in this manual to help users find information that might be appropriate to their specific circumstances. In practice the contexts can overlap; however, in the manual they are addressed individually to allow more detailed discussion of context-specific information.

Rangeland Seeding Objectives

Rangeland seeding often has multiple objectives depending on the management context. The most common objectives for seeding are:

- **Forage enhancement** – to improve forage quantity and quality for livestock and/or wildlife.
- **Invasive plant suppression** – to suppress or prevent spread of invasive or weedy plants.
- **Erosion control** – to encourage soil stabilization and prevent soil erosion.
- **Soil Improvement** – to improve soil nutrient or physical properties.
- **Grazing season extension** – to lengthen the use period or to extend the grazing season for livestock and/or wildlife.
- **Native plant community** – to maintain or move toward the potential natural community (PNC) for a site.
- **Vegetation control** – to influence or change plant succession on a site.
- **Sociocultural and/or aesthetic** – to enhance or support cultural values or to meet aesthetic requirements.

To meet these objectives, seed needs a suitable microsite for germination and at least some contact with mineral soil. It also needs adequate moisture and temperature for germination, and light for eventual establishment.

When forage production is the primary objective, conversion of a native plant community may be desired. In this case, creating a suitable seedbed is critical. Competing vegetation may need to be controlled. In multiple use contexts, a seedbed or partial seedbed may be created by disturbances related to timber harvest activities. In some cases, natural disturbance events such as fire, or soil erosion, may result in a suitable seedbed.

Potential Natural Community and Plant Succession

Successful rangeland seeding applications depend on knowledge of the Potential Natural Community (PNC) for a site, and the process of plant succession.[2] The PNC is the natural grouping of plants expected to develop over time given the specific climate, soils, aspect, and natural disturbance regime for a site. Succession describes the path, or the transition from one state to another, as a site moves toward the PNC. Determining the PNC provides insight into site potential and provides clues about how succession will proceed after seeding. This assessment is also required to select suitable species for seeding. The BEC system is the primary reference for the assessment of the PNC.

In some situations, the plant community is maintained in an early successional stage to meet management objectives. This is often the case on improved pasture in British Columbia, where the PNC most always includes a forest component. Fire, planned grazing, and mechanical and chemical treatments are tools that can be used to keep plant communities in a desired state.

After a severe disturbance like logging, or an extreme wildfire event, site potential may be altered so much that the normal successional path for a site may change. Seeding can be a useful tool for meeting both short- and long-term management objectives in these situations.

The Three R's: Rehabilitation, Reclamation, and Restoration

With the wide variety of management contexts encountered in British Columbia's rangeland system, it is important to highlight three related approaches to revegetation. This manual has adopted the interpretation of rehabilitation, reclamation, and restoration presented in *A Guide to Using Native Plants on Disturbed Land,*[3] derived from Allen and the National Academy of Sciences.[4] The end condition reached under each of these approaches differs in their similarity to the original pre-disturbed ecosystem (Figure 1.2. Graphic from E.B. Allen).

Rehabilitation results in an altered ecosystem, with different function and structure from the original system. Rehabilitation implies that the site will have a form and productivity that fit with a prior land use plan.[5] It also suggests ecosystem stability preventing further deterioration.

Reclamation is a process that returns land to a former or other productive use.[6] Ecosystem function is retained, but the structure may be less complex than a restored condition. The ability of the land to support various uses after reclamation is similar to that of the land before reclamation, but individual uses will not necessarily be identical.[7]

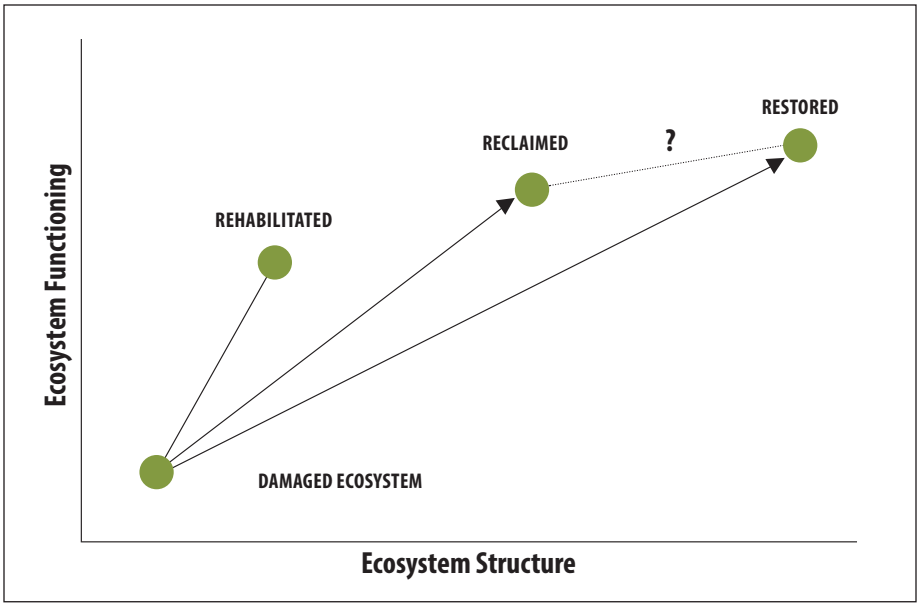


Figure 1.2 Rehabilitation, reclamation, and restoration goals in relation to ecosystem structure and function.

Source: Adapted from E.B. Allen, "Restoration ecology: limits and possibilities in arid and semiarid lands," in Proceedings of the Wildland Shrub and Arid Land Restoration Symposium, Roundy, BA; McArthur, ED, 1995, 7–15.

Restoration is the process of establishing the ecosystem that existed before disturbance. Depending on the site this may include the PNC, or a plant community that will transition to the PNC. Restoration may be the goal, but in practice it may be difficult to attain. It assumes that post-disturbance conditions influencing ecosystem processes are the same as pre-disturbance conditions. Restoration efforts can go a long way toward regaining original ecosystem function and structure, but the effect of human intervention may not be erased from the landscape, at least in the short term.[8] Restoration should support an ecological integrity that includes cultural, historical, and social dimensions. Restoration may also involve simulating the natural disturbance regime necessary to maintain an ecosystem, such as the use of prescribed burning and other treatments in fire-maintained ecosystems altered by fire suppression programs of the last 70 years.[9]

The Seeding Decision

A number of factors must be considered when deciding whether or not to seed. Even once seeding is considered an appropriate action to achieve desired objectives, decisions must be made about what, how, and when to seed to maximize the likelihood of success. This manual suggests a four-level decision aid framework to help guide the first stages of the seeding decision process (Figure 1.3.) – each level corresponds to a chapter.

The situation analysis is introduced in Chapter 2 and considers social, economic, and other factors. The six rangeland seeding management contexts are outlined in Chapter 3; each begins with a brief description of factors to consider when deciding whether to seed, and ends with a context specific decision aid diagram. Chapter 4 presents a step-wise process along with information and evaluation tools to guide users through site and objective analysis – a process that is common to all management contexts. Regional precipitation, BEC zone maps, and a species summary ratings table (species filters) , based on species adaptation characteristics, make up Chapter 5.

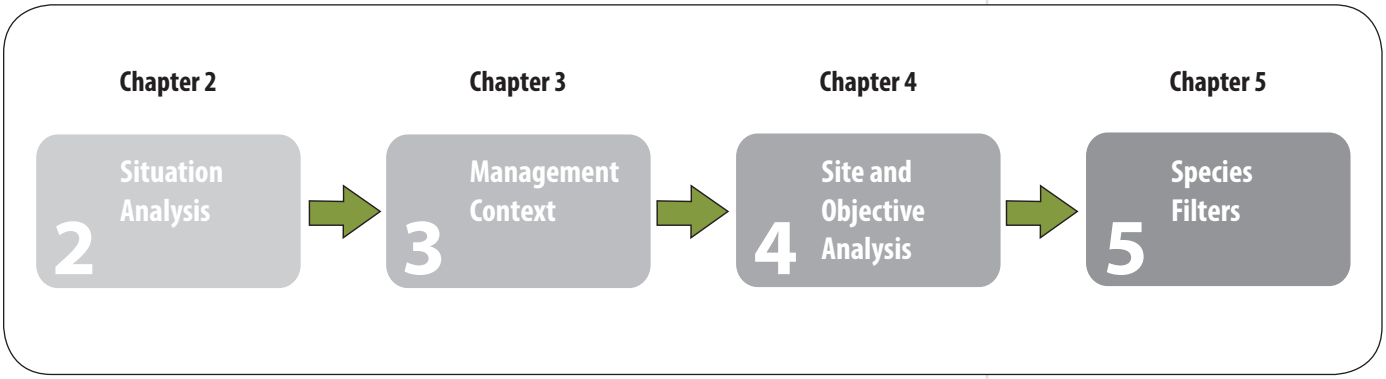


Figure 1.3 Four level rangeland seeding decision aid flow chart.

Further choices are necessary once a decision is made to seed, and a list of species that can potentially satisfy objectives has been identified. The seeding application method (e.g., broadcast or drill seeding) can have a direct bearing on seedling establishment and the overall success. This and additional information on seeding rates and mixes are discussed in Chapter 6 – Seedling and Stand Establishment. The availability, price, and quality of seed can have a major impact on seeding decisions. Critical information on sourcing seed is provided in Chapter 7. Detailed descriptions of agronomic and native grass and legume species are provided in Chapter 8.

How to use the manual

The manual is an information source designed to help users make informed seeding decisions in various management contexts. Experienced land managers will have good knowledge of management context, plant communities, and local climate, and may be looking for an appropriate mix of species to match their individual site objectives. In this instance, the user might go directly to the species summaries or the species summary table (page 112) to explore potential species for a seeding or seed mixture.

Others may be in the process of exploring seeding objectives, and are seeking information about whether seeding may be appropriate in their particular situation. These users may explore the manual using the four-level decision aid framework and then move through the decision aids and tools to inform their decisions. Other users may find it useful to look at the detailed stand establishment or seed sourcing information.

Chapter 1. Notes

[1] An example is Section 41 (1) of the *Forest and Range Practices Act*, Range Planning and Practices Regulation: "A person who constructs a range development must ensure that any exposed soil is revegetated with ecologically suitable species within 2 years after the construction is completed."

[2] For information on range site assessment, see: D.A. Fraser. 2006. *Range resources assessment procedures*. B.C. Min. For. Range. Range Br., Kamloops, B.C. http://www.for.gov.bc.ca/hra.

[3] H. Sinton Gerling et al., *A Guide to Using Native Plants on Disturbed Lands*. Edmonton, Alta: Alberta Agriculture, Food and Rural Development, 2003.

[4] E.B. Allen, "Restoration ecology: limits and possibilities in arid and semiarid lands," in *Proceedings of the Wildland Shrub and Arid Land Restoration Symposium, Roundy, BA; McArthur, ED*, 1995, 7–15.

[5] C. B. Powter and Alberta. Alberta Environment. *Glossary of reclamation and remediation terms used in Alberta Edmonton, AB.: Alberta* Environment, 2002.

[6] Ibid.

[7] Government of Alberta, *Alberta Environmental Protection and Enhancement Act*, Conservation and Reclamation Regulation, 1993.

[8] Related B.C. statutes and regulations do not appear to reflect this framework, although the distinctions between rehabilitation, reclamation and restoration are accepted by some professionals working in the field. Section 19 of B.C. *Oil and Gas Activities Act*, Environmental Protection and Management Regulation, is an example.

[9] See ecosystem restoration management context.

Chapter 2. Situation Analysis

A situation analysis is meant to identify the overarching institutional, social, economic, and ecological factors that will frame the seeding decision. This process will help determine whether seeding is appropriate, what kind of seeding treatment is applicable, and how success should be evaluated. The main factors to be considered are depicted in the flow chart below. Some details in the situation analysis may change as the decision making process progresses, and information is gathered. These aspects should be monitored through other levels.

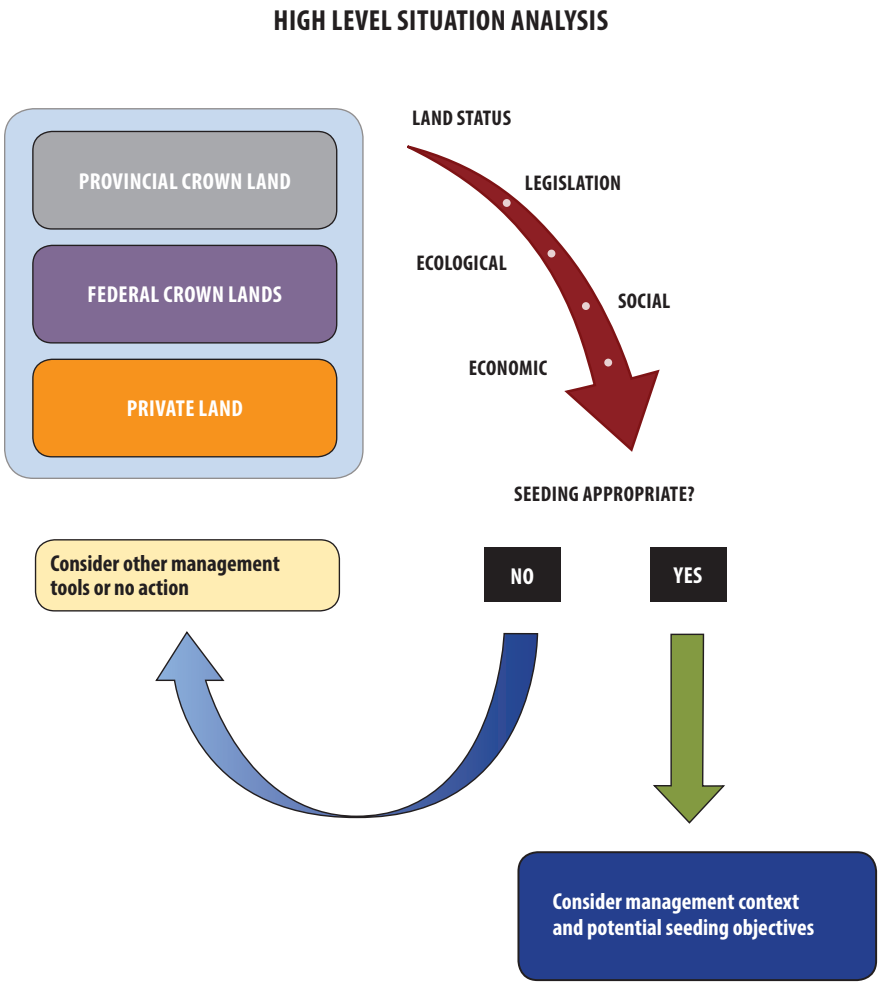


Figure 2.1 Situation analysis flow chart.

Land Status

Determining the status of the land being considered for a seeding application is the first step. In British Columbia, 94% of the land is provincial Crown land, 5% is privately owned, and 1% is federal land.[1] Each type will determine how the seeding decision should be approached. Seeding on provincial Crown lands must consider provincial land management legislation and policy, licensee, First Nations and other stakeholder interests, and the broader public interest. This information, as well as higher-level and/or land use plans should be considered when a seeding prescription is developed.



Photo credit: P. Folkard.

Cattle grazing in the Lundbom Commonage in the Nicola Valley.

Legislation

Specific provincial regulations may influence seeding applications depending on land status. The need to explore a seeding treatment might be triggered by regulation depending on the management context. A number of provincial regulations mention invasive plants, and these provisions may require measures such as seeding as a potential management tool. A brief outline of some provincial regulations that may have an impact on seeding decisions is summarized in the inset on pages (18-19).



Photo credit: P. Folkard.

Grassland with Idaho fescue.

PROVINCIAL REGULATIONS RELATED TO REVEGETATION AND SEEDING

Section 41 (1) Forest and Range Practices Act, Range Planning and Practices Regulation

A person who constructs a range development must ensure that any exposed soil is revegetated with ecologically suitable species within 2 years after the construction is completed.

Section 47 Forest and Range Practices Act

A person carrying out a forest practice or a range practice must carry out measures that are either specified in a management plan or authorized by the minister to prevent the introduction or spread of prescribed species of invasive plants.

Section 51 Forest and Range Practices Act

Unless authorized in writing by the minister, a person must not store hay on Crown range, or carry out, construct, modify, remove, damage or destroy a range development on Crown range.

A person, other than the holder of an agreement under the Range Act, must obtain the authorization of the minister before maintaining a range development on Crown land.

The minister may grant an authorization under this section only if it is consistent with any range use plans, range stewardship plans and objectives set by government for the area covered by the authorization, and the minister is satisfied that the authorization will adequately provide for the range resources of the area to which it applies.

Section 14 Forest and Range Practices Act, Woodlot Licence Planning and Practices Regulation

Measures must be specified in the woodlot licence plan to prevent the introduction or spread of species of plants prescribed in the Invasive Plants Regulation, if the introduction or spread is likely to be the result of the holder's forest practices.

Section 40 Forest and Range Practices Act Forest Planning and Practices Regulation

Soil exposed by the construction or deactivation of a road must be revegetated within two years if the erosion of the soil would cause sediment to enter a stream, wetland or lake, or have a material adverse effect on other resource values and revegetation would materially reduce the likelihood of erosion.

Section 17 (b) and (c) Wildfire Act, Wildfire Regulation

a site rehabilitation plan must be prepared that specifies measures for maintaining natural drainage patterns for all of the fire control works to minimize surface soil erosion by stabilizing and re-vegetating soil disturbed or exposed by heavy equipment, stabilizing the stream channel and stream bed at stream crossings, and stabilizing sump and dam locations that were created for the purpose of carrying out fire control. The measures specified in the site rehabilitation plan must be implemented.

Section 8 Ecological Reserve Act, Ecological Reserve Regulations

No person shall introduce into an ecological reserve any plant or animal species without the written permission of the administrator.

Sections 15 and 19 Oil and Gas Activities Act, Environmental Protection and Management Regulation

Section 15

A person carrying out an oil and gas activity on an operating area must

make reasonable efforts to ensure that seed, plant parts or propagules of an invasive plant are not transported into the area while carrying out the oil and gas activities, and

prevent invasive plants from becoming established, revegetate areas disturbed by the oil and gas activity using seed of ecologically suitable species as soon as practicable after the disturbance, and

ensure that invasive plants do not become established on the well site or facility area.

Section 19 (1)

A person who carried out an oil and gas activity on an operating area and who no longer intends to do so must, as soon as practicable, restore the operating area by doing the following:

de-compacting any soils compacted by the oil and gas activity;

redistributing any retrievable surface soils that were removed from the operating area during construction so that the soil structure is restored, to the extent practicable, to its condition before the oil and gas activity was begun;

if the natural surface drainage pattern was altered restore the drainage pattern to its condition before the alteration;

re-vegetating any exposed soil on the operating area using seed or vegetative propagules of an ecologically suitable species that

promote the restoration of the wildlife habitat that existed on the area before the oil and gas activity was begun, and

stabilize the soil if it is highly susceptible to erosion;

removing any structure that was constructed to cross a stream, wetland or lake and ensuring that the site of the structure is in a stable condition;

stabilizing any cut slopes or fill slopes in well sites and facility areas;

re-contouring bladed areas or excavations in pipeline corridors and seismic lines.

Section 28 Oil and Gas Activities Act, Drilling and Production Regulation

Immediately after ceasing drilling or workover operations, or as soon after cessation as weather and ground conditions permit, a well permit holder must restore the ground surface of those areas of the well site and associated remote sumps and camp sites that will not be required for future operations to a state that eliminates hazards, enables control of weeds and runoff and prevents erosion.

Section 8 Weed Control Act, Weed Control Regulation

Where a noxious weed is not established in an area, no person shall within that area

sow any grain or other seed that is intermixed with seeds of the noxious weed, or apply fertilizer, lime, topsoil or other substance that contains the noxious weed or seeds of the noxious weed, or

sell for delivery within that area any fertilizer, lime, topsoil or other substance that contains the noxious weed or seeds of the noxious weed.

Source: Province of British Columbia, "Statutes and Regulations," BC Laws, 2011.

Note: This is not an exhaustive list. It is the responsibility of the manual user to determine the applicable legislation and regulations for any seeding project.

Ecological

The seeding decision process involves ecological considerations, although how they affect the decision may vary with land status. At this high level, the impact of seeding agronomic and adapted native species on long-term ecosystem integrity should be assessed. There are research gaps in this area. Increasingly the justification of seeding for short-term benefits, without an understanding of long-term ecosystem effects, is being questioned by some land managers. This is especially true for large-scale applications in marginal situations where objectives are unclear and benefits are not clearly supported by available research.

Special land management designations such as protected areas, ecological reserves, and parks should be identified. Where ecological values are high and the retention of natural successional processes is an agreed and desired goal for a landscape, seeding is likely to be inappropriate. Biodiversity and other concerns should be documented and carried forward in the decision making process if there are adjoining areas where seed drift may be a concern.[2]

Social

Broad based social and cultural concerns should also be balanced with stakeholder interests. In some situations, concerns may be community based. In others, concerns may exist among a number of different communities or stakeholder groups. For example, a large area of exposed bare ground highly visible to the public may require establishing a vegetative cover quickly to alleviate potential concerns about erosion and invasive plants.
The native grasslands of British Columbia provide one of the best examples where social and cultural concerns must be considered. Society has placed a high value on these lands in their intact state for their cultural importance, biodiversity, and other ecosystem services they provide.[3] Seeding non-native species on grasslands may diminish these values. The high ecological and social value of grasslands arises in part because of their scarcity: they occupy less than 1% of B.C. lands, and provide habitat for 30% of its red- and blue-listed species.[4,5] The need to consider social values on grasslands may be more pronounced on Crown land, but also extends to grassland held under private ownership (see "Grassland Restoration").

Economic

Economic factors have a direct impact on seeding projects and should be considered as seeding objectives are developed. Budget constraints could influence the seeding decision and final seeding plan. The potential project scale, the size of the area to be seeded, and the location can all affect costs. The cost of native seed, relative to the cost of the more widely applied agronomic species, may be a constraint in some management contexts. These limitations should be identified and established early in the decision making process.

In some contexts, such as site rehabilitation, economic factors will be a consideration but the decision to seed or not to seed may be prompted by regulations. Rarely do seeding projects undergo a full cost–benefit analysis. A recent assessment of social and economic benefits of rangeland conservation practices in the United States, found that while there was a large volume of information for designing economically successful seeding projects, few studies evaluated the economic success of range seeding projects.[6]

On private land, or on Crown land where forage production is the primary intended use, individual project costs (expenditures) and benefits (revenues) can be estimated over the life of the project, and the net present value determined (see example Appendix A). On Crown lands with multiple uses and users, the cost–benefit analysis is more complex and should try to consider all the benefits and costs to society as whole.[7] The risk, or cost, of seeding failure as well as opportunity costs should be included in the analysis.

Research and information gaps make comprehensive cost–benefit analyses challenging. It is argued the value of things like biodiversity cannot be accounted for in strictly monetary terms.[8] Similarly, the cost of soil erosion in fish-bearing streams or weedy species invasion is difficult to estimate. Determining the amount an individual would be willing to pay to receive the benefit, or avoid the loss, is sometimes used as a way to estimate these values. However, establishing willingness-to-pay estimates, through surveys and other means, is an overwhelming and costly task in itself. As a result, these estimates are sometimes borrowed from existing studies in other jurisdictions. With this complexity and the assumptions that are required, it becomes clear that a full cost–benefit analysis on a project-by-project basis is often impractical.

Still, land managers need some way to evaluate the economics of seeding and to make informed seeding decisions. Ultimately, costs – including risk of a failed seeding effort – can be reduced through sound planning and the use of research-based information. When cost–benefit analysis is not practical, a simple list of all costs, risks, and all potential benefits should be developed. Each item on the list can be rated with a + sign or – sign, and a rating scale. These items can be followed through the decision making process, and changed accordingly as the seeding application is developed or modified. This type of evaluation is subjective, but can be useful for ensuring all potential costs and benefits are considered, and has some value for monitoring and evaluating the success of a seeding.

Chapter 2. Notes

[1] Government of British Columbia, "Land Tenures Branch - Ministry of Forests, Lands and Natural Resource Operations," n.d. http://www.for.gov.bc.ca/Land_Tenures/crown_land_application_information/program_areas.html.

[2] A main point of the biodiversity argument is that the introduction of foreign plant material into the community may limit the adaptation potential of native plant communities, and influence community function and structure in unpredictable ways. See: J. Belnap, "Genetic integrity: why do we care? An overview of the issues," General technical report INT. No. 315–316 (1995):265.

[3] For some discussion on this topic, see J. Reid, "The Grasslands Debates: Conservationists, Ranchers, First Nations, and the Landscape of the Middle Fraser," *BC Studies: The British Columbian Quarterly 160* (2008):93–118.

[4] BC Grasslands, "BC Grasslands Home," Grassland Conservation Council of British Columbia, 2011, http://www.bcgrasslands.org/.

[5] Red- and blue-listed refer to species designations under the federal *Species at Risk Act* (SARA).

[6] J. A. Tanaka, M. Brunson, and L. Allen Torell, "A Social and Economic Assessment of Rangeland Conservation Practices," in Conservation Benefits of Rangeland Practices: Assessment, Recommendations, and Knowledge Gaps, ed. D.D Briske. U.S. Department of Agriculture, Natural Resources Conservation Service, 2011. http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1045804.pdf.

[7] A. Boardman et al., *Cost–benefit analysis : concepts and practice*, 4th ed. Upper Saddle River N.J.: Prentice Hall, 2011.

[8] See: M. Sagoff, *The economy of the earth : philosophy, law, and the environment*, 2nd ed. New York, N.Y.: Cambridge Univ. Press, 2008.

Chapter 3. Management Contexts

Each management context presents different circumstances that can impact rangeland seeding decisions. The purpose of this section is to help users identify factors that affect seeding success in each context, and identify situations where seeding may be appropriate (see Figure 3.1 for management context descriptions and index).

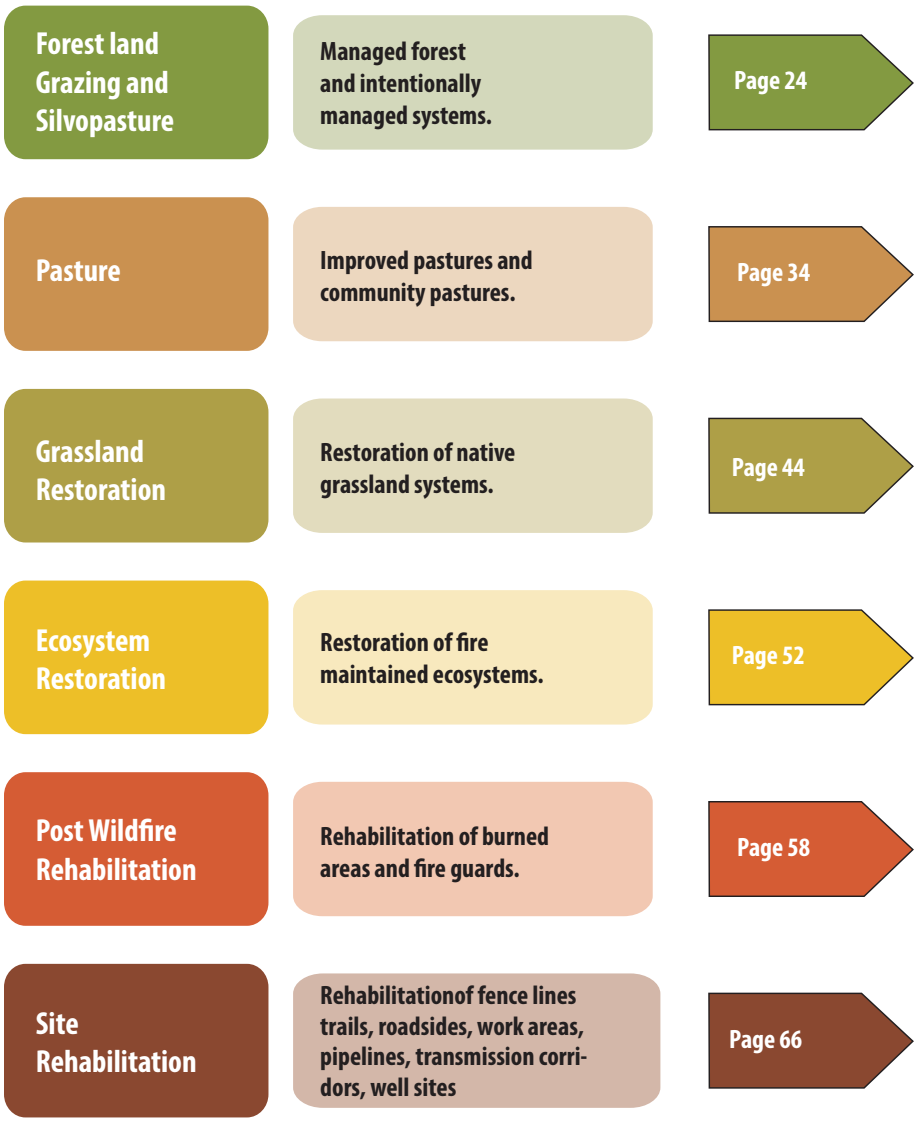


Figure 3.1 Management context descriptions and index.

FOREST LAND GRAZING AND SILVOPASTURE



Photo credit: A. Dobb.

Forest land grazing and silvopasture are related systems. They each involve the harvest of forest products and the production of forage for livestock, but they differ in how these objectives are managed in relation to each other. Timber production and livestock grazing are just two of several multiple uses on Crown forest land. Grazing is often an important and primary use in open-canopy forests and transitional areas. In more productive forest areas, timber harvest and other forestry operations predominate while grazing is considered a secondary use. However, forestry activities effectively create grazing opportunities, with cutblocks, roads, landings, and skid trails. These opportunities are relatively short lived and shift across the landscape as newly established forests grow.

In silvopasture systems, the forest, forage, and livestock are intentionally managed, often as a single enterprise.[1] Objectives for timber and forage are considered throughout the management process.

Active Forestry Areas

Disturbances created by forest management activities and timber harvest provide opportunities for seeding applications to achieve a variety of objectives. They include:

- forage enhancement,
- vegetation control,
- soil improvement,
- invasive plant suppression, and
- erosion control.

In many situations forage values are enhanced by seeding applications designed to meet other objectives.

Seeding cutblocks with agronomic species to increase forage production after clearcut harvest was common practice by the 1960s. Over 29,000 ha were seeded with grasses and legumes during that decade.[2] A substantial area was seeded through the 1970s, 1980s and 1990s in the central and southern interior of the province. A wide variety of seed mixes have been recommended for forest land situations.[3,4] Most were designed for broad application on either dry forest (i.e., Interior Douglas–fir) or wet forest (i.e., Engelmann Spruce–Subalpine Fir) types. Since 2000 there has been a substantial reduction in the seeded area within the province, primarily because fewer cutblocks have been seeded (see Table 3.1).

Table 3.1 Area seeded to forage species in B.C. forests, 1983–2008.

Area Seeded in B.C. Forests: cutblocks, roads, and landings[a]				
Year	1983-1984	1992-1993	1999-2000	2007-2008
Area in Hectares	6132	4942	1821	317

[a] Area seeded information included in annual silvicultural site preparation treatment reports. All forest regions.

Source: Province of British Columbia, "Annual Reports - Ministry of Forests, Lands and Natural Resource Operations - Province of British Columbia," B.C. Ministry of Forests, Lands and Natural Resource Operations, 2011, http://www.for.gov.bc.ca/mof/annualreports.htm (accessed December 2, 2011).

Seeding practices have changed for several reasons, including shifts in policy and legislation, uncertainty around impacts on long-term forest production, and questions about economic costs and benefits.[5] The direct competition between forage and timber objectives has also played a role.

Seeding for Forestry Objectives

Seeding of agronomic species has been used to control native vegetation that might otherwise reduce tree seedling survival on some sites. Research on the effects of grass and legume seeding on forest regeneration with no livestock grazing has generally shown that: [6, 7, 8, 9, 10]

- Forage seeding generally has minimal effect on tree seedling survival.
- Forage seeding may reduce native herbaceous vegetation, but may have little effect on woody species; total biomass production is likely to be higher with the introduction of seeded species.
- Forage seeding impedes tree seedling growth in proportion to the cover or volume of the resulting vegetation; there is some evidence that shows differences in growth disappear after 5–7 years, and turn into gains in subsequent years.
- Direct competition between forage and tree seedlings is most often related to light and moisture. On drought-prone sites, moisture deficits are the probable cause of tree mortality and poor tree seedling growth.

Snow press, or the effect of tall vegetation being bent over top of tree seedlings, is a concern for silviculturists. In the Boreal White and Black Spruce zone in the Peace River region, seeding may be a suitable treatment to inhibit snow press and severe competition from bluejoint reedgrass, a taller native species.[11] The size and height of plants are factors in the competition between tree seedlings and surrounding vegetation. The stature of seeded species should be considered in seeding decisions especially if grazing is absent, or does not adequately control the height of vegetation.

Seeding and Rodents

There have been concerns about increased rodent populations following seeding in logged areas. Increased rodents have a two-fold effect. They may interfere with the establishment of forages through direct seed consumption by seed-eating rodents and grazing by voles. They may also interfere with tree seedling establishment through girdling by voles. Substantial tree mortality has been attributed to rodent damage.[12] At least one B.C. study has demonstrated that the increased feed source provided by seeding resulted in an increase in the number of deer mice and voles compared to control areas.[13] Some seeded species may also act as cover to protect rodents from predators; however, grazing management can act to limit this effect.

Seeding Legumes for Soil Improvement

A number of trials have examined legume seeding to improve nitrogen levels on logged and burned sites with mixed results.[14, 15, 16] Variation among sites, site preparation treatments, and seasonal weather patterns make this research challenging to conduct. Treatment effects are often inconclusive, and few long-term results are reported. Continued long-term research is required to establish the value of this practice.

Livestock Grazing and Tree Interactions

Livestock grazing on seeded and reforested areas introduces additional complexity. The following summary points are drawn from a recent review of related research on tree and livestock interactions:[17]

- Trampling of trees by livestock is incidental to grazing activity (i.e., they are not intentionally damaged). Damage levels are generally low (<5% of tree seedlings are affected) with moderate stocking and management to prevent concentrations of animals.
- Trampling damage decreases once trees reach 60 cm in height.
- High levels of trampling can slow growth of, deform, and kill trees. Overall tree seedling mortality resulting from trampling is quite low.

- Reductions in tree growth may not be lasting; damage may be more detrimental to younger trees and trees that set their annual terminal bud.
- Livestock may browse trees, although the level of browsing is not uniform and is a function of individual animal preference and the availability of other forage and browse. Cattle generally do not browse coniferous species unless there is little other forage available.
- Sheep may browse some coniferous species more readily than cattle; however, preferences are variable depending on the surrounding vegetation.
- There is generally a positive or neutral effect of grazing on early tree growth through a reduction in competing vegetation. Limited longer-term data suggest neutral or net positive effects on tree growth.
- Negative impacts on forest stand productivity from livestock grazing are more likely to occur from mortality of tree seedlings than through reductions in individual tree growth.
- There are minor effects of grazing on forest soil compaction and other aspects of soil chemistry.

Acceptable livestock grazing effects on trees depend on grazing management, and appropriate manipulation of stocking density, stocking rate, and stocking period. To minimize conflict between silviculture and range objectives, the management of these two resources must be compatible and cooperative. The potential for successful seeding applications, satisfying both objectives, increases as management becomes more integrated. This relationship is shown in Figure 3.2.



Photo credit: A. Dobb.

Naturally revegetated and planted clearcut following disc trenching site preparation treatment.

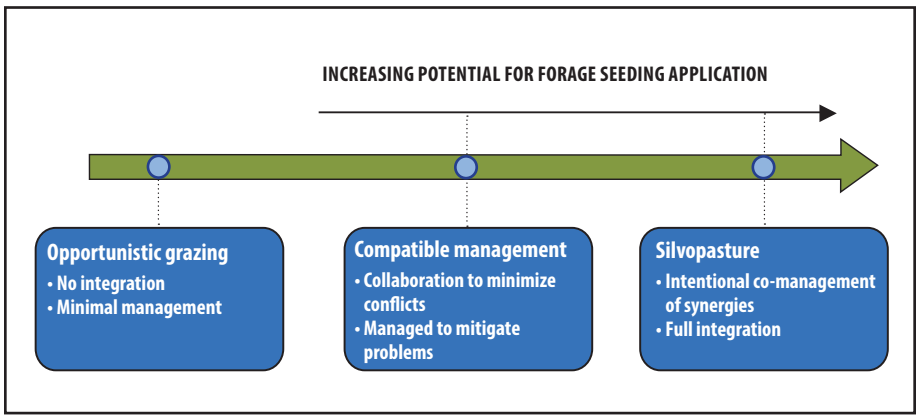


Figure 3.2 Management continuum in forest land grazing and silvopasture systems and potential opportunity for seeding applications.

Source: Adapted from George W. Powell, Silvopasture Resources Synthesis for British Columbia (Agriculture and Agri-food Canada and B.C. Ministry of Agriculture In cooperation with British Columbia Agriculture Council, 2007).

Seeding for Forage Objectives

Opportunities for forage seeding can be created by timber harvest operations. Mineral soil exposure is a critical factor in establishment on seeded areas. The amount of mineral soil exposure will depend on the forest type, harvest method, and the post-harvest forest regeneration plan.

Silvicultural Site Preparation

Silvicultural site preparation, or the post-harvest regeneration plan for a site, is an important factor determining the potential effectiveness of a seeding application. Site preparation treatments can vary from broadcast burning to various mechanical treatments including blading, disc trenching, chaining, and ripping (see "Site and Objective Analysis" for more detail).[18]

Even when forage seeding is not planned, site preparation can influence livestock distribution. Orienting woody debris and other restrictions like trenching to allow livestock movement on a site can improve distribution and therefore reduce trampling of seedlings.[19] Locating tree seedlings close (within 10 cm) to woody debris or other small obstacles can limit potential trampling by livestock.[20]

An estimate of the amount of mineral soil exposure on a site is critical to the seeding decision. Mineral soil exposure is different than the soil disturbance limits established by the *Forest and Range Practices Act, Forest Planning and Practices Regulation*. In the regulation, "Soil disturbance" means disturbance to the soil in the net area to be reforested in a cutblock from temporary access structures, gouges, ruts and scalps, or compacted areas.[21] Mineral soil exposure for the purposes of seeding for forage objectives is assessed on a different scale, and focuses on microsites where seed might find contact with mineral soil. It may take into account gouges, ruts and scalps, but the estimate is based on the amount of exposed mineral soil over all areas of the site.

The amount of mineral soil exposure can affect seeded species establishment, and therefore the economics of a project. This is an important factor determining the native plant community response, especially in the first- and second-growing season. Mineral soil exposures of 25–30% have been commonly used as a required disturbance level for seeding.[22] Mineral soil exposure has not consistently been reported in seeding trials.

Silvilcultural site preparation is an important area for collaborative management and planning. When silviculture plans and assessments of long-term forage requirements are shared, areas for complementary treatments may be identified. For example, sites can be highlighted where the site preparation plan matches the mineral soil exposure required for seeding when there is a need for increased forage. There are many factors to consider when balancing objectives for timber and forage (i.e., on some sites the contribution of seeded agronomic species to total forage production can be relatively short lived).[23]



Photo credit: Mike Dedels.

Mineral soil exposure created by silvicultural site preparation.



Photo credit: Kamloops District Range Staff.

Silvicultural site preparation with substantial woody debris. Note planted tree seedlings in row centre foreground.

Increasing Forage Production – Quantity and Quality

Seeding can increase both the quantity and quality of forage, although these effects may not be long lasting in some situations. At one site near Helmer Lake in the Montane Spruce zone, forage production was equal to unseeded controls by the seventh year.[24] Research in the Engelmann Spruce–Sub-alpine Fir, and Montane Spruce zones in the southern interior of the province has shown increases in forage production from 40 to 200% over unseeded controls, with yields of 500 to 1,500kg/ha.[25] Production will vary with the climate, seeding rate, species seeded, and site preparation.

Higher average daily gain of cows and calves might be anticipated on seeded versus native vegetation. However, in a study in the Montane Spruce zone, there was no difference in daily gains in either cows or calves in relation to seeding or grazing treatment.[26] Average daily gain can vary with the type, kind and class of animal as well as grazing conditions. Other work found the average daily gain for yearling steers on native range in the Interior Douglas-fir zone was 0.8 kg/day.[27] The four year average daily gain for calves on a seeded clearcut in the Engelmann Spruce–Subalpine Fir zone was 0.64 kg/day.[28] The clear and more substantial benefit of seeding appears to be the increase in forage per unit area, allowing an increased stocking rate and a corresponding increase in beef production in kilograms per hectare. Beef production on the native forest land range study was 20 kg/ha, and on the clearcut in the Engelmann Spruce–Subalpine Fir zone it was 60 kg/ha.



Photo credit: A. Dobb.

Plantation seeded with agronomic grass and clover mixture.

Temporary Landings, Skid Trails, and Burn piles

Temporary landings and skid trails have higher levels of soil disturbance and compaction than other harvested areas. The characteristics of landings and skid trails will vary with the silvicultural system, individual logging operations and site conditions. For example, skid trails may receive heavier use in selective logging than in clearcut operations where machine impacts may be more dispersed. Where silviculture site preparation is prescribed, temporary landings and skid trails are likely to receive the same treatment as the larger harvest openings. Temporary disturbance areas are distinguished from more severely disturbed and compacted areas like bladed skid trails, and roads and landings where logs are loaded on trucks; these severely disturbed sites require site specific treatments and are considered in the site rehabilitation context.

Seeding temporary landings and skid trails for a forage enhancement objective might be considered, but only in compatible forest and range management situations (Figure 3.2). In active forestry areas, most of these sites would be marked for forest regeneration. Practically speaking, they are treated like other harvest openings. The size, location and level of disturbance of a temporary landing may require some redistribution of woody debris and an assessment for other revegetation objectives like erosion control and invasive plant suppression.

Like temporary landings, burn piles are likely to receive site preparation similar to the harvest opening. However, depending on conditions, machine-created piles can produce a very hot burn at their centre, severely damaging soil properties. These severe microsite disturbances are especially susceptible to occupation by invasive plants. In some situations this might be mitigated by piling debris in windrows instead of large single piles. Windrows may reduce burn severity, and because they are long and narrow, may also allow native vegetation to reestablish more rapidly from the edges. Where invasive species are a concern, burn piles are prime sites for seeding to suppress potential invasive plants.



Photo credit: A. Dobb.

Burned debris pile: a potential site for seeding.

Silvopasture

Silvopasture is one of five types of agroforestry systems that have practical application in British Columbia. Other systems include: alley cropping, shelterbelts, integrated riparian buffers and forest farming.[29] Silvopasture intentionally blends management of trees, forage and livestock so the interactions among these components are planned and managed throughout the production cycle. The system is operated and evaluated as a single enterprise rather than as separate parts.

Silvopasture systems may be either intensively or extensively managed, but their main feature is the intentional and complementary active management of trees for fibre and pasture for livestock and/or wildlife. Currently, there are few examples of working silvopasture systems in British Columbia. There is opportunity for increased use of these systems with the substantial forest and forage growing potential in the province. As with any management approach, implementation will be dependent on site-specific attributes, economics and resource management objectives.

Both pastures and treed areas can be adapted and managed for both timber and forage production using shared objectives. Management intensity will vary depending on the silvopasture design and desired results. For example, choices might include whether to maximize the production of forage and livestock with timber as a secondary product, or to target enhanced tree growth and co-manage for some enhanced forage and livestock values. Applications are wide and varied including both Crown and private land opportunities. An important feature of these systems is that objectives for both timber and forage are considered throughout the management cycle. In addition, livestock grazing needs to be appropriately managed especially during the period of tree establishment.



Photo credit: Lisa Zabek.

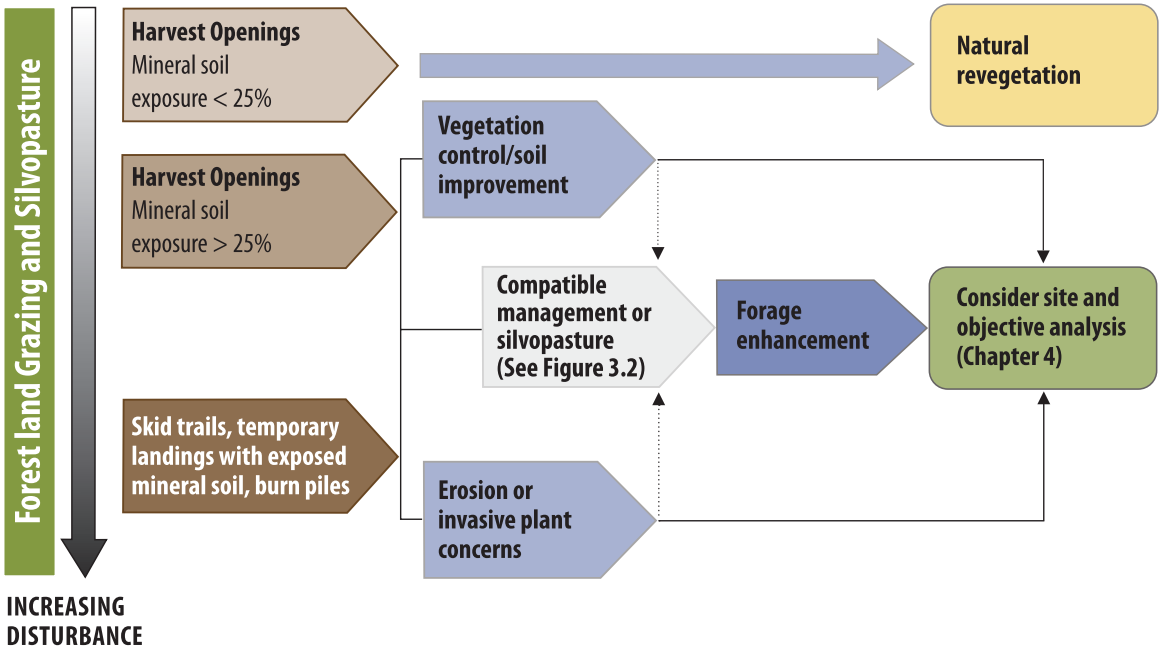
Sheep grazing among young larch in a silvopasture system.

Seeding of improved species may be useful for improving forage production in silvopasture systems. As with the forest land grazing system discussed previously, the appropriateness of seeding will depend on the nature of the system itself. The available land base, the scale of production and how the harvest of forage and trees are combined to satisfy the economic goals of the enterprise are major factors affecting the seeding decision.

Many of the points raised in the discussion related to forest land grazing will be relevant to seeding decisions made in a silvopasture context. The application of this information will depend upon the goals and the design of the silvopasture system. As well, it is suggested that users interested in silvopasture seeding applications also explore the pasture context, and other decision aids in this manual.

DECISION AID

Forest land Grazing and Silvopasture



Management Context Decision Aid – Forest land Grazing and Silvopasture

Management goals for forest land grazing and silvopasture balance forest products and forage. Seeding objectives include vegetation control and soil improvement for silviculture, forage enhancement, erosion control and invasive plant suppression. Typical BEC Zones: PP, IDF, MS, ESSF, BWBS, SBS, SBPS

Figure 3.3 Forest land grazing and silvopasture seeding decision aid.

PASTURE



Photo credit: A. Dobb.

The main feature of pasture systems is that forage production for livestock grazing is a primary goal. Pasture systems are common on private lands in livestock producing areas that may be unsuited to annual cropping or intensive cultivation. The Agriculture census for B.C. reports 226,298 ha were in seeded or tame pasture in 2011.[30] Nearly half of this pasture area was located in the Peace River region. Even on Crown forest lands, forage objectives may occasionally take priority over other uses in some specific cases. The best examples are Crown land agricultural leases and the improved forage areas of community pastures. Much of this land has been cleared and seeded with agronomic forage species. Community pastures are located almost entirely in the Bulkley-Nechako, Cariboo–Fraser-Fort George, and the Northeast–Peace River-Liard regions, and they cover just over 200,000 hectares.[31]

Seeding on pastures may be carried out for any number of objectives including invasive plant suppression and soil improvement. But because forage production for livestock grazing is the primary goal on these lands, improving the quality and quantity of forage and extending the grazing season are common seeding objectives. With the land-use objective well established, seeding decisions in the pasture context should be informed by economic and productive efficiency. However, ecological relationships and long-term pasture productivity remain important in determining these efficiencies.

There are various types of pasture in the province, but they can be usefully divided into two categories. Each presents different opportunities and constraints for seeding to enhance forage production.

- **Pasture on converted land** – these are pastures that have been established by land clearing, breaking, rock and root removal, and seeding of agronomic forages. They may be periodically cultivated to re-establish or rejuvenate forage stands. They have received sufficient disturbance over time - mainly through cultivation - that ingrowth by early successional tree species like willow, alder, and aspen is unlikely in the short term. Many pastures on private land fall into this category.
- **Pasture on logged or cleared land** – these are pastures that have been established after disturbance such as logging or land clearing, but because of rock, steep slopes, or limited soil capability are not suited to breaking and periodic cultivation. These pastures may or may not have been previously seeded with agronomic forages. They might be at various stages of succession with aspen and other native species making up part of the plant community. Areas on community pastures, private lands, and other Crown lands that were seeded with agronomic forage species as many as 40–50 years ago also fall into this category.

Principles of seeding in the pasture context are not unlike those of other management contexts. A major difference is that the primary goal is generally to maintain forage production on a specific unit of land over time.

Pasture Establishment

As with forest land grazing and silvopasture, seeding applications in the pasture context require some form of disturbance to provide a suitable seedbed. There are typically more options for establishing pasture on converted lands. Often traditional tillage and seed drills can be used, and this approach can improve seed germination and establishment. Various specialized direct or "zero till" seed drills with a range of different soil openers can be used in some situations. Direct seeding can eliminate the need for more intensive cultivation, reducing costs and preventing soil erosion. However, pasture conditions and existing vegetation will determine the appropriateness of this type of seeding application. Other treatments may be required to eliminate competing vegetation.

On newly logged or cleared lands, additional site preparation is often necessary to make seeding worthwhile. The level of disturbance can be a factor determining the useful life of the pasture and the response of native vegetation. More site preparation will tend to extend the productive life of the pasture, and lengthen the time before woody species become established. However, this will also be affected by the species seeded and grazing management. Sufficient disturbance can be created if stumps and other debris are piled and burned. A heavy duty disc, drag scarifier, or other heavy equipment can be used where additional disturbance is required. Broadcast seeding applications are common because rough surface conditions prevent the use of traditional seed drills. Depending on site conditions, areas can be floated or rolled after seeding to improve seed-to-soil contact. In situations where grazing is intensively managed, animal hoof action can serve this purpose.

Although clearcut logging may provide an opportunity for a seeding application, the costs of additional site preparation and the seeding itself should be justified by greater returns in the form of increased forage production. The need for increased forage production, overall management, and the ability to institute appropriate grazing management are important factors to be considered. In one study, forage production of native vegetation, mainly bluejoint reedgrass, after aspen harvest in the Peace River region averaged 847 kg/ha.[32] This is considerably less than the estimated production of 2,200–6,600 kg/ha for improved pastures seeded to agronomic forages in the same area. A five year study on Sunset Community pasture estimated stocking rates at 0.13–0.17 ha/animal unit month (AUM). This suggests production of at least 2,650–3,461 kg/ha using an AUM requirement of 450 kg/AUM.[33] Several producers in this region have avoided site preparation and seeding after aspen harvest and demonstrated that aspen regrowth can be successfully controlled with intensively managed grazing.[34]

Pasture Rejuvenation

As mixed legume and grass pastures mature, production and quality often decline. Levels of available nutrients for plant growth, mainly nitrogen, change as grasses increase and legumes decrease in a stand. This leads to lower forage production. The composition of seeded species may decrease, and weedy or woody species may come into the stand. Rapid change in the pasture, for example over three to five years, can be an indicator of improper grazing management. In other situations, changes in vegetation may be slower and attributable to native plant succession. This is certainly the case when forest is part of the potential natural community for a site.

Seeding is just one of many options that might be considered to rejuvenate or remediate pasture that is declining in productivity or quality. Traditionally, pastures were rejuvenated with expensive tillage and reseeding operations. While this path may be a practical and economical alternative on converted-land pasture, it may not be justified for pasture on logged or cleared land. If mechanical methods are used on unconverted lands, they are likely to involve specialized heavy equipment that may not be available locally, thus adding to the cost. Rejuvenation decisions should be considered carefully, and a cost–benefit analysis should support the selected alternative (see cost–benefit analysis example in Appendix A). The decision should take the following into account:

- total forage requirements,
- past management practices including species seeded in previous applications,
- expected life of the rejuvenation option,
- estimated increase in forage production,
- cost of the rejuvenation option,
- related costs including fencing and water development,
- risk associated with failure,
- loss of forage production in year of rejuvenation, and
- livestock and grazing management.

Current pasture condition and management practices should be assessed to determine the appropriateness of various pasture rejuvenation methods. This requires a close inspection of the pasture (see "Pasture assessment tool", Table 4.2). Some knowledge of the potential natural community and natural succession for the site will also be helpful for judging potential responses to various treatments (see "Assessment of Vegetation and Potential Natural Community"). Site characteristics that should be noted include:

- species diversity (i.e., mix of native and agronomic grasses and legumes),
- cover and vigour of desirable plants,
- presence and cover of invasive, woody, or undesirable species,
- amount of bare ground,
- potential for erosion,
- amount of litter or plant residue,
- levels of use,
- patterns of use,
- and problem areas.



Photo credit: A. Dobb.

Intensively managed grazing using electric fence in the Peace River Region.

Intensively Managed Grazing

Intensively managed grazing can be an effective way of improving pasture production and extending the life of established stands of seeded forage. Its main advantage is that it can be adapted to all pasture situations. Its main disadvantage is that it can be challenging to apply successfully in extensive pasture systems. Increased management inputs, as well as investments in additional infrastructure, may be required. Intensively managed grazing has been successfully used to control aspen regrowth in the parkland regions of Alberta and the Peace River region of British Columbia. Herbage production can be increased by as much as two-thirds with intensively managed grazing in healthy aspen stands with high sucker density.[35]



Photo credit: A. Dobb.

Effect of grazing on aspen at the Peavine Pasture exclosure in the Cariboo Region. Exclosure on left side of fence.

Fertilization

Fertilizer, especially nitrogen, can be used to rejuvenate pastures when soil fertility is low. The response to fertilizer will be species and site-specific. Nitrogen fertilization may have a greater effect on grass only pastures. Less nitrogen is needed to increase the production of grass and legume mixed pastures. Fertilizer applications may not be appropriate on pastures where woody species are becoming established, and may be less effective on pastures that are sod bound with rhizomatous or creeping rooted species like creeping red fescue. When possible local research and information on fertilizer response should be consulted.

Over-seeding and Direct Seeding

Over-seeding and direct seeding will be most applicable to the rejuvenation of pastures on converted lands, or pastures that are intensively managed. The success of over-seeding legumes and grasses onto already established pastures will depend on favourable weather conditions. Pasture condition, and especially the amount of bare ground, will be the main indicators for determining when over-seeding might be a suitable treatment. Hoof action from properly timed high density stocking with grazing, or harrowing or other light disturbance, can be used to get seed-to-soil contact and improve germination.

Alsike clover, white clover, red clover, timothy and orchardgrass have been the most commonly used species for over-seeding.[36] Seeding rates are one-half to three-quarters of those used in conventional seeding, and seed is usually broadcast. Legumes have a hard seed coat that is not digested in ruminants, and can be fed to cattle so the seeds are excreted in their feces over the pasture. Seed can be fed with loose salt at a rate of 5–10% by weight.[37] This method of getting seed onto the pasture requires good distribution of animals and success may be variable.

Direct seeding requires specialized seeding equipment. The primary application in British Columbia will be into pasture on converted lands. Pasture on logged and cleared land in most cases will be too rough, rocky, or hilly for direct seeding equipment to work properly. Pasture condition will determine how the treatment is applied. There are generally two approaches for direct sod seeding. One is to direct seed into the existing forage stand; this would be most suitable where there is some bare ground and space between plants. The other approach is to direct seed shortly after spraying the existing stand, usually with a non-selective herbicide such as glyphosate and/or a broadleaf weed herbicide.

A third approach found to be very effective is to convert the pasture into a direct seeded annual crop (e.g., oats or barley for green feed) for a year or two.[38] This break from perennial forage provides an opportunity to address alfalfa auto-toxicity issues, although a longer period may be required. It also provides more opportunities to address weed problems with repeated applications of herbicides at different times in the growing season. Specific guidance and recommendations for herbicide use and direct seeding rotations can be found in the Alberta Forage Manual, in the Manitoba Sod Seeding Manual, and from research work conducted for Minor Use Registrations.[39]



Photo credit: Kim Will.

Trial renovation for hawkweed control at Giscome Community Pasture. Glyphosate and direct seeding treatment is on the left.

Herbicide Control

The presence of undesirable plants in a pasture may be a symptom of improper grazing management. This possibility should be carefully assessed before any herbicide treatment is considered. Invasive plants such as hawkweed may also require localized control pre- and post-pasture rejuvenation. The effects of any herbicide application will be short lived if the causes of invasive plant infestations are not addressed. In some situations, and particularly on logged and cleared lands, the appearance of woody species is common and part of the normal successional pathway. Herbicide applications can be used successfully to control woody species in pastures.

Healthy aspen stands have limited understory production because of shading by the overstory. Herbicide treatment followed by burning and seeding increased forage production by nearly four-fold, in research trials conducted in Alberta. This treatment was also found to be cost effective when compared to no treatment and a clearing and breaking treatment evaluated on a 25-year time horizon.[40] This option may be applicable in the Peace River region; however, burning also assumes risk that may not be manageable for private landowners. Herbicide regulations and approved uses should be reviewed, and any necessary authorization obtained before carrying out any herbicide application.

Fire

Prescribed fire may be a beneficial treatment where sufficient fine fuels exist to carry a burn. Again, risks and responsibilities associated with prescribed fire may not be manageable for private land owners. There may be some application for prescribed fire on community pastures. Planning for prescribed fire should be coordinated with local regional districts and wildfire protection authorities.

Mechanical Disturbance

Mechanical disturbance may be useful for improving pasture forage production on sod bound or compacted soils. Specialized aeration equipment can be used, but any regular tillage equipment will work if soil is moderately disturbed to a depth of 13 cm (5 in.). These options may be practical for pasture on converted or improved lands. Some research from central Alberta has shown there is no consistent benefit to mechanically aerating pasture or hayland alone.[41] Aeration has also been applied to pastures in the Peace River region, and observations of some producers indicate that using mechanical aeration in combination with a nutrient application or capturing available moisture after aeration improved results. Aeration also allowed delaying the need to plough to a year with conditions more conducive to its success.[42]

Again, the very rough conditions found on logged or cleared land may limit the type of equipment that can be used effectively. Brush control on this type of pasture can sometimes be accomplished by using a heavy bark scraper (made from grader blade or cat tracks), or with one pass from a heavy disc. Removing bark from young trees will kill the above-ground growth, releasing the understory vegetation. Heavy duty brush mowers have some use on these lands.



Photo credit: J.L. Dobb.

Brush mower cutting willow and aspen.

Winter Pasture Feeding

Winter feeding on perennial pastures has been used as a way to add additional nutrients to old and depleted forage stands. Cattle utilize approximately 10–25% of the nutrients in ingested feed for maintenance and production. The remaining nutrients are excreted in feces and urine, and a portion of these nutrients become available for plant growth. Wasted feed, or hay used as bedding, also becomes a source of nutrients for future plant growth. Winter feeding is often carried out close to where forage is stored or produced. Purchased hay can be a source of weedy species, and these may be introduced into a pasture from wasted hay on the ground. When possible, hay should be weed free, purchased from a reputable producer or fed in the field where the weed infestation occurs.

Winter feeding can also change the species mix in pastures. Due to unfavourable conditions during haying season, mixed-grass hay may contain a small percentage of seed heads. Even if the percentage of viable seed is low, germination is enhanced by the ideal conditions provided by the nutrients and moisture retention under winter feeding areas.

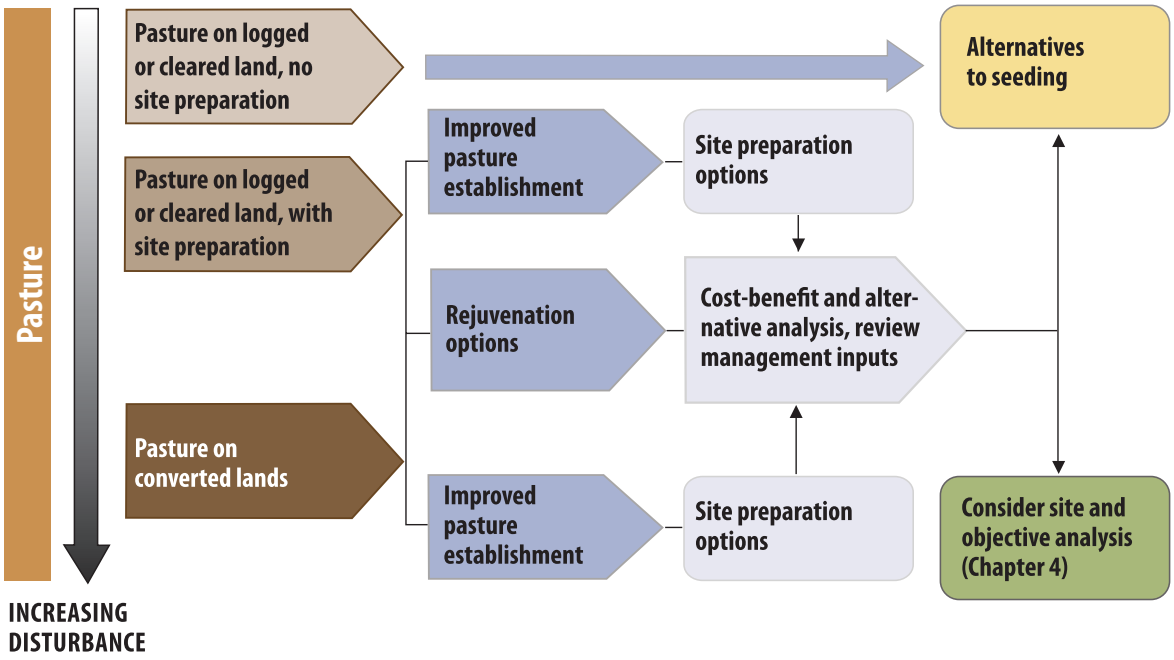


Photo credit: Sandra Burton.

Pasture growth response after winter feeding in the Peace Region.

DECISION AID

Pasture



Management Context Decision Aid – Pasture

The management goal for pasture is to provide long term grazing opportunities for livestock. The primary seeding objective is forage enhancement although secondary objectives can include vegetation control, erosion control and invasive plant suppression. Typical BEC Zones: BWBS, SWB, SBS, SBPS

Figure 3.4 Pasture seeding decision aid.



Photo credit: J.L. Dobb.

Grasslands occur throughout all of British Columbia's rangeland areas. The southern interior grasslands of the Cariboo, Thompson-Okanagan, and Kootenays are well known, as they form a continuous expanse in the lower elevation valley landscapes and are connected to the cultural history of both First Nations and the ranching industry. Grasslands in these regions cover approximately 647,000 ha, and are an extension of what are known as the Palouse grasslands in the U.S. Pacific Northwest.[43] An additional 114,100 ha of grasslands in these regions have been lost to intensive agriculture (irrigated crops and vineyards) and urban development. Minor pockets of native grassland occur on the south-facing slopes and along river valleys in the Bulkley Basin. Peace River region grasslands are an extension of the Northern Great Plains. They cover approximately 28,800 ha, mostly along the steep slopes of the Peace River and its tributaries. Roughly 62,000 ha of shrub/grassland, alpine grassland and subalpine shrub grassland can be found in the Muskwa and Liard Highlands.

Historic Grassland Rehabilitation

Common conceptions of "rangeland seeding" are often associated with its wide application on overgrazed and deteriorated western ranges. Large areas of crested wheatgrass were seeded in the depression era on the Canadian Prairies and the Northern Great Plains of the United States.[44] The relative vigour and ease of establishment of crested wheatgrass compared to native species, the abundance of inexpensive seed, and government policy led to its widespread acceptance in the intermountain western United States. Between 1945 and 1965 several million acres of sagebrush rangeland were seeded to crested wheatgrass.[45] Advances in mechanical technology in the 1940s and 1950s led to the development of

various types of rangeland drills, which also improved seeding success on rough, uncultivated rangeland.

This type of rangeland seeding was also practiced on British Columbia's overgrazed sagebrush-dominated grasslands. Early model rangeland drills arrived in British Columbia from California,[46] but were unsuited to the rough terrain, and did not provide adequate disturbance in heavy sagebrush.[47] This led to the development of a Rangeland Seeder by the B.C. Ministry of Agriculture in the mid to late 1970s. The seeder consisted of double independent offset disc gangs for vegetation control and soil tillage, and a free floating double ganged packer behind. Seed and fertilizer dripped through tubes between the packer gangs from a calibrated seed box above. Two versions of this heavy equipment were used throughout the southern and central interior of the province through the 1980s. By the 1990s, 45,000 ha in the bunchgrass zone had been seeded.[48]

Why Grassland Restoration?

Historic rangeland seeding applications in British Columbia are examples of grassland rehabilitation. They were considered successful at the time because the productivity of severely degraded grassland was increased. Seeding crested wheatgrass was justified in part because forage yields for livestock could be increased by two to five times depending on the previous cover.[49] However, seeded areas were not always managed properly and some crested wheatgrass stands became coarse and unpalatable. Crested wheatgrass was criticized for being a monoculture replacement for multi-species native grassland, which was critical habitat for many endangered and threatened species.[50] In the period since grassland seeding was widely practiced, the big sagebrush/bluebunch wheatgrass and many other native grassland associations are recognized as red-listed ecological communities (endangered or threatened).[51] Acknowledgement of these biodiversity values by society means they must be accounted for in land management decision making, including decisions that might involve rehabilitation and restoration.



Photo credit: Judy Millar.

Antelope-brush grassland near Okanagan Falls.

The broader assessment of ecological value is a requirement on British Columbia's Crown grasslands. These lands represent 46% or nearly 352,000 ha of the total grassland area in the province; grasslands under federal jurisdiction including Indian Reserve and other reserves cover just over 77,500 ha or around 10%. The high ecological value and relative scarcity of British Columbia's grasslands suggests land managers should aspire to restoration over rehabilitation when there is a significant and unavoidable disturbance on grasslands. Changing grazing management should be the first choice when long-term continuous use by livestock has been the main cause of damage to grasslands. When possible, management efforts should support natural succession and movement toward the potential natural grassland community for the site.

Seeding and Restoration

By their nature, grasslands are dry and difficult environments for plant establishment. A species can often tolerate wetter conditions, but the specific adaptation of seeded species to semi-arid site conditions is essential for survival. The goal of restoration is often to re-establish species that are part of the potential natural community for a site. Seeding may be just one of several methods used to accomplish this goal. In many situations, establishing plants from vegetative plugs or transplants may be most effective, or, these methods may be used in combination with seeding. The full range of plant community structure, including shrub layers, needs to be part of the restoration effort. Shrubs can have a positive microclimatic effect necessary for grass establishment in very arid environments.[52]

Seeding attempts to speed up succession by introducing desired species or creating an environment for desired species to become established. At the same time, soil disturbance required for typical seedbed preparation can potentially alter or delay the path of succession.[53] Unmanaged invasive plants like cheatgrass, knapweed, Dalmatian toadflax, and sulphur cinquefoil can quickly colonize unoccupied spaces and disturbed soils in semi-arid grasslands, and interrupt recovery. These competitors make the establishment of desired species, either through natural revegetation or seeding, more difficult. Therefore, it may be better to apply seed to bare soil surfaces without trying to improve seedbed conditions, even though seedling establishment may take place over several years. Severe disturbances can also disrupt soil microbial populations necessary for successful native plant establishment.[54]

Grassland restoration efforts can be challenging, be labour-intensive, and have long time horizons. These constraints can be alleviated by involving local stakeholders, conservation groups, and volunteer organizations. In the end, seeding may or may not be appropriate depending on the nature of the disturbance, objectives for the site, and pre-existing conditions.

Disturbances and Restoration

Intentional disturbances in British Columbia's grasslands should be avoided if at all possible. Where disturbance is unavoidable, using previously impacted areas should be considered before any new disturbance created. Utility corridors and road and trail access construction projects should have a restoration plan in place before construction begins, and the plan should include a vegetation inventory. Live plant material, seeds, and microbiotic crust can all potentially be collected from the site before the disturbance and used in the restoration effort.[55] Very large industrial projects may consider developing seed propagation programs as part of restoration efforts.

New disturbances in protected and sensitive areas will require restoration, but there are likely to be other situations where site rehabilitation may be a more practical goal. Rehabilitation can still be useful in the grassland context at small scales, especially if it succeeds in preventing further establishment of troublesome invasive plants on severely disturbed areas.

Natural disturbances caused by wildfire may also be considered for restoration. Burn severity, invasive plant concerns, and other factors will determine whether restoration is required. Wildfire is a natural part of grassland ecosystems, and management interventions may be inappropriate.



Photo credit: Judy Millar.

Damage to grassland caused by recreational vehicle use.

Past Rehabilitation Efforts: The Time Horizon

Nature's successional pathways are not always predictable. While some of the historic rehabilitation seeding on British Columbia's southern interior grasslands still have a dominant cover of crested wheatgrass, others have shifted to native bunchgrass. One pasture in the Beaver Dam Lake area near Clinton was seeded 25–30 years ago to crested wheatgrass, smooth bromegrass, and timothy. Crested wheatgrass is the only seeded species persisting now, but bluebunch wheatgrass has come into the stand. It is thought that a shift from spring to fall grazing on the pasture may have been a factor in the vegetation changes.[56]

In another historic example, near the Afton mine approximately 10 km from Kamloops in a 250–300 mm (10–12 in.) precipitation zone, crested wheatgrass is still present, but Sandberg's bluegrass, bluebunch wheatgrass, and big sagebrush have re-established (see photo below). The site is thought to have had little grazing use since it was seeded about 35 years ago, while other ungrazed seeded areas still have dominant stands of crested wheatgrass, but essentially no native grass cover.[57]



Photo credit: A. Dobb.

Plant community outside Afton mine exclosure near Kamloops.

Crested wheatgrass was found to be persistent but not invasive in an evaluation of five grazed crested wheatgrass seedings adjacent to native bunchgrass range.[58] The crested wheatgrass stands ranged in age from 14 to 60 years. There was very little crested wheatgrass found in the bordering range. Native species tolerant to livestock grazing such as big sagebrush, Sandberg's bluegrass, needle and thread grass, and pasture sage re-established in the grazed crested wheatgrass stands. Bluebunch wheatgrass, which has a lower tolerance to grazing, failed to re-establish in the crested wheatgrass stands.

It is not clear what lessons might be drawn from these examples for the future management of rehabilitated areas. There is some indication that adaptive and planned grazing may help the shifts to native vegetative cover take place. These changes are likely to occur over long time horizons.

Invasive Plants

In a review of weed control and range planting in the United States, all but two of the 52 studies surveyed concluded weed control was necessary, or at least beneficial, to successful seeding establishment.[59] Documented grassland restoration studies in British Columbia support the view that weed control is beneficial. In these studies, planting followed disturbance caused by wildfire and pipeline construction. In another project, where disturbance was caused by historic cattle grazing, both hand pulling and herbicide were effective controls for diffuse knapweed.[60] However, the largest reduction in weed cover occurred with the elimination of livestock grazing. After five years there was a significant increase in native grass and herb cover with this treatment. Invasive plant control and grazing management are key to successful seeding establishment when weedy species are present on a site.

Native Seed Sources

The most challenging aspect of grassland restoration is finding local sources of viable native seed in large enough quantities to be cost effective. Seed collection from nearby areas is possible, but will be labour-intensive and viability of collected native species seed can vary greatly between years.[61] There are questions about introducing genetic variability, and how far away plant materials should be collected to maintain ecological integrity and genetic sources. Will commercial native cultivars or common native seed from distant sources help restore ecological function or change it? These questions are not easily answered. Various alternatives should be balanced against the overall objectives, project costs, and site conditions. In the end, a regional seed propagation project may be the best solution to meet the seed volume requirements for large local restoration projects.

Some Guidelines for Native Seed Collection

- Avoid rare and endangered habitats, parks, and protected areas. Consider collecting seed from outside parks and protected areas when these areas are the focus of restoration.
- Obtain necessary land owner permission and /or authorization.
- Collect from areas intended for development, or disturbance, where possible.
- Develop knowledge about the species before collecting; collect common species or those from large populations.
- Collect undamaged seed or cuttings, not entire plants.
- Leave 50% of seed in place to allow natural propagation, and to leave food for insects, birds, and small mammals.
- Reduce the amount of seed collected in areas that might be depleted by grazing or other uses.
- Collect seeds from sites no more than every other year to limit impacts on localized seed banks.

Source: Adapted from H. Sinton Gerling et al., A Guide To Using Native Plants on Disturbed Lands (Edmonton, AB: Alberta Agriculture, Food and Rural Development, 2003).

One approach to assist with decision making around the use of different native seed sources is to use the Restoration Gene Pool Concept.[62] This ranking assigns the plant materials in order of declining genetic connection to the target population. It eliminates the simple native and non-native classification, placing more emphasis on the genetic relationship with the target species. The ranking model below has been suggested for use in western U.S. National Conservation Areas.[63] The primary ranking should be used when it is both practical and supports management objectives. Lower rankings should be used when the higher rankings do not "work" or do not support the management objectives.

Restoration Gene Pool Concept

Rank 1. Primary – includes only material from the target site or adjacent connected areas.

Rank 2. Secondary – includes material from genetically disconnected sites of the target species.

Rank 3. Tertiary – have been intimately connected to the evolution of the target species but modern gene flow has been interrupted.

Rank 4. Quaternary – have at most been remotely connected to the evolution of the target species but can provide similar ecosystem structure and function, including introduced species.

Knowledge about the genetics of each species is required to use the ranking system, but it can also be helpful when used more subjectively. For example in British Columbia's southern interior grasslands, bluebunch wheatgrass is a key species for grassland restoration. To date there is no commercially available bluebunch wheatgrass cultivar developed entirely from B.C. genetic sources. However, there has been some study of the genetic variability of local populations.[64] The ranking might be applied in the following way using bluebunch wheatgrass as an example.

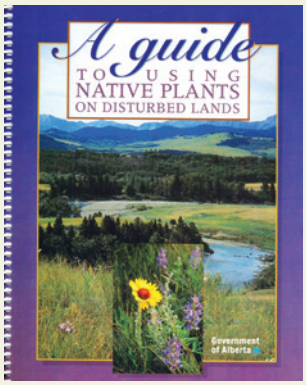
Rank 1. Primary – bluebunch wheatgrass seed collected from the site and immediate nearby areas.

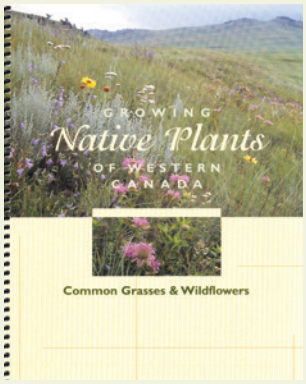
Rank 2. Secondary – bluebunch wheatgrass seed collected from areas some distance away from the site, for example from sub watersheds in the same valley.

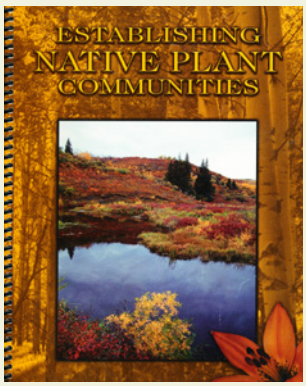
Rank 3. Tertiary – bluebunch wheatgrass cultivars developed in the Pacific Northwest US, Palouse grasslands mostly from Washington and Idaho accessions, i.e., Anatone (B53), Goldar, Whitmar, P-7 (see bluebunch Wheatgrass species summary).

Rank 4. Quarternary – This would include other members of the genus Pseudoroegneria, (all introduced), Snake River wheatgrass and crested wheatgrass. Sheep and hard fescue would not be considered for the Rank 4 restoration gene pool because they are not remotely connected to the evolution of bluebunch wheatgrass, and would potentially have a different role in ecosystem structure and function.

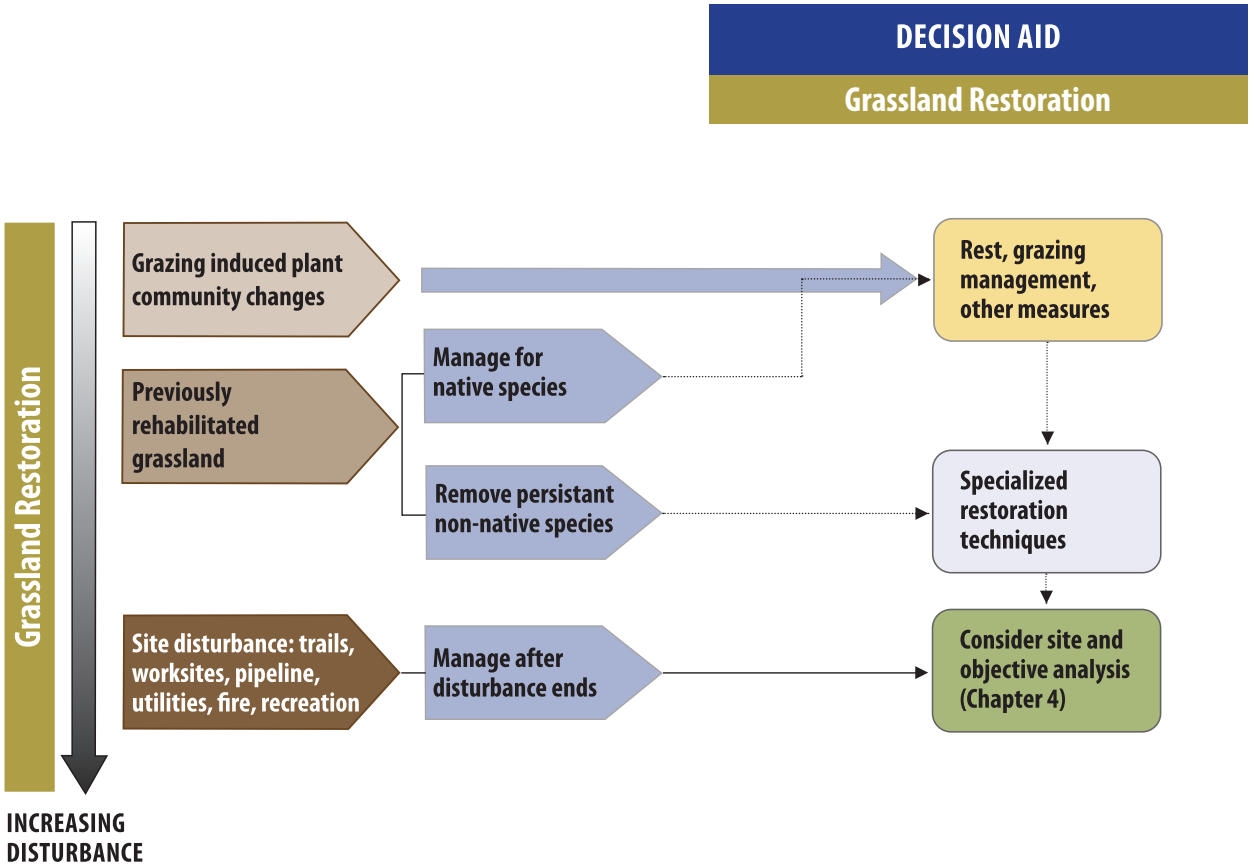
Information sources for restoration







https://www.agric.gov.ab.ca/app08/showpublications?ttype=NP



Management Context Decision Aid – Grassland Restoration

The management goal for grassland restoration is to re-establish pre-existing ecosystem structure and function. This includes the plant community and wildlife. Complete restoration also involves a cultural component. The primary seeding objective is to introduce plant species that move the site toward the PNC, or the pre-existing plant community. Other objectives might include erosion control and invasive plant suppression. Typical BEC Zones: BWBS, BG, PP, IDF

Figure 3.5 Grassland restoration seeding decision aid.

ECOSYSTEM RESTORATION



Photo credit: Judy Millar.

Restoration efforts may be applied to any variety of ecosystems, including wetland, riparian and marine. For this manual, ecosystem restoration refers specifically to the restoration of fire-maintained ecosystems. This is a natural disturbance type that corresponds to the fire frequency and severity regime that existed before European settlement. It takes into account First Nations land management activities, like burning, that were practiced before European contact.[65] In British Columbia, these are lands in the Bunchgrass, Ponderosa Pine, and Interior Douglas-fir biogeoclimatic zones.[66]

Historically, these zones have been important range areas, supporting both domestic livestock and wildlife. After decades of successful fire suppression efforts, these ecosystems have changed in various ways. Previously open and productive forests have become ingrown, and trees have encroached into once-open grasslands. Overall forage production has declined, and forests are more susceptible to disease and insect outbreaks.

Through its Ecosystem Restoration (ER) program, the provincial government has made the restoration of fire-maintained ecosystems a priority. Parks and conservation organizations have also been involved in their own ER efforts. Much of the provincial ecosystem restoration work to date has been focused in the Rocky Mountain Trench of the East Kootenay region. Over the last several years the program has expanded, and treatments have been applied to Crown land in other regions including the Thompson-Okanagan and Cariboo-Chilcotin.

Forest Encroachment into Grasslands

Forest encroachment has substantially reduced the area of British Columbia's grasslands. For example, there was a 37% decrease in grassland area due to encroachment between 1962 and 1993/95 on Becher Prairie in the Cariboo region.[67] By definition, grassland restoration is a type of ecosystem restoration. Grassland restoration treatments aimed at encroachment problems reintroduce fire, or surrogates for fire, and are directly aimed at changing ecosystem structure. They tend to focus on the interface zone between grassland and forest and involve slashing and fuel reduction. This differs from the restoration approaches applied to disturbances caused by overgrazing, off-road vehicle use, and utility line construction in open grasslands that focus on the re-establishment of native species. For this reason, grassland restoration activities related to forest encroachment are dealt with in the ecosystem restoration management context.



Photo credit: A. Dobb.

Tree encroachment into grassland at Becher Prairie.

Ecosystem Restoration Objectives

The overall goal of ecosystem restoration treatments is to achieve pre-settlement fire-maintained forest and range conditions. Specific ecosystem restoration objectives may vary with site conditions and may aim to:

- increase biodiversity,
- reduce fire hazard,
- increase habitat for species at risk,
- improve the condition of native grassland communities,
- increase First Nations food and medicinal plants,
- increase cover of native grass species,
- improve forage quality and quantity for wildlife and livestock,
- reduce forest canopy cover, and
- minimize mineral soil disturbance.

Ecosystem Restoration and Seeding

As explained in the introductory chapter of this manual, restoration seeks to establish pre-existing ecosystem structure and function. Therefore a treatment that introduces non-native or invasive species represents a departure from the ecosystem being restored, at least in the short term. For this reason seeding decisions in the ecosystem restoration context can be challenging to make.

It might be assumed only native species from locally sourced seed should be used in this context. But in areas where there are severe problems with weedy species, budgets are limited, and forage requirements are high, it may be advisable to consider short-lived, easy to establish, introduced species to minimize the opportunities for invasive plant colonization after mineral soil disturbance. Native seed alternatives should be explored to see what options are practical. In areas where a high degree of ecological integrity is required and the project scale is small, transplants of appropriate native species may be a reasonable alternative.[68] The Restoration Gene Pool Concept (page 50) can also be usefully applied in ecosystem restoration to assist with decision making.

Continued monitoring of existing treatments and research areas, and a clear identification of objectives is required to inform seeding decisions in the ecosystem restoration context. Some research and monitoring efforts have reported the understory response after forest canopy reduction. Most, if not all, mention the long-term nature of understory changes after treatments. For example, increased pinegrass cover after treatment may limit the ability of bunchgrasses to re-establish on some sites, at least in the medium to short term. Most efforts rely on native plant regeneration and natural succession for revegetation after disturbance treatments.

There is little reported documentation of seeding applications in the ecosystem restoration context as it is currently practiced. However, some operational restoration prescriptions include seeding provisions where there is significant mineral soil disturbance and invasive plants are a threat.



Photo credit: Kevin Wilson.

Small burn pile area broadcast seeded.



Photo credit: Kevin Wilson.

Established seeding on small burn pile area with sulphur cinquefoil in foreground.

Disturbance Associated with Restoration Treatments

Three primary treatments are used in the restoration of fire-maintained forest ecosystems. They include:

- prescribed fire;
- slashing – cutting or removing undesirable trees to reduce density; and,
- timber harvest, which includes commercial thinning.

The level of disturbance associated with restoration treatments is a key factor in determining the appropriateness of seeding. Minimizing mineral soil disturbance in ecosystem restoration treatments should be a stated objective and written into prescriptions. Winter operations can often reduce mechanical treatment impacts. Severe disturbance may be inevitable in some cases (e.g., where mechanical fireguards are needed for a prescribed fire).

Burning is often required to remove slash. In some conditions it can be eliminated with prescribed fire and natural fire breaks. In other situations, where slashing is required but prescribed fire is not desired, slash may need to be piled and burned. The size and shape of piles will determine the level of disturbance from burning. Where slash is light, for example where encroaching juvenile trees have been cut and left in place on open range, burning may not be required. Mechanical innovations such as sled burning, where material to be burned is placed on a steel platform, have been developed to eliminate soil disturbance caused by burning. Disturbance from burning can also be eliminated by chipping providing that excessive chip accumulation is managed appropriately. The costs of treatment innovations should be weighed against the expected benefits given the overall goals of a restoration program. The scale, or total amount, of mineral soil disturbance relative to the total treatment area should also be considered.



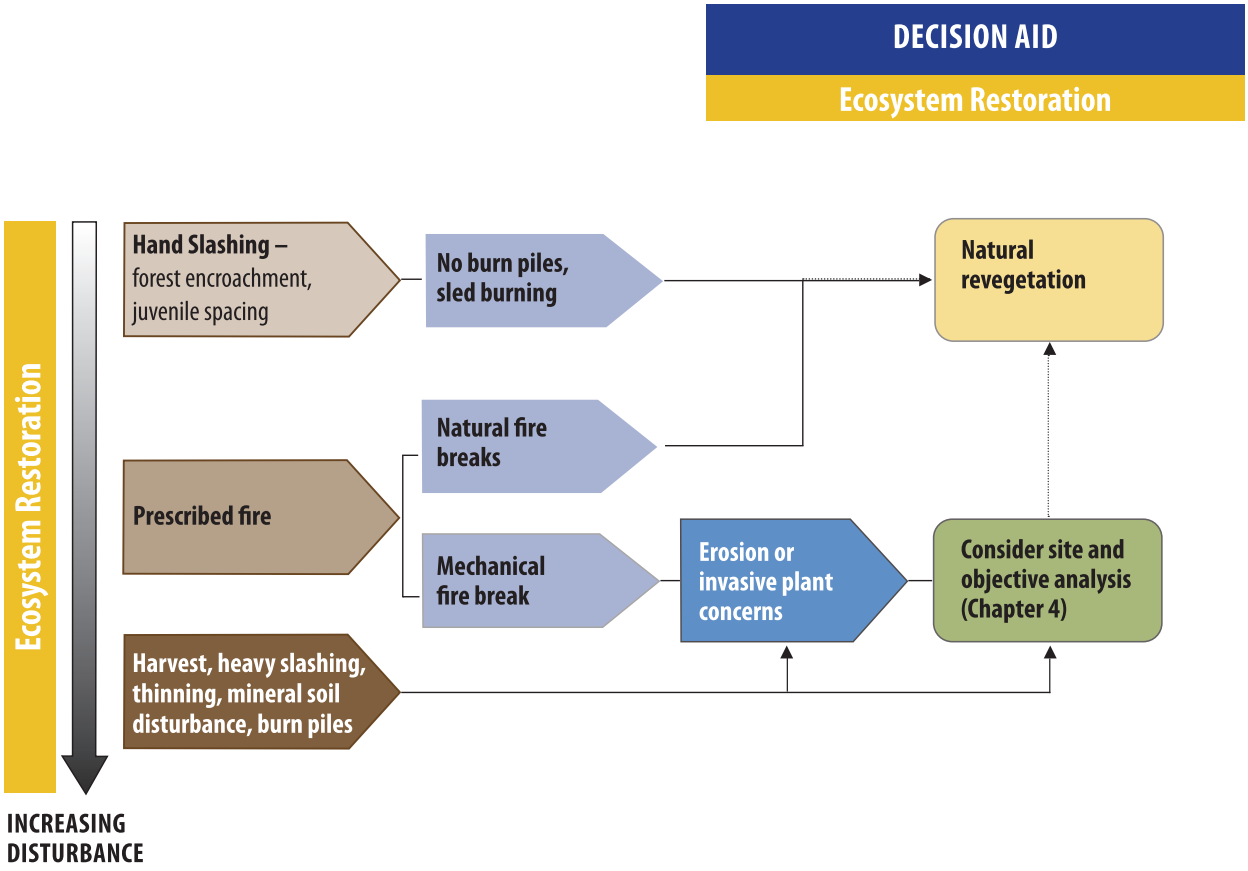
Photo credit: Judy Millar.

Chipping slash material to minimize site disturbance from slash pile burning.



Photo credit: Judy Millar.

Slash pile burning.



Management Context Decision Aid – Ecosystem Restoration

The management goal for ecosystem restoration is to re-establish ecosystem structure and function by introducing the preexisting disturbance regime. Seeding objectives include erosion control, invasive plant suppression, forage enhancement and native plant community. Typical BEC Zones: PP, IDF, BWBS.

Figure 3.6 Ecosystem restoration seeding decision aid.

POST - WILDFIRE REHABILITATION



Photo credit: Kamloops Fire Centre, BCFS.

Wildfires are natural and common occurrences in many grassland and forested ecosystems. Over much of the province, the natural forest disturbance regime that was once dominated by fire and insect attack has shifted to one of forest harvest and insect attack. This change has been caused in part by successful fire suppression efforts. However, in the last decade several large wildfires have raised public awareness around the issue of wildfire protection. They have also brought more focused attention on efforts to rehabilitate areas after severe wildfire.[69]

Large Fires and Fire Statistics Summary 2000–2009

- Pelican Lake complex of fires west of Quesnel 2010 – 35,506 ha
- Meldrum Creek complex of fires west of Williams Lake 2010 – 47,293 ha
- Binta Lake Fire, south of Burns Lake 2010 – 40,000 ha
- Lava Canyon Fire in the Chilcotin 2009 – 66,719 ha
- Liard River Fire 2009 – 23,182 ha
- Kelly Creek Fire, Edge Hills Provincial Park 2009 – 20,925 ha
- McLure Fire 2003 – 26,420 ha
- Chilko Lake Fire 2003 – 29,202 ha
- Okanagan Mountain Fire 2003 – 25,600 ha

The average annual number of fires in the province for the 10-year period (2000–2009) was 1,969 ha; the average annual area burned for the period was 98,541 ha.

Source: Adapted from "Wildfire History - Wildfire Management Branch - Ministry of Forests and Range - Province of British Columbia", 2011, http://bcwildfire.ca/History/ (accessed January 11, 2012).

Rehabilitation after wildfire is mandated by the *Wildfire Act, Wildfire Regulation* (see page 18). A site rehabilitation plan must be prepared that specifies measures for maintaining natural drainage patterns for all fire control works to minimize surface soil erosion. Seeding fireguards and trails is a common practice used to meet obligations under the Act.

Wildfire Rehabilitation Objectives and Seeding

The re-establishment of native plant cover after fire is part of the natural succession. Therefore, seeding all burned areas is unnecessary and inappropriate in the context of managing for a natural landscape. However, there are areas where seeding might be considered to meet other land management objectives. These might include:

- surface erosion control in burned areas;
- invasive plant suppression on fireguards, trails, and burned areas; and
- enhancement of forage quality and quantity for wildlife and livestock.

Most post-wildfire rehabilitation activities in British Columbia take place on Crown lands. In general these lands are managed to maintain a natural landscape. Species seeded to meet rehabilitation objectives should have low to moderate persistence so that natural plant communities can re-establish.

Surface Erosion Control

Seeding has been widely applied as a surface erosion control measure in burned areas. However, there is a lack of rigorous scientific evidence to suggest seeding is an effective erosion control measure.[70] Seeded plant establishment is often most successful on areas where it is needed least, like on gentle slopes and in water catchment areas.[71] The main challenge for seeding as an erosion control measure is that surfaces are vulnerable to precipitation events and natural runoff for at least one year until plants are established. Depending on the burn severity, native vegetation can re-establish during this period making seeding unnecessary.

A comprehensive study of fire rehabilitation effectiveness was completed in the year 2000 for the western United States.[72] It included a review of research literature, over 400 fire reports, and interviews with 98 operational specialists. Aerial broadcast seeding of grasses was the most common of all hill slope rehabilitation treatment practices. In terms of total spending, it ranked second only to contour felling, which has substantially higher average per hectare cost. Variations in site conditions and seeding recommendations, and a lack of monitoring of storm events immediately after fire made the evaluation of actual effectiveness challenging. The following points are drawn from the report:

- Seeding has a low probability of reducing erosion the first wet season after fire.
- Seeding can provide reasonable cover late in the first season and in the second year.

- There is a need to do other treatments in critical areas.
- Understanding of natural revegetation after fire is important.
- Seeding may not be needed as often as currently thought.
- Cereal grains like fall rye offer better first-year protection, and generally do not interfere with later regeneration of native vegetation.

A burn severity, erosion risk, and vegetation assessment should be carried out to develop an appropriate treatment plan to prevent surface erosion (see Chapter 4 "Site and Objective Analysis"). If seeding is part of the prescription, the goal should be to establish a plant cover as quickly as possible while still allowing for native plant regeneration.

The additional disturbance created by salvage logging after wildfire can increase the risk for large-scale erosion.[73] If salvage logging is part of the wildfire rehabilitation prescription, seeding should take place after logging so that additional disturbance areas are covered by the seeding application.

Invasive Plant Suppression

As with many disturbances, fire may create suitable conditions for the establishment of invasive and weedy species by reducing competing vegetation and increasing nutrient availability. High fire severity has been linked to invasions of invasive plants in the mixed-conifer forests of the Rocky Mountains in the United States.[74] Seeding to slow the spread of invasive plants and weedy species is an important objective in the Wildfire Rehabilitation context, especially on fireguards and trails. These linear disturbances can become corridors for animal and human movement, and vectors for invasive plant spread. Once established invasive plants can be easily transported down a trail or line and re-established into new areas.



Photo credit: Rick Tucker.

Fireguard before seeding.



Photo credit: Rick Tucker.

Fireguard same location as photo on previous page after seeding and establishment. Note thistle within woody debris.

Wide-spread application of broadcast seeding in post-wildfire rehabilitation and the increased number of large severe wildfires have led to more research and effectiveness monitoring. In a recent evidence-based analysis of published post-wildfire seeding research, eleven studies were examined with direct data on the effects of seeding on non-native species after fire in forested ecosystems.[75] Six of the eleven studies found seeding to be effective in reducing non-natives, and five did not. Two of the studies showing effectiveness were conducted on prescribed burn or slash pile burned areas.

When seeding is shown to be an effective suppressant, it usually involves the use of non-natives; five of the six studies showing effectiveness used introduced annuals. Effectiveness against non-seeded invaders appears to be related to the competitive advantage of the seeded introduced species. Successful exclusion of invasive plants also appears to require high plant cover. Use of clean weed-free seed is a requirement for all seeding objectives, as well as invasive plant suppression. Otherwise, achieving control of one species may be at the expense of introducing another weedy species.

Research on the effectiveness of seeding to control weed invasion is also being carried out in British Columbia. A grass-legume mix of Italian ryegrass, creeping red fescue, Canada bluegrass, timothy western wheatgrass, and Rambler alfalfa was seeded after a moderate-to-severe wildfire in 2003 in the hot dry Interior Douglas-fir zone near Kamloops. The May 2004 seeding reduced the frequency of prickly lettuce, horseweed, and cheatgrass in the second and third year following the aerial application.[76] However the seeding did not reduce the frequency of two alien invasive plants recorded on the site—Canada thistle and Dalmatian toad-flax. Italian ryegrass was quick to establish as expected, but was virtually nonexistent after three years. The cover of western wheatgrass and timothy was only 1% or less at year three. Alfalfa, Canada bluegrass and fescue cover had increased and were suitably established at year three with 15%, 11% and 6% cover, respectively.

Forage Enhancement

Wildfires in British Columbia's interior forests frequently occur within tenured Crown range areas. Fire can dramatically decrease short-term forage values, and/or the ability of livestock and wildlife to access forage. The expected forage productivity and availability after wildfire depend on factors related to fire size, burn severity, the location of the burn within a tenured area, and the relative forage production before the burn. Changes begin immediately after fire, and for high severity fires extend through the roughly 15- to 20-year period required to establish a free-growing forest.

If a fire is large and burn severity is high, there may be a need for replacement forage within a tenure area. When burn severity is high and all understory vegetation is killed, the site returns to an early stage of plant succession. There may be an abundance of bare ground, annual plants, residual forbs, and a lack of perennial forage grasses at this stage. This could mean limited and potentially low quality forage production for several years (at least three to four) after fire. Seeding severely burned areas may be necessary to provide adequate forage.

Burn severity may be high enough to create a suitable seedbed for seeding, but there may still be enough live plants left after fire to produce limited forage. At the same time, improved access may compensate for reduced forage production in the first season following fire, making replacement forage seeding unnecessary. Access to grazing for wildlife and livestock can be improved by the reduction of physical barriers to grazing, and by forage being exposed after the removal of dead material.



Photo credit: Reg Newman.

Natural revegetation of pinegrass in moderately burned area, Bull Canyon Fire (2010) in August 2011.



Photo credit: A. Dobb.

Area burned in Chilko Lake Fire (2003) in May 2009.

Care should be taken to balance the amount of new forage created by seeding with the overall expected forage demand within a management unit. Successful forage establishment over large areas may result in underutilization, which could negatively affect the establishment of new tree seedlings. When tall seeded vegetation is left ungrazed, it can cause snow press, provide shelter for potentially damaging small mammal activity, and increase fire hazard. Increased forage quantity and quality with seeding can also concentrate and intensify livestock use in an area. Unintended livestock distribution caused by seeding should be managed and coordinated with forest regeneration plans.

Forage Quantity and Quality

Seeding introduced species can improve forage quantity and quality in tenure areas where forage from transitional grazing opportunities related to forestry activities are in decline. Large areas that have burned sufficiently hot to create a seedbed, but still have a live plant understory – pinegrass is especially resistant to fire, and would likely be the live remnant – would be suitable for satisfying this objective.

Animal Distribution

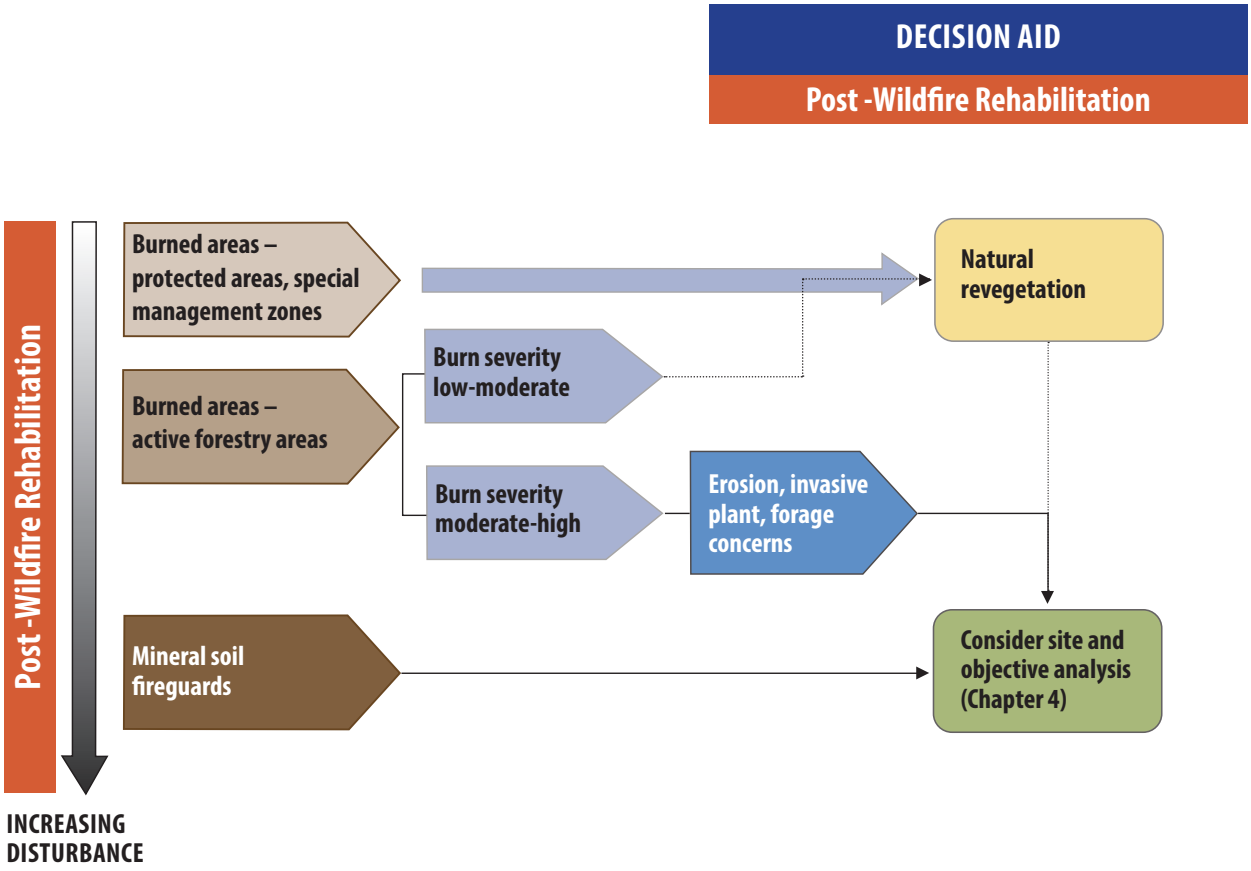
Wildfire can alter livestock distribution patterns. Increased forage and newly accessible areas for grazing should be expected after light to moderate severity fires where understory vegetation is not killed. A careful evaluation of slope, location(s) of water for livestock, natural barriers, and sensitive areas should be made before seeding for forage objectives. Seeding introduced species can be used strategically to influence distribution, but the effectiveness of this treatment is likely to be site specific and dependent on management and the particular livestock involved. The combined effects of fire and the enhanced forage from seeding need to be considered as a whole when planning range use.

For additional information see Fire Effects on Rangeland Series Factsheets #3, 5, and 6

http://www.agf.gov.bc.ca/range/factsheets.htm#top

Fire Rehabilitation in Protected Areas and Special Management Zones

Many human-caused disturbances can be purposely avoided in ecologically important protected areas (e.g., parks) and special management zones.[77] However, wildfire often crosses land management boundaries into these natural areas. If wildfire rehabilitation efforts are considered for these lands, they need to satisfy established management plans. Seeded species persistence and interactions with the native plant community should be well understood. The Restoration Gene Pool Ranking Concept (page 50) may be useful for making seeding decisions in this context.



Management Context Decision Aid – Post-Wildfire Rehabilitation

The management goal for post-wildfire rehabilitation is to regain partial ecosystem function after fire. Seeding may be just one of several treatments considered. Objectives include erosion control, invasive plant suppression, and forage enhancement. Typical BEC zones: BG, PP, IDF, MS, ESSF, SBS, SBPS, BWBS, SWB.

Figure 3.7 Post-wildfire rehabilitation seeding decision aid.

SITE REHABILITATION



Photo credit: Garth Lenz.

Site rehabilitation is often required on severely disturbed sites. Utility corridor and pipeline construction, roads, rights-of-way, well sites, facility sites, sumps, and work areas are examples. The need for site rehabilitation can be specific to individual development projects, or incidental to land management activities like timber harvest and wildfire protection. Incidental disturbances include roads, landings, bladed trails and fence lines, fire retardant mixing sumps, campsites, and staging areas.

Site Rehabilitation Seeding Objectives

The goal of rehabilitation is to re-establish a level of productivity, ecosystem function, and prevent further deterioration following disturbance. Erosion control and invasive plant suppression are often primary seeding objectives on disturbed areas with exposed mineral soil. Within tenured range, and pasture areas on private land, forage objectives can be important. On sites with public access, or within a public view-scape, a revegetation objective may contain an aesthetic objective consistent with local values.

The Importance of Site Rehabilitation

All forest activities have site-specific disturbances associated with them. Up to 7% of a harvestable area or cutblock can be occupied by permanent access structures (FRPA Regulation Section 36 [1]). Permanent access structures consisting of mainly roads and landings require rehabilitation along edges for erosion control and potential reforestation. This does not include additional disturbance associated with temporary

access structures including bladed trails, landings, compacted areas, ruts, and other soil disturbances. In areas where mineral soil is exposed, seeding grasses and legumes can help achieve revegetation and other objectives.

Disturbances associated with the oil and gas industry are common in Northeast British Columbia. A GIS analysis estimates that a little over 1% of this region has been subject to oil and gas activity permits as of November 2010.[78] Access roads, well sites and facilities make up about 56% of this area. Pipelines and geophysical programs (e.g., seismic exploration) account for 46%. As with the forest industry, revegetation of disturbed sites associated with oil and gas activities is required.

Role of Seeding in Site Rehabilitation

Seeding is just one of several different treatment options that may be required for successful site rehabilitation. The approach taken in rehabilitation varies with the type of disturbance, site conditions, and uses planned for the site after it is revegetated. Soil and site preparation are generally required before the process of revegetation can begin. There are clear and detailed guidelines for soil and site preparation treatments for rehabilitating access structures in Forestry operations (see the BC Forest Practices Code Soil Rehabilitation Guidebook). Many of the basic principles in these guidelines are applicable to the rehabilitation of disturbances created by other activities.

The edges and berms of well sites, plant and pump stations, sumps, roads, and permanent landings should be rehabilitated. In forest management areas some landings and road sides will be slated for tree seedling establishment, and may not be seeded. Pipeline and utility corridors require rehabilitation, and some projects will have long-term vegetation management plans to prevent tree establishment. Longer-term uses and plans should be considered in seeding decisions.



Photo credit: A. Dobb.

Drilling platform construction with perimeter berm, and stored topsoil in foreground.



Photo credit: Garth Lenz.

Gas drilling platform.

Soil and Site Preparation

The main constraints limiting revegetation in site rehabilitation efforts are:

- increased surface water runoff;
- interruption and/or redirection of natural drainage patterns;
- compaction of soils;
- removal of topsoil and exposure of sub-surface layers unsuitable for plant growth; and
- mixing of topsoil with subsurface layers.

If these conditions are not managed and/or treated, revegetation will be slow or might fail completely. Seeding into unsuitable conditions, and at the inappropriate time, is likely to result in seeding failure. Soil and site conditions after construction will vary with type of activity, regional location, and position on the landscape. Whether construction activity and access structures are temporary or permanent will also have a bearing on what type of soil and site preparation is suitable in each circumstance. Timing of the soil disturbance will also be a factor. On many sites, soil disturbance can be minimized if activities and soil handling take place in dry and dormant periods before freeze up.

Temporary Sites and Access Structures

Many bladed trails, fence line clearing, landings, work areas, and sites associated with fire protection are temporary. In general, soil disturbance is less severe, working widths are narrower, and soil compaction is less because structures may have use or traffic for only one season. Because these features are temporary there is usually less soil movement and potential for soil layers to become mixed. There is also some potential for natural revegetation. Making this determination will require a site and vegetation assessment (see "Site and Objective Analysis").

Soils may need decompacting before seeding depending on the soil texture. The soil might be tilled with an excavator shovel, piling blade, or heavy disc. Heavier soils may require treatment with a winged sub-soiler or ripper. If topsoil has remained in place during use, then tillage and or decompacting should not go deeper than necessary to get suitable soil aeration and water permeability. Equipment and depth should be adjusted to minimize mixing of topsoil and subsoil layers.

Similar treatments can be applied to campsites or temporary work sites. Compaction is usually the main constraint to rehabilitation. If these areas are bladed before the work being carried out, soil and organic debris should be conserved for rehabilitation and re-spread before seeding. Topsoil can contain a substantial native seed bank; however, seeding may be required depending on the size of disturbance and site conditions. Topsoil replacement in the fall or in the dormant period before the first post-construction growing season is recommended for natural revegetation.[79]

In forest management areas, woody debris and the organic forest floor–if it has been conserved – can be placed on deactivated areas with a track excavator. This surface texturing can be sufficient to prevent erosion, get water infiltration, and initiate natural revegetation. If woody debris and suitable organic materials are in short supply, seeding may be required.

Revegetation of rights-of-way clearings can have much in common with other management contexts in this manual. The appropriate context will depend on the management goals for the land they traverse. For example, a right-of-way crossing over Crown range tenure areas may incorporate forage and vegetation control objectives (see Forest land grazing and pasture contexts). Site-specific treatments are likely to be required over long distances, as the landscape features and management goals change.



Photo credit: Lance Brown.

Revegetation of transmission line right-of-way for forage objectives.

Pipeline, Transmission Line

Pipeline and transmission lines may have longer-term impacts, but the primary disturbance occurs when the construction takes place. The impacts of pipeline construction will depend on the size of the pipe and whether the line is buried or above ground. Buried pipeline is more common and requires excavation to create a trench for the pipe. Temporary work space is usually required to allow construction. Best practice suggests soil profile management and replacement after excavation. Therefore, topsoil should remain on the surface at the end of construction, and ready for seeding if natural revegetation is not expected. Some natural revegetation is possible on well-managed, small diameter collector pipeline installation.

As with other linear features that receive temporary vehicle or equipment traffic, soils may need decompacting before seeding depending on the soil texture. This is especially true on larger diameter distribution pipe installations where more equipment is involved. If topsoil has remained in place during construction and use, then tillage and or decompacting should not go deeper than necessary to get suitable soil aeration and water permeability. The equipment used for decompacting should be adjusted to minimize mixing of topsoil and subsoil layers.

Topsoil is the key[80]

Topsoil is a valuable resource containing a seed bank and important microbial flora and fauna that are essential for successful plant establishment. Soil mixing should be minimized, and there is generally no need to screen or sieve topsoil. Direct placement onto a prepared site where the integrity of topsoil layers is retained provides the best conditions for revegetation. When this is not possible, soil can be stockpiled for short periods. Longer storage periods increase the potential for compaction, losses of seed viability, and decreases in the beneficial properties of micro- and macro-faunas and floras. Seeding topsoil that is stored for periods longer than one year improves viability and reduces the potential for unwanted invasive plants. Topsoil conservation can reduce rehabilitation costs. The introduction of narrower blading widths during pipeline construction in Alberta reduced seeding costs by 40%.[81]

Permanent Sites and Access Structures

Permanent structures require cutting and filling to establish a grade suitable for vehicle traffic or equipment installation and operation. Topsoil is removed and subsoil exposed; offsite materials like road base and gravel may be brought to the site. There is potential for mixing of topsoil with sub-surface layers unless topsoil is properly managed. Because of the scale and severity of disturbance, permanent structures and their edges and berms require more intensive and varied treatments. Natural revegetation on or at the edges of these structures will likely be inadequate to meet rehabilitation objectives. Seeding is necessary after suitable soil and site preparation.

If topsoil has been managed it should be re-spread or placed to provide a suitable seedbed. If subsoils are compacted, ripping or deep cultivation may be required before topsoil is spread or placed. Operational experience with heavily used log landings suggests ripping to a depth of 60 cm in heavy soils. Where topsoil has not been managed or is in short supply, amendments will be required. The goal of soil rehabilitation is to: (1) increase soil organic matter content; (2) increase water holding capacity; (3) improve soil structure; and, (4) restore nutrient dynamics.

Wood chips and fertilizer application when combined with legume seeding have been successfully used to rehabilitate landings with fine-textured soils. Although, this helps to restore more sustainable nutrient dynamics to the soil, better results are obtained when topsoil is conserved and reused.[82] Because of the high carbon to nitrogen ratio of coarse organic material like wood chips, available soil nitrogen may be completely immobilized. In this case, additional fertilization may be required to achieve suitable tree establishment and growth. In the landing rehabilitation above, wood chip treatments received 600 kg/ha of N as 34-0-12 in addition to a later application of 400 kg/ha application of 18-18-18. Less nitrogen is required if the added organic material has a lower carbon to nitrogen ratio. Material containing chipped tree tops and green leaves would have a lower carbon to nitrogen ratio.

This example illustrates the importance of proper topsoil management during site disturbance. Innovative and holistic approaches are required for cost efficient and effective rehabilitation.



Photo credit: Percy Folkard.

Deactivated and seeded road in the Chilcotin.

Resource Roads

Where there is significant cutting and filling for road construction, materials should be managed to maximize the potential for revegetation. Fill slopes are likely to be deeper and naturally better suited to revegetation and seeding. Care should be taken on the cut-slope side of roads to create a suitable seedbed by slope rounding and keeping some topsoil in reserve to create a seedbed. Hydro seeding and additional erosion control measures may be required for slopes over 60%. When cuts are shallow, woody debris can be used to stabilize slopes.

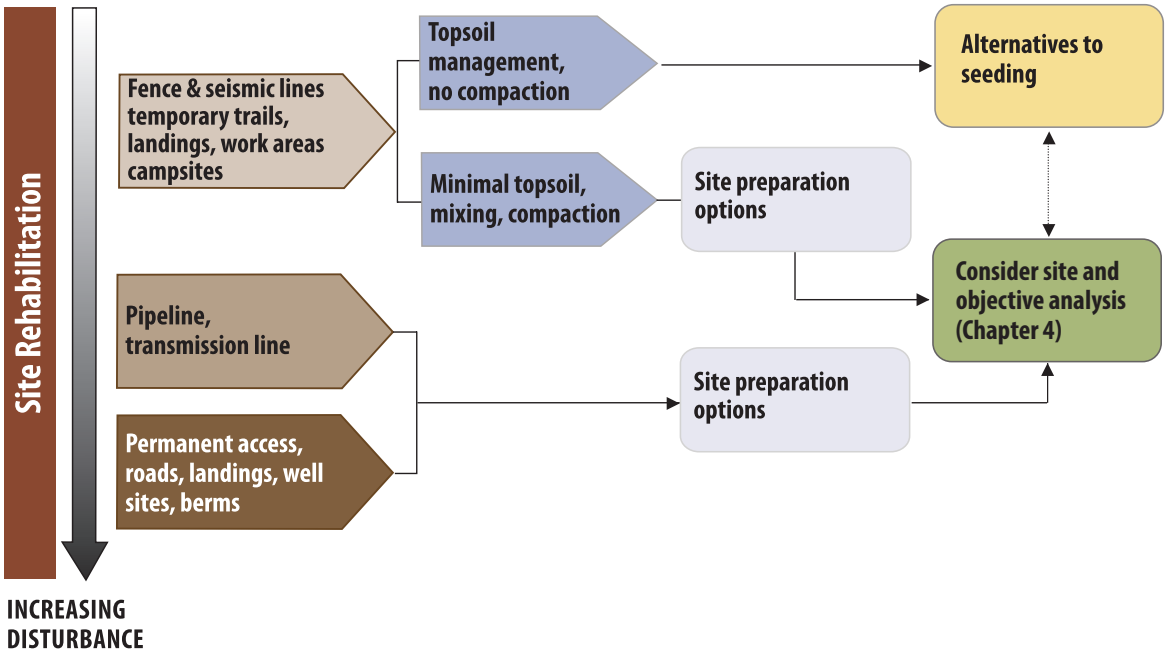


Photo credit: A. Dobb.

Resource road through Crown range tenure in the Peace Region. Cut-slope on the left and fill-slope on the right.

DECISION AID

Site Rehabilitation



Management Context Decision Aid – Site Rehabilitation

The management goal for site rehabilitation is to regain partial ecosystem function after major disturbance. Seeding may be just one of several treatments considered. Common seeding objectives include erosion control, invasive plant suppression, and forage enhancement. Typical BEC zones: MS, ESSF, BWBS, SWB, SBS, SBPS. For grassland sites see Grassland Restoration Context. BEC Zones: BG, PP, IDF.

Figure 3.8 Site rehabilitation seeding decision aid.

Chapter 3. Notes

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[31] Source: Province of British Columbia, Range Tenure spatial layer, Land and Resource Data Warehouse (28 Community pastures or associations, downloaded August 18, 2011).

[32] M. Krzic et al., "Aspen regeneration, forage production, and soil compaction on harvested and grazed boreal aspen stands," *BC Journal of Ecosystems and Management* 5, No. 2 (2005): 30–38.

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[34] J. Robinson and S. Burton, *Increased Forage by Intensively Managed Controlled Grazing of Logged Lands* (Peace River Forage Association of BC, February 2002), http://www.peaceforage.bc.ca/forage_facts_pdfs/FF_12_intensive_grazing.pdf.

[35] E. W. Bork, D. Gabruck, and B. Klein, "Trembling aspen: Comparative strategies to manage aspen in Canada's Parkland" (Greencover Canada Program, 2008).

[36] A. Aasen and M. Bjorge, *Alberta Forage Manual*, 2nd edition (Edmonton, AB: AB Agric Agdex 120/20-1, 2009), www.agriculture.alberta.ca/publications.

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[38] J. Robinson, *Does Zero-Till Fit the Bill* (Peace River Forage Association of BC, 2006), http://www.peaceforage.bc.ca/forage_facts_pdfs/FF_38_Zero_Till.pdf.

[39] Reference for the Alberta Forage Manual see note above; the Manitoba Sod Seeding Manual is: Orla Nazarko, "Seeding forages into existing stands using minimal tillage" (Manitoba Forage Council, Manitoba Agriculture, Food And Rural Initiatives Agriculture and Agri-Food Canada, 2008), http://www.gov.mb.ca/agriculture/crops/forages/pdf/sodseeding.pdf; Additional information on minor use registration can be found on the research page at the Peace River Forage Association website, http://www.peaceforage.bc.ca.

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[44] K. Boersma et al., "Soil and vegetation of ungrazed crested wheatgrass and native rangelands," *Canadian Journal of Soil Science* 80, No. 3 (2000): 411–417.

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Ecology, Management, and Restoration of Intermountain Annual Rangelands, May 18-22, 1992, Ogden, UT: U.S. Dep. Agric. Forest Service, Intermountain Research Station, 1994), 5–8.

[46] It is likely this equipment originated from the US Forest Service Equipment Development Center in San Dimas, California. See W. A. Hubbard, "Increased Range Forage Production by Reseeding and the Chemical Control of Knapweed," *Journal of Range Management* 28, No. 5 (1975): 406–407; It is likely this equipment originated from the U.S. Forest Service Equipment Development Center in San Dimas, California. See J.E. Asher and R.E. Eckert, "Development, Testing, and Evaluation of the Deep Furrow Drill Arm Assembly for the Rangeland Drill," *Journal of Range Management* 26, No. 5 (1973): 377–379.

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1962 and 1993/95" (Prepared for the B.C. Ministry of Agriculture. Ross range and reclamation services, Cranbrook, B.C., 1997).

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[69] Forest Practices Board, "Post-fire Site Rehabilitation: Final Report Special Investigation," 2005, http://www.fpb.gov.bc.ca/publications.aspx?id=2648&terms=fire+rehabilitation.

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[76] R.F. Newman, *Seeding to control weed invasion on the Strawberry Hills fire - Annual Report - 2007* (Research Branch, B.C. Ministry of Forests and Range, 2007).

[77] About 14% of the province has been designated for special management—generally for wildlife or other ecological values, and sometimes recreational and cultural values. These zones are often adjacent to protected areas and help preserve ecological integrity. See: British Columbia Ministry of Forests, "British Columbia's forests and their management," 2003, http://www.for.gov.bc.ca/hfd/pubs/Docs/Mr/Mr113/BC_Forest_Management.pdf.

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Chapter 4. Site and Objective Analysis

After the management context is identified and explored, a detailed assessment of site conditions and seeding objectives is required. The purpose of this section is to offer guidance and various tools to assist with this process. Figure 4.1 shows a step-by-step process for carrying out the site and objective analysis. The bottom section of the chart shows the linkage between each step and species selection. Information collected in the assessment should be carried forward for use with regional precipitation and BEC zone maps and the species summary table (Chapter 5). Users may also find it useful to revisit management context sections once detailed site information has been assembled.

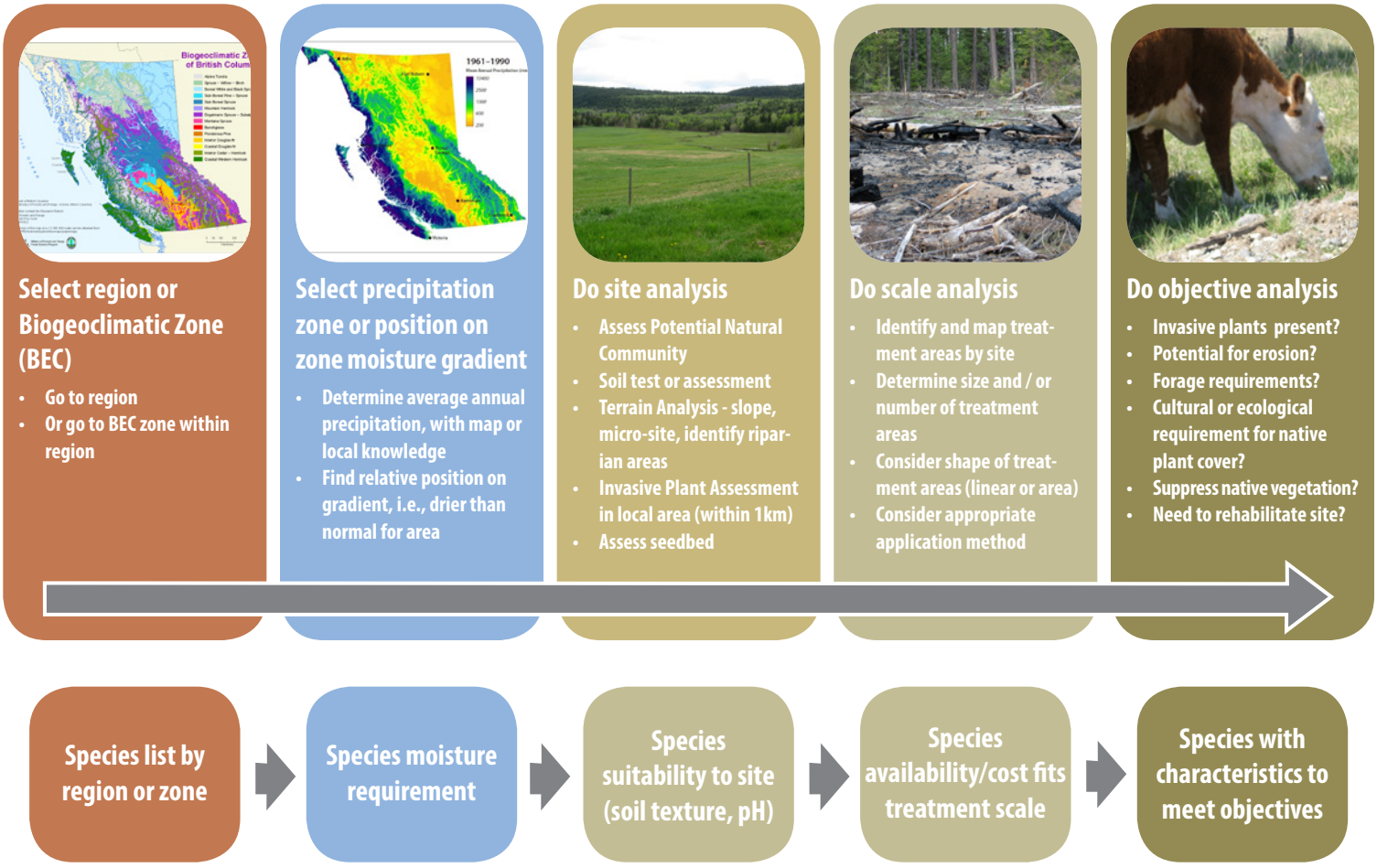


Figure 4.1 Site and objective analysis process flow chart.

Note on Species Selection, Adaptation, and Timelines

The sequence for species selection outlined in the flowchart in Figure 4.1 is important. Adaptation of the species to the region and the site should come first. Selection for species characteristics to meet objectives is secondary. The ability of a species to germinate, establish, and persist on a site ultimately determines whether its plant characteristics can be expressed.

The timeline for species selection will depend on the project and the management context. Ideally, the species selection should begin the year before seeding is planned. In forest land grazing and silvopasture, planning for seeding may have a long time horizon that is fully integrated with timber harvest activities. Grassland restoration projects can require substantial time and advance planning. Decision making around seeding and seed procurement may take place over several seasons. Large projects may even initiate propagation of specific seed sources on their own, or with seed producers.

In most management contexts, seeding must be done immediately after a prescribed or natural disturbance to meet revegetation objectives and ensure success. In regions where wildfire and site rehabilitation are part of on-going land management activities, it makes sense to develop some specific species recommendations and guidelines for the most common types of seeding applications. Regional or zonal specific recommendations have the advantage of allowing efficient seed procurement. If storage conditions are cool and dry, some seed can be warehoused for up to two years to fulfil these needs. There is some disadvantage to this approach however, if the standard recommendations are over-applied and more specific site recommendations are not made when they should be. Existing species and mix recommendations should always be re-evaluated with the site and objective analysis before they are applied.

Region or BEC Zone in Region

Site conditions vary widely throughout the province and within regions. Identifying the region, however, is helpful for narrowing the list of potential species for seeding and providing greater insight into management contexts. Regions can also be connected to more specific climate and site information. Users experienced with the BEC system may prefer to identify their zone and subzone to gain information about climate and other site characteristics (see Chapter 3).

Precipitation Zone

Available moisture is a key factor determining species adaptability, especially in the southern and central interior parts of the province. A difference of 50 mm (2 in.) in total annual precipitation can be critical when selecting species for seeding in dry areas. Regional precipitation gradient maps are included in Chapter 5. These are based on long-term (1961-1990) precipitation averages for most weather stations in British Columbia. Precipitation for areas between weather stations is based on interpolated values from a predictive model (PRISM).[1]

Precipitation and Climate Change

The maps used in this manual are based on long-term average total annual precipitation for the years 1961–1990. Annual precipitation can vary considerably between years, and this should be considered in the interpretation of these maps. The distribution of precipitation in any year can also be highly variable, and can thus influence plant establishment. Both the distribution and amount of precipitation are expected to change in the future. Models have been developed to predict the total average annual precipitation for British Columbia in the year 2050. Precipitation maps based on these models can be found at: http://www.hectaresbc.org/app/habc/HaBC.html.

More detailed regional climate models can be found at http://pacificclimate.org/tools-and-data.

Average precipitation should be used as a reference only. The actual available moisture for plant establishment and growth will be site specific and can be highly variable. When possible, local knowledge should be used as a check against precipitation values taken from maps and tables. Estimates of precipitation ranges for BEC zones covered within the manual are shown in Table 4.1. There is a wide range of precipitation values within zones, illustrating the importance of a site analysis, which often begins with an assessment of the surrounding native vegetation and the potential natural community, is important.

Site Analysis

An infield site analysis provides critical information for the seeding decision that cannot be obtained from maps and other sources. It can help verify information gathered from databases and inventories. Site conditions created by mechanical disturbance (i.e., cultivation, or other site preparation treatments) can only be determined by field inspection.

BEC Information Online

- Detailed subzone and variant field maps can be downloaded from : http://www.for.gov.bc.ca/hre/becweb/resources/maps/field_map_download.html
- For users with GIS capability, spatial data can be acquired from the Land Resource Data Warehouse (LRDW), which can be accessed from: http://geobc.gov.bc.ca/
- BEC zone and subzone descriptions and interpretative information can be found at: http://www.for.gov.bc.ca/hre/becweb/resources classificationreports/subzones/index.html
- Regional field guides can be downloaded from: http://www.for.gov.bc.ca/hfd/pubs/ Lmh.htm

Table 4.1 Predominant Biogeoclimatic Zones within British Columbia's interior range area and their geo-climatic ranges.

BEC Zone	Geo-Climatic Range	
	Elevation (m)	Precipitation Range (mm)
Bunchgrass (BG)	300–1000	< 200–335
Ponderosa Pine (PP)	335–900	280–500
Interior Douglas-fir (IDF)	350–1450	300–750
Interior Cedar Hemlock (ICH)	400–1500	500–1200
Montane Spruce (MS)	1000–1700	380–900
Engelmann Spruce—Subalpine Fir (ESSF)	900–2300	400–2200
Sub-boreal Spruce (SBS)	490–1290	440–900
Sub-boreal Pine Spruce (SBPS)	850–1500	335–580
Boreal White and Black Spruce (BWBS)	230–1300	330–570
Spruce-Willow-Birch	900–1700	460–700

Sources: B.M. Wikeem et al., "An overview of the forage resource and beef production on Crown land in British Columbia," Canadian Journal of Animal Science 73, No. 4 (1993): 779–794; D.V. Meidinger and J. Pojar, Ecosystems of British Columbia, Special Report Series (B.C. Ministry of Forests), 0843-6452 6 (Victoria, B.C.: Ministry of Forests, 1991).

Assessment of Vegetation and Potential Natural Community

An assessment of the existing vegetation and the PNC for a site can provide information for judging seeded species adaptability. Depending on the context and the objectives, the assessment can also be helpful in determining whether seeding is a necessary action. In the forest land grazing and silvopasture context, information from pre-harvest site work should be incorporated into the assessment. Knowledge of understory vegetation in the pre-harvest condition can be useful for predicting native vegetation response after logging. In contexts where disturbance is more severe, like site rehabilitation, vegetation on the edge of the disturbance, and areas of undisturbed vegetation within the site, should be considered in the assessment.

Information from the vegetation and the PNC assessment can be used to:

- **Assist in species selection** – The existing vegetation and the PNC of a site reflect the unique combination of characteristics including available moisture, temperature and soils. These characteristics may be influenced by slope, aspect, and geographic position in the landscape. In general, if the species to be seeded is part of the plant community or the PNC, it will be adapted to the site. If agronomic species are to be seeded, their adaptive characteristics should fit those reflected by the native plant community.
- **Assist in determination of site productivity** – The vegetation assessment can be useful for determining overall site productivity. Productivity can be related to the species present on the site. It can also be related to the total biomass present when compared to other similar areas. Information related to productivity is important for planning, and alternative analysis, when establishing improved forage areas in the pasture and forest land grazing and silvopasture contexts. Sites with greater productivity may justify the investment in seeding improved forages.
- **Project the path of plant succession after seeding** – Knowledge about the species present on a site and the PNC can provide clues about the direction of plant succession after seeding. For example, if a short-lived non-persistent species like Italian ryegrass is seeded after a disturbance, it is possible to project which native species will come to dominate the site as the Italian ryegrass dies out. Knowledge of the successional pathways can be especially helpful when deciding whether to seed early seral or late seral native species in restoration efforts.
- **Project the path of succession without seeding** – With careful assessment of the current species present on a site and knowledge of the PNC, it is also possible to project the sequence of plant community development after disturbance. Availability of native seed sources for re-establishment on a site is often a key factor.

How the vegetation and PNC assessment is carried out will depend on the management context. In most cases, subjective assessments listing the herbaceous, shrub, and tree species present on the site will be sufficient. In some situations (e.g., restoration), it may be useful to establish several plots to measure plant cover by species both before and after seeding. Various sources are available to provide background information for vegetation monitoring.[2]

Sources of information to assist with Vegetation Assessments

- Biogeoclimatic Ecosystem Classification system (BEC)
- Local and regional plant guides
- Professional agrologists, biologists, foresters, and naturalists
- Online sources:

http://www.bcgrasslands.org/grasslands/communities.htm

http://www.geog.ubc.ca/biodiversity/ eflora/BooksandFieldGuides.html

In the pasture context, it may be helpful to combine the vegetation and PNC assessment with broad productivity criteria like those outlined in Table 4.2. It is important that comparable sites are used to establish baselines for estimating site productivity.



Photo credit: Sandra Burton.

Getting down to ground level to do vegetation assessment.

Table 4.2 Pasture assessment tool.

Condition [a]	Criteria	Potential Action
Excellent	- 75–100% of the potential yield for the area - 95% of the yield coming from desirable species - Desirable species vigour high	Maintain current management
Good	- 60–75% of the potential yield for the area - 75–94% of the yield coming from desirable species - Desirable species vigour high	Maintain current management
Fair	- 50–60% of the potential yield for the area - 51–74% of the yield coming from desirable species - Desirable species vigour low-medium	Review management and consider adjustments
Poor	- Desirable species vigour low	Rejuvenation alternatives

Source: Adapted from A. Aasen and M. Bjorge, Alberta Forage Manual, 2nd edition (Edmonton, AB: AB Agric Agdex 120/20-1, 2009), ***http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex3882***

[a] Condition ratings in this pasture assessment tool are based on pasture productivity; they are different than range condition ratings that are based on the similarity to the potential plant community composition for a site.

Plant counts of bunch-type grasses and legumes can be used in conjunction with criteria listed in Table 4.2. Local reference areas—other good condition pastures—should be used to determine desired plant densities and production potential. Plant counts are not suitable for assessing the condition of pastures with sod-forming grasses, where dense cover and litter accumulation over time may indicate low production.

Invasive Plant Assessment

The invasive plant assessment should be carried out on site, and should also include a review of local and regional invasive plant information. Invasive and weedy plants detected during the on-site vegetation assessment should be documented. It is possible that these plants may rapidly colonize newly disturbed areas unless these sites are successfully revegetated. Known and suspected invasive plants should be identified and checked against provincial and regional priority lists (see inset). Once identified, the information can be considered in the rejuvenation and seeding decision.

The Ministry of Forests, Lands and Natural Resource Operations Invasive Alien Plant Program (IAPP) documents and maps the distribution of invasive alien plants and their management in British Columbia. This information can be accessed by land managers via the internet to determine proximity of invasive plant sites to areas being considered for seeding. The dispersal vectors for each invasive plant species should also be considered when evaluating the potential for invasion. Common dispersal vectors include humans, animals, vehicles, wind, water, and insects. The potential risk of invasion by each species should be assessed to establish a safe buffer distance to aid seeding decisions.



Photo credit: Judy Millar.

Orange hawkweed infestation.

BC Invasive Plant Information Online

E-Flora:
http://www.geog.ubc.ca/biodiversity/eflora/invasives.html

The Invasive Species Council of BC:
http://www.bcinvasives.ca/

Ministry of Forests, Lands and Natural Resources, Invasive Alien Plant Program:
http://www.for.gov.bc.ca/hra/plants/index.htm

Field Guide to Noxious and Other Selected Weeds of British Columbia:
http://www.agf.gov.bc.ca/cropprot/weedguid/weedguid.htm

Provincial and Regional noxious weed lists, *Weed Control Act, Weed Control Regulation* Schedule A:
http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/10_66_85

Soil Test or Assessment

Plant species have different soil texture preferences. Therefore, making a rough determination of soil texture is a useful first step when identifying soil conditions on a site. Adding water to a small amount of soil in the palm of the hand, and then working the two together with the thumb is a quick field test for determining soil texture. Coarse-textured (sandy) soils will not form a ball, while fine-textured soils will stick together and can be worked into ribbons of various lengths depending on the proportions of silt and clay. Soils information is provided by the BEC system, and should be verified by a soils inspection on site. A series of regional field guides have been developed to assist in site interpretation.

Disturbed sites, especially in the site rehabilitation context, may have severely compacted soils caused by vehicle and heavy machinery traffic. Some sites may have had the topsoil removed and the resulting exposed subsoil may be highly compactable clay. Soil horizons can become mixed during construction if soil management practices have not been followed or soil management plans are not in place. Soils in this context may also be highly saline or contain industrial contaminants. These types of extreme soil conditions are unlikely to provide a suitable seedbed and may require additional pre-seeding soil amending treatments.

It may be useful to take soil samples to determine soil nutrients and pH particularly where forage production is the primary objective for a seeding. Boron and sulfur are critical micronutrients for the establishment of forage legumes, and have been shown to be deficient in the central interior regions of the province.[3] In general, forest soils are acidic. It is advisable to sample and test soils for pH where seeding is critical, particularly if legumes are to be seeded to improve soil nutrients. Estimates of soil pH can be found in BEC field guides.

Soils are likely to be highly variable with microsite conditions, and care should be taken to get representative samples for soil testing. Soil tests may be especially useful if fertilizer applications are being considered for pasture rejuvenation or site rehabilitation.

Soil Assessment Keys and Information

The following keys can be found in the Field Manual for Describing Terrestrial Ecosystems at: http://www.for.gov.bc.ca/hfd/pubs/docs/Lmh/Lmh25-2.htm

- Hand texturing key
- Soil moisture regime key
- Nutrient regime key

Terrain Assessment - Slope, Erosion Hazards, Microsite, Riparian Area Identification

An assessment of the site terrain serves several purposes. It can provide information to assist in species selection for seeding, but it can also help establish the suitability of different seeding methods. An assessment of the site terrain also allows for the determination of slope and erosion hazards. This is especially important in site rehabilitation and post-wildfire rehabilitation, because of the potential for high amounts of exposed mineral soil in these contexts.

The B.C. Ministry of Forests Hazard Assessment Keys for Evaluating Site Sensitivity to Soil Degrading Processes Guidebook includes a series of tools for rating soil compaction, soil displacement, erosion, and risk of stream sedimentation.[4] The soil erosion hazard assessment key is presented in Table 4.3 and is intended for use on surface soils on logged areas and other contexts where the subsoil has not

been exposed (e.g., post-wildfire rehabilitation). High erosion hazard ratings may require additional or alternative erosion control measures.

Seeding may or may not reduce immediate erosion risk, as seeded species must germinate and establish before they can stabilize erosion susceptible sites. Much depends on the nature of the precipitation events that follow immediately after the disturbance. Seeding with a species that establishes quickly, like Italian ryegrass, along with slower-to-establish perennials on sites with a high erosion hazard rating can reduce erosion risk over the short- to mid-term. It is important that seeding take place as quickly as possible after disturbance or site preparation.

The general nature of the landscape should be noted in the terrain assessment. Hummocks and swales can create microsites that have different moisture and nutrient regimes. This condition may suggest a seed mixture that contains a species suited to each micro-environment. Very steep slopes may affect seed placement and distribution in aerial broadcast applications, with seeds moving down slope and collecting in depressions and slope toes.

Identification of streams and riparian areas should also be part of the terrain assessment. These areas may need to be intentionally excluded from seeding to protect riparian values, and reduce the potential of attracting livestock to sensitive areas. Conditions in these areas are likely to be different from upland conditions and if revegetation is required here, a planned riparian restoration approach should be employed. The identification of streams and other watercourses is also required to determine risks of sedimentation. This risk should be assessed along with the soil erosion hazard.

Seedbed or Disturbance Assessment

The purpose of the seedbed or disturbance assessment is to determine the potential for seed to make contact with mineral soil, and find suitable conditions for germination and growth with a particular seeding method. Seedbed conditions are critical in deciding whether seeding should go ahead. This is particularly important in broadcast seeding applications. An ideal seedbed should:

- be firm immediately below the seeding depth, which helps conserve moisture for germination;
- be granulated and not cloddy or crusted on top to ensure seed-to-soil contact;
- be free from live resident undesirable plant competition;
- be free of seed from competitive, weedy species; and
- have moderate amounts of mulch or plant residue (litter) on the soil surface to help maintain soil moisture and soil tilth.[5]

Although an ideal seedbed may be difficult to attain, optimal conditions should be the goal when mineral soil is exposed. When seedbed conditions are suboptimal, stands still may establish over time as mature plants self-seed or spread by rhizomes. The risk of seeding failure and overall expectations for seeding success should be part of the assessment when conditions are less than ideal.

While it is possible to measure the amount mineral soil exposure on a site, a visual or subjective assessment is likely to be more practical. It is important to walk different areas of a site to observe the full range of disturbance present. Mineral soil exposure can vary substantially with topography, so each type of microsite should be visited.

Large amounts of debris left by fire or logging can make assessment of mineral soil exposure challenging (see photo). Subjective assessments can be aided and improved in these situations by establishing a few plots (1 x 1 m), and accounting for the relative amounts of debris and vegetation in the plot. The remaining percentage will be an estimate of the exposed mineral soil or bare ground for the plot.



Photo credit: A. Dobb.

Site with significant debris left from logging with limited mineral soil exposure.

It can be easier to estimate the amount of mineral soil exposure when a systematic silviculture site preparation treatment like disc trenching is applied. For example, this can be accomplished by measuring the relative width of the trench, the soil from the trench, and any remaining vegetation or undisturbed area (see photo). Irregular site treatments like drag scarification result in conditions that are more difficult to assess, and a few plots in representative areas may aid in determination of mineral soil exposure. Where topsoil has been bladed and then redistributed, as might be the case in fireguard rehabilitation, mineral soil exposure will be high and soil to seed contact will not be hard to attain.



Photo credit: Rick Tucker.

Mineral soil exposure created with disc trenching, and natural revegetation between trenches.

Table 4.3 Erosion hazard assessment tool.

Site Factors	Degree of Contribution of Factors			
	Low	**Moderate**	**High**	**Very High**
Climate Precipitation factor (points)[a]	Low **2**	Moderate **2**	High **6**	Very High **8**
Topography Slope gradient (%) (points) Length/uniformity (points)	Low **2** short broken **1**	Moderate **4** short uniform **2**	High **6** long broken **3**	Very high **8** long uniform **4**
Depth to water restricting layer (cm) (points)	> 90 **1**	61-90 **2**	30-60 **3**	< 30 **4**
Surface soil detachability (0-15cm)[b] (points)	SiC, SiCL, Si, SiL, FSL **1**	SICL, CL, CCL **2**	SL, L **4**	SI, SIL, FSL, LS, S **8**
Surface coarse fragments (0-15cm)[b] (points)	> 60 **1**	31-60 **2**	16-30 **3**	> 16 **4**
Subsoil permeability texture (16-60cm) (points)[b]	FSL, SiL, Si, SiC **1**	L, SIL, SI **2**	CL, SCL, SI, CL **3**	C, SC, SIC **4**
Soil erosion hazard rating (point total)[c]	**Low** **< 16**	**Moderate** **16-22**	**High** **23-31**	**Very High** **> 31**

[a] See Appendix B for values. In general dry BEC zones and subzones are rated low; wetter zones and moist dry subzones are rated moderate; and very wet subzones are rated high and very high.

[b] If two contrasting textures or coarse fragment contents occur in the depth, use the one with the highest point rating.

[c] Gently sloping areas with long, uniform slopes may rate as high soil erosion hazard. The reason is that substantial erosion can occur on these sites given the right conditions.

Short slopes are those with < 150 m of unbroken slope length between level or adverse slopes that will impede the continued flow of water. Long slopes are those with > 150 m of unbroken slope length between level or adverse slopes that will impede the continued flow of water. Broken slopes are variable, complex, or benched slopes.

Source: B.C. Ministry of Forests, Hazard Assessment Keys for Evaluating Site Sensitivity to Soil Degrading Processes Guidebook, 2nd edition, Version 2.1. (B.C. Min. For., For. Prac. Br., Victoria, B.C. Forest Practices Code of British Columbia Guidebook, 1999), ***http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/Guidetoc.htm.***

In a pasture context where specialized seeding equipment might be used, soil exposure can be created by the seeding equipment itself. However, it should still be evaluated to ensure desired effects are being achieved. This is especially important when competing vegetation present on a site may not have been controlled before seeding. With direct seeding methods in this context, mineral soil exposure is not a factor but the method does require proper seed placement in the soil.

Creating an ideal seedbed in the grassland restoration context may be inappropriate in some situations. This will depend on the desired objectives and seeding methods used. Additional disturbance can increase the potential for invasive plant establishment. If parts of the native plant community remain on the site to be restored, an assessment of existing plant cover – including invasive species – and the amount of bare ground should be part of the assessment.

In a post-wildfire rehabilitation context, burn severity is the key variable determining the level of disturbance and the path of natural revegetation after fire. A burn severity classification tool is shown in Table 4.4. This tool should be applied early in the decision making process (see "Post-wildfire rehabilitation," page 65).



Photo credit: Rick Tucker.

Low-moderate severity burn.

Table 4.4 Burn severity assessment tool.

Soil and Litter Parameters	Burn Severity		
	Low	Moderate	High
Litter	Scorched, charred, consumed	Consumed	Consumed
Duff	Intact, surface char	Deep char, consumed	Consumed
Woody debris – small	Partly consumed, charred	Consumed	Consumed
Woody debris – logs	Charred	Charred	Consumed, deeply charred
Ash colour	Black	Light coloured	Reddish, orange
Mineral soil	Not changed	Not changed	Altered structure, porosity, etc.
Soil temp. at 10 mm	(< 50°C)	(100–200°C)	(> 250°C)
Soil organism lethal temp.	To 10 mm	To 50 mm	To 160 mm

Source: P.R. Robichaud et al., Evaluating the effectiveness of postfire rehabilitation treatments (U.S. Dep. Agric. Forest Service, Rocky Mountain Research Station, 2000); Adapted from: L.F. DeBano, D.G. Neary, and P.F. Ffolliott, Fire's effects on ecosystems (Wiley, 1998); R.D. Hungerford, "Soils-fire in ecosystem management notes: Unit II-I," Marana, AZ: U.S. Dep. Agric. Forest Service, National Advanced Resource Technology Center (1996).

In a site rehabilitation context, a seedbed assessment is critical, as many situations may have soils that have been severely compacted with the topsoil removed. If an adequate growing medium does not exist on the site, there will be little point in seeding until a soil amendment or preparation treatment is applied. The most desirable situation is to have compacted soils ripped, raked, disced, or opened up with a winged sub-soiler to allow the movement of air and moisture into the soil profile. Topsoil, which should be managed during site construction, can then be re-spread and this will provide the best seedbed. Mulches may be used to improve soil surface conditions on compacted sites when topsoil coverage is absent or inadequate.

Scale Analysis

The scale, or size, of the area being considered for seeding is an important consideration in decision making. The scale can determine:

- suitability of seeding methods,
- site preparation methods,
- suitability of post seeding treatments,
- economics of the seeding application,
- choice of species based on seed availability, and
- amount of seed required.

Treatment Areas

A useful first step for determining the scale of a potential seeding is to map the areas under consideration. Large-scale projects are likely to have existing maps made for other purposes such as timber harvest, or wildfire suppression. These base maps can be used to classify disturbance types, and identify BEC subzones, topographical features, and riparian areas. Areas to be seeded can be marked and colour-coded to reflect different seeding applications and treatments. Large scale projects are also likely to use GIS, and this very specific information can be used to accurately determine the size of areas to be seeded.

Smaller-scale projects will also benefit from mapping, even if only rough sketch maps are created. These can be useful for recording notes and identifying special concerns related to the seeding project. The size of the seeded area can be estimated by pacing length and width dimensions and determining the area in square metres or feet. If areas are sufficiently large, they can be mapped using free web-based software like Google Earth or ArcGIS Explorer. The total area and number of sites considered for seeding should be summarized and used for making seeding calculations and determining costs.

The geo-reference (latitude and longitude) information provided by GIS programs can be useful for carrying out the invasive plant assessment and interpreting information from the IAPP database. Most of this information is available within various layers on the iMapBC site maintained by the provincial government (http://www.geobc.gov.bc.ca).

Treatment Area Shape

Like scale, the shape of areas to be seeded can determine seeding methods and overall economics. Long linear features like pipelines and fireguards can be efficiently seeded using a variety of methods, including ATV-mounted broadcast spreaders. In contrast, large rectangular or square blocks might only be seeded efficiently using aerial broadcast methods. What effect shape may have on application method should become apparent through mapping and area determinations.

The shape and extent of treatment areas can also influence how plant succession proceeds on a site. Disturbed areas within narrow linear disturbances are often much closer to undisturbed native vegetation and this may increase the potential for natural revegetation. Fence-line clearing is a good example. This, however, will depend entirely on the type and severity of disturbance and proximity to invasive plant infestations. Other types of linear features, like trails, can be severely disturbed because activities are confined and not dispersed over the landscape. These types of disturbance can become vectors for the spread of invasive plants.

If linear features are extremely narrow and surrounded by forest on both sides, shade may be a factor in seeded species selection. Orientation in relation to the sun and the height of nearby trees will determine overall shade and moisture effects. Shade and light effects have been noted in silvopasture applications when narrow alleys were created in aspen stands.

Objective Analysis

An analysis of objectives is necessary to determine if seeding is justified in a given management context. The degree to which seeding objectives are met will be a measure of seeding success. A clear statement of objectives is needed to select the appropriate species for seeding. It is also needed to conduct a cost–benefit analysis, when such an analysis is practical or warranted. Objectives should be rated or ranked when seeding for multiple purposes. Carefully reviewing the management context will assist with this process. Objective ranking can be extremely helpful for species selection.

Forage Enhancement

Seeding to improve forage quantity and quality for livestock and/or wildlife is a primary objective in several contexts, or it can be a secondary objective in any management context. When forage is the main objective, reasonable levels of erosion control and invasive plant suppression can be expected without sacrificing forage objectives.

On the other hand, seeding for erosion or invasive plant suppression using a species rated high in both categories may limit forage production. For example, hard fescue is especially noted for both erosion control and invasive plant suppression. It produces a huge volume of root material below ground (> 19,000 lbs/acre), but its above-ground herbage production is much lower than other forage species.[6] It is also very persistent in a stand and may come to dominate over time, at the expense of better-forage producing species. Forage enhancement is most commonly associated with introduced agronomic species. Some forage potential might be sacrificed when there is also a native plant community objective.

For livestock producers, maintaining a consistent supply of forage is a key concern. In the pasture context, forage enhancement should be planned to fill gaps in seasonal forage supply and to replace forage so that stored or stockpiled sources can be increased. Several agronomic species can be used to improve forage quality.

The analysis of forage objectives on Crown rangeland requires a long-term perspective. Total forage demand needs to be assessed within the context of a dynamic forest system that is continually changing with timber harvest, insect outbreaks, and wildfire. The current level of range use in a tenure area in AUMs provides a benchmark for judging whether additional forage is required. Forage production in a tenure area can decrease over time as regenerated areas reach a closed canopy state. New forage is usually provided by new harvest openings. If the new forage is insufficient to meet the tenure demand, seeding might be considered to improve the quantity of forage over a smaller harvested area. For planning purposes, the additional forage production created by the seeding will need to be estimated so an appropriately sized area is seeded.

Invasive Plant Suppression

An established stand seeded for most objectives is likely to have reasonable value for the suppression of invasive and weedy plants. However, effects of seeding may be variable depending on the specific weeds that are of concern. Some highly invasive noxious weeds are able to colonize small, open spaces within healthy plant communities.

The control of invasive plants with seeding is likely to be variable. Reduced or slowed establishment of weedy species is a realistic expectation with a successful seeding. But successful establishment with high plant cover where weedy species are present can have a more controlling effect. This may be more pronounced on moist sites. Suppression of invasive plants with seeding is likely

to be more challenging in semi-arid environments. Species choices are limited in this case (i.e., crested wheatgrass, hard/sheep fescue), and these persistent long-lived species maybe unsuited to areas with high ecological values. For post-wildfire rehabilitation, research suggests effective control depends on extra competitiveness provided by seeded agronomic species.

The invasive plant assessment should provide information on weedy species, distribution vectors, and regional invasive plant issues. This information can then be used to consider buffer zones appropriate to the region, management context, species and the types of dispersal. An invasive plant risk evaluation tool is shown on page 95.

Once invasive plant suppression becomes a priority seeding objective:

- Select species with a moderate to high invasive plant suppression rating.
- Choose a reputable seed supplier, and examine seed analysis certificates.
- Request another seed analysis test of the seedlot(s) if the contaminant or weedy species listing is incomplete or has insufficient detail.
- Do not use mulch material from off the site (i.e., hay or straw, unless it can be certified weed free).
- Have a clean vehicle program in place to further reduce the risk of invasion by weedy species. Do not allow vehicles or equipment on the site unless they have been thoroughly cleaned. Undercarriages, track pads, and the top surface of horizontal structural members are perfect places for invasive plant parts to become lodged and transported.

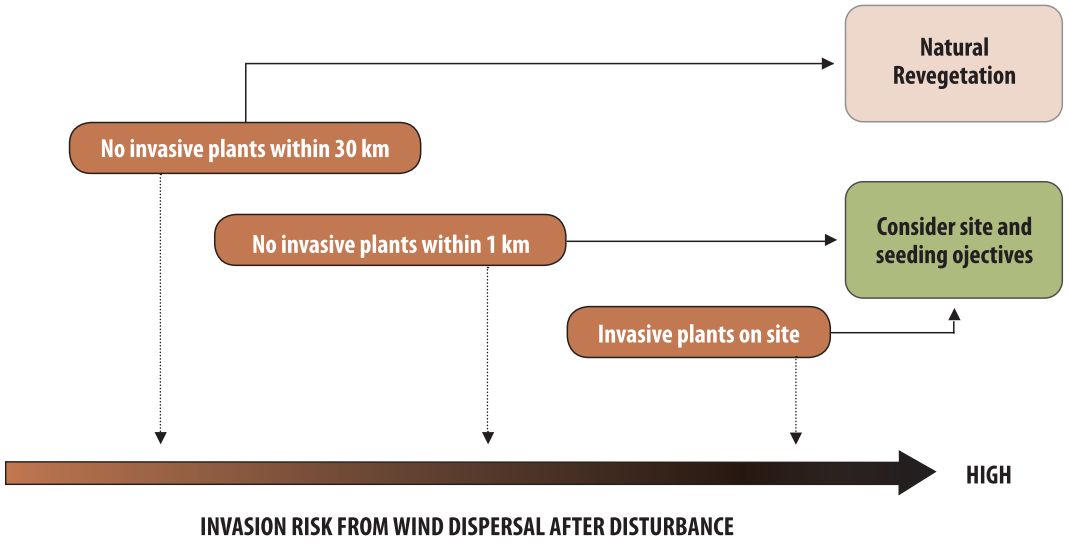


Figure 4.2 Invasive plant risk evaluation tool.

Invasive Plant Risk Evaluation Tool

Assessing the relative risk of colonization by invasive plants on a site after disturbance can be used to help establish an invasive plant suppression seeding objective. Risk level and buffer distance should be adjusted for the relevant context, regional invasive plant species and their potential spread rates, and the potential for dispersal where there is a substantial human population and / or travel frequency.

Erosion Control

Erosion control is a common objective in rehabilitation projects. Planning and choosing species for erosion control can be straightforward when it is the primary objective, as it would be in a roadside seeding project. However, decision making becomes more challenging when erosion control is required in remote and/or natural settings where ecological values are also high and native species might be required. Proper assessment of erosion hazard is the key to establishing this as an objective. Management context will also help establish the priority of this objective. As noted in post-wildfire rehabilitation, erosion control on burned areas is often an objective, but seeding may not necessarily be an effective treatment. This should be clearly established by a detailed site and erosion hazard analysis.

Soil Improvement

In general, creating a plant community by seeding a disturbed site or bare mineral soil will have a positive effect on soil physical properties. The fibrous roots of grasses and dead material above ground add organic matter and help build soil structure. When site conditions permit, including a nitrogen-fixing legume in the mix will improve soil nitrogen levels and overall nutrient cycling. In log landing site rehabilitation, seed mixtures containing only legumes have been used to improve soil conditions for tree seedling establishment.[7] A soil improvement objective might be appropriate in the pasture context as well. Improved soil nitrogen will increase forage production, which may be accomplished by including an adapted legume in a forage mix. To maximize the nitrogen-fixing capability of legumes, they should be inoculated with appropriate *Rhizobia spp.* before seeding (see Table 6.2).

Extending the Grazing Season

Extending the grazing season is a specialized seeding objective and most commonly associated with pasture on converted lands. There may be some application of this objective in specialized silvopasture situations. Some species noted for extending the grazing season can require traditional seedbed preparation and/or specialized seeding equipment. The value of creating an extended grazing season with forage seeding can be estimated by looking at the annual forage budget for the livestock enterprise. The direct benefit of the seeding is determined by the reduced number of feeding days and the associated hay cost savings. This would be one factor in the cost–benefit analysis needed to fully evaluate this option.

Native Plant Community

A native plant community objective implies more than simply seeding native species. In restoration contexts, short-lived introduced species may play a role in restoration after disturbance by helping to conserve soil, and maintain some

ecosystem function until native species can re-establish. This objective implies that seeded species selection allows for native plant re-establishment. Seeding native species with a native plant community objective may be inappropriate in rehabilitation contexts where there has been severe site disturbance. These sites may be so severely altered that seeding slow-to-establish native species may lead to further loss of function through soil loss and weed or invasive plant establishment. If soil conditions have been severely altered, species selection may need to be adapted to the site in its present condition.

Hard Fescue Persistence

The persistence of hard fescue has been documented in a study of introduced grasses used for rehabilitation in the Columbia and Great Basins in the United States: "Several decades after hard fescue had been seeded either alone or with other species and varieties at three sites in Washington State, it occupied almost half of the seeded areas."[8] A similar series of variety plots were seeded at various locations in the southern interior of British Columbia by the Ministry of Agriculture in the late 1970s. One of these is near the Afton mine approximately 10 km from Kamloops in a 250–300 mm (10–12 in.) precipitation zone. The fence enclosing the trial and some of the wooden stakes identifying the species and varieties that were seeded still remain at this dry site. Hard fescue now dominates the exclosure, along with big sagebrush and rabbit brush, and is spreading from the enclosure into a previously rehabilitated range, downslope of the exclosure. Whitmar bluebunch wheatgrass, Summit crested wheatgrass, Altai wildrye, Sherman big-bluegrass and Roamer alfalfa were among some of the species seeded at the site, but are essentially absent now.



Photo credit: A. Dobb.

Species and variety trial at the Afton mine exclosure near Kamloops more than three decades after establishment.



Photo credit: A. Dobb.

Hard fescue in the Afton mine exclosure more than three decades after establishment.

A native plant community objective with a restoration approach usually requires more investment in time and labour, but may be an alternative for small-scale projects. The native plant community objective is suited to moderate to severe disturbances in rehabilitation contexts (e.g., post-wildfire rehabilitation), if the soil profile has not been severely altered or mixed.

It may be possible to select appropriate, easier-to-establish early successional species where disturbance has been more severe. Later successional species might also be included in a seed mix, if the successional stages for the site can be identified.

Vegetation Control

Introduced agronomic species have been used to suppress native vegetation on some sites to improve tree seedling survival and productivity in forestry contexts. This is a specific objective that has usually been applied on moister sites where quick and very competitive native plant response is expected after timber harvest. Research trial results evaluating this objective have been mixed. However, some have suggested some potential for this type of seeding on certain sites.[9] Most research has evaluated silviculture effects of vegetation control through seeding, without grazing from livestock. There may be some potential for combined objectives, in cooperatively managed forest land grazing and silvopasture situations.

Close evaluation of growth form is important when choosing species for this objective. Plants should be well adapted and be able to compete with robust early successional native species. The height and physical attributes of the species when they approach the end of the growing season should also be considered in species selection. Tall species that collect snow can cause what is called "snow press" of young tree seedlings. Some seedlings can recover from snow press, but seedling deformities and mortality can occur. Where there are forage and vegetation control objectives, managed grazing is an effective means of removing tall forage thereby minimizing any risk of snow press.

Sociocultural and/or Aesthetic

If a high level situation analysis is performed, important sociocultural contexts should be documented. Cultural issues around seeding frequently involve discussions about native and non-native species. In some situations, cultural requirements for a seeding program will already be established. When cultural values are high, and when agreements are in place, other objectives may become secondary. A community grassland restoration project would be an example.

When disturbances are highly visible to the public, seeding can have an aesthetic objective. This may come up in rehabilitation contexts where there is a high level of disturbance. While seeding may be carried out to meet other objectives as well, getting a quick "green cover" might be considered an objective in these situations.

Chapter 4. Notes

[1] C. Daly et al., "A Knowledge-based Approach to the Statistical Mapping of Climate," *Climate Research* 22, No. 2 (2002): 99–113.

[2] For information see: D. Gayton, *British Columbia grasslands [electronic resource]: monitoring vegetation change,* FORREX Series 7 (Kamloops, B.C.: FORREX, 2003), http://www.forrex.org/publications/FORREXSeries/FS7.

[3] J. Tingle. October 19, 2011. Personal communication.

[4] B.C. Ministry of Forests, *Hazard Assessment Keys for Evaluating Site Sensitivity to Soil Degrading Processes Guidebook*, 2nd edition, Version 2.1 (B.C. Min. For., For. Prac. Br., Victoria, B.C. Forest Practices Code of British Columbia Guidebook, 1999), http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/HAZARD/HazardAssessKeys-web.pdf.

[5] Ideal seedbed conditions adapted from: J. Vallentine, *Range development and improvements*, 2nd edition (Provo, Utah: Brigham Young University Press, 1980).

[6] A. L Hafenrichter et al., *Grasses and legumes for soil conservation in the Pacific Northwest and Great Basin States*, Agriculture Handbook, No. 339 (Washington, D.C.: Soil Conservation Service, U.S. Dept. of Agriculture, 1979).

[7] Sanborn et al., *Soil Rehabilitation Research at the Aleza Lake Research Forest: Techniques for restoring productivity to fine-textured soils.*

[8] R.D. Harrison et al., *Competition, biodiversity, invasion, and wildlife usage of selected introduced grasses in the Columbia and Great Basin* (Logan, UT: Utah State University, Agriculture Experiment Station, 1996).

[9] O. Steen and A. Smith, *Grass and legume seeding for vegetation control on blade scarified sites in the ICH and ESSF zones in the central interior of British Columbia*, FRDA Report 182 (Victoria, B.C.: Forestry Canada, B.C. Ministry of Forests, 1991).

Chapter 5. Regional Species Filters

British Columbia's five interior regions are shown in Figure 5.1. The following pages include biogeoclimatic ecological classification (BEC) zone and precipitation maps for each region. The species summary table (Table 5.1, page 112) provides a list of agronomic and native grasses and legumes, and rates their adaptive characteristics for important climate and soil properties. The table also provides suitability ratings for three common rangeland seeding objectives.



Figure 5.1. Interior regions of British Columbia.

Source: Spatial data from the Province of British Columbia.

Bulkley – Nechako

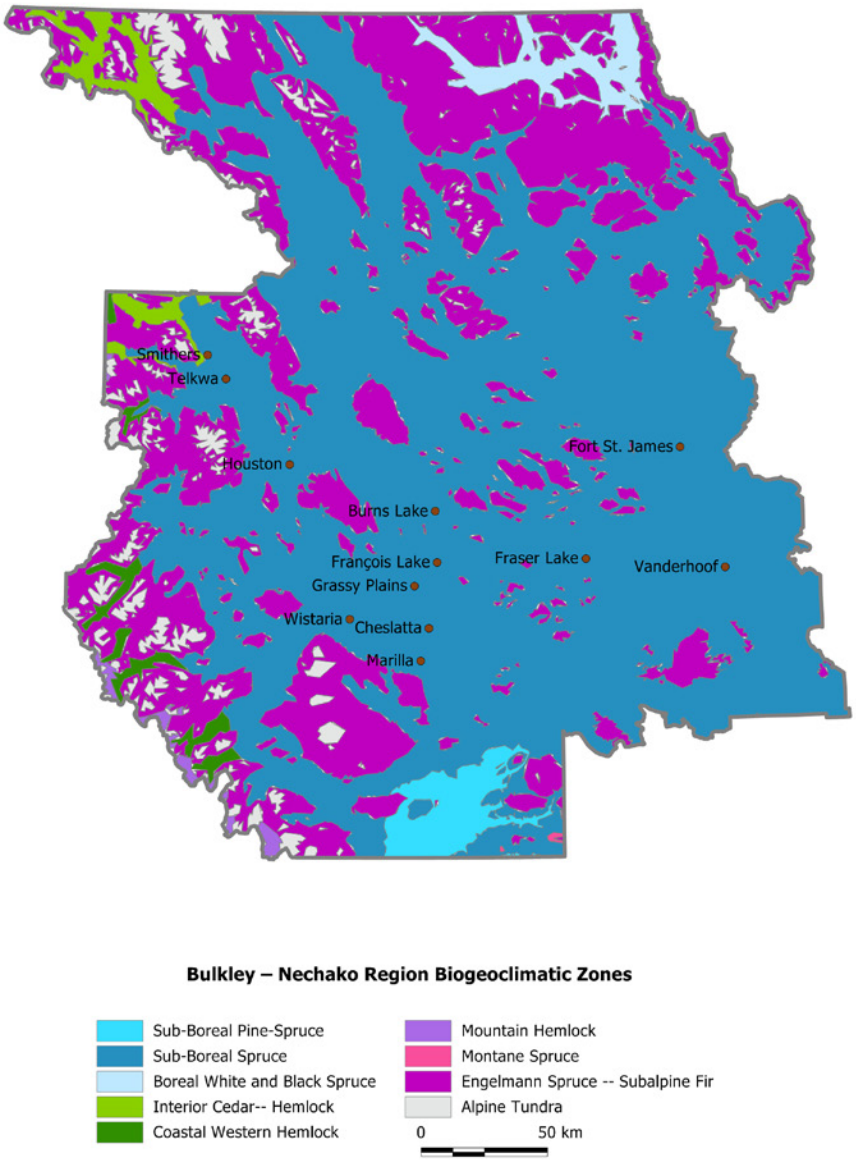
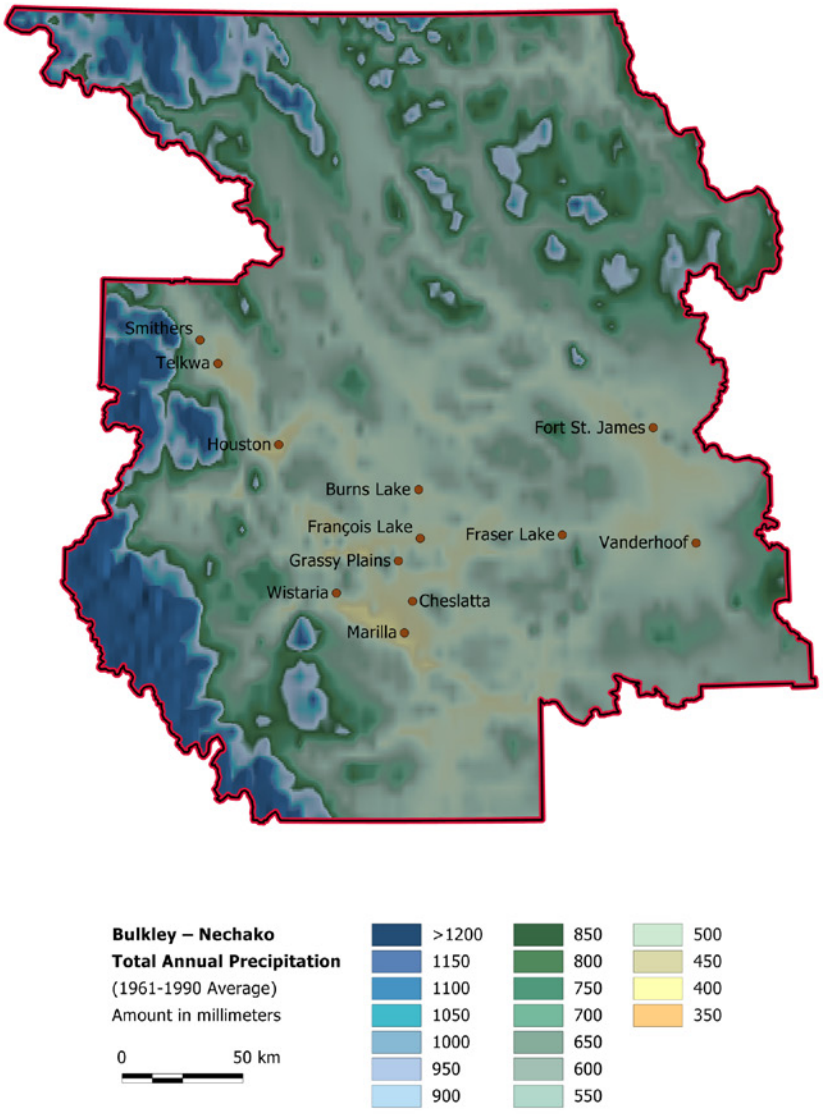


Figure 5.2(a) Bulkley - Nechako Biogeoclimatic Zones

Source: Spatial data from the Province of British Columbia.





5.2(b) Bulkley - Nechako total annual precipitation (1961 - 1999 average)

Source: Adapted from T. Wang et al., "Development of Scale-free Climate Data for Western Canada for Use in Resource Management," International Journal of Climatology 26, No. 3 (February 21, 2006): 383–397.

Cariboo – Fraser-Fort George

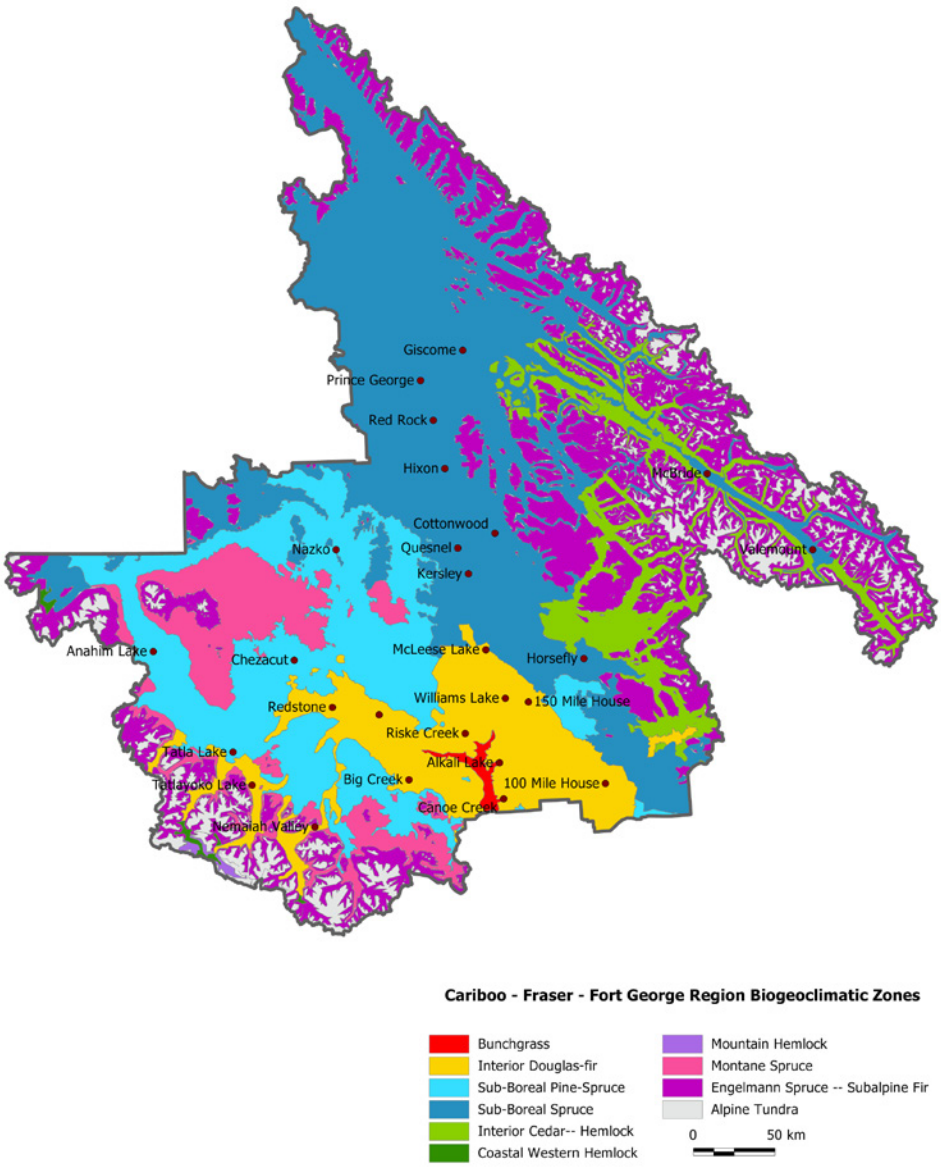


Figure 5.3(a) Cariboo – Fraser-Fort George Biogeoclimatic Zones.

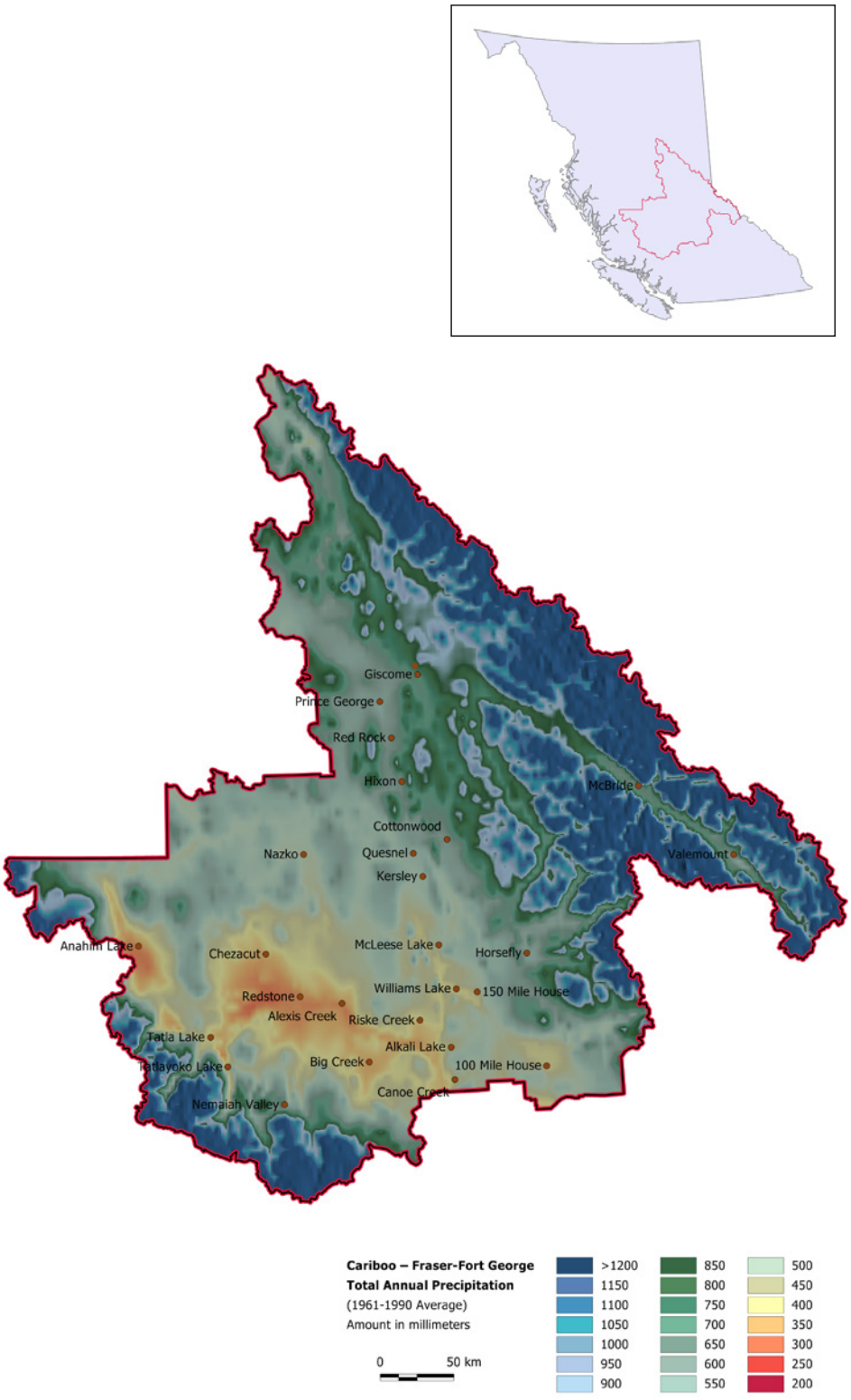


Figure 5.3(b) Cariboo – Fraser-Fort George total annual precipitation (1961-1990 average).

Kootenay

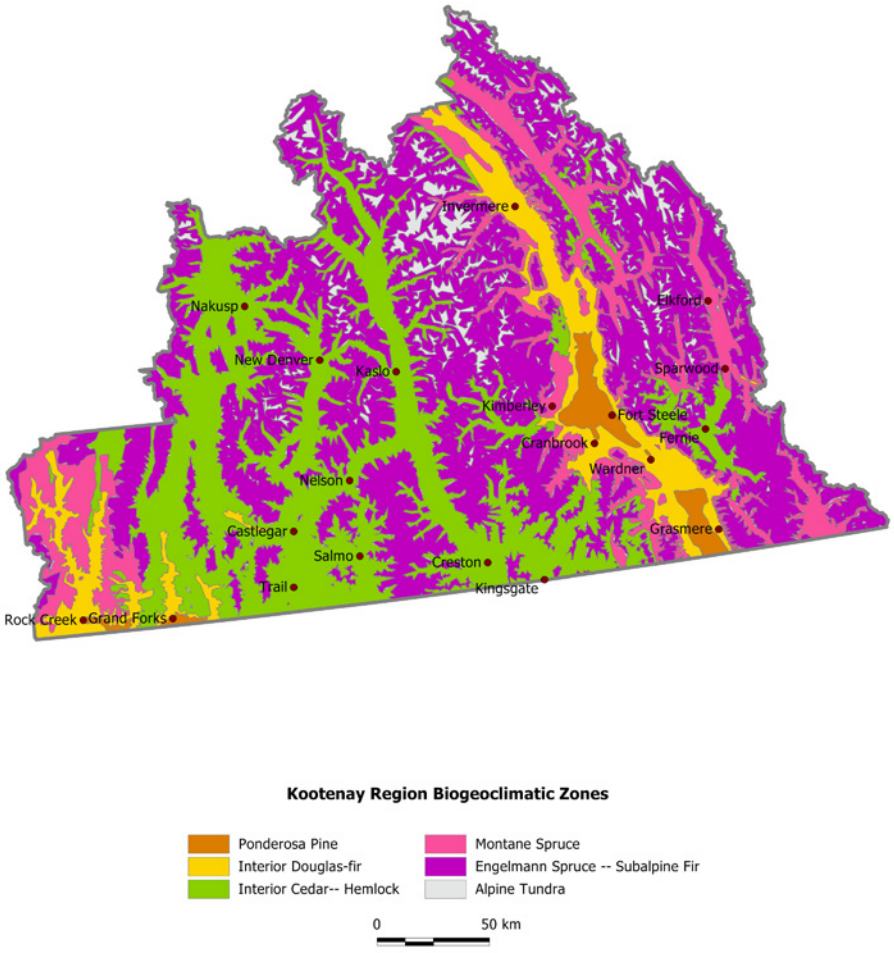


Figure 5.4(a) Kootenay Biogeoclimatic Zones.



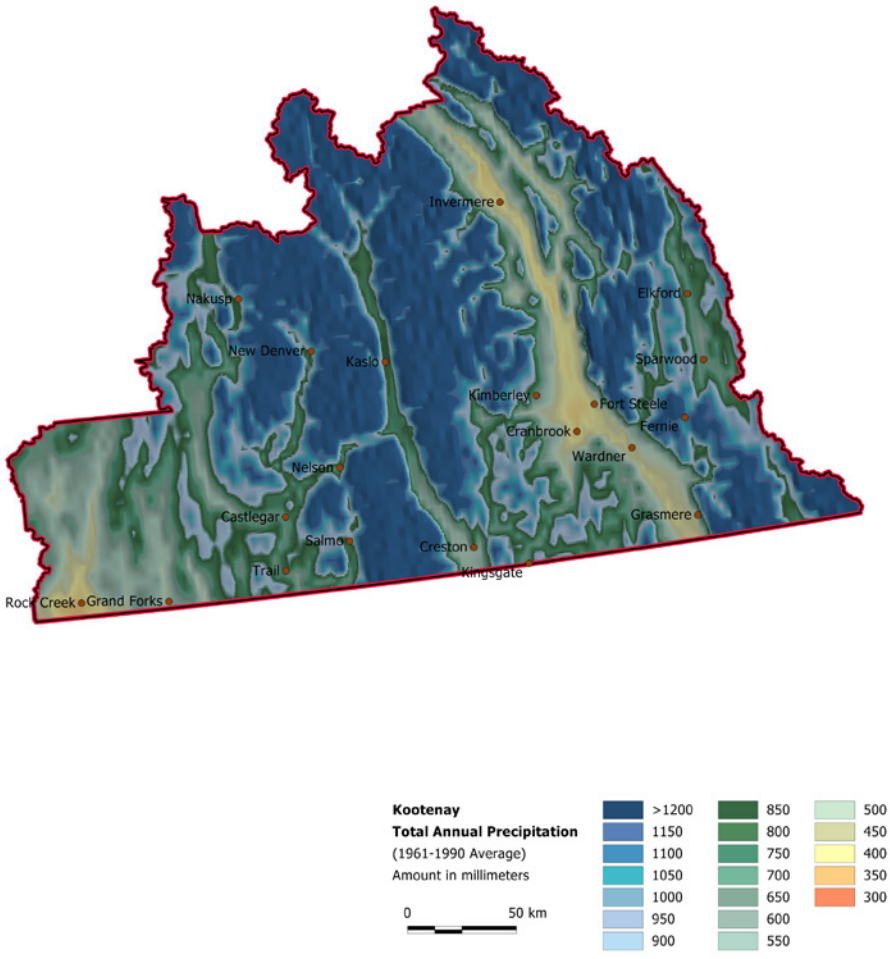


Figure 5.4(b) Kootenay total annual precipitation (1961-1990 average).

Northeast – Peace-Liard

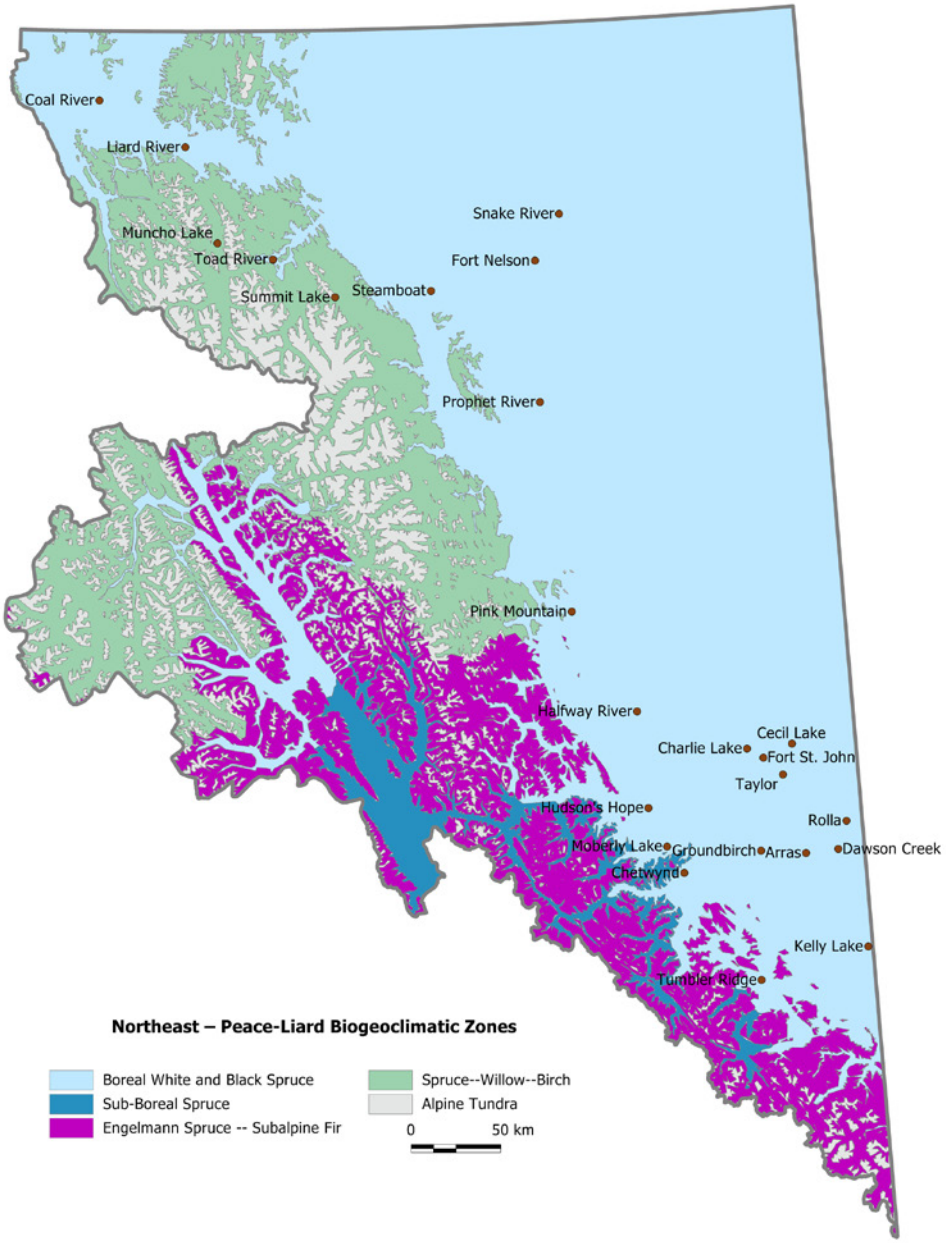


Figure 5.5(a) Northeast – Peace-Liard Biogeoclimatic Zones.



Figure 5.5(b) Northeast – Peace-Liard Biogeoclimatic Zones.

Thompson – Okanagan

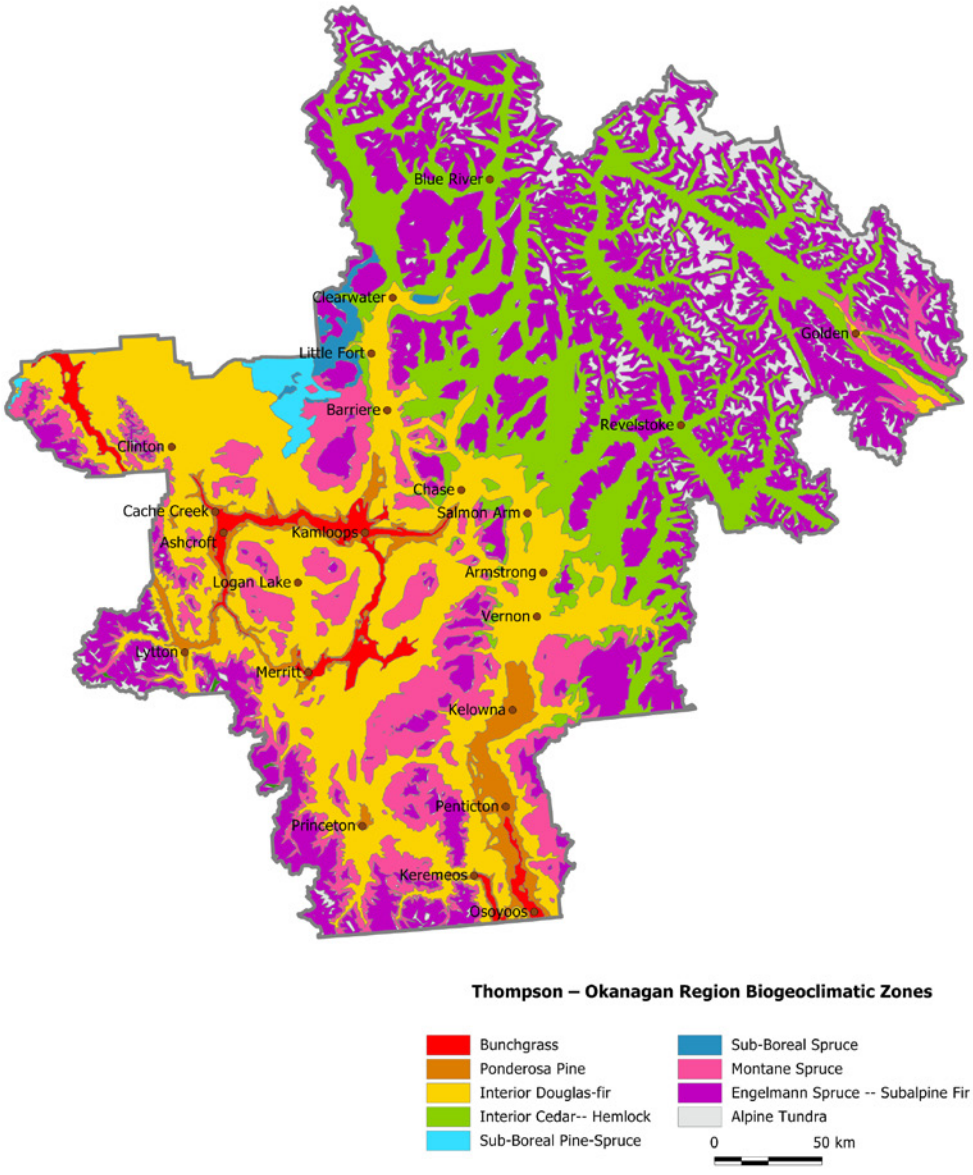


Figure 5.6(a) Thompson – Okanagan Biogeoclimatic Zones.

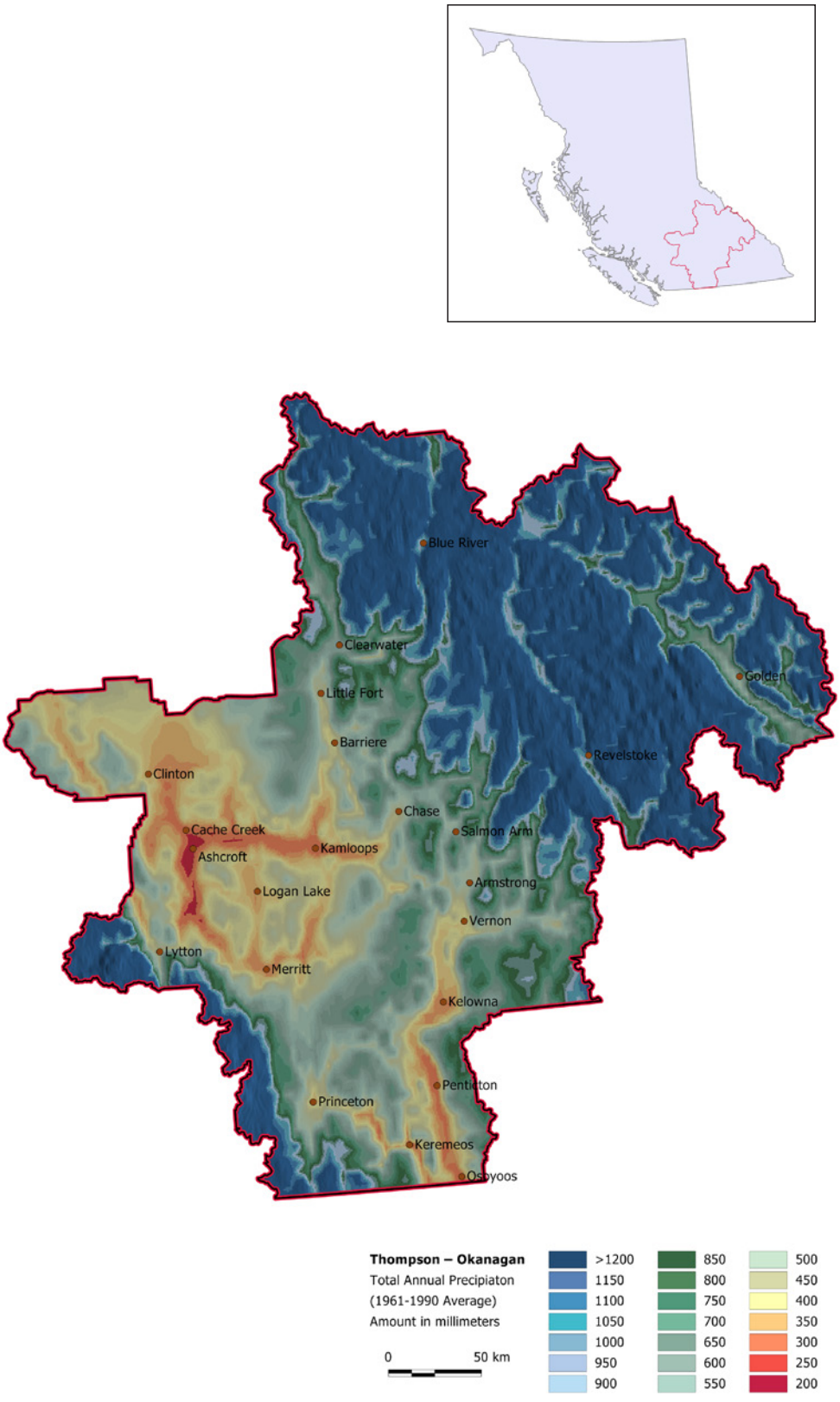


Figure 5.6(b) Thompson – Okanagan total annual precipitation (1961-1990 average).

Table 5.1 Species summary ratings (species filters).

Precipitation and Objectives Filter

SPECIES FILTERS

Agronomic Grasses	Min ppt (mm)	Max ppt (mm)	Drought Tolerance	Flooding Tolerance	Control Erosion	Suppress Inv Plants	Enhance Forage
Canada bluegrass	300	1100	H		H		M
Kentucky bluegrass	350	1100	M	M	H	M	M
Hybrid bromegrass	300	600	H	M	M	H	H
Meadow bromegrass	350	600	H	L	M	L	H
Smooth bromegrass	350	600	H	H	H	H	H
Chewings fescue	400	600	H	M	M	H	L
Creeping red fescue	400	600	M	M	H	L	M
Hard/sheep fescue	300	760	M-H	L	H	H	L
Tall fescue	400	600	M	M	M	M	H
Orchardgrass	400		M	M	L	M	M
Italian ryegrass [a]	400	600	L	H	H	H	H
Perennial ryegrass [a]	400	600	L	H	H	H	H
Red top	450		M	M	H		L
Timothy	400	600	L	H	M	L	M
Crested wheatgrass	200	450	H	L	M	H	M
Intermediate/Pubescent wheatgrass	330	1120	M	L	H	M	H
Tall wheatgrass	300	550	H	M	M		M
Dahurian wildrye	300	600	H	M	L	L	H
Russian wildrye	200	450	H	L	L	L	M
Agronomic Legumes	**Min ppt (mm)**	**Max ppt (mm)**	**Drought Tolerance**	**Flooding Tolerance**	**Control Erosion**	**Suppress Inv Plants**	**Enhance Forage**
Alfalfa	300	600	H	M	M	L	H
Birdsfoot trefoil	400	600	M	H	L	L	M
Alsike clover	400	600	L	M	M	M	M
Red clover	400	600	M	M	M	M	H
White clover	400	600	L	M	M	M	M
Sainfoin	300	600	M	L	M	L	H
Cicer milkvetch	350	600	M	L	H	L	H
Common vetch	310	1630	L	L	H	H	H
Hairy vetch	450	1650	H	M	H	H	H

[a] Suitability ratings short-term unless combined with longer-lived species.

Legend

Abbreviations in Headings
Precipitation

Min = Minimum
Max = Maximum
ppt = Precipitation

Suitability & Adaptation Ratings

L = Low
M = Moderate
H = High

Seeding Objectives

Control Erosion = Erosion Control
Suppress Inv Plants = Invasive Plant Suppression
Enhance Forage = Forage Enhancement

Adaptation and Soils Filter

Agronomic Grasses	Ease of Estab	Winter Hard	Persist	Comp	Long	Graz Recov	Texture	Acidity	Salinity
Canada bluegrass	M	M	M	M	M	L	A	M	
Kentucky bluegrass	M	H	H	H	H	H	A	H	L
Hybrid bromegrass	H	H		H	H	H	A	M	M
Meadow bromegrass	M	H		M	H	H	A	M	M
Smooth bromegrass	M	H	H	H	H	L	A	M	H
Chewings fescue	H	M	H	H	H	M	MC	H	M
Creeping red fescue	H	H	M	M	H	H	A	H	M
Hard/sheep fescue	M	M	H	H	H	M	FM	L	
Tall fescue	M	M	L	M	M	H	FM	H	H
Orchardgrass	H	L	M	M	M	H	FM	H	L
Italian ryegrass	H	L	L	H	L	H	A	H	M
Perennial ryegrass	H	L	L	H	L	H	FM	H	L
Red top	M		H		H	L	F	H	L
Timothy	M	H	M	M	H	L	A	H	L
Crested wheatgrass	M	H	H	M	H	M	A	M	H
Intermediate/Pubescent wheatgrass [b]	H	H	M	M	M	L	FM	M	M
Tall wheatgrass [b]	L	M	M	L	H	M	FM	L	H
Dahurian wildrye	H	M	L	M	L	H	A	M	H
Russian wildrye [b]	L	H		H	H	M	FM	M	H
Agronomic Legumes	**Ease of Estab**	**Winter Hard**	**Persist**	**Comp**	**Long**	**Graz Recov**	**Texture**	**Acidity**	**Salinity**
Alfalfa	H	M	M	M	H	M	A	L	M
Birdsfoot trefoil	L	L	M	L	M	M	FM	H	H
Alsike clover	H	H	M	M	L	H	F	H	L
Red clover	H	M	L	H	L	M	A	H	L
White clover	H	L	M	M	L	H	FM	H	L
Sainfoin	M	H	L	L	M	L	A	L	L
Cicer milkvetch	M	H	M	M	H	H	A	L	L
Common vetch	M	L	H	M	L	M	A	M	
Hairy vetch	H	H	L	H	L		C	L	L

[b] Tolerance for alkaline soils with pH up to 9.0; source: U.S. Department of Agriculture NRCS. 2011. The PLANTS Database, National Plant Data Team, Greensboro, N.C. http://plants.usa.gov/java [Accessed June 13, 2011].

Legend

Abbreviations in Headings Adaptation & Soils

Ease of Estab = Ease of Establishment
Winter Hard = Winter Hardiness
Persist = persistence
Comp = Competitiveness
Long = Longevity
Graz Recov = Recovery after use
Texture = Soil Texture
Acidity = Acidity Tolerance
Salinity = Salinity Tolerance

Suitability & Adaptation Ratings

L = Low
M = Moderate
H = High

Soil Texture Ratings

A = All Textures
C = Coarse textured
MC = Medium to Coarse textured
M = Medium textured
FM = Fine to Medium textured
F = Fine textured

Precipitation and Objectives Filter

Native Grasses	Min ppt (mm)	Max ppt (mm)	Drought Tolerance	Flooding Tolerance	Control Erosion	Suppress Inv Plants	Enhance Forage
Fringe bromegrass	400		M	L	H	M	H
Big bluegrass [c]	255	610	M	L	H	M	L
Fowl bluegrass	450	1270	L	L	M	M	L
Reed canarygrass [c]	350	600	M	H	H	M	H
Bluejoint reedgrass	360	1650	M	H	H	H	L
Pinegrass	400	660	H		H		L
Junegrass	300	500	H	M	M	M	M
Rocky Mtn/Alpine fescue	350	900	H	L	H	L	L
Idaho fescue [c]	305	510	M	L	M	L	M
Rough fescue	350	610	L	L	L		M
Tufted hairgrass [c]	400		L	H	M	L	M
Bluebunch wheatgrass [c]	200	500	H	L	L	L	M
Slender wheatgrass [c]	350	600	M	M	M	M	M
Western wheatgrass [c]	300	510	H	M	H	M	M
Blue wildrye [c]	400	1500	M	L	M	M	M
Canada wildrye [c]	500	1140	M	L	H	L	L
Fuzzy-spike (Hairy) wildrye	400	900	H	M	H		L
Native Legumes	**Min ppt (mm)**	**Max ppt (mm)**	**Drought Tolerance**	**Flooding Tolerance**	**Control Erosion**	**Suppress Inv Plants**	**Enhance Forage**
Creamy peavine	400	700	L	L	L	L	M
American vetch	225	1270	H	L	L	L	H

[c] Recognized varieties have been developed for these species. Plant materials used in the development of these selections may come from geographically diverse and/or distant populations. In restoration situations where there is a native plant community objective, and a desire to maintain a high level of ecological integrity, seed from local ecotypes or wild populations may be preferred (see Restoration Gene Pool Concept on page 50 – Chapter 3, and Native Seed and Native Seed Production 148 – Chapter 7 for guidance).

Legend

Abbreviations in Headings
Precipitation

Min = Minimum
Max = Maximum
ppt = Precipitation

Suitability & Adaptation Ratings

L = Low
M = Moderate
H = High

Seeding Objectives

Control Erosion = Erosion Control
Suppress Inv Plants = Invasive Plant Suppression
Enhance Forage = Forage Enhancement

Adaptation and Soils Filter

Native Grasses	Ease of Estab	Winter Hard	Persist	Comp	Long	Graz Recov	Texture	Acidity	Salinity
Fringe bromegrass	H	H	H	H	M	L		M	L
Big bluegrass [c]	M	M	M	H	H	H	A	M	L
Fowl bluegrass	M	H		M	M	L	FM	H	L
Reed canarygrass [c]	L	H	H	H	H	H	FM	H	L
Bluejoint reedgrass	H	H	H	H	H	M	A	H	M
Pinegrass	L	M	M	H	H	H	FM	H	
Junegrass	L	H	M-H	H	M	L	MC	L	L
Rocky Mtn/Alpine fescue	H	H	M	L	H	M	MC	M	L
Idaho fescue [c]	L	H	H	M	H	M	M	M	M
Rough fescue	L	M	M	H	H	L	MC	M	
Tufted hairgrass [c]	L	H		M	L	H	A	M	M
Bluebunch wheatgrass [c]	L	M	M	M	H	L	MC	L	L
Slender wheatgrass [c,d]	H	H	M	M	L	L	FM	M	M
Western wheatgrass [c,d]	M	H	M	M	H	M	FM	L	M
Blue wildrye [c]	H	M	M	H	L	L	A	M	L
Canada wildrye [c]	H	M	L	L	L	L	MC	M	M
Fuzzy-spike (Hairy) wildrye	M	H		L			C	M	M
Native Legumes	**Ease of Estab**	**Winter Hard**	**Persist**	**Comp**	**Long**	**Graz Recov**	**Texture**	**Acidity**	**Salinity**
Creamy peavine	L	M	H	L	M	L	MC	L	M
American vetch	L	M		L	H	L	A	L	M

[c] Recognized varieties have been developed for these species. Plant materials used in the development of these selections may come from geographically diverse and/or distant populations. In restoration situations where there is a native plant community objective, and a desire to maintain a high level of ecological integrity, seed from local ecotypes or wild populations may be preferred (see Restoration Gene Pool Concept on page 50 – Chapter 3, and Native Seed and Native Seed Production 148 – Chapter 7 for guidance).

[d] Tolerance for alkaline soils with pH up to 9.0; source: U.S. Department of Agriculture NRCS. 2011. The PLANTS Database, National Plant Data Team, Greensboro, N.C. http://plants.usa.gov/java[Accessed June 13, 2011].

Legend

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A = All Textures
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Chapter 6. Seedling and Stand Establishment

Previous chapters of this manual considered the questions: "When is seeding appropriate?" and "what species might be suitable for seeding given various regional site conditions and objectives"? This chapter looks at the details of successful seedling and stand establishment. This information is critical for rangeland seeding in British Columbia, where management contexts and site conditions are highly variable.

Key factors and the stages of seedling and stand establishment are summarized in Figure 6.1. The interaction between the seed and the soil surface is critically important in the first three stages of this process: (1) seed application; (2) pre-germination, and (3) germination. Important interactions between the seedling and the soil continue through stage 4, the period of seedling establishment. In the growth and mature stand phases, post-seeding management practices like grazing and mechanical treatments can influence productivity of the seeded stand and the progress of succession toward a native plant community. These factors are especially important on forest sites.

The **Seed Application** stage is critical since it is here that site conditions are created or modified to enhance seed-to-soil contact. Important application considerations include the management context, seeding method timing and depth of seeding, seed mix calculations, legume inoculation, and seeding rates.

In the **Pre-germination** stage, soil temperatures sufficient to stimulate germination are needed. With some exceptions, most agronomic species have "normal" germination requirements and do not require temperature stratification. Stratification, scarification, and the use of hormones are additional methods used to break seed dormancy and are sometimes used to improve the germination rate of native species. In the period before germination, seeds are vulnerable to depredation by insects, birds, and small mammals especially if they are left exposed on the soil surface.

At the **Germination** stage, seed viability, soil surface conditions, moisture and soil coverage, drought and flooding tolerances, risk of freezing, and disease are important factors.

Major factors in the **Establishment** stage of plant growth are soil moisture, freezing and drying cycles, soil fertility, competition, and post seeding practices such as weed control, grazing and mowing, and risk of disease or insects.

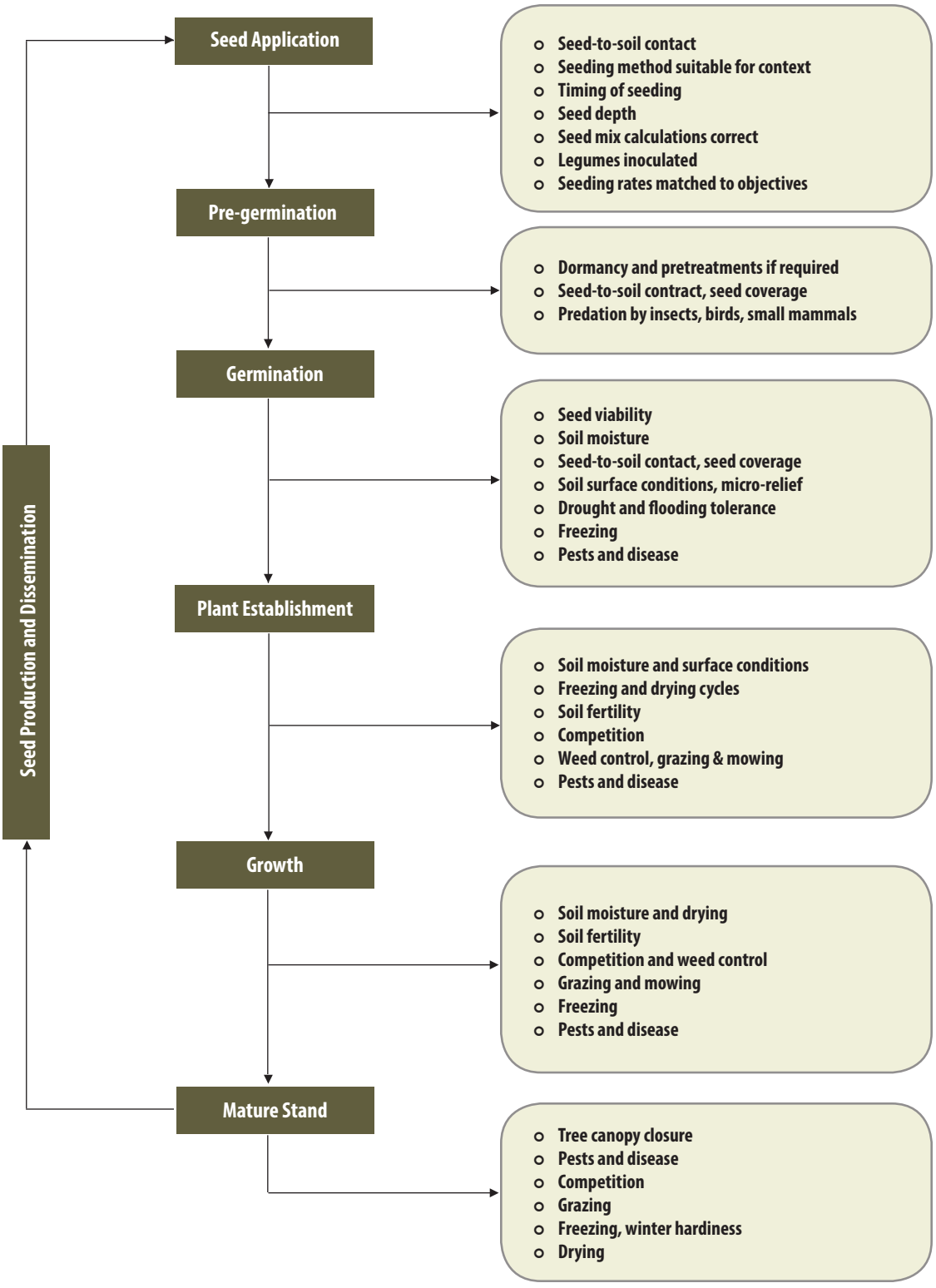


Figure 6.1 Factors affecting seedling and stand establishment.

Source: Adapted from P. Youwe et al., Effects of Areal Seeding on Forage Stand Development on Montane Spruce Clearcuts: Project 3.55, FRDA Research Memo No. 184 (Victoria, B.C.: Canadian Forest Service and B.C. Ministry of Forests, 1991).

Seed-to-Soil Contact

Sufficient seed-to-soil contact is critical for germination and establishment, and is the primary purpose of carrying out a seedbed or disturbance assessment (see Chapter 4). If the seed cannot take up moisture from the soil and establish roots, it will not survive. A hard bare soil surface is an inhospitable place for germination and establishment. Soil and seedbed conditions need to be considered in all situations, regardless of the management context, objectives, land preparation, site disturbance, or seeding method.

The idea of seed-to-soil contact is best appreciated by getting right down to the level of the seed and the soil surface. Researchers have suggested successful establishment is determined by the number of "safe" microsites in the soil surface.[1] Ultimately, plant density is determined by the number of safe sites available rather than just the number of seeds. Numerous studies have shown that safe microsites can be equated to placement in the soil, or conditions on the soil surface that allow contact and protection of the seed.[2] The beneficial effects of plant litter on the surface have been demonstrated in many research trials.[3,4] However, there are situations where too much litter can be a problem. The number of suitable microsites can be increased with various site preparation treatments.

Smaller seeds have much lower food reserves and thus little flexibility for false starts. However, small-seeded species appear to have superior surface germination qualities. It is suspected that small seeds are better able to find, or fall into, safe microsites when broadcast methods are used. For larger-seeded species, seed-to-soil contact can be improved by harrowing, packing, rolling, or very light cultivating or other disturbance immediately after seeding. It can also be enhanced by animal hoof action, manure, compost, hay, straw, or other soil amendments and erosion blankets. All post-seeding treatments must be applied appropriately to have the desired effect.



Photo Credit: A. Dobb.

Small depression providing a safe micro-site for grass seedling establishment on bare tailing surface.



Photo credit: A. Dobb.

Seed broadcast on textured soil surface with some safe microsites for germination.

Seeding Methods

Seeding methods can be broadly grouped into three different categories: (1) broadcast methods; (2) drilled or direct seeding methods; and (3) specialized methods. In British Columbia, the seeding method is determined largely by the management context and terrain, but also by site conditions, objectives, and project scale. Broadcast methods are the most common form of seed application, and can be used in all contexts. Unfortunately, some broadcast methods present additional challenges to seed germination and establishment, especially if the seeding application is not followed by an additional light disturbance. The greatest number of seeding options is available in the pasture context, but only for pasture on converted lands (see "Pasture context" page 143). The entire range of seeding methods is presented in Table 6.1, along with the appropriate project scale, resources required, advantages, limitations and concerns, and applicable contexts.

Table 6.1 Description of common seeding methods by appropriate project scale, resources required, advantages, limitations and concerns, and typical management context.

Seeding Methods	Scale of Project	Resources Required	Advantages	Limitations and Concerns	Typical Context
BROADCAST METHODS					
Hand seeding	Small	Low cost Low equipment needs	Rates may not be accurate Raking to improve results	Rates may not be accurate Raking to improve results	
Hand driven cyclone seeder	Small	Low cost Easily acquired equipment	Works well for roads, landings, skid trails, fencelines, suitable various terrain	Needs raking, harrowing for best result	
Motor driven cyclone spreaders	Medium	Moderate - low cost Minimal equipment needs	Works well for roads, skid trails, landings	Needs raking, harrowing for best results	
Seed attachments to disturbance equipment	Medium	Moderate - low cost Moderate equipment needs	Seeding at disturbance Improved soil seed contact without additional treatment	Uneven seed distribution and soil cover depending on design	
Floaters, Valmar and other dribble attachments	Medium	Moderate - low cost, common equipment in agriculture areas, can be modified	Can provide consistent application rates	Needs post-seeding disturbance or rolling	
Air blast seeders	Medium to large	Relatively low cost	Convenient for remote locations and large volumes of seed in short time span	Only on slopes < 2:1, similar limitations to other broadcast methods	
Hydro seeders	Medium	High cost Specialized equipment	Good method for steep slopes and critical areas	May require a mulching pass prior to seeding	
Aerial seeding by helicopter or airplane	Large	Costs dependent on scale, distance from air operations base; pilot and trained ground crew required	Convenient for remote locations and large volumes of seed in short time span	Seed drift, variable rates, some form of post seeding disturbance for best results	
DRILLED OR DIRECT SEEDING METHODS					
Drilled seed into cultivated seedbed	Medium	High cost, equipment and time required	Seed-to-soil contact Phosphorus can be placed	High disturbance leaves soil vulnerable	
Direct seeding or sod seeding	Medium	High capital, specialized equipment, informed labour	Seed-to-soil contact Soil moisture conserved Phosphorous can be place	May need to reduce competitive vegetation, requires prep.	
SPECIALIZED METHODS					
Erosion blankets with seed	Small	Higher cost per unit area, specialized equipment and labour	Soil to seed contact Immediate erosion control Moisture retained	Knowledgeble labour	
Spreading soil with seed bank	Medium	Medium cost spreader with vertical beaters ideal	Soil to seed contact, topsoil salvaged, moisture retained	Variable establishment	
Seed with amendments (manure, compost, hay)	Medium	Moderate to high cost, Spreader with vertical beaters ideal	Soil to seed contact Erosion control Moisture retained	Can be weed concerns with manure and hay	
Hay seeding or seeding with ripened stems and seed	Small	Moderate cost and labour needed	Can provide mulch, moisture retention	Need straw or hay of appropriate species	
Seed with livestock salt	Small to medium	Low cost, holistic management	Seed-to-soil contact with hoof action, fertility enhancement	Suited to species with superior surface germination	

Legend:

Forest land Grazing and Silvopasture · Pasture · Grassland Restoration
Ecosystem Restoration · Post-Wildfire Rehabilitation · Site Rehabilitation

Broadcast Seeding Methods

Broadcast methods have a relatively low cost/unit area, and are the only seeding methods suitable for rough and steep terrain (excluding erosion blankets). Inaccurate seeding rates and seed drift can be problematic especially with aerial seeding. Seed drift may be more pronounced with fixed-wing applicators, where air speed is higher. Airplane seeding is suitable when large areas need to be covered. Access to a suitable landing strip is important for remote fixed-wing applications. Helicopter seeding is more flexible, accurate, and better suited to smaller areas.



Photo credit: Courtesy of Truax Company, Inc.

Small cyclone seeder mounted on ATV.

Coverage can be uneven when the seed is broadcast using a propeller mechanism (e.g., cyclone spreaders). This is especially true for seed mixtures, where lighter seed is not propelled as far as heavier seed. However, the versatility of these units attached to quads or other all-terrain vehicles is hard to beat for many applications. Light harrows or floats can also be pulled behind these units when site conditions allow.

When more accurate seeding is required on relatively even terrain, dribble- or gravity-type applicators are more suitable. Dribble seeders usually have a metered seed box extending the full width of the applicator. Plastic tube openers at even intervals allow for seed drop. Post-seeding disturbance can be accomplished at the same time depending on design and how they are attached to the machine or implement. Often these units are followed by culti-packers in the same pass. Some air type attachments have a central seed tank, and seed is distributed through tubes and dropped to the ground at evenly spaced intervals. This type of seed distributor can be mounted to just about any type of equipment.



Photo credit: Courtesy of Truax Company, Inc.

Imprinter attachments follow behind dribble seed tubes on combination dribble/direct seed drill.

Floaters are large self-propelled machines with floatation tires, a seed tank, and booms that extend 12-19 m (40–60 feet). Seed is distributed by air through tubes mounted on the booms and dropped on the ground. Terrain needs to be relatively flat with no obstructions. This method is most suitable on converted pastures

The main limitation of broadcast methods is uneven germination and establishment, particularly without some form of post seeding disturbance like raking, harrowing, rolling, culti-packing, or floating. Seed loss due to depredation can be significant without soil cover.[5] In rehabilitation contexts, post seeding disturbance treatment and cover can sometimes be provided by the heavy equipment involved in soil replacement.

Drilled or Direct Seeding Methods

Drilled or direct seeding methods involve equipment that places the seed into the soil. These methods include traditional agricultural seed drill equipment (double disc and hoe drills) as well as modern specialized equipment and various minimum tillage and air seeders. These methods are only suitable on relatively level terrain that is free of large rocks and woody debris, limiting their use mostly to converted pasture lands. However, there may be some application of some equipment for large-scale site rehabilitation.

Traditional seed drills require a cultivated seedbed, introducing additional cost and leaving soil vulnerable to erosion. However, this method allows ultimate control of the seedbed and more exact placement of seed.

Exact seed placement can also be achieved with minimum tillage (direct) and sod seeding equipment. Soil and moisture conservation is the main advantage of this type of seeding method. Though specialized equipment is required, costs are generally reduced because cultivation is not required to prepare the seedbed.

Specialized Seeding Methods

Specialized seeding methods are often used in rehabilitation and restoration contexts. They are typically designed for site-specific applications, and often incorporate mulches or other soil additives (e.g., compost). Other specialized approaches emulate natural seeding such as hay seeding, where mature plant material with attached seed heads is spread on areas to be revegetated. Seeding with livestock by feeding seed with salt is another natural method although it is mostly suited to legumes (see "Pasture context"). Livestock impacts can be integrated with hay or straw feeding to provide disturbance and stimulate nutrient cycling on severely disturbed sites.



Photo credit: T. Wheeler.

Cattle and hay used to stimulate nutrient cycling and establishment of vegetation on mine tailings.

Erosion blankets are manufactured from straw or other organic materials and are stitched together inside a webbing material to maintain their structure. They are placed over a seeded soil surface and pinned to the ground, usually on highly erosive areas and steep slopes. While they are not practical at very large scales, these specialized methods are very useful for seeding difficult sites on challenging terrain or soil conditions.

Timing of Seeding

Proper timing of seeding balances several factors. Minimal time since disturbance, the season that provides the best general conditions for germination, and establishment to meet objectives of the seeding are the main considerations. Seeding should take place as soon as possible after the disturbance treatment or when the seedbed is ready. Leaving a site unseeded for too long opens up the possibilities of increased soil erosion, compaction, and weed or invasive plant competition.

The timing of seeding must also meet the germination and establishment requirements of the seeded species. Adequate soil moisture and threshold temperatures are needed. Soils need to be warm enough. Soil temperatures between 10 and 20° C are optimum for germination, although germination may occur at lower temperatures. There are three commonly recognized seasons for seeding.[6,7]

Spring seeding is usually carried out from March to mid-June. Cool season grasses adapted to British Columbia often establish best if seeded in early spring. The main advantage of this season in many parts of British Cobumbia is the moisture available from snow melt to assist in germination, and the early timing allows plants to establish over the growing season.

Early fall seeding refers to seeding from August to September. This is late enough so that vulnerable seedlings avoid high temperatures and summer droughts, but early enough to avoid risk of frost damage. Growing conditions and soil moisture must be ideal for quick germination, establishment, and sufficient growth before a hard frost. Six to eight weeks is usually required to get alfalfa to the two-leaf stage and grasses to the two- or three-leaf stage. The unpredictability of fall precipitation makes early fall seeding riskier than other seasons, especially if there is insufficient moisture in the seedbed at the time of seeding.

Late fall or winter seeding refers to seeding from late October to March. Winter seeding is also called frost-seeding or snow-seeding. Seeding in the winter is useful when a species requires a dormancy period before germination, and where freeze-thaw cycles are needed to break dormancy. Grasses seeded in this season do well and there have been recent successes with legumes. If the legume seed has been scarified, late fall seeding is preferred. Freeze-thaw cycles can have negative impact on the survival of snow-seeded alsike clover compared to orchard grass.[8] Germination is possible at very low temperatures (1–5° C) if conditions remain moist and dormancy requirements have been met. Low temperature germination is possible under snow cover in the Interior Douglas-fir zone.[9]

Seed Depth

Seeding at the wrong depth in the seedbed is one of the most common reasons for plant establishment to fail for both agronomic and native species.[10,11,12] Seeds need sufficient oxygen to germinate. This is especially a problem for direct seeding methods. Incorrect seed depth can also be a problem for broadcast methods, if post seeding disturbance is too severe. For example, seeding before the spreading of topsoil in a rehabilitation context can be an efficient way of getting seed cover, providing the topsoil is evenly spread to the appropriate depth. However, seed could end up too deep in the soil if the spreading is not carefully monitored, or if the machine operator is not informed. If broadcast methods are used, and there is no incorporation or post seeding disturbance, small seeded species that are better surface germinators should be considered. These include species like timothy, fescues, clovers, and many native species.[13] In contrast bromegrasses, ryegrasses, alfalfas, and companion crops such as fall rye establish better when they have soil cover.

Seed depth should be no more than five times the diameter of the seed. Seed drills are often set at depths appropriate for annual crops or set too deep for the size of the seed. Other times operators are trying to place seed to contact sub-soil moisture, which can be quite deep in an overworked seedbed. Additional harrowing or culti-packing passes following direct seeding methods should not leave the seed too deep in the seedbed.

Seeding depth can be checked at the time of seed rate calibration in direct seed methods. This procedure can be made easier by the use of seed carriers, such as roasted dyed grains, starter phosphate fertilizer, or coated seeds. Seeding depth in broadcast methods depends on a light disturbance to the surface like raking, harrowing, packing, or floating. When these treatments are not applied, broadcast seed can find "safe" microsites in small crevices, or places in the surface where seed-to-soil contact is possible (see "Seed-to-soil contact" section). However, this will depend on the site and soil conditions, the type and severity of disturbance, and pre-seeding treatments.



Photo credit: Lance Brown.

Spring seeding in early June with dribble seeder mounted above double gang packers and pulled behind double gang offset disc on transmission line right-of-way in the Cariboo region.



Photo credit: Lance Brown.

Successful germination and establishment (photo taken at the same location in early October).

Mixtures and Calculations

Species are sometimes selected to be seeded alone for a specific objective, or combined into seed mixtures. Both approaches have specific advantages in certain situations.

Advantages of single species:

- Easier to seed evenly at desired rate
- Easier to achieve uniform growth, grazing, palatability, and regrowth
- Used sometimes to utilize species of lower palatability
- Establishes more stable stand of plant composition
- Meets specific requirements of difficult site rehabilitation conditions, and
- Fills more specifically a shortage in forage calendar

Companion or cover crops have been nicknamed "smother crops" by forage researchers and many successful grass and legume seed growers.[14] They should be avoided unless soil moisture and nutrients can be provided for both the intended species and the companion species. Many native grasses are not very competitive and are slow to establish so including a companion or nurse crop can defeat the purpose of the seeding. If a companion crop absolutely must be included for other reasons, it needs to be seeded at one-third the normal seeding rate and preferably cross-drilled or seeded between the grass or legume species rows in direct seeding methods.

Advantages of mixtures:

- Easier to establish a stand over variable climate and soil microsites
- Broadens the grazing or "green period"
- Can provide higher yield and nutritive value, when legumes are included in the mix
- Reduces the risk of total stand loss due to climate or insect damage
- Provides more plant diversity and multi-species use (e.g., wildlife, insects, pollinators), and
- Allows more flexibility if some seed sources are in short supply

There are several factors to consider in developing a seed mix. Some have already been mentioned in the Objective Analysis section in Chapter 4. The characteristics of selected species should be suited to the desired objectives. Species characteristics are expressed through growth form and other traits including:

- rooting profile
- nitrogen-fixing ability
- growth form and ability to provide erosion control (e.g., creeping, tufted, bunched)
- forage yield and quality (i.e., palatability, total energy, protein)
- ease of establishment and seedling vigour (often related to size of seed)
- competitiveness and aggressiveness of plant species, and
- persistence over time (e.g. winter hardiness, drought tolerance, flooding tolerance, grazing recovery, longevity)

Ratings for some key characteristics are provided in the species summary table (Chapter 5) and in the species summaries (Chapter 8) to assist in designing the best seed mix for the situation.

Seed mixes can be complex "shotgun" mixes of 6 to 12 species or as simple as a single grass species combined with a legume species. The shotgun approach may have its place in low risk, small-scale revegetation projects. However, this approach may not meet seeding objectives in many situations. This manual recommends establishing objectives and developing seed mixes to specifically meet those objectives.

Mixes should be developed so that each species has a role to play in the mix. Some species may be chosen for their adaptability for certain microsite conditions, while others may be chosen for their suitability to meet specific objectives. Species should be selected first for suitable adaptation characteristics, and second for their ability to meet desired objectives.

Legumes are included to improve soil condition, fix nitrogen, or improve forage quality. The amount of legume desired in the stand will depend on the context and forage objectives. In the pasture context, 30 to 40% legume is usually sufficient. In restoration contexts, the percent legume may be targeted to match the initial plant community composition. For some objectives, two or three legumes might be used, combining a quick-to- establish, short-lived legume with a longer-lived legume. Another approach may be to combine one legume species with a shallow tap root and mat-forming stolons for erosion control, with a deeper, tap-rooted legume to increase soil porosity.

Grass species are often included to out-compete weeds, stabilize sites, control erosion, and improve the site's forage production yields. There has been considerable research selecting agronomic grass species that perform well for these purposes; however, the management context and/or objectives may favour the use of native species.

Inoculants for Legumes

To effectively fix nitrogen, legumes require the presence of sufficient rhizobia bacteria close to the roots. Inoculating agronomic legume seed ensures that the appropriate bacteria are high enough in numbers and close enough to the roots for effective nodulation and nitrogen fixation. Inoculants are available in different forms (powdered, coated, granular) and in different strains. Most legume seed is available pre-inoculated but the expiry date should be checked. Inoculant can be mixed with seed by hand or with auger arrangements, but a sticky liquid (two tablespoons of corn syrup in a litre of water) may need to be added to improve adhesion to the seed, if not already part of the inoculant mixture.

Some soils may contain naturally occurring rhizobia bacteria, or the rhizobia introduced from previously seeded vegetation. There are many strains of naturally occurring rhizobia in Canadian soils; however, how these might be used to benefit nitrogen fixation by seeded native legumes has not been fully explored.[15] The bacteria associated with nodulation on common native northern legumes, such as vetch (nodulated by *Rhizobium leguminosarum*) and Astragalus (nodulated

by *Mesorhizobium* spp.) has been identified. However, the benefit of using commercial inoculants currently available on native legumes has not been tested.[16]

Table 6.2 Inoculants for some common agronomic legumes.

Species	Appropriate Inoculant
Alfalfa, Sweet clover	*Sinorhizobium meliloti*
Alsike clover, Red clover, White clover	*Rhizobium trifolii*
Birdsfoot trefoil	*Rhizobium loti*
Cicer milkvetch, Sainfoin, Kura clover	*Rhizobium* spp. (species specific strains)

Source: A. Aasen and M. Bjorge, Alberta Forage Manual, 2nd edition (Edmonton, AB: AB Agric Agdex 120/20-1, 2009), www.agriculture.alberta.ca/publications.

Seeding Rates and Calibration

Seeding rates are commonly provided in kilograms per hectare (kg/ha) or pounds per acre (lb/acre). Commercial seed is bagged and sold by weight, so it is easy to determine whether the seed is being applied at the desired rate based on the area covered. Some seeding rate recommendations are developed from field trials, with species drill seeded in rows under optimal seedbed conditions. Other recommended rates, like those provided for seeding forest clearcuts to increase forage production, are developed from a combination of research trials and operational experience.[17] In general, more research is needed to support specific seeding rate recommendations in a variety of climates and situations.

Pure Live Seed and Desired Plant Density

In the rehabilitation and restoration contexts, seeding rates are sometimes expressed as pure live seed per square metre (PLS/m^2). Pure live seed is a measure of seed viability and quality used in the seed production and processing industry. It is calculated by multiplying percent germination by percent pure seed (excludes weed seed, other crop seed, and inert material). Both of these percentages should be available from the seed supplier or the seed analysis laboratory by request (see Chapter 6). Live seed is determined in specialized germination chambers or by tetrazolium chloride or TZ testing —a chemical that stains living seed. TZ testing is better suited to species with a large amount of dormant seed.[18] If seed has been stored for more than one year, a quick germination test can be done by placing 100 seeds on a damp paper towel in a petri dish to determine the percentage of germinated seed.

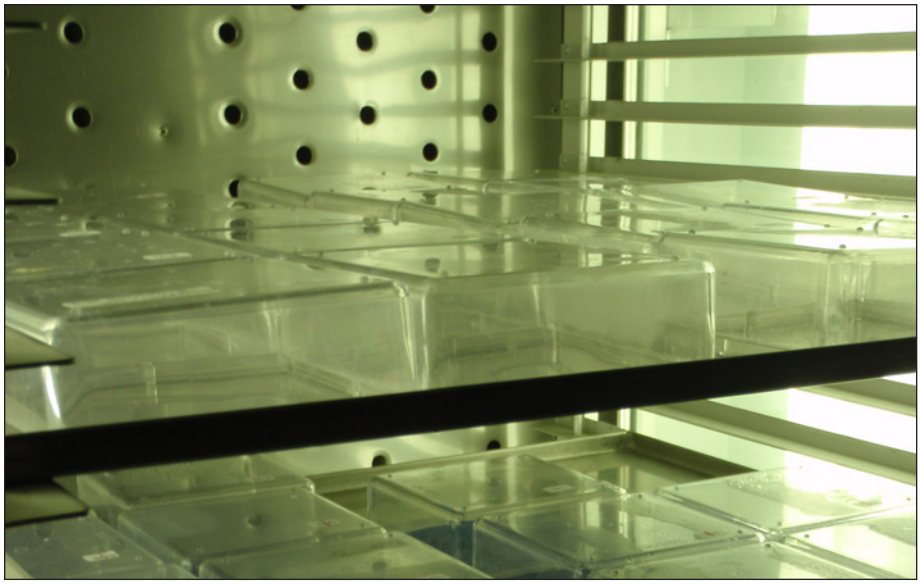


Photo credit: Owen Lee.

Seed germination chamber.

Seeding rates are based on a desired plant density at establishment. Considering desired plant density is an especially useful way of developing seeding rates for mixes chosen to achieve complex objectives. For example, Italian ryegrass is a quick-to-establish, short-lived grass used to mitigate erosion after wildfire in warmer regions. In this context, a quick cover is needed, followed by slower establishing perennials that eventually allow the native plant community to re-establish. Using the PLS/m^2 and establishment factors, the amount of seed of each species needed in the mix can be estimated (see example calculation in Appendix C). Seeding rates given as PLS/m^2 can easily be converted to kg/ha or lb/acre for applying seed.

Seed Weights

Seed numbers per unit of weight can vary widely between species. The seed number per standard unit of weight depends on the species, variety, seed size, density, and presence of a seed coating. Sometimes there are differences between tetraploid and diploid varieties. Actual seed numbers per unit weight can be different than reported values (see species summaries, Chapter 8). The number of seeds per unit of weight is determined by weighing a known number of counted seeds (i.e., determining the weight of 1,000 seeds) and converting this weight to number of seeds per gram or pound.

This manual (and most references) provides a rough measure of seed size based on the number of seeds per kilogram. The percentage of each species in a prepared seed mixture will look different depending on whether the calculation is done using weight or seed count. These differences are illustrated in Table 6.3. When small seeded species such as Canada bluegrass and timothy are expressed as a percent by seed count, the mix appears more balanced. The expression based on seed count gives a better indication of what is being seeded, and what an established stand might look like. However, seed establishment factors like dormancy, seed size and failed seed germination must be considered when

projecting the final composition of a stand. Seeding rates and mixes should be adjusted to account for germination and establishment factors. This is especially critical when seeding native species (see Appendix C).

Table 6.3 Difference in seed mix compositions when expressed as % by weight versus % by seed count.

Common Name	Scientific Name	% by Weight	% by Count
Italian ryegrass	*Lolium multiflorum*	32	30
Creeping red fescue	*Festuca rubra*	5	15
Canada bluegrass	*Poa compressa*	4	15
Timothy	*Phleum pratense*	4	10
Western wheatgrass	*Pascopyrum smithii*	35	15
Rambler alfalfa	*Medicago sativa*	20	15

Source: Adapted from R.F. Newman, Seeding to control weed invasion on the Strawberry Hills fire - Annual Report - 2007 (Research Branch, B.C. Ministry of Forests and Range, 2007).

Seed carriers can affect seeding rates. Examples of seed carriers include cracked or roasted grains, starter phosphate fertilizer, vermiculite, or inert materials. These are sometimes used to improve flow characteristics for extremely small seeds, or for species prone to bridging in seeding and handling equipment, such as meadow bromegrass. The addition of an annual cereal grain like fall rye to a mix can significantly increase the recommended seeding rate. For this reason, recommended rates for specific mixes are not necessarily interchangeable in any context.

Calibration

Calibration method varies with the method of seeding. Hand seeding can be the most difficult to calibrate, but since this method is often used at smaller scales the need for accuracy may not be as great. Most cyclone spreaders (both hand- and motor-driven types) provide instructions and calibration charts.
When seeding with tillage, direct or sod seeding equipment calibration is usually set for a desired number of plants per row. There are various calibration tools, kits, or procedures available, specific to these seed drills or air seeders. Seed carriers, dyed or coated seed can be used to assist with both seeding rate and depth calibration.

When specific calibration tools or procedures are unavailable, as in many broadcast methods, seed can be collected over a tarp (i.e., a known area; or from a bag attached to an individual seed drill opener over a known or measured distance) and weighed. When a tarp collection method is used to calibrate broadcast methods, the rate of travel (i.e., air speed or machine speed) used in

calibration and the seeding application should be the same. Seed collected from tarps can be weighed and converted to kg/ha or lb/acre. A square metre sticky board can also be used to check seed number/m^2. Hydro seeding and aerial seeding are used for larger-scale projects, and inaccurate calibration with these methods can have a substantial impact on project costs. Calibration and efficient seed refilling requires an informed crew of at least three people.



Photo credit: Kamloops Forest District Range staff.

Helicopter with broadcast seeding unit getting ready for a seeding rate calibration pass over tarp.



Photo credit: Kamloops Forest District Range staff.

Seed supply and ground crew for aerial seeding with helicopter.

Rates are often increased for broadcast methods, in rehabilitation contexts and when seeding native species to compensate for germination concerns and slower establishment. However, there are limits to this concept as higher rates do not always improve results. One British Columbia revegetation research study found seeding rate of several native species was optimized at between 750 and 1,500 PLS/m^2, corresponding to 190–301 established plants per square metre. There was no significant difference in cover between seeding densities of 1,500, 3,000, and

6,000 PLS/m^2 in the second year.[19] Seed densities as low as 375 PLS/m^2 produced plant cover in the second year after seeding equivalent to that observed at 3,000 PLS/m^2 in the first year.

Forage research from the seed production areas (Figure 7.1) shows that lower seeding rates establish better seed-producing stands. In ideal conditions, densities of 50 to 75 plants/m^2 for species with larger seeds like tall fescue, or 170 plants/m^2 for species with smaller seeds like timothy are optimal.[20,21] Seed production from native species that may be re-establishing on a site is also a factor in the seeding rate determination.

Pre-germination Issues

Seed dormancy can be an issue, especially with some native species. A permeable seed coat is needed to allow for the uptake of moisture. Germination of dormant seed-lots can often be enhanced by one of the following pre-treatments:[22]

- scarification of hard seed coats: on most legumes,
- pre-chilling and stratification (e.g., western wheatgrass),
- treatment with hormones like GA (gibberillic acid) to break dormancy, and
- dehulling seeds (e.g., green needlegrass, porcupine grass).

The degree of dormancy should be established through testing. Unselective use of pre-treatments can reduce germination. Some species are better suited to surface germination. This characteristic should be considered before choosing a broadcast seeding method, particularly when there is no post-seeding disturbance or incorporation treatment planned as part of the application.

Seeds may need to be protected from depredation in some situations by being covered with soil or using a direct seeding method. Insects, birds, and small mammals can all reduce the number of seeds available for germination and the effective seeding rate. The amount of hiding cover for birds and small mammals remaining after disturbance will likely be a factor in seed depredation.[23]



Photo credit: A. Dobb.

Example of bird or small rodent use of timothy seed in an established post-wildfire rehabilitation seeding.

Seedling Establishment

After germination, young seedlings may fail to establish because of:[24]

- **Drying** – Seed in loose soil may germinate after a light rain, but this type of soil can dry out quickly if not kept moist. Seedlings will die if roots are not sufficiently developed.
- **Freezing** – Seeds are sensitive to freezing just as young roots break through the seed coat. Temperatures below -3° C are lethal. Soil cover will provide insulation for seedlings at this stage. Once roots are better established, young seedlings can withstand colder temperatures.
- **Soil crusting** – soil crusts can prevent seedling emergence. Soil crusts often form in finer-textured soils, especially if they have been overworked.

Litter or mulch on the surface of the soil will minimize the effects of freezing and drying, and the formation of soil crusts.

Stand Establishment

The approach to successful stand establishment will vary with management context. For large-scale, post-wildfire rehabilitation or cutblock seeding, for example, establishment will be largely dependent on factors relating to the seed application, site preparation, and climate and site conditions after seeding (see application, pre-germination and germination stages, Figure 6.1).

When possible, planning for successful stand establishment should begin the year before seeding. This is especially true in a pasture context where it may be more cost effective to consider controlling perennial or invasive weeds or improving soil fertility before seeding. Stands that are uniform, vigorous, productive, and competitive are indicators of successful establishment. Conversely, poor establishment will often equate to poor growth for the life of the stand. It is very difficult to compensate for poor establishment in later years, and the original seeding objective(s) may not be met.

Weed Control

A plan for controlling weeds needs to be approached from an integrated pest management viewpoint well in advance of the seeding operation. The plan needs to involve actions before seeding, after seeding and during the establishment stage. Where practical, mechanical methods such as mowing, swathing, cultivating, or harrowing can be used to set weed growth back. A seeding operation may be delayed to allow weed growth and timely control before seeding.

Some specific invasive plants may have effective biological control agents established at or near the site, while other plants may have agents that may be difficult to source (refer to the Invasive Plant Assessment in Chapter 4 for information on the Invasive Alien Plant Program).

Livestock can be taught to graze weeds, and an intensive grazing period can be planned to target unwanted plants. Another method of managing competition from invasive plants or weeds is by the use of herbicides, such as glyphosate, in the year before seeding. There is considerable research into other pre-harvest and post-emergent minor use herbicides suitable for use with forage grasses and legumes.[25] Always read the herbicide labels for current and detailed information about use with grass and legume species. Updated label and other pesticide information can be found at the B.C. Ministry of Agriculture website: http://www.agf.gov.bc.ca/pesticides/.

One of the best methods to control unwanted plants is vigilance and hand pulling before viable seed has formed. This technique is used extensively by pedigreed seed growers and is applicable for small- to medium-scale seeding projects in some management contexts. This method removes weed and invasive plant problems in the early stages, before they can spread.

Establishing narrow (3–4 m) buffer strips around a seeded area is another technique used by seed growers to protect their stand from invasive plants and weeds. The buffer strips are maintained free of any plant growth. Buffer strips may have some application in a grassland restoration project in semi-arid areas, where encroaching invasive plants are problematic. Buffers should be maintained for enough time for the seeded area to establish into a competitive stand that is relatively resistant to weeds and invasive plant encroachment.

Soil Fertility

Soil fertility is important for developing strong, vigorous seedlings. Soils should be tested to determine nutrient and pH levels. Correcting deficiencies enhances the desired plant's ability to grow and compete. It can also shift which species dominate and increase tolerance of some invasive plants.

Macro-nutrient deficiencies are most often considered when assessing soil fertility. Phosphorus is important for root development of both agronomic grasses and legumes. For grasses, nitrogen is especially important for vigorous growth after establishment, while legumes or legume mixes tend to require phosphorus, potassium, and sulphur.

Low rates of phosphorus can be applied with the seed to help in plant establishment. If forage production is an important objective, nitrogen can be applied annually, usually in the fall by broadcasting. Less nitrogen will be required if a suitable legume is included in the seed mix. Nitrogen placed with the seed has been shown to reduce seedling emergence.[26]

With native seed applications, fertilization may not be desirable and is not usually recommended. Making a site too fertile, especially with nitrogen, may instead favour weed growth over growth of the seeded species. Fertilization may also favour early successional species and grasses over other plant types. However, this may have to be revisited if there is a significant macro- or micro-nutrient deficiency showing up in the soil tests. A nitrogen deficiency may be addressed by including a suitable native legume in the mix. Other deficiencies may be compensated for with an organic soil amendment or mulch before seeding.

Soil pH influences the availability of nutrients needed for plant growth. Also, some species are more sensitive to low or high pH levels than others. Sensitivities to salinity levels in the soil are frequently important in rehabilitation and reclamation scenarios. Adaptation ratings for pH and salinity for each species are provided in the species summary table (Chapter 5) and in the species summaries (Chapter 8).

Plants can have greater access to nutrients, phosphorus in particular, with the presence of root fungal mycorrhizae. Research has shown that introducing particular strains can improve plant establishment, but very few fungal strains are commercially available. They may be present on-site in the topsoil, yet another reason to ensure topsoil is conserved in the site rehabilitation process.

In restoration contexts, where a key objective is to establish native plant communities after disturbance, natural nutrient cycling within the plant community is the main source of fertility and nutrients. Over time, an established plant community will build organic matter content by additions from root materials and above-ground plant litter. In situations where the site is inhospitable, dry, and infertile, organic matter is even more critical to conserve moisture and provide nutrients. An invasive plant or weed-free organic material or mulch may need to be added as a site preparation for seeding.

Grazing

The timing and intensity of grazing are important. Seeded areas should not be grazed for at least one growing season to allow for seedling and stand establishment. Effective animal distribution can be challenging on large, extensively managed Crown range tenures. Natural barriers, woody debris, and other legacies of the logging or site disturbance can also be used to direct grazing livestock away from seeded areas. Creating an irregular ground surface, or pulling logging debris onto trails or rehabilitated landings can discourage animal travel and congregation.

The potential for concentrated grazing on seeded areas should be anticipated. Season of use and turnout should be adjusted to meet the readiness criteria for the seeded species and management objectives. Salt blocks should be used to draw livestock from newly seeded forage stands. Grazing periods should be shortened and utilization should be monitored closely on seeded areas, and particularly where reforestation efforts are occurring such as cutblocks. Season of use and turnout should be adjusted to meet the readiness criteria for the seeded species and management objectives. Where newly logged aspen lands are being converted to pastures, grazing may need to be early enough to suppress aspen suckering and encroachment. The month of June is likely the optimum time for controlling aspen suckers with intensively managed grazing.[27]

An adequate amount of regrowth, or standing material, should be left on newly seeded stands in the fall. This can serve two purposes. It is important to have adequate root reserves for winter hardening and green-up the following spring and standing plant material can help hold snow through the winter. Areas bared of snow can be susceptible to winter kill. Freeze thaw cycles that allow a build-up

of ice can be damaging, especially to alfalfa. Snow provides insulation, which prevents ice build-up, as well as moisture for plant growth in the spring.

Seeded species and the choice of species can be used to influence grazing. Seeding roadsides, landings, and cutblocks can help to move and disperse cattle from other areas. Low-growing or unpalatable species can be selected to minimize grazing, while also meeting other objectives such as erosion control.

More intensive grazing management can be accomplished with various techniques depending on the context. Regular herding of livestock (using horses, dogs, or other means) is often used to manage grazing. Remote waterers (solar or wind-powered, nose pumps) and portable electric fencing can help achieve grazing management objectives.[28]



Photo credit: A. Dobb.

Example of portable electric fencing used for more intensive grazing management.

Mechanical Treatments

Mechanical treatments such as mowing can be a tool to control weeds, to remove excess litter or biomass, and to increase seed production. The timing is important. Early mowing or cutting can control competition from weeds and increase vegetative growth. Later mowing or cutting helps spread of seed from the current season or can stimulate flowering and seed production in the following year.

Chapter 6. Notes

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Chapter 7. Sourcing Seed

Once the decision to seed is made and species are selected, finding a commercial source for the seed is usually the next step. Depending on the project this can be challenging, particularly if native species are to be used. If seed production is down in any year and inventories are low, the selected species may be unavailable. Substitutes might have to be made. Alternatively, projects might be delayed until the desired species are available. Having knowledge of seed regulations and the seed industry is critical for this part of the seeding decision.

Purchasing Seed

If purchasing agronomic or native grass and legume seed in British Columbia, it is extremely important to understand:

- Canadian seed grades and standards (and those of individual neighbouring US states if sourcing seed from there),
- how to interpret seed grades and seed analysis certificates, and
- the importance of sourcing seed from seed producing areas closest to the region or closest to the environment it will be used in.

It is essential to know the geographic origin of the seed, its quality, and if weed or other unwanted seeds are present. The seed production region may influence seed adaptability. Individual seed producing areas can have unique advantages in terms of being free from problem weed species, certain crop seed contaminants or particular diseases.

When sourcing and buying seed:

- understand the difference between varietal purity (i.e., pedigreed vs. common grades) and mechanical purity (established with a seed analysis certificate, and to a relative standard by the grade number i.e., No. 1 or No. 2. - see Table 7.1 for example);
- request a seed analysis certificate for mechanical purity – listing all weed and other crop seeds present, and germination – from the supplier for each lot of each species prior to purchasing and blending seed;
- buy seed with highest mechanical purity possible, to prevent the spread of unwanted and/or weedy species;
- if a mixture is desired, consider buying individual seed lots of each species, and having them mixed and bagged (this will often produce a higher quality mix because weed tolerances for pre-packaged mixtures are lower, and some may have lower quality seed that cannot make a grade blended in);
- when buying native seed, know the geographical and/ or genetic origins of the parent seed;
- when buying a variety, know the development history, its genetic origins and local performance;
- know your seeding objectives; in many situations it is reasonable to sacrifice varietal purity if the mechanical purity and germination in an available common grade lot are higher.

Canadian Seed Grades, Standards, and Seed Tags

All seed sold within or into Canada is governed by the *Canada Seeds Act*.[1] There are grade standards for Canada foundation, registered, certified, No. 1 or 2, and common No. 1 or 2. Weed seeds are listed as prohibited, primary, secondary or other weed seeds (see Table 7.1). Additional tables for other species can be found in Schedule 1 of the Seeds Regulation.[2]

Pedigreed Seed

Pedigreed seed is genetically pure seed of a known variety, developed with unique characteristics such as disease or drought resistance, or improved yield. The term "pedigreed" means that the ancestry of the seed can be traced all the way back to the plant breeder who developed it. The varietal purity of pedigreed seed is maintained by limiting the number of generations from the parent seed, and other strict production guidelines. Field inspection, verification, and documentation of seed plots are the primary tools for establishing pedigreed.

Once pedigreed seed is harvested, it must be graded to meet mechanical purity and germination standards of the specific pedigreed grade that applies. Breeder, Select, Foundation, and Registered seed are classes used for multiplication. Certified seed is considered the terminal pedigreed class and the seed recommended for commercial crop production.[3]

After receiving a grade, pedigreed seed ensures specified germination for even emergence and a productive stand. It contains uniform seed sizes, providing consistency in planting and crop performance. Optimum seed size encourages uniformity in the crop and promotes seedling vigour, high yields, and low disease levels to maintain crop health and minimal contamination from other crops or different varieties of the same crop. Allowances for other crop seeds, noxious weeds, and other weed seeds are established by *Canada Seed Act, Seeds Regulations* (see Table 7.1).

To help provide additional assurances of variety purity and seed quality, the Canadian Seed Growers' Association (CGSA) have created a Pedigreed Seed Crop Directory. This interactive web tool can be used for sourcing quality seed anywhere in Canada by variety, by province, or by a region closest to the seeding project.[4]

Examples of Pedigreed Seed Classes

Breeder Seed is developed and maintained by the CSGA-recognized plant breeders of public research institutions and private companies.

Foundation Seed is the first generation for most open-pollinated crops, and second generation for most self-pollinated crops. It is produced from Breeder seed and rogued for off-types to meet variety descriptions and strict Foundation purity standards.[5]

Certified Seed is the terminal pedigreed class. It must meet two main sets of criteria. First, it must be produced by a registered seed grower according to the Canadian Seed Growers' Association's Regulations and Procedures for Pedigreed Seed Production.[6] The field must also be inspected before harvest by an Agriculture and Agri-Food Canada (AAFC)/ Canadian Food Inspection Agency (CFIA) accredited field inspector. Second, once the seed is cleaned, it is graded and analyzed by an accredited seed processor according to the *Canada Seeds Act, Seeds Regulations*. Upon meeting these requirements, a crop certificate and number are issued assuring the purity and traceability of the variety and grade. Certified seed is identified with a blue tag (see Figure 7.1a).

Seed tags provide seed purchaser's with critical information, as shown in Figure 7.1(a) and 7.1(b).

Common Seed

Unlike pedigreed seed, common seed is identified to species only and is regulated by the *Canada Seeds Act, Seeds Regulations* to control standards for mechanical purity and percent germination. The weed tolerance is often higher than for pedigreed seed, and there are no field production standards or field inspections. There is also no requirement for an officially recognized test for grading, but common seed still requires testing by an officially recognized lab, or a seed testing lab supervised by members of an identified seed testing association, to establish purity and germination. It is not a designation to allow for weed infested seed.

In some situations common seed can be more weed free than pedigreed seed. Both meet standards for noxious and prohibited weeds, but the pedigreed system is focussed on assurance of variety, purity, and vigour. It guarantees that the species and variety grown by the seed grower are within a specified number of generations away from foundation or plant breeder seed. Sometimes common seed grown by reputable seed growers is very clean and weed free but is one generation too many removed from the foundation seed to meet purity requirements for the certified grade.[7] Therefore a seed analysis certificate, which shows the mechanical purity and germination, becomes the key tool to assure quality, when variety purity is less important for the particular application (see Figure 7.2).

Table 7.1 Canada Seeds Regulations, Grade Table (VIII) applicable to alfalfa, red clover, sweet-clover, and cicer milkvetch.

Maximum Number of Seeds per 25 g Except Where Otherwise Stated							
Noxious Weeds				Other Crops			
Grade	Primary	Primary + Secondary	Total Weeds	Sweet clover	Brassica Crops Including S. alba	Other Non-Brassica	Minimum Percentage Germination
Canada Foundation No. 1	0	0	5	1	0	5	85
Canada Foundation No. 2	0	2	30	2	2	20	70
Canada Registered No. 1	0	0	5	1	0	5	85
Canada Registered No. 2	0	2	30	2	2	20	70
Canada Certified No. 1	0	5	50	20	4	1% by weight	80
Canada Certified No. 2	0	10	75	30	6	2% by weight	70
Varietal Blend No. 1	0	5	50	20	4	1% by weight	80
Varietal Blend No. 2	0	10	75	30	6	2% by weight	70
Common No. 1	0	5	75	25	8	2% by weight	80
Common No. 2	5	10	100	50	10	3% by weight	70

Notes:
For any kind or species not set out in Schedule I and having 251 to 600 seeds per gram, seed shall meet the minimum weed seed and other crop seed standards set out in Table VIII. (6(2)(d)). Column 5 of Table VIII does not apply to sweet-clover seed. (7(6)). For information on Canadian and British Columbia listed noxious weeds see Chapter endnote 10.

Source: Government of Canada, "Canadian Food Inspection Agency, Schedule I to the Seeds Regulations (Sections 2, 5 to 7, 11 and 12, 18, 23 to 27, 30 and 40) Grade Tables", November 14, 2007, http://www.csi-ics.com/pdfs/CFIAACIAGradeTables_EN.pdf.

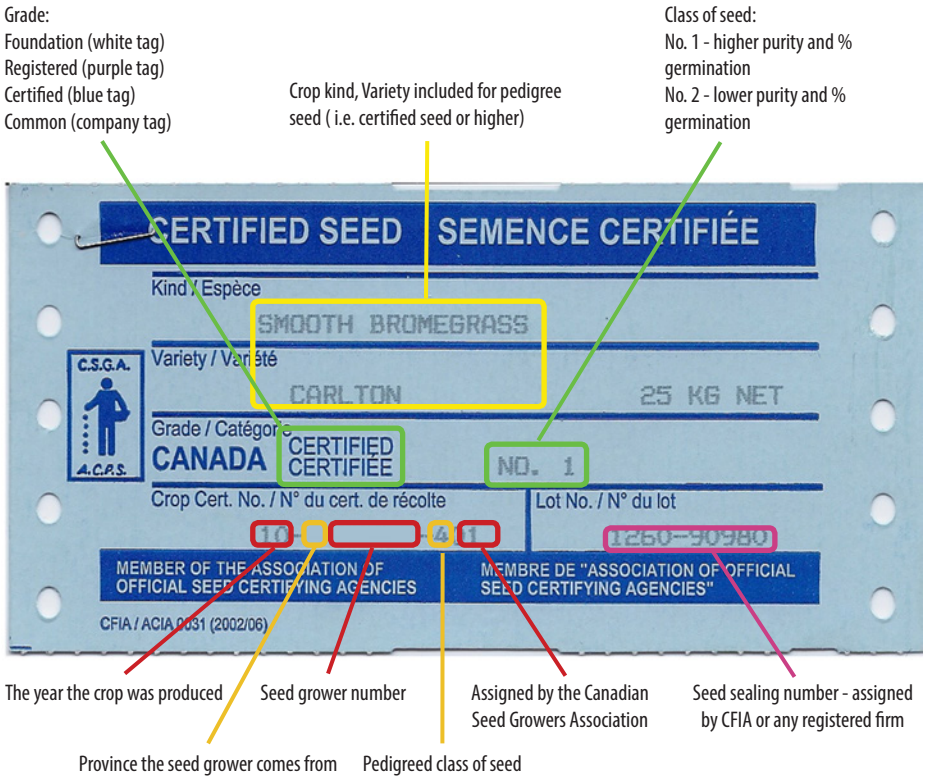


Figure 7.1(a) Example of a pedigreed seed tag.

Source: Johnson, T. and S. Burton. Seeding Your Knowledge (Peace River Forage Association of BC, 2012),http://www.peaceforage.bc.ca/forage_facts_pdfs/FF_60_Seeding_your_knowledge.pdf

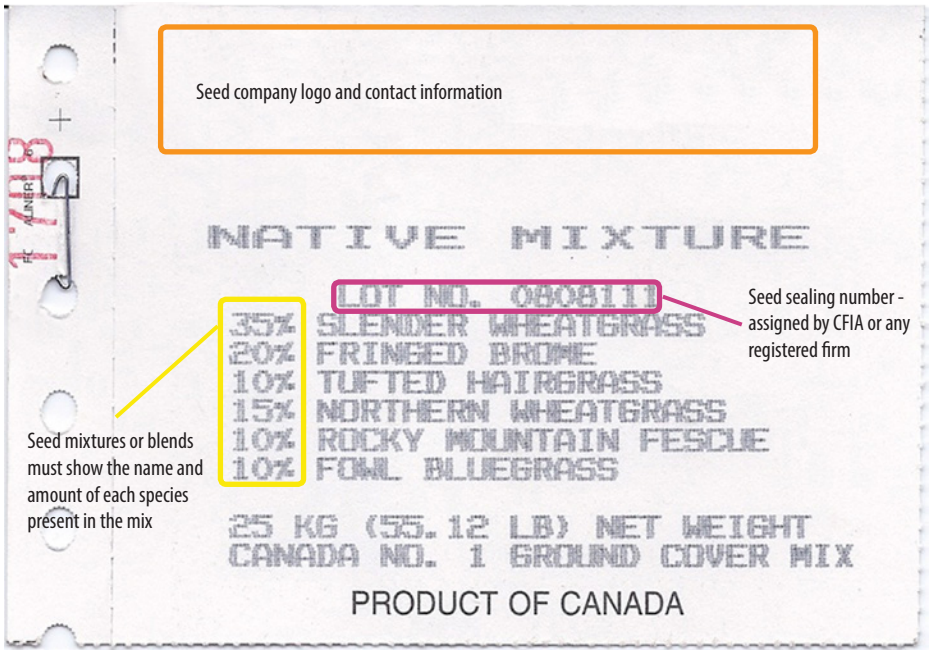


Figure 7.1(b) Example of a ground cover mixture tag.

To use mixed seed, the seed purchaser has the choice of buying the seed of each species separately and combining them into a mixture, or purchasing pre-mixed seed prepared and labelled by the vendor. It is important to understand how the Common and Certified grading standards apply to these two options. Purity and quality levels of common mixtures can sometimes be lower than when each species is purchased separately. For example, the specifications listed for Canada Certified No. 1 Forage or Common No. 1 Forage Mixtures of alfalfa and bromegrass state that they can have 10 secondary noxious weed seeds per 25 gram, compared to only 4 to 5 when the two are purchased as separate lots.

The labelling of forage seed mixtures is also regulated by the *Canada Seeds Act*. If each of the component species meets the specifications for certified seed, the blue certified seed tag will be attached. But if any one of the specifications for varietal purity, germination, or weed seed for any species in the mixture are not met, the mixture must be tagged as common seed. Seed mixtures can be formulated to exceed specifications, especially on request from the seed purchaser.[8]

Important Information

When any seed or mixture of seed are specified for land reclamation, soil conservation, green cover, wildlife grazing or habitat, wetland restoration, and similar purposes, and contain species not listed in Schedule 1 of the Act (Schedule 1 includes agronomics and some native cultivars), they must meet the minimum weed and crop seed standards listed for forage mixtures (Table XIII to Schedule 1). **Mixtures specified as "Ground Cover" (Canada No. 1 and No 2.) have much higher tolerances for weed species, and should not be used for the applications mentioned above.**

Common seed can be a mixture of varieties from different sources. When seed mixtures contain one or more kinds of common seed, the official CFIA seed tags cannot be used and seed companies must use their own tags (see Golden Acre Seeds tag Figure 7.1(b)).[9] These tags still can be used for traceability by producers and seed companies.

Seed Analysis Certificate for Mechanical Purity and Germination

When purchasing common or certified seed, ensuring mechanical seed purity is critical. A seed analysis certificate can be requested from reputable seed processors and suppliers before purchase is finalized, and prior to any blending of seed-lots into a mix (Figure 7.2). These certificates give important information about weed seeds present, inert material, germination, and pure live seed (PLS). They are used to establish the grades of both pedigreed and common seed. They also provide the necessary information if a seedlot needs to be tracked back through the system. In the case of pedigreed seed, a seed lot could be traced back to the registered grower, field, and name of the field inspector in the event of a problem.

A seed analysis certificate will be attached to many seed lots, and will be a requirement for seed imported to Canada. At a minimum, labs will report federally listed noxious weeds, and some labs may also report results based on regionally listed (i.e., state or provincial) noxious weeds.[10] Listed noxious weeds may be specific to the jurisdiction where the seed analysis is conducted. A second seed analysis can be ordered and paid for by a customer, with the request to list every weed species detected at any level. This would be extra insurance against the potential introduction of unwanted species, and is advisable for special seeding projects in sensitive areas where a high level of ecological integrity must be maintained.

It is possible to have seed custom cleaned to a higher standard with a "0" tolerance for particular weeds. This may be difficult to do depending on the species and the specified weed seeds. But in some cases seed cleaning plants can improve results by double running and adding extra screens if they are adequately compensated. Suppliers may also be able to find an alternate lot of the desired species with no undesirable contaminants.



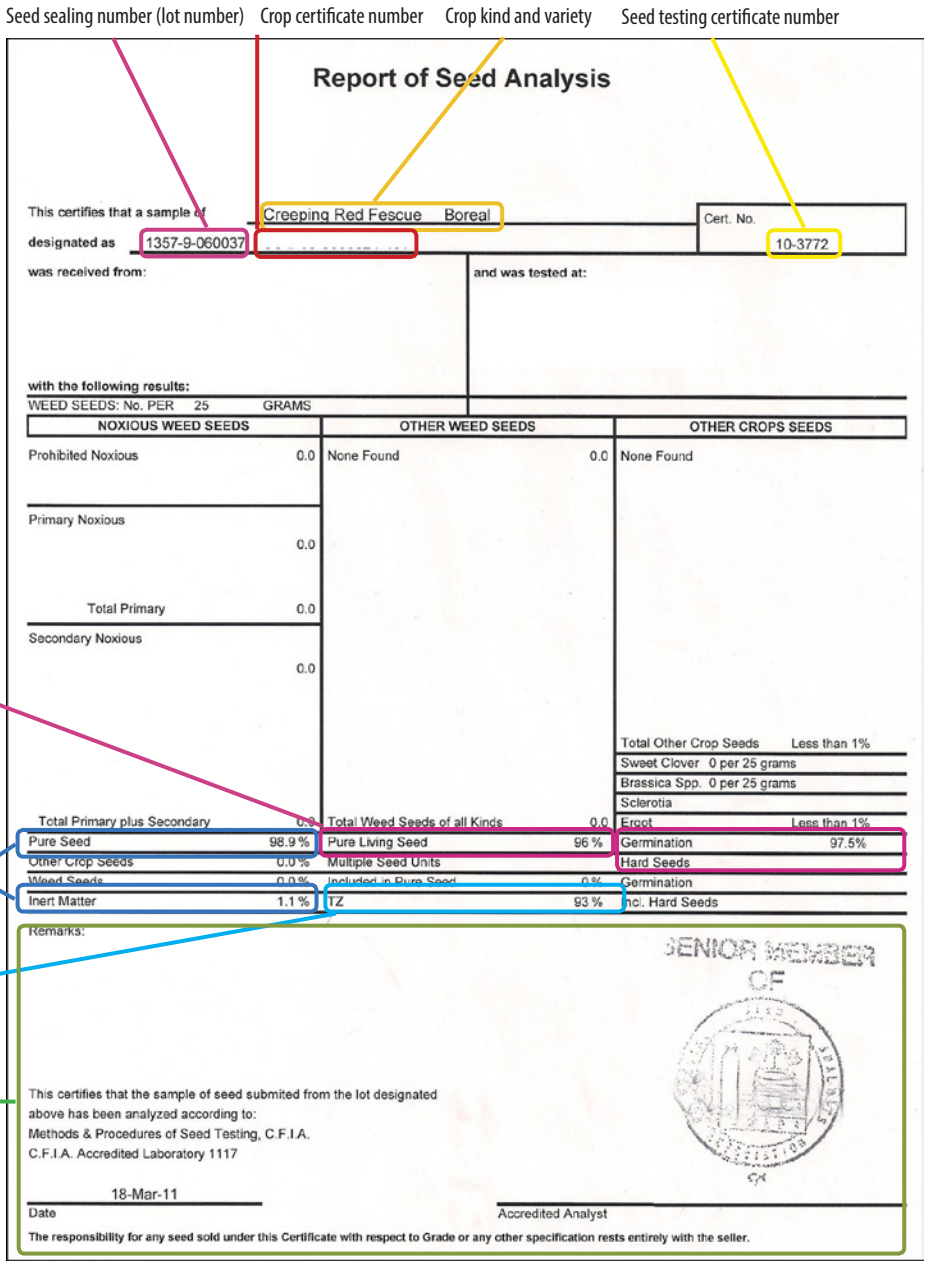
Photo credit: A. Dobb.

Seed cleaning equipment.



Photo credit: A. Dobb.

Sandberg's bluegrass being cleaned.



Germination - percent of seeds that grow
Hard Seeds (only relevant to legume seeds) - seeds still included in germination
Pure Living Seed - seed that is pure and viable

Pure Seed = crop seed only
Inert Matter = stems, seed husks, dirt, etc.

TZ = Tetrazolium test - determines percent viable seed

Signed and stamped by accredited seed analyst
Place and date of analysis

Figure 7.2 Example of a seed analysis certificate.

Native species and the *Canadian Seeds Act, Seeds Regulations*

Understanding and interpreting the *Canada Seeds Act* and *Seeds Regulations* can be challenging. When questions arise, seek out additional information from seed industry professionals or the Canadian Food Inspection Agency. Native species with varieties registered in Canada are listed in Schedule I of the Seeds Regulation under the specific grade tables that apply. Native species not listed in Schedule I are assigned to the appropriate grade table based on seed size. For example, *any kind or species of grass not set out in Schedule I and having 1,501 seeds or more per gram, seed shall meet the minimum weed seed and other crop seed standards set out in Table XII. (6(2)(g))*. Junegrass, multiplied from a local population and with over 3,000 seeds per gram, would fall into this category and the standards for the common grade in Table XII would apply. Only if non-pedigreed (common) seed is **not advertised for sale**, and is grown, sold and delivered by a producer on the producer's premises for seeding by a purchaser ,is an exemption from labelling – which requires listing the species and grade – allowed by the regulation.

U.S. Standards

In the United States, each state has their own set of standards and regulations. Like the Canadian system, there are limits for restricted and prohibited weed seeds, but each state has different tolerances. For example, timothy is considered a restricted weed in the Eastern Seaboard States. For similar examples and information, see the U.S. Department of Agriculture state noxious weeds website.[11]

The United States uses what they call "truth in labelling" so that all purity and germination information is listed right on the tag (see photo "U.S. seed labels"). They also have a "clear tag" system, which means anything with a clear tag meets that particular state's noxious weed requirement. If the seed lot does not meet the requirements for the particular state it is being sold into, weed species must be listed on the back of the tag. Like Canada, they use accredited labs to provide seed analysis. Seed that comes into Canada from the United States must be resampled and must meet the standards in the *Canada Seeds Act*. It must also have an import release and interagency CFIA tag.



Photo credit: A. Dobb.

U.S. seed labels.

Labelling requirements for seed made available for sale within Canada or for export can be found on the Canadian Food Inspection Agency "Seeds" website.[12] Seed trade representatives indicate a large portion of their time is spent understanding seed regulations and keeping abreast of changes. They are an informative resource when buying seed.

Native Seed and Native Seed Production

In Canada, many native seed producers are also agronomic seed growers and market their seed applying standards of the Canadian Pedigreed seed system. However, only developed native cultivars (varieties) can be grown as pedigreed seed. All other native seed is grown as common seed. There is no distinction within the "common" seed designation to identify seed from native cultivars that may have failed to meet pedigreed standards, and seed that is collected from wild populations.

However, there is increased demand for locally adapted, genetically diverse native seed for restoration and reclamation and this has led to more native seed producers. Native seed in this scenario is collected from the wild and propagated in nurseries or small fields. In these cases, assurance of seed purity to species level and freedom from weeds is still important, even if genetic consistency to the level of cultivar or ecotype is not a requirement. Seed labs will provide seed analysis certificates for a fee.

In the United States, the increasing demand for native seeds for restoration has led to modifications of the seed classification system in some states to include source identified, selected, and tested classes. This provides intermediate grading between the higher level pedigreed seed grade system and the wild or seed derived from wild stock (source identified).[13]

The Canadian Seed Growers' Association (CSGA) has developed a similar native plant certification program following standards of pre-variety germplasm standards of the Association of Seed Certifying Agencies (AOSCA).[14] Two classes are identified under the program:

Source Identified class seed crops are produced from a parental population where no selection or testing has been done and crops are certified for originating from a specific geographic location. Since there is often not enough seed from natural harvests to meet commercial demand, seed production fields are planted for seed increase and are also included in this class.

Selected class seed crops are produced from phenotypically selected plants of untested parents that have promise (but no proof) of genetic superiority or distinctive, identifiable characteristics. CSGA emphasizes the importance of identifying the specific selection criteria and the comparative data requirements for certification in the selected class.

Labelling under this program involves CSGA tags, which provide third-party assurance of identity and origin. As in most U.S. programs, a second label provides assurance of germination (and date tested), pure live seed, mechanical purity statement (of other crop or weed seeds), and other information (such as packager's name and address, package weight, and lot number) required by official seed regulations.

If seeds are used from any of these sources, it is critical to get as much information from the seed supplier about the seed lot as possible. For example, has this species been successfully grown in the area where it is going to be seeded? Or has it been successfully grown under similar climate, soil and day-length conditions? Is there any information about expected yields, origins or collection sites from scientific journals and seed grower organization websites?

Careful transport and storage of the seed is required to maintain its quality and shelf life. This is particularly true with many native seeds. It is important to store seed in cool, dry, and dark storage. Generally, seed life doubles for every 1% drop in soil moisture and for every 4° C drop in seed temperature. Legumes with their hard seed coats can have much longer and less fragile shelf lives.[15]

Cultivars, Ecovars, and Wild Collections

Cultivars or named varieties are structurally distinct and have been developed and selected for specific traits. Plant breeders keep their genetic character intact by growing breeder seed. They have documented performance records on such characteristics as yield, winter hardiness, or ease of establishment. The pedigreed seed system helps identify the number of generations from the plant breeder seed, thus giving an indication of its genetic purity or trueness to variety.

Ecovars™ (Trademark of Ducks Unlimited Canada) are ecological cultivars that emphasize genetic diversity and adaptation, while still meeting a standard for certain adaptive characteristics. In contrast to varieties, ecovars are collections or selections from a large geographic area of genetic diversity and developed through phenotypic selection. Ecovars might be classed as either source identified or selected class under the CGSA native plant certification program.

Wild Collections are seed collected from native plants from undisturbed areas. If native species cannot be accessed as cultivars or ecovars, or as a third-party verified seed under the CSGA native plant certification program, this may be the only seed source available for certain types of restoration projects. Careful planning is needed to ensure that collections can be timed when seed is available.

Seed Producing Areas and the U.S. Pacific Northwest

Forage seed production in British Colombia is limited mostly to the aspen parkland of the Peace River Region.[16] This has implications for sourcing native cultivars adapted to semi-arid areas of British Columbia's southern interior, which have more in common with the ecology of the interior U.S. Pacific Northwest. Consequently, rangeland seeding projects in this area may source seed produced in the United States. Major forage seed producing areas in western Canada and the Pacific Northwest U.S. states are shown in Figure 7.3. This map also outlines the grassland steppe, and parkland ecoregions—most forage seed is produced in these areas.

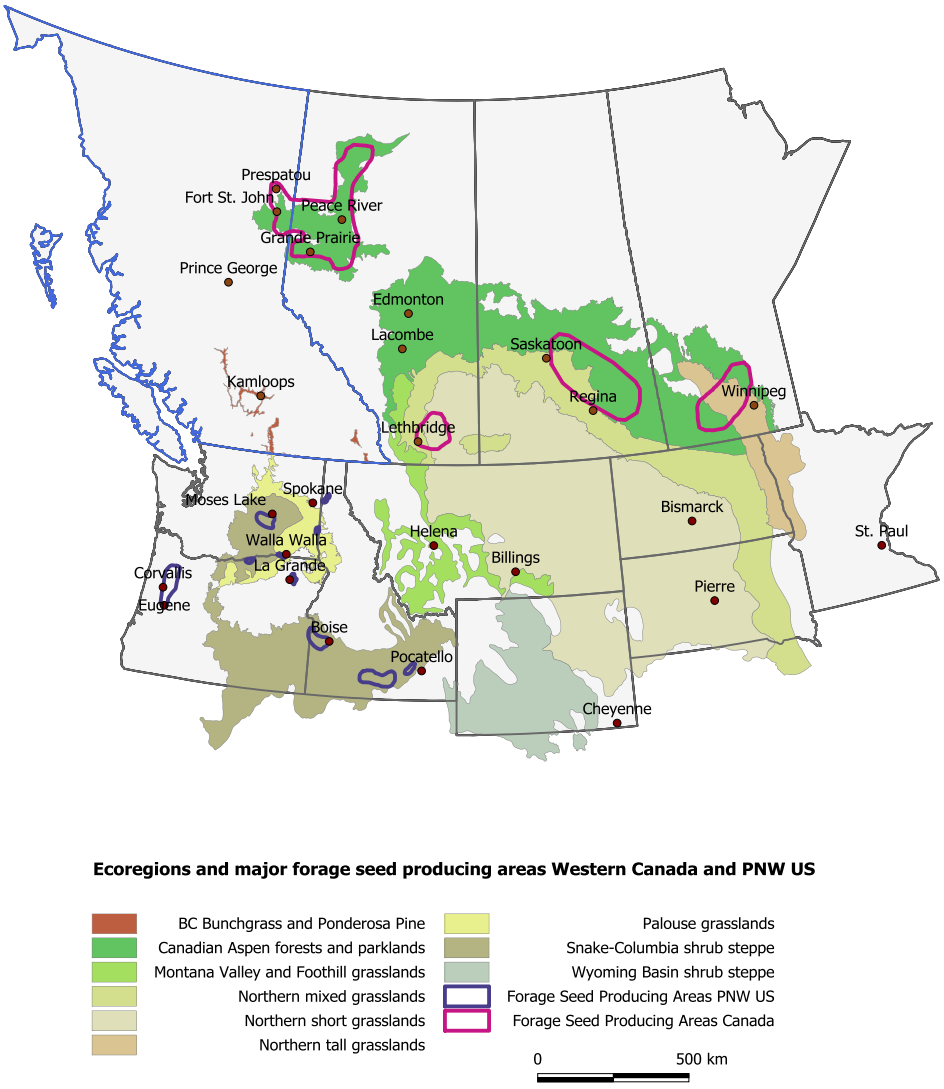


Figure 7.3 Ecoregions and major forage seed producing areas in Western Canada and the U.S. Pacific Northwest.

Note: Designated seed producing areas indicate generalized regions of production and do not reflect total land area, or all locations of forage seed production. Pacific Northwest US seed producing areas adapted from: C.W. Edminster, "Seed Production in the Pacific Northwest," TPI Turf News, 1998, http://archive.lib.msu.edu/tic/turfn/articles/1998julaug51.pdf; Ecoregion spatial data except BC Bunchgrass and Ponderosa Pine from: D.M. Olson et al., "Terrestrial Ecoregions of the World: a New Map of Life on Earth," BioScience 51, No. 11 (2001): 933–938 [version 2.0, 2004].

Seed Producing Areas in Canada

Canada is the world's second largest producer of grass and legume seed (with the United States #1 and Denmark #3). However, acres of forage seed grown for seed were down substantially in the 2011 census (326,526 acres) compared to 2006 (661,923 acres; see Table 7.2).

Table 7.2 Canadian acres in grass and legume seed crops.

Year	Area (acres)
2011	326,526
2006	661,923
2001	799,415
1986	406,350

Source: Statistics Canada, Census of Agriculture, Farm and Farm Operator Data.

Canadian export values of grass and legume seed increased steadily from 2004-2008, but have levelled off to a 2011 value of just over $100 million (Table 7.3). Grass and legume seed is used to produce forage for livestock feed, for turf (lawns, sports fields, golf courses) and increasingly for rehabilitation and reclamation. The majority of the grass and legume seed grown in north-western and western Canada is exported, primarily to the United States but also to European Union countries and increasingly to China. While export was valued at $144.7 million dollars in 2008, the domestic market was worth $28.9 million dollars.

Table 7.3 Canadian export values for grass and legume seed crops.

Year	Canadian Export Value (million $)
2011	100.9
2010	77.9
2009	106.2
2008	144.7
2007	139.8
2006	116.1
2005	88.9
2004	95.5

Source: Statistics Canada

Western Canada, especially the Peace River Region, is well positioned to produce quality seed for a variety of buyers and users. A large land base, experienced innovative growers, and large seed processing capacity improve the potential to supply quality seed both domestically and for export to the United States, Europe, and China. In addition, there is opportunity to expand production contracts and pedigreed seed contracts with growers who consistently produce clean seed that meets high quality market specifications.

Western Canada Forage Seed Collaboration

There is a history of effective collaboration among the Western provinces' seed organizations and seed industries in Western Canada. These groups work together on:

- **Research trials** – Western Grass Seed Testing program, trials for minor use herbicide registrations and pest monitoring networks.
- **Forage Seed News** – a quality magazine that updates growers, processors and researchers on research and industry developments in each region; and recently
- **Forage Seed Canada** – a recently formed association representing these groups and regions on common issues.

The collaboration between seed growers and the seed trade developed over many years and is now an asset for anyone working with the industry, or simply wanting to purchase or sell seed. This type of effort translates into consistently higher quality seed and a responsive industry ready to fill identified gaps and needs.

Peace River Region of British Columbia and Alberta

The Peace River Region of British Columbia and Alberta is Canada's primary location for turf, forage, and native seed production. For more than half a century, this region has had an international reputation for quality seed production and is the 2nd largest production area in the world (behind only Oregon's Willamette Valley). Approximately 40% of Canada's forage seed is grown in the region where the northerly latitude (55–58° north) provides environmental conditions that are uniquely conducive for triggering and enhancing seed production of several temperate forage grasses and legumes. The long daily periods of sunlight during the short summer growing season ensure that the seed of most grass crops matures early before the onset of grain harvest, thus spreading the work load and crop harvest risks over a longer time frame.

On average, the Peace River Region has 200,000 to 250,000 acres of turf and forage seed production, translating into up to $40 million of farm gate sales in some years. Turf and forage seed are produced at both the common and certified level, although most of the seed produced is designated as common production (approximately 85%). Certified seed production is on the rise as this region becomes recognized for its ability to produce high quality cool season, turf and forage seed crops.

The region is world renowned for the production of creeping red fescue seed, which comprises over half of the turf and forage seed acres in the area. After fescue, major crops include the bromegrasses, timothy, clovers, and specialized production of other turf, forage, and native species. Turf seed crops include creeping red fescue, hard fescue, tall fescue, sheep fescue, and chewings fescue. Forage crops include alfalfa, birdsfoot trefoil, clovers (alsike, red clover, sweet), cicer milkvetch, bromegrasses (meadow, hybrid, smooth), fescues (creeping red, tall, meadow, fine), orchardgrass, reed canarygrass, ryegrasses (annual, perennial),

timothy, and wheatgrasses (crested, tall, intermediate, northern). As well there are numerous native grass seed crops, many grown on smaller scales for niche markets including junegrass, tufted hairgrass, bromegrasses (fringe, nodding), green needlegrass, bluegrasses (Canby, fowl), tickle grass, fescues (Rocky Mountain, alpine), and wheatgrasses (slender, western).



Photo credit: Sandra Burton.

Meadow bromegrass seed production in the Peace Region.



Photo credit: Sandra Burton.

Swathing creeping red fescue seed crop in the B.C. Peace River Region in late July.

To accommodate the turf and forage seed industry, the seed processing infrastructure is well established with eight processing facilities located throughout the region. Typically, raw seed is harvested, then processed (cleaned and/or mixed), and bagged. The majority of forage seed that leaves the region is hauled out in bags via container trucks (grass seed at 40–50,000 lb truckloads). Current existing markets are into the U.S. Pacific Northwest (Oregon/ Washington), Eastern Canada, the Eastern U.S. Seaboard, Europe, Southern and Mid-western United States, Pacific Rim, and some into South America.



Photo credit: Sandra Burton.

Warehoused fescue seed in the Peace Region ready for shipping and distribution.

Saskatchewan

Saskatchewan's forage seed industry accounts for around 29% of Canada's forage seed production acres or over 78,700 ha (194,500 acres) (Statistics Canada, Census of Agriculture, 2006). This represents both tame and native forages and is an increase of almost 30,000 acres from the 2001 census figures. The main crop for Saskatchewan is alfalfa seed, where from 70 to 75% of Canada's alfalfa seed is grown. Other major crops, in terms of dollar value, include red clover, and annual and perennial ryegrass. Legume species grown in this province include birdsfoot trefoil, black medic, cicer milkvetch, clovers (alsike, red, sweet), and sainfoin. Grass species include bluegrasses (fowl, Kentucky), bromegrasses (meadow, hybrid, smooth), fescues (chewings, creeping red, hard, meadow, tall), timothy, reed canarygrass, ryegrasses (annual, perennial, hybrid), wheatgrasses (hybrid, northern, pubescent, slender, streambank, tall) and wildrye grasses (Altai, Canadian, Dahurian, Russian).[17]

There were about 200 seed growers in this province in 2009, showing a slight decline in numbers. This decline in grower numbers is similar to other provinces and tends to be cyclic. The alfalfa leaf cutter bee industry is a side industry intimately linked with the alfalfa seed production industry. Optimal seed set is only possible with the pollination by leaf cutter bees. Keeping the bees healthy can be challenging, and Canada is recognized internationally for its innovative research into control of leaf cutter bee parasites and disease and for their Western Canadian growers' specialized management practices. The export of disease-free leafcutter bees amounts to an additional $10 to $15 million for the province per year.

Manitoba

In the 2010 crop year, 384 producers sold forage seed, up slightly from 2009. The number of inspected forage seed acres (certified) was approximately 60,000 and the estimated cash value of sales from the 2010 crop year was $18,233,223. Manitoba producers grow both certified and common seed; however, the majority of the seed produced is certified. The main forage seed crops grown in Manitoba are alfalfa, annual ryegrass, tall and meadow fescue, perennial ryegrass, timothy, sweet clover, and trefoil. Other legume and grass seed crops grown are Kentucky bluegrass, other clovers, meadow bromegrass, and wheatgrasses. The leafcutter bee industry is also a component of the forage seed industry with approximately 80 producers managing bees.[18]

Willamette Valley, Oregon

The lush green Willamette Valley in Oregon is the largest turf and forage seed production region in the world. The value of grass and legume seed crops in 2010 in Oregon was over $250 million. A total of 557,000 acres was under production in 2007.[19] Grass seed crops accounted for 90.6% of this ($228 million) and legume crops, 9.4% ($23.7 million). Other growing areas in Oregon are located near Hermiston, La Grande, Madras, Klamath Falls, and Medford. The main seed crops grown are annual ryegrass, perennial ryegrass, tall fescue, Kentucky bluegrass, orchardgrass, Chewings fescue, creeping red fescue, hard fescue, Colonial bentgrass, and creeping bentgrass. In Oregon, the industry is represented by the Oregon Seed Growers League and more information can be found on their website at: http://cropandsoil.oregonstate.edu/seed-ext/commissions/seed-growers.htm.

Other Areas in the U.S. Pacific Northwest

Washington and Idaho are minor but important forage seed producing areas. Washington had approximately 80,000 acres under production in 2002, while Idaho had about 95,000 acres. Plant material centres at Corvallis (Oregon), Pullman (Washington), and Aberdeen (Idaho) operated by the U.S. Department of Agriculture have contributed to the development of important cultivars used for restoration and rehabilitation of the Palouse grasslands, and the Snake Columbia shrub-steppe. Knowledge of native seed production and cultivar development in these areas is important for grassland restoration work in southern British Columbia.

Seed Companies in Western Canada

Peace River Region of British Columbia and Alberta

Active forage seed companies with seed processing facilities in the Peace River region include BrettYoung Seeds, Dynamic Seeds, Fosters Seed and Feed, Golden Acre Seeds, Moore Seed Processors, Peace River Forage Seed Co-op, Pickseed Canada, and Peace Country Seed. Other forage seed companies active in the Peace include DLF International, Scott Seeds, Barenbrug, Snow Brand Seeds, and other companies contracting seed production in the region. Many of these companies have branches or affiliates in other regions of Alberta.

Saskatchewan

Seed buyers/ processors active in Saskatchewan include Ag Vision Seeds, Birch Rose Acres, Dartmore Farms, Fenton Seed Farm, Hetland Seeds, Pask Farms, Pickseed Canada, Nodricks Norsask Seeds, Phillips Seeds, Tebbutt Seeds, Trawin Seeds, and Viterra Forages.

Manitoba

Eight companies in Manitoba are actively buying and processing seed from growers: BrettYoung Seeds, Dyck Forages and Grasses, Imperial Seed, Interlake Forage Seeds, Johnson Seeds, Northstar Seed, Norcan Seeds, and Pickseed Canada.

This list is not exhaustive. For a more complete list of seed companies working in Canada go to the Canadian Seed Trade Association Website: http://cdnseed.org/csta-members/csta-members/

Forage Seed Associations

Forage seed associations can provide important information on sourcing seed, industry innovations, and native seed production.

The Peace Region Forage Seed Association (PRFSA) represents the turf, forage and native grass industry in the Peace Regions of both Alberta and British Columbia. Currently, this association consists of over 1,100 seed growers, eight seed processors, and eight forage researchers/research groups. In 2004, the association brought in an inter-provincially harmonized refundable levy of $0.0075 on every dollar of seed sold to support the research and development of the industry. Levy funds are used to increase the consistency and quality of the seed produced in the region. Collaborative research develops agronomic and pest management practices for growers. The association also conducts grass and legume seed cultivar trials to test the potential of growing new species or varieties in the region. PRFSA makes it a high priority to allocate resources to increase the grower knowledge base by sharing information through publications, factsheets, tours, workshops, and website updates. Seed trade companies have noted a dramatic increase in the quality and consistency of the seed delivered to their processing plants as a direct result of these efforts. Website: www.peaceforageseed.ca

The forage seed industry in Saskatchewan is represented by the Saskatchewan Forage Seed Development Commission (SFSDC) and the Saskatchewan Leafcutters Association (formerly the Saskatchewan Alfalfa Seed Producers Association). Website: http://www.saspa.com/

The Manitoba Forage Seed Association supports the development and promotion of the forage seed industry in Manitoba. The first priority of the association is research, looking for solutions to production problems in the industry and communicating that information to growers and industry partners. This group was one of the first turf and forage seed associations to initiate a levy collection system ($0.0075/lb of seed sold) so that growers could support and encourage relevant research and industry development initiatives. Website: www.forageseed.net

Chapter 7. Notes

[1] See: The Canadian Food Inspection Agency "Seeds" website for links to the *Seeds Act, Seed Regulations* and other information, http://www.inspection.gc.ca/plants/seeds/eng/1299173228771/1299173306579.

[2] Government of Canada, "Canadian Food Inspection Agency, Schedule I to the Seeds Regulations (Sections 2, 5 to 7, 11 and 12, 18, 23 to 27, 30 and 40) Grade Tables", November 14, 2007, http://www.csi-ics.com/pdfs/CFIAACIAGradeTables_EN.pdf.

[3] Canadian Seed Growers Association, "Canadian Regulations and Procedures for Pedigreed Seed Crop Production--Circular 6 Revision 1.7-2012," 2012, http://www.seedgrowers.ca/cropcertification/circular.asp.

[4] "Pedigreed Seed | Canadian Seed Growers Association Seed Locator", 2011, http://www.seedlocator.net/.

[5] Roguing is a seed production term, and is the process of removing undesirable plants from plots. Undesirable plants may be weeds, or plants that do not exhibit qualities of the variety being grown. See: Canadian Seed Growers' Association, "Rogues and roguing manual for pedigreed seed crops," 2009, http://www.seedgrowers.ca/pdfs/Rogues%20Roguing%20Manual_EN_2009.pdf.

[6] Canadian Seed Growers Association, "Canadian Regulations and Procedures for Pedigreed Seed Crop Production--Circular 6 Revision 1.7-2012," 2012, http://www.seedgrowers.ca/cropcertification/circular.asp.

[7] C. Yoder. Alberta Agriculture. November 2011. Personal communication.

[8] J. Roy. Peace River Seed Coop. January 2012. Personal communication.

[9] H. Kerschbaumer. Golden Acre Seeds. December 2011. Personal communication.

[10] For the Canadian noxious weed list see: "Weed Seeds Order, 2005 Consolidated," http://laws-lois.justice.gc.ca/eng/regulations/SOR-2005-220/; for the British Columbia Provincial and Regional noxious weed lists see: *Weed Control Act, Weed Control Regulations* Schedule A: http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/10_66_85.

[11] USDA Agricultural Marketing Service, "State Noxious Weed Seed Requirements Recognized in the Administration of the Federal Seed Act" (Livestock and Seed Program, Seed Regulatory and Testing Branch, 2010), http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=STELPRD3317318.

[12] See: http://www.inspection.gc.ca/plants/seeds/eng/1299173228771/1299173306579.

[13] M.D. Pahl and A. Smreciu, Growing Native Plants of Western Canada: Common Grasses & Wildfowers (Edmonton, AB: Alberta Agriculture, Food and Rural Development & Alberta Research Council, 1998).

[14] Canadian Seed Growers Association, "Native Plant Certification Program," n.d., http://www.seedgrowers.ca/cropcertification/otherprograms.asp.

[15] Pahl and Smreciu, Growing Native Plants of Western Canada: Common Grasses & Wildfowers.

[16] The Creston and Fraser Valleys have minor production.

[17] L. Thompson, "The Value of Saskatchewan's Forage Industry: A Multi-Level Analysis" (Saskatchewan Forage Council, 2010), http://www.saskforage.ca/publications/Forage%20Industry%20Analysis%20Final%20Report%20low%20res.pdf.

[18] H. McBey. Manitoba Forage Seed Association. January 2012. Personal communication.

[19] D. Wong, "Oregon's Grass and Legume Seed Industry", Government of Alberta, Agriculture and Rural Development, 2004, http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sis9062.

Chapter 8. Species Summaries

The species summarized here include agronomic and native species that might be considered for range seeding projects in British Columbia. It is by no means a complete list, particularly if an objective is restoration of a native plant community. The species summaries were developed from various sources, and while the desire was to present complete information in a consistent format, this was not always achievable. In general, the information related to the adaptation and seeding of agronomic species is extensive. By comparison, the body of information related to the propagation and seeding of native species is increasing, but still limited.

Many agronomic species have wide adaptability and may be suitable for all regions. Also, varieties may be selected for greater environmental tolerances to improve performance in a given region. Adaptation of native species can be closely related to the climatic conditions and plant communities in which they are found. Still, many native species—especially grasses—can be found in a wide range of biogeoclimatic ecological classification (BEC) zones. Individual site conditions and/or BEC zone variants should be used to interpret specific species adaptability. Cultivars (varieties) have been developed from some native grasses, and these selections may exhibit different characteristics than locally adapted native populations.

The BEC zones listed for each species include only those zones that are used for domestic livestock grazing in the interior range area of the province. Though the alpine BEC zones are used for livestock grazing in some regions, these zones were not considered in the scope of this manual. Alpine zones are indicated for a few native grass species commonly associated with those zones.

Forage yield information is provided for some species and reference is made to the brown, black, and gray soil zones. These terms are from the soil–climatic zone classification used on the Canadian prairies. The Black and Gray soil zones have application to the Peace River region and to some parts of the north central interior. Yields will be highly variable on dryland range sites in the southern interior, and this information is reported when available.

Species ratings for different environmental characteristics are subjective and approximate. Precipitation values attempt to reflect an adapted range rather than absolute limits—reported values, especially maximums, are highly variable.

Ease of establishment ratings are also subjective. Actual results will vary depending on the seeding method, the seedbed, and moisture conditions. In general, improved establishment can be expected with drilled seeding methods, or broadcast methods that employ some form of post seeding disturbance (see Chapter 6). Some species (e.g., Russian wildrye) can be difficult to establish even when direct seeding methods are used. Soil surface conditions that allow soil-to-seed contact and safe microsites for germination are critical in broadcast seeding applications where no post-seeding disturbance is planned. Smaller-seeded species like timothy, clovers, and fine fescues are better surface germinators, and might be considered in those situations.

Plant descriptions, site characteristics and regions of the province should be considered when interpreting these ratings as characteristics can be expressed differently depending on the environment. For example, crested wheatgrass persistence and value for invasive plant suppression are rated "High" in reference to areas in the southern interior where it is well adapted. Persistence is lower in northern regions.

Canada Bluegrass



Photo credit: Reg Newman, (BC FLNR).



Scientific name:
Poa compressa L.

Type:
Agronomic grass

General description:
Canada bluegrass is a widely adapted, cool season, non-native, perennial grass. It has many characteristics similar to Kentucky bluegrass (*Poa pratensis*), except for its distinctive blue-green leaf colour and flat leaf shape. It has a role as an early colonizer or pioneer species, especially on disturbed sites with low fertility and moderate acidity.

Its roots are shallow and fibrous, concentrated near the soil surface. The creeping rhizome root system has similar soil-binding characteristics to *P. pratensis*, but does not form as dense a sod. It has flattened, wiry stems and numerous basal leaves that narrow to a pointed, boat-shaped tip. It can produce seed asexually. Seeds are adapted for short distance dispersal (less than 10 m) and some persistence in seed banks. Seeds do not shatter easily, which assists in easier harvest.

Origin:
Canada bluegrass is an introduced species from Eurasia, but it has naturalized throughout much of North America.

Distribution:
Found in British Columbia and throughout North America, it is most common along the southern border of Canada and along the northern border of United States.

Habitat and climate:
This non-native grass is often found in open meadows, open deciduous and coniferous forests, disturbed sites, and moist areas. Canada bluegrass can also be found in high elevation subalpine and alpine areas. It will tend to dominate on sites that are too infertile, poorly drained or dry for other grasses to survive.

Regions:
Bulkley - Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson - Okanagan

Typical BEC range:
Coastal Douglas-fir
Engelmann Spruce–Subalpine Fir
Interior Cedar–Hemlock
Interior Douglas-fir
Ponderosa Pine
Spruce–Willow–Birch
Sub-Boreal Pine–Spruce
Sub-Boreal Spruce

Annual precipitation minimum (mm): 300

Annual precipitation maximum (mm): 1,100

Uses:
Grazing, turf, reclamation, erosion control

Recovery after use (rating): Low
Canada bluegrass does not form a sod like Kentucky bluegrass and regrowth is slow following grazing or clipping.

Forage yield (rating): Low
Production is low Palatability/nutritional value: Canada bluegrass is nutritious and highly preferred by livestock, elk and deer.

Longevity (rating): Moderate

Persistence (rating): Moderate

Seed banks can persist in soil for up to four years.

Invasiveness (rating): Moderate
Canada bluegrass is not as invasive as Kentucky bluegrass, but both these bluegrasses have been found to be invasive in some ecosystems. It is listed as a minor upland invasive on E-flora BC's invasive, noxious, and problem plants of British Columbia.

Competitiveness (rating): Moderate

Erosion control (rating): High
The creeping rhizome roots have soil-binding characteristics.

Drought tolerance (rating): High

Winter hardiness (rating): Moderate

Low to moderate rating: Low winter hardiness is inferred by its occurrence in southern Canada to moderate winter hardiness when it occurs in alpine and northern areas.

Seed size: Small

Seeds per kg: 5,511,500

Application requirements:
It is preferable to drill or place seed 0.6 cm (1/4 in.) deep. In better soil moisture conditions the seed can also be broadcast and harrowed in. Seeding rates should be kept low and seed carriers can assist in maintaining accuracy. In mixtures, 0.6 kg/ha (0.5 lb/acre) is sufficient, while in pure stands target 1.1 kg/ha (1 lb/acre).

Suggested mixtures:
Substitute alternative native species where objectives require native species composition and diversity. When determining mixtures, get seed weights verified before calculating a mixture since seed size varies from 3,500,000 to 5,511,500 seeds per kilogram.

Typical seeding objectives:
Erosion control, forage enhancement

References:
B.C. Ministry of Forests. 1998. Knowing grasses and grasslike plants in British Columbia: self-study guide to identification of selected species mostly by vegetative characteristics. 3rd draft. Forest Practices Branch, Range Section, Victoria, B.C.

Douglas, G.W., D.V. Meidinger, and J. Pojar (editors). 2001. *Poa compressa* L. Canada bluegrass Poaceae (grass family) In: Klinkenberg, B. (editor) 2012. E-Flora BC: electronic atlas of the plants of British Columbia [eflora.bc.ca]. Lab for Advanced Spatial Analysis, Department of Geography, University of B.C., Vancouver, B.C. [Accessed Mar. 7, 2012].

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Perzoff, T. 2012. E-flora BC invasive, noxious and problem plants of British Columbia - March 2012 Update. E-flora BC. http://www.geog.ubc.ca/biodiversity/eflora/Invasive_Species_Checklist_2012.pdf [Accessed Mar. 17, 2012].

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Photo credit: Reg Newman, (BC FLNR).



Kentucky Bluegrass

Scientific name:
Poa pratensis L.

Type:
Agronomic grass

General description:
Kentucky bluegrass is a widely adapted, long-lived, persistent, low-growing perennial grass. Its roots are shallow, fibrous and concentrated near the soil surface. It eventually forms a very firm sod from the spread of slender rhizomes. Characteristics of the rhizomes vary with variety.

Kentucky bluegrass produces fine stems up to 75 cm (30 in.). The leaves are basal, soft, and smooth. At the bud stage, leaf blades are folded, flat, or V-shaped, with a boat-shaped tip. Leaf blades when flattened out are 2 to 5 mm wide.

Seed heads form on bluish-coloured triangular-shaped panicles about 5 to 10 cm (2 to 4 in.) long. There are 3 to 5 flowers on each spikelet. Seed is produced by either cross-pollination or vegetative means, and seeds are very small, about 5 mm long.

Origin:
Kentucky bluegrass was introduced to North America from Europe, where it was known as "smooth meadow grass." It became known as the "white man's foot grass" to the First Nations, because it followed settlement as it moved west.

Habitat and climate:
Kentucky bluegrass is widespread and adapted to a variety of soils. This grass grows well in open, montane woodlands, grasslands, moist and dry meadows, and the boreal forest. It readily competes with and often dominates native species on disturbed sites.

Regions:
Bulkley - Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson - Okanagan

Typical BEC range:
Bunchgrass
Ponderosa Pine
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Engelmann Spruce–Subalpine Fir
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce

Annual precipitation minimum (mm): 350

Annual precipitation maximum (mm): 1,100

Uses:
Used in reclamation, grazing, and turf.

Optimal time of grazing use:
Early season grazing is best.

Recovery after use (rating): High
Kentucky bluegrass is highly resistant to grazing. Under moist conditions, recovery and regrowth after grazing are quick. Grazing Kentucky bluegrass to a height of 5 to 15 cm (2 to 6 in.) helps maintain its forage quality.

Forage yield (rating): Moderate
Forage yield: Produces 6,400 kg/ha (5,750 lb/acre) (Breton, Gray soils) or 6,000 kg/ha (5,300 lb/acre) (Lacombe, Black soils). Poor productivity when moisture limiting.

Palatability/nutritional value:
In the vegetative stage, Kentucky bluegrass has 12% protein and a digestibility (Total Digestible Nutrient) composition of 67%. Quality declines significantly as this grass matures.

Longevity (rating): High

Persistence (rating): High
Kentucky bluegrass can be especially persistent in older pastures, moister regions, meadows, and swales on native range.

Seed banks can persist in soil for up to four years.

Invasiveness (rating): Moderate
It is considered a minor upland invasive in E-Flora BC's Invasive, Noxious and Problem Plants of British Columbia 2012 Update. Its competitiveness means that it can invade pastures and native range, especially when closely grazed. It can persist in the lower part of the plant community and increases as taller species decrease.

Competitiveness (rating): High

Erosion control (rating): High
Eventually forms a dense root system that is excellent for long-term erosion control.

Drought tolerance (rating): Moderate
Goes dormant during periods of drought.

Winter hardiness (rating): High

Soil texture preference (rating): All
Prefers well-drained, fertile, moist soils. Because of its need for moisture, Kentucky bluegrass often grows better on clay, silty, or peat soils.

Flooding tolerance (rating): Moderate
Can withstand 1 to 2 weeks flooding in the spring, several days of flooding during the growing season, and tolerates excessive root zone moisture.

Salinity tolerance (rating): Low

Acidity tolerance (rating): High
Tolerates pH as low as 5.0, but prefers pH of 5.5 to 7.5

Shade tolerance: Medium shade tolerance

Fire tolerance (rating): Low

Pest and/or disease threats:
Silvertop can be a problem, especially with some varieties. Other disease concerns include powdery mildew, leaf rust, and ergot.

Seed size: Small

Seeds per kg: 4,800,000

Ease of establishment (rating): Moderate
Seeds germinate easily but may emerge slower than other grasses, especially where there is competition for moisture.

Suggested mixtures:
Compatible with legumes such as birdsfoot trefoil, alsike clover, and especially compatible with white clover.

Management considerations:
Kentucky bluegrass has a high demand for moisture, nitrogen, and phosphorus.

Typical seeding objectives:
Erosion control

References:
Aasen, A. and M. Bjorge. 2009. Alberta forage manual. 2nd edition. AB Agric Agdex 120/20-1, Edmonton, AB. www.agriculture.alberta.ca/publications.

B.C. Ministry of Forests. 1998. Knowing grasses and grasslike plants in British Columbia: self-study guide to identification of selected species mostly by vegetative characteristics. 3rd draft. Forest Practices Branch, Range Section, Victoria, B.C.

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Perzoff, T. 2012. E-flora BC invasive, noxious and problem plants of British Columbia - March 2012 Update. E-flora BC. http://www.geog.ubc.ca/biodiversity/eflora/Invasive_Species_Checklist_2012.pdf [Accessed Mar. 17, 2012].

Tannas, K. 2003. Common plants of the western rangelands volume 1: grasses and grass-like species. Alberta Agriculture and Rural Development, Edmonton, AB.



Hybrid Bromegrass

Scientific name:
Bromus inermis Leyss. x *Bromus riparius* Rehm.

Type:
Agronomic grass

General description:
Hybrid bromegrass is a newly developed, slightly creeping, winter hardy, long-lived perennial forage grass. It was developed from a cross between smooth bromegrass (*Bromus inermis* Leyss.) and meadow bromegrass (*Bromus riparius* Rehm.). It is a dual purpose forage for both hay and pasture systems, producing a high quality, high volume first cut hay crop (like smooth bromegrass) followed by good regrowth for grazing and stockpiling (like meadow bromegrass). Several varieties developed by researchers at the University of Saskatchewan are currently being tested in the Peace Region.

It has short, slowly spreading rhizomes on its roots, and is therefore less invasive than smooth bromegrass in pasture mixtures. Hybrid bromegrass grows stems that are slightly taller than both its parents, growing upright to 100 cm (39 in.). Leaves are wide and have a similar "W" constriction halfway to the leaf tip, like smooth bromegrass. But like meadow bromegrass, leaves are hairy, with thicker shorter hairs.

Seed heads are produced in the 2nd or 3rd week of June, progressing to seed ripening by late July. More heads are produced in older stands and yields are higher than meadow bromegrass. Hybrid bromegrass is cross-pollinated. Seed size and chaffiness can cause bridging when harvesting or applying seed.

Origin:
Developed in Saskatoon, Saskatchewan, from crossing smooth bromegrass with meadow bromegrass in 1976 and 1977. Initial variety releases from Agriculture and Agri-Food Canada were AC Knowles in 2000 and AC Success in 2003.

Distribution:
The distribution of hybrid brome is limited to where it is introduced as the two species do not normally cross because of differences in maturity.

It is has wide adaptation similar to the parent plants.

Typical BEC range:
Ponderosa Pine
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Engelmann Spruce–Subalpine Fir
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce

Annual precipitation minimum (mm): 350

Annual precipitation maximum (mm): 600

Uses:
Used for pasture, hay, and stockpiled grazing. There may be some potential for use in silvopasture and rehabilitation settings.

Optimal time of grazing use:
First grazing when plant reaches 20 to 30 cm (8 to 12 in.), as with meadow bromegrass. But hybrid bromegrass will mature 4 to 7 days ahead of meadow bromegrass as its growth rate is intermediate between smooth bromegrass and meadow bromegrass.

Recovery after use (rating): High
Stand recovers after 8 weeks (56 days) of rest. If cut or used early enough in the season, it can be used for stockpiled grazing. Like meadow bromegrass, the growing tip on vegetative leaves is usually below the level of grazing, enabling the plant to keep growing without any pause or change in rate of growth. However, in tillers that have become reproductive, the growing tips may be removed during grazing, and regrowth will be slower, having to come from auxiliary buds.

Forage yield (rating): High
Similar in forage yield to smooth bromegrass and 10% higher than meadow bromegrass in all soil zones. It has similar regrowth to meadow bromegrass. Yields of 6,500 kg/ha (5,800 lb/acre) in the Dark Brown soil zone and 6,300 kg/ha (5,600 lb/acre) in Black and Gray soil zones have been produced.

Palatability/nutritional value:
Very palatable to all classes of livestock especially in the spring and early summer. This grass has low fibre content and crude protein levels of 10 to 12%.

Longevity (rating): High
Lives at least 10 years.

Invasiveness (rating): Low
Hybrid bromegrass is much less invasive than smooth bromegrass when grown in mixtures.

Competitiveness (rating): High
Similar to meadow bromegrass in competitiveness.

Erosion control (rating): Moderate
Hybrid bromegrass has some rhizomes on its roots which give it some erosion control potential.

Drought tolerance (rating): High
Like other bromegrasses, hybrid bromegrass goes dormant during severe dry periods. It regrows quickly when there is moisture again.

Winter hardiness (rating): High
Similar to smooth bromegrass in winter hardiness; leaves in the fall tolerate more frost than smooth bromegrass but less than meadow bromegrass.

Soil texture preference (rating): All
Suited to all soils but prefers well drained soil.

Flooding tolerance (rating): Moderate
Can withstand 1 to 2 weeks of spring flooding.

Salinity tolerance (rating): Moderate

Acidity tolerance (rating): Moderate
It may tolerate pHs as low as 5.5. Similar to other bromegrasses in acidity tolerance.

Seed size: Large

Seeds per kg: 200,000

Ease of establishment (rating): High
Establishes very easily with very vigorous seedlings.

Application requirements:
Stands can be poor if seed placement is poor or rates are low. Will establish well if seed is placed 1.5 to 2 cm (1/2 to 3/4 in.) deep and seeded at higher rates. A seeding rate of at least 10 kg/ha (9 lb/acre), or a minimum seeding density of 175 PLS/m^2 is recommended. Surface broadcasting without soil incorporation is not effective. To prevent seed bridging, add agitation to the seed tank or mix seed with fertilizer or heated grain.

Suggested mixtures:
Mix with alfalfa for pasture or hay, or combine with grass species.

Management considerations:
Hybrid bromegrass responds well to fertilization and in a mixture with alfalfa.

Typical seeding objectives:
Forage enhancement
Erosion control

References:
Aasen, A. and M. Bjorge. 2009. Alberta forage manual. 2nd edition. AB Agric Agdex 120/20-1, Edmonton, AB. www.agriculture.alberta.ca/publications.

Coulman, B. 2004. Knowles hybrid bromegrass. Canadian Journal of Plant Science 84(3):815–817.

Sask Forage Council. 2007. Forage factsheets - species profiles from: Dryland forage species Adaptation CD. http://www.saskforage.ca/sfc/high/docs/profile_all.pdf [Accessed Sept. 23, 2011].



Photo credit: Percy Folkard, (BC FLNR).



Meadow Bromegrass

Scientific name:
Bromus riparius Rehm.

Type:
Agronomic grass

General description:
Meadow bromegrass is a hardy, long-lived, high-yielding, cool season perennial grass. It regrows very quickly after grazing, even late in the season. Meadow bromegrass has fibrous roots and short rhizomes which spread slowly.

Stems grow up to 1.2 m (47 in.) tall with many basal leaves in established stands. Both the leaves and sheaths have long, sparse hairs. Growing points remain near the ground throughout the growing season. Seedheads are 20 cm (8 in.) long with purple-tinged spikelets, which have 5 to 10 cross-pollinated flowers. Seeds are very long and awned, which causes bridging in seed drills.

Meadow bromegrasss is sometimes identified as *Bromus biebersteinii* R & S. However, based on plant characteristics, most North American introductions and varieties should be classified as *Bromus riparius*.

Origin:
It was imported into North America from Zek, Kars Province in Turkey, in 1949.

Distribution:
Not widely distributed except where it has been introduced for use on pasture. It is not as drought tolerant or winter hardy as smooth bromegrass, and is better adapted to the cooler and moister areas within the adaptation range of Smooth bromegrass.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Ponderosa Pine
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Engelmann Spruce–Subalpine Fir
Sub-Boreal Pine–Spruce
Sub-Boreal Spruce
Boreal White and Black Spruce

Annual precipitation minimum (mm): 350

Annual precipitation maximum (mm): 600

Uses:
Pasture, hay, stockpiled grazing.

Optimal time of grazing use:
First grazing after the plant reaches 20 to 30 cm (8 to 12 in.). Early grazed or cut meadow bromegrass can be stockpiled for fall, winter, or spring grazing.

Recovery after use (rating): High
Requires 4 to 6 weeks rest after grazing; but regrows very quickly. Meadow bromegrass can be grazed repeatedly over the season, since defoliation from grazing is usually well above the growing tip.

Forage yield (rating): High
Can yield 4,600 kg/ha (4,100 lb/acre) in Black and Gray soils of northern prairie regions. Stocking rates of 3.25 AUM/ha (1.3 AUM/acre) for each grazing are possible.

Palatability/nutritional value:
Before flowering and head development, crude protein can be 15 to 20% and digestibility 70 to 75%. Meadow bromegrass maintains its quality well during the fall, winter, and spring.

Longevity (rating): High 10 to 20 years.

Invasiveness (rating): Low

Competitiveness (rating): Moderate
Slow to spread so requires higher seeding rates to establish successfully.

Weed resistance (rating): Low
Weeds can compete with new seedlings; but weed resistance improves as stand becomes established.

Erosion control (rating): Moderate

Drought tolerance (rating): High
Meadow bromegrass has good tolerance to drought and recovers quickly, with brown leaves becoming green as soon as moisture is available. Drought tolerance may not be dependable in areas of low precipitation.

Winter hardiness (rating): High
Tolerates early frosts and maintains its forage quality throughout the cold season.

Soil texture preference (rating): All

Flooding tolerance (rating): Low
Meadow bromegrass has poor tolerance to spring or growing season flooding and has poor tolerance to excess soil moisture. It may withstand flooding for up to 10 days.

Salinity tolerance (rating): Moderate
It has slightly less salinity tolerance than smooth bromegrass.

Acidity tolerance (rating): Moderate
It can tolerate soil pH levels as low as 5.7 but highest yields are on soils pH 6.0 to 7.5.

Pest and/or disease threats:
Usually minor problems but can include threats of head smut and silvertop, especially of concern for seed growers.

Seed size: Large

Seeds per kg: 182,000

Ease of establishment (rating): Moderate
Seedlings are vigorous and establish quickly. Establishment can be challenging if low seed rates are used or seed-to-soil contact and placement is compromised.

Application requirements:
Will establish well if seed is placed 1.5 to 2 cm (1/2 to 3/4 in.) deep and seeded at higher rates. A seeding rate of at least 10 kg/ha (9 lb/acre), or a minimum seeding density of 175 PLS/m^2 is recommended. Surface broadcasting without soil incorporation is not effective. To prevent seed bridging, add agitation to the seed tank or mix seed with fertilizer or heated grain.

Suggested mixtures:
Meadow bromegrass can be seeded with legumes such as alfalfa, red clover, and alsike clover.

Typical seeding objectives:
Forage enhancement
Erosion control

References:
Aasen, A. and M. Bjorge. 2009. Alberta forage manual. 2nd edition. AB Agric Agdex 120/20-1, Edmonton, AB. www.agriculture.alberta.ca/publications.

Araujo, M.R.A. de. 2001. Variation and heritability in meadow bromegrass (*Bromus riparius* Rehm.). PhD thesis. University of Saskatchewan. http://library.usask.ca/theses/available/etd-10212004-002904/ [Accessed Mar. 8, 2012].

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Photo credit: Percy Folkard, (BC FLNR).



Smooth Bromegrass

Scientific name:
Bromus inermis Leyss.

Type:
Agronomic grass

General description:
Smooth bromegrass is a high-yielding, cold hardy, long-lasting, creeping perennial grass. Roots are deep, fibrous, and very fine. Once established it grows creeping rhizomes and can become root bound.

Stems can reach as high as 1.2 m (48 in.) in height. Leaf blades are rolled, hairless, large and wide, up to 1.5 cm (1/2 in.). There is often a "W" constriction in the upper leaf.

Smooth bromegrass forms long seed heads 20 cm (8 in.) long with 7 to 10 spikelets and flowers. It is cross-pollinated and develops seed easily. Seeds are purplish-brown, long, and narrow with a short awn.

Origin:
Smooth bromegrass is native to Germany, Hungary, France, and northern Asia. The first seed grown in northern Canada was from northern Germany; while southern types were from Hungary and France.

Distribution:
Is adapted to a wide range of environments and is widely distributed throughout most regions of British Columbia.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC zones:
Bunchgrass
Ponderosa Pine
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Engelmann Spruce–Subalpine Fir
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce

Annual precipitation minimum (mm): 350

Annual precipitation maximum (mm): 600

Uses:
Most commonly grown as grass for hay. Some use in pastures but regrowth after grazing is poor. Used for roadside site rehabilitation and erosion control, and for forage in forest land grazing contexts but increasingly being avoided in many areas because of its invasive nature.

Optimal time of grazing use:
Good early season grazing.

Recovery after use (rating): Low
Smooth bromegrass requires long rest periods and is slow to recover after cutting or grazing.

Forage yield (rating): High

Forage yield:
One of the highest yielding grasses. Yields of 10,550 kg/ha (9,400 lb/acre) have been reported at Lacombe, AB. Three-year average dry matter yield at Prince George, B.C., was 4,592 kg/ha (4,100 lb/acre).

Palatability/nutritional value:
Very palatable to livestock with protein levels of 11 to 14% and digestibility of 64%.

Longevity (rating): High

Persistence (rating): High

Invasiveness (rating): High
Smooth bromegrass is included on the E-Flora BC 2011 Invasive, Noxious and Problem Plants of British Columbia. It can become invasive on upland range and wetland areas.

Competitiveness (rating): High

Weed resistance (rating): High

Erosion control (rating): High
Because of its sod-forming nature, smooth bromegrass is excellent for erosion control.

Drought tolerance (rating): High
Smooth bromegrass is less tolerant to drought than crested wheatgrass, but more tolerant to drought than orchardgrass or timothy.

Winter hardiness (rating): High

Soil texture preference (rating): All
Well adapted for all soils (including ditches and wastelands), and grows really well on loam soils.

Flooding tolerance (rating): High
Tolerates spring flooding and can tolerate excess moisture in the root zone.

Salinity tolerance (rating): Moderate
Smooth bromegrass is suited to revegetate areas that have high salinity levels. When seeded in saline areas, smooth bromegrass will grow on patches and margins with lower salt levels. As its growth helps lower the salinity levels, it then can spread and fill in gaps.

Acidity tolerance (rating): Moderate
Tolerates pH levels as low as 5.5 and most productive on soils with pH 6.0 to 7.5.

Shade tolerance:
Good shade tolerance but competes with other plants in the mixture.

Pest and/or disease threats:
Usually minor threats expected on robust smooth bromegrass. Disease issues can include ergot and leaf spot. Insect threats for seed growers especially include seed midge.

Seed size: Medium

Seeds per kg: 300,000

Ease of establishment (rating): Moderate
Seed-to-soil contact is important when establishing smooth bromegrass. Germination can be better in dark conditions at cooler temperatures, but it is widely adapted to a broad range of seedbed conditions. Smooth bromegrass seed germinates easily into strong seedlings but stand can be slow to establish and thicken in the first year.

Application requirements:
Awns on seeds may cause bridging problems when seeding; but agitation or seed coatings may alleviate this problem.

Suggested mixtures:
Often seeded with alfalfa, but stand must be managed to maintain percentage of alfalfa in the stand.

Management considerations:
Need to fertilize to favour and maintain legumes in mixed stands. With very light use in early summer, can be stockpiled for fall or early winter grazing. Not a good candidate for stockpiling for use in early spring as it does not maintain its feed quality over the winter.

Typical seeding objectives:
Forage enhancement
Erosion control
Invasive plant suppression

References:
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Photo credit: Reg Newman, (BC FLNR).



Chewings Red Fescue

Scientific name:
Festuca rubra L. ssp. *fallax* (Thuill) Nyman

Type:
Agronomic grass

General description:
Chewings red fescue is a long-lived, loosely tufted perennial that usually grows from rhizomes and appears in many forms and variants. Both introduced and native types have been recognized as separate species. Over 100 varieties of this complex are sold in Europe. Some have been introduced to North America and have hybridized with native forms.

Chewings red fescue differs from creeping red fescue in that it has no creeping roots and is finer in appearance. Since it is so often used in turf situations it can often have high endophyte levels. It is renowned as one of the most shade and drought tolerant of the cool season grasses.

It forms dense fibrous roots near the surface and dense stands. It is more upright like tall fescue but has leaves like other fine fescues.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Ponderosa Pine
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Engelmann Spruce–Subalpine Fir
Sub-Boreal Pine–Spruce
Sub-Boreal Spruce
Boreal White and Black Spruce

Annual precipitation minimum (mm): 400

Annual precipitation maximum (mm): 600

Uses:
Mainly used for turf, and sometimes included in erosion control and roadside mixes with other fescues. It is grown for seed in the Peace River Region.

Optimal time of grazing use:
Should not be grazed unless it can be tested for endophyte levels to prevent poisoning of livestock. Most turf varieties of Chewings red fescue have endophytes to improve their drought resistance and shade tolerance.

Recovery after use (rating): Moderate
Recovery after close clipping is good.

Forage yield (rating): Low

Longevity (rating): High

Persistence (rating): High

Competitiveness (rating): High

Weed resistance (rating): High
Used in Prince Rupert Region to suppress fireweed and thimbleberry in cutblocks.

Erosion control (rating): Moderate
Perhaps somewhat lower erosion control value than other fescues.

Drought tolerance (rating): High
Many turf varieties are infected with endophytes to increase drought tolerance.

Winter hardiness (rating): High

Soil texture preference (rating): Medium-Coarse
It prefers to grow on sandy soils of low fertility.

Flooding tolerance (rating): Moderate

Salinity tolerance (rating): Moderate
Low to moderate salinity tolerance.

Acidity tolerance (rating): High
High acidity tolerance but only moderate tolerance of alkalinity.

Shade tolerance:
Chewings red fescue is known for its shade tolerance.

Seed size: Small

Seeds per kg: 1,068,380

Ease of establishment (rating): High

Suggested mixtures:
Mixes well with other grasses.

Management considerations:
Be aware that most Chewings red fescue varieties are endophyte enhanced to increase their drought and shade tolerance and increase their resistance to diseases. Endophytes can be poisonous to livestock.

Typical seeding objectives:
Invasive plant suppression
Erosion control
Vegetation control

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Photo credit: Allen Dobb.



Creeping Red Fescue

Scientific name:
Festuca rubra

Type:
Agronomic grass

General description:
Creeping red fescue is a long-lived, hardy, creeping rooted, cool season perennial grass, important for its use in stabilizing soil, as stockpiled forage, as blending for the turf industry, and as a seed crop in the Peace Region.

Root systems are fibrous with short rhizomes. Roots form a thick sod that is resilient to traffic, but they are less dense than smooth bromegrass or Kentucky bluegrass.

Stems are up to 90 cm (35 in.) tall and are often reclining at the base. Mostly basal leaves are produced and are 5 to15 cm (2 to 6 in.) long.

Seed heads are up to 15 cm (6 in.) and branch mostly upright. Spikelets are up to 15 mm long and 4–8 are flowered, producing purple-tinged flowers.

Origin:
Native to Europe and North America. The early seed in Canada came from Czechoslovakia.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Boreal White and Black Spruce
Spruce–Willow–Birch
Sub-Boreal Pine–Spruce
Engelmann Spruce–Subalpine Fir
Montane Spruce
Interior Douglas-fir

Annual precipitation minimum (mm): 400

Annual precipitation maximum (mm): 600

Uses:
Turf grass, pasture, reclamation, as stockpiled forage.

Optimal time of grazing use:
Creeping red fescue is adapted to early spring or fall grazing.

Recovery after use (rating): High
Recovery is usually good as growing points are often below grazing level, especially if not continuously grazed.

Forage yield (rating): Moderate
Forage yields are moderate with yields up to about 5,400 kg/ha (4,800 lb/acre) in the Black soil zone.

Palatability/nutritional value:
Creeping red fescue is not only palatable in the fall but also over winter into the spring. It has average total digestible nutrients of 61% and 12% crude protein in the vegetative state. When stockpiled, this species has adequate nutrition for a dry pregnant cow.

Longevity (rating): High

Persistence (rating): Moderate

Invasiveness (rating): Low

Competitiveness (rating): Moderate
Creeping red fescue is competitive in moist areas.

Weed resistance (rating): Low
Creeping red fescue has low weed resistance until it is established.

Erosion control (rating): High
A very good species for controlling erosion and often used for revegetation of waterways and canals since it forms a thick, soil-binding sod, but does not impede water movement.

Drought tolerance (rating): Moderate
Creeping red fescue has fair to moderate drought tolerance.

Winter hardiness (rating): High
Winter hardiness is good when adequate snow cover is present.

Soil texture preference (rating): All
Creeping red fescue can be grown on a wide range of soil textures. It is most suited to moist, sandy, loamy, and clay soils in the Black and Gray soil zones.

Salinity tolerance (rating): Moderate

Acidity tolerance (rating): High
Soil pH as low as 4.5 is tolerated.

Flooding tolerance (rating): Moderate
Creeping red fescue can tolerate up to 2 weeks of spring flooding or waterlogged soils.

Shade tolerance:
Good shade tolerance so it can grow under taller species when seeded in mixtures.

Pest and/or disease threats:
Pests can include sod webworms, thrips, cutworms, and cereal leaf beetles. The most common diseases of creeping red fescue are stem eyespot and silvertop.

Seed size: Medium

Seeds per kg: 826,000

Ease of establishment (rating): High
Seedlings are vigorous, and creeping red fescue is relatively easy to establish.

Application requirements:
Manage cover crops and perennial weeds to ensure good establishment.

Suggested mixtures:
Can be seeded with legumes such as alfalfa and cicer milkvetch.

Management considerations:
Use appropriate stocking rates and allow rest following grazing. Creeping red fescue may increase in abundance if seeded with other species in a pasture mix. It also increases in overgrazed pasture situations.

Typical management objectives:
Erosion control
Forage enhancement
Extending grazing season
Vegetation control
Invasive plant suppression

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Photo credit: Percy Folkard, (BC FLNR).



Hard Fescue/Sheep Fescue

Scientific name:
Festuca trachyphylla (Hack.) Kraj.

Type:
Agronomic grass

General description:
Hard fescue is an introduced, cool season bunchgrass with fibrous roots. Hard fescue is not native to North America and was introduced from Europe. There is some confusion about the scientific naming of the species, mostly because in older works it was considered a subspecies of sheep fescue (*Festuca ovina* var. *duriscula*). Sheep fescue is also introduced from Europe, but is closely related to the red fescue (*F. rubra*) complex, which is native to North America. As of 2007, over 90 cultivars of hard fescue have been released. "Durar" hard fescue is a common variety that was released in 1949. It serves as a reference type for hard fescue. Similarly, "Covar" serves as a reference type for sheep fescue and was introduced from Konya, Turkey. Recently Covar has been re-identified as *F. valesiaca* (false sheep fescue); it is almost impossible to distinguish Covar from native fescues and potential naturalization is considered a threat. Covar is more drought tolerant than Durar, and Durar is more drought tolerant than Chewings (red) fescue.

Stems of hard fescue are from 30 to 75 cm (12 to 30 in.). Nodes are exposed. Leaves are narrow (0.4 to 0.6 mm) and mostly from the base. The leaves of hard fescue are somewhat wider than the leaves of sheep fescue.

Origin: Europe and Eurasia

Distribution: Through seeding and hybridization, hard fescue is now distributed throughout much of North America.

Habitat and climate: Hard fescue is found on dry to moderately moist, disturbed sites.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Bunchgrass
Ponderosa Pine
Interior Douglas-fir
Montane Spruce
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce

Annual precipitation minimum (mm): 300

Annual precipitation maximum (mm): 760

Uses:
Hard fescue is used primarily for erosion control, stabilization of roadsides and skid trails, weed and invasive plant suppression, and groundcover in orchards. It is sometimes used in forage applications although less preferred than other species. Hard fescue is also grown for seed production in the Peace River Region.

Optimal time of grazing use:
Hard fescue remains green though the growing season, and may be used in spring, summer and fall. Hard fescue should not be grazed in the year of establishment.

Recovery after use (rating): Moderate

Forage yield (rating): Low
Forage yield will depend on site conditions and precipitation.

Palatability/nutritional value:
Considered by itself, hard fescue is considered good forage for cattle, sheep, and wildlife. When compared with other species, it might be considered only fair forage. Forage quality is typically better on more moist sites and can be improved with fertilization.

Longevity (rating): High
Hard fescue is long lived.

Persistence (rating): High
Once established on very dry sites, hard fescue is very persistent, sometimes remaining up to 50 years and often becoming a monoculture. However, after 20 years "Durar" hard fescue plots seeded on Douglas-fir sites in the Pacific Northwest were invaded and completely taken over by pinegrass and elk sedge (Harrison et al.). It appears to be more persistent on drier sites. (see manual page 97).

Invasiveness:
Hard fescue is not considered invasive, but its ability to spread into adjacent areas appears site specific.

Competitiveness (rating): High
Hard fescue is very competitive, and can increase and become dominant once established.

Weed resistance (rating): High
Hard fescue has been noted for its weed resistance, particularly against cheatgrass and other annuals. Weed resistance is related to the extensive root systems that develop in established stands.

Erosion control (rating): High
Hard fescue is highly suitable for erosion control because of its extensive root system once it is established.

Drought tolerance (rating): Moderate
Hard fescue "Durar" has moderate drought tolerance, but is less drought tolerant than sheep fescue.

Winter hardiness (rating): Moderate
Hard fescue has moderate winter hardiness and cold tolerance.

Soil texture preference (rating): Fine-Medium
Hard fescue prefers fine to medium textured soils that are well drained.

Flooding tolerance (rating): Low

Acidity tolerance (rating): Low
Prefers pH levels of 6.0 to 8.0.

Shade tolerance:
Has medium shade tolerance, and is adapted to forest margins and openings.

Pest and/or disease threats:
No significant insect or disease threats noted.

Seed size: Small

Seeds per kg: 1,243,000

Ease of establishment (rating): Moderate
Seedlings are delicate and may be susceptible to soil crusting. Spring seeding may be preferable. Plants remain small in the first year. Typically cover increases substantially in the second year of establishment.

Application requirements:
Suitable for broadcast applications.

Suggested mixtures:
Other species may be included depending on management objectives.

Management considerations:
Fertilization may help maintain stands on heavily used areas.

Typical seeding objectives:
Invasive plant suppression
Erosion control
Vegetation control

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Photo credit: Percy Folkard, (BC FLNR).



Tall Fescue

Scientific name:
Festuca arundinacea Schreb.

Type:
Agronomic grass

General description:
Tall fescue is a deep-rooted, medium- to long-lived, perennial bunchgrass. Although it is considered a cool season grass, tall fescue can tolerate more heat than other cool season grasses, and is considered a transition between the two types. Longevity in northern regions is extremely variable and dependent on variety. It is similar to meadow fescue but is distinguished by having wider, less glossy leaves.

It has an extensive coarse, dense root system and short rhizomes.

Tall fescue has stems that grow to a height of over 100 cm (39 in.). They are smooth, semi-erect, and fairly thick. Leaves are mostly basal, with blades that are flat, dark green and hairless. They are often 12 mm wide with shiny undersides.

Seed heads develop with 3 to 10 flowers per spikelet. Tall fescue is cross-pollinated and the seed shatters easily.

Origin:
Native to central Europe and North Africa. First seed in Canada originated from England and Germany.

Distribution:
Infrequent distribution in southwest British Columbia and rare in the southern interior. Grown in the Peace River Region for seed production.

Habitat and climate:
Adapted to cool and humid climates, northern Great Plains, and irrigated areas of the Pacific Northwest states. Dry to wet seepages, pastures, roadsides, and disturbed areas in lowland, steppe to montane zones.

Regions:
Bulkley – Nechako
Cariboo – Fraser Fort. George
Northeast – Peace Liard

Typical BEC range:
Sub-Boreal Spruce
Boreal White and Black Spruce

Annual precipitation minimum (mm): 400

Annual precipitation maximum (mm): 600

Uses:
Used originally as pasture forage, especially in sub-humid irrigated areas. Also used for erosion control and more recently being grown as turf seed.

Optimal time of grazing use:
Tall fescue is a high-yielding and quality forage that maintains quality well after fall frosts. Good for summer grazing or stockpiling for fall and early winter grazing.

Recovery after use (rating): High
Tolerates frequent, close grazing by producing more basal leaf growth. Sod is resistant to animal hoof traffic. Rest from grazing over the last 4 to 6 weeks of the growing season improves winter hardiness.

Forage yield (rating): High

Palatability/nutritional value:
Good palatability in vegetative stages. Endophytes can be a problem for livestock, especially with turf varieties.

Longevity (rating): Moderate

Persistence (rating): Low
Dependent on variety, persistence is low at the northern extent of its range because of limited winter hardiness.

Invasiveness (rating): Moderate
Potentially invasive depending on location and variety. In some habitats, tall fescue, especially those varieties with endophytes, are considered invasive and persistent.

Competitiveness (rating): Moderate
Once established, tall fescue is competitive.

Weed resistance (rating): Moderate

Erosion control (rating): Moderate

Drought tolerance (rating): Moderate
It has moderate tolerance to drought and recovers quickly.

Winter hardiness (rating): Moderate
Winter hardiness is limited and highly dependent on variety, snow cover conditions, drought, and breaks in dormancy. Some varieties may recover partially from winter damage to produce forage growth but not set seed.

Soil texture preference (rating): Fine-Medium
Prefers deep, moist, silty to clayey soils, or organic soils.

Flooding tolerance (rating): Moderate
Has moderate tolerance to flooding during the growing season, and has good tolerance to internal excess moisture.

Salinity tolerance (rating): High
Good tolerance to salinity makes it a good choice for irrigated saline pasture land.

Acidity tolerance (rating): High
Tolerates soil pHs as low as 4.7 but yields better on slightly acidic to neutral soils.

Pest and/or disease threats:
Diseases of concern include leaf rust, ergot, and snow molds. Insect pests include grasshoppers, cutworms, sod webworms, beetle larvae, and silvertop.

Seed size: Medium

Seeds per kg: 501,000

Ease of establishment (rating): Moderate
Strong seedling vigour helps tall fescue establish relatively easily, especially if competition and soil fertility are managed.

Application requirements:
Tall fescue responds well to nutrient additions, especially nitrogen.

Suggested mixtures:
Alfalfa, red clover, and alsike clover.

Management considerations:
Test for endophytes if using for feeding or grazing.

Typical seeding objectives:
Forage enhancement
Erosion control

References:

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Photo credit: Reg Newman, (BC FLNR).



Orchardgrass

Scientific name:
Dactylis glomerata L.

Type:
Agronomic grass

General description:
Orchardgrass is a very productive, highly palatable, perennial bunchgrass. Root systems are extensive and fibrous with a distinctive bunch growth. Crowns increase in size over time through tiller production.

Stems are 100 cm (39 in.) tall or more, and are distinctive in their flattening near the soil surface. Lots of basal leaves are produced, with smooth, folded leaves. Young leaves have boat-like tips, while older leaves have pointed tapered tips. Leaves are light green to blue green and up to 1 cm (3/8 in.) in width.

Seed heads are up to 20 cm (8 in.) long with clustered spikelets. Each spikelet produces 3 to 4 small cross-pollinated flowers. Seeds are small but light, awned and chaffy. Orchardgrass seed viability declines rapidly in storage.

Origin:
Native to Europe, northern Africa, and Asia. Most introductions into Canada came from Russia.

Distribution:
This introduced species is common throughout southern British Columbia.

Habitat and climate:
Orchardgrass is widespread in fields, meadows, and roadsides.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Coastal Douglas-fir
Coastal Western Hemlock
Engelmann Spruce–Subalpine Fir
Interior Cedar–Hemlock
Interior Douglas-fir
Montane Spruce
Sub-Boreal Pine–Spruce
Sub-Boreal Spruce

Annual precipitation minimum (mm): 400

Uses:
Used in pastures and to a limited extent for hay. Orchardgrass is also commonly used for seeding of roadsides, log landings, skid trails, and forested sites.

Optimal time of grazing use:
Can be grazed in the late spring once plants reach 20 to 25 cm (8 to 10 in.) in height, and repeatedly through mid- to late-autumn. It can be stockpiled for grazing later in the fall, but should be left to accumulate reserves in late summer and early fall. If livestock are allowed to continuously graze orchardgrass, they will preferentially graze it and damage its ability to withstand winter injury.

Recovery after use (rating): High
With adequate moisture and fertility, orchard grass recovers very quickly after cutting or grazing. Can be regrazed after 4 to 6 weeks rest.

Forage yield (rating): High
Yields of 8,900 kg/ha (7,950 lb/acre) (Breton, AB., on Gray wooded soil) and 7,900 kg/ha (7,050 lb/acre) (Lacombe, AB., on Black soil) have been recorded when fertility is maintained and multiple clippings done. Recent first-year forage trial results in a dry year with one clipping at a non-irrigated site east of Williams Lake yielded 2,195 kg/ha (1,960 lb/acre) (Kay) and 3,261 kg/ha (2,911 lb/acre) (AC Nordic).

Palatability/nutritional value:
This is one of the most palatable grasses, with crude protein ranging from 13 to 15% and digestibility of 67% when in vegetative stage. However, quality drops off quickly when it forms seed heads. Livestock do very well on orchardgrass and seek it out in mixed stands. In early stages it is highly palatable to mule deer and elk.

Longevity (rating): Moderate
2 to 6 years and is longer lived in some ecosystems.

Persistence (rating): Moderate
Persistence of orchardgrass is very dependent on the ecosystem and variety.

Invasiveness (rating): Low
Orchardgrass is generally considered to be non-invasive, but is considered invasive and persistent in the Garry oak ecosystem on Vancouver Island.

Competitiveness (rating): Moderate
Lack of winter hardiness can limit competiveness in colder areas. In southern interior regions orchardgrass will co-exist with native species in most ecosystems.

Weed resistance (rating): Moderate
Even though orchardgrass stands can be relatively open, in productive pasture situations invading weeds have trouble establishing in them. In the Ponderosa Pine zone, orchardgrass is unable to compete with cheatgrass on uncultivated plots. On cultivated plots, orchardgrass had little effect on Dalmatian toadflax and St. John's-wort.

Erosion control (rating): Low

Drought tolerance (rating): Moderate
Orchardgrass is more drought tolerant than timothy, but not as much as bromegrasses. However, once a dry period ends, it recovers quickly.

Winter hardiness (rating): Low
Winter hardiness is dependent on snow cover conditions, carryover stubble height, and variety improvements. Carry over stubble height should be should be at least 20 cm (8 in.) in colder regions.

Soil texture preference (rating): Fine-Medium

Soil texture preference:
Orchard grass is suited to fine- to medium-textured soils with a high water holding capacity, and does well in areas with 45 cm (18 in.) of moisture.

Flooding tolerance (rating): Moderate
Has moderate tolerance to spring flooding of up to 1 week with excess moisture in the root zone. However, it does not do well with waterlogging of root zone during growing season.

Salinity tolerance (rating): Low

Acidity tolerance (rating): High
Tolerates soil pH levels as low as 5.0, but does not do well on high pH or alkaline soils.

Shade tolerance:
Moderate shade tolerance and heat tolerance.

Fire tolerance (rating): Low

Pest and/or disease threats:
Pest threats include cereal leaf beetle, European skipper, grass plant bugs, white grubs, and grasshoppers.

Seed size: Small

Seeds per kg: 1,442,000

Ease of establishment (rating): High
Orchardgrass grows as vigorous seedlings that establish quickly, are shade tolerant, and will tolerate a companion or nurse crop. Spring growth is somewhat slower than other grasses.

Suggested mixtures: Alfalfa, clovers.

Management considerations:
It responds well to fertilizer, especially nitrogen. Must go into the winter with enough residue to store carbohydrates in the stem to survive. Snow cover is important to insulate the crowns. Most productive with rotational grazing.

Typical seeding objectives:
Forage enhancement
Invasive plant suppression

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Photo credit: Reg Newman, (BC FLNR).



Italian Ryegrass

Scientific name:
Lolium multiflorum Lam.

Type:
Agronomic grass

General description:
Italian ryegrass is a short-lived, highly tillered, cool season biennial bunchgrass. It is usually grown as an annual forage or a quickly establishing, green ground cover. There are two types of ryegrasses: Italian and Westerwold, both with diploid and tetraploid varieties. Ryegrasses cross-pollinate freely and it is difficult to maintain genetic purity. Often they form a mixture of perennial and annual species.

Italian ryegrass is a bunchgrass that grows very dense, fibrous, shallow roots that do not tolerate drought. Vegetative growth can be vigorous with stand height reaching to 40 cm (16 in.), which can become thick and often lodged. Leaves are long, tapered, about 10 mm wide, keeled, and dark green. One side is glossy and the edges are smooth.

Seed heads develop on stems up to 100 cm (39 in.) long as spikes up to 25 cm (10 in.) long with alternately arranged spikelets that are placed edgewise to the rachis. Spikelets form 10 to 20 flowers that cross-pollinate. Seeds shatter very easily.

Origin:
Italian ryegrass originates from northern Italy. Westerwold ryegrass was developed in the Netherlands from Italian ryegrass, and can set seed in the year of sowing.

Habitat and climate:
Well adapted to mild, moist climates.

Annual precipitation minimum (mm): 400

Annual precipitation maximum (mm): 600

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC zones:
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce

Uses:
Italian ryegrass is used for hay and irrigated or intensively managed pasture. It is also used extensively for quick ground cover in post-wildfire rehabilitation and other rehabilitation contexts. Westerwold ryegrass is used for silage, hay, or seed, but winter survival depends on variety, conditions, and management. Italian ryegrass is used as a lure crop for waterfowl and is intercropped with corn in southern British Columbia.

Optimal time of grazing use:
Throughout the season and a good option for extending grazing into late fall and early winter.

Recovery after use (rating): High
Excellent tolerance to grazing and quick recovery to use. Allow 3 to 5 weeks for regrowth. Vegetative material is soft and easily damaged by trampling. Although continuous grazing is acceptable, trampling damage can be reduced with managed or rotational grazing.

Forage yield:
Italian ryegrass yielded 8,960 kg/ha (8,000 lb/acre) over 2 harvest operations in 1 year (at Melfort, SK., 1998–2000). Westerwold ryegrass yielded 10,400 kg/ha (9,300 lb/acre) at the same research site. Single-year yields from three irrigated sites in the Cariboo and Chilcotin ranged from 2,760 to 5,610 kg/ha (2,464 and 5,008 lb/acre). A non-irrigated site in the same region produced 487 kg/ha (435 lb/acre).

Palatability/nutritional value:
Highly palatable and highly digestible. Fall regrowth showed crude protein 17 to 23% (dependent on sampling time and variety, at Melfort, 1992).

Longevity (rating): Low
Will only live 1 to 2 years.

Persistence (rating): Low

Competitiveness (rating): High
Highly competitive in the first year of growth.

Drought tolerance (rating): Low

Winter hardiness (rating): Low
Winter severity determines whether plants survive for a second year.

Soil texture preference:
Grows best on fertile, well-drained soils but is adapted to a wide range of soil types and textures.

Flooding tolerance (rating): High
Good tolerance to excess moisture and short period of flooding.

Salinity tolerance (rating): Moderate

Acidity tolerance (rating): High
Italian ryegrass has good tolerance to acidity.

Fire tolerance (rating): High

Seed size: Medium

Seeds per kg: 501,000

Ease of establishment (rating): High
Italian ryegrasses are easy to establish. Seed in mid- to late-May or if concerned about weed pressure, delay seeding until mid-June. Responds well to fertilizer applications (especially N and P). If broadcasting N, apply before seeding or after plant is at the 2- to 3-leaf stage. Functions very well as a nurse crop while establishing other slower growing forage crops.

Suggested mixtures:
Italian ryegrasses can be seeded in mixtures, although they should be seeded at a low rate to allow establishment of slower to establish perennials.

Typical seeding objectives:
Extending the grazing season
Erosion control

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Photo credit: Percy Folkard, (BC FLNR).



Perennial Ryegrass

Scientific name:
Lolium perenne L.

Type:
Agronomic grass

General description:
Perennial ryegrass is a short-lived, perennial, cool season bunchgrass. It is closely related to Italian ryegrass, but is smaller, has folded rather than rolled leaves, and lacks awns. Perennial ryegrass produces a shallow, fibrous root system, with the majority of roots in the upper 15 cm (6 in.) of soil. It tillers freely and produces a dense sod.

Perennial ryegrass produces a dense cover of low-growing leaves, and stems that are up to 60 cm (24 in.) long with a slender spike up to 30 cm (12 in.) long. Leaves are dark green, narrow, hairless, keel-shaped, and folded when young. Lower surface is glossy and smooth, while upper surface is veined and duller coloured.

There are diploid and tetraploid genetic types (double chromosome types often associated with more vigorous growth but less hardiness) with a tremendous variation in seed size both between and within genetic types.

Origin:
Originates in Europe, and is sometimes called English ryegrass.

Distribution:
This introduced species grows well in southern British Columbia.

Habitat and climate:
Perennial ryegrass is best suited to areas with cool summers of reasonable moisture without summer drought, and mild winters. May have broader range of application when used as short lived (annual or biennial) for erosion control.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce

Annual precipitation minimum (mm): 400

Annual precipitation maximum (mm): 600

Uses:
Seed size can be quite variable between and within diploid and tetraploid types. Perennial ryegrass grows quickly so it is well suited for use in pastures, usually under short-term intensively managed grazing and irrigated pastures. It is used for dairy silage, for turf (depending on variety), and for conservation purposes.

Optimal time of grazing use:
Perennial ryegrass produces high quality forage but requires good fertility.

Recovery after use (rating): High
Can be frequently grazed close to the ground, and is adapted for either continuous or rotational grazing systems.

Palatability/nutritional value:
Very palatable as perennial ryegrass can be one of the highest quality forage grasses for grazing. Precautions need to be taken to test for endophytes and a toxin called lolitrem B, especially if feeding perennial grass seed straws from varieties favoured by the turf industry.

Longevity (rating): Low

Persistence (rating): Low
Persistence has been improved by crossing perennial ryegrass with tall or meadow fescues.

Invasiveness (rating): Low

Competitiveness (rating): High

Erosion control (rating): High
Used often in turf and conservation mixes because of its quick green growth and ground cover, early in the year of establishment.

Drought tolerance (rating): Low

Very intolerant of drought or high temperatures.

Winter hardiness (rating): Low
Extreme variation in winter hardiness among varieties.

Soil texture preference (rating): Fine-Medium

Flooding tolerance (rating): High

Salinity tolerance (rating): Low

Acidity tolerance (rating): High

Fire tolerance (rating): High

Seed size: Medium

Seeds per kg: 501,000

Ease of establishment (rating): High
Perennial ryegrass is easy to establish but somewhat less aggressive than annual or Italian ryegrass.

Application requirements:
Seed into a firm fine seedbed, with uniform shallow depth. It is possible to get good establishment with broadcast methods if they are followed by a roller packer.

Typical seeding objectives:
Forage enhancement
Grazing season extension
Erosion control

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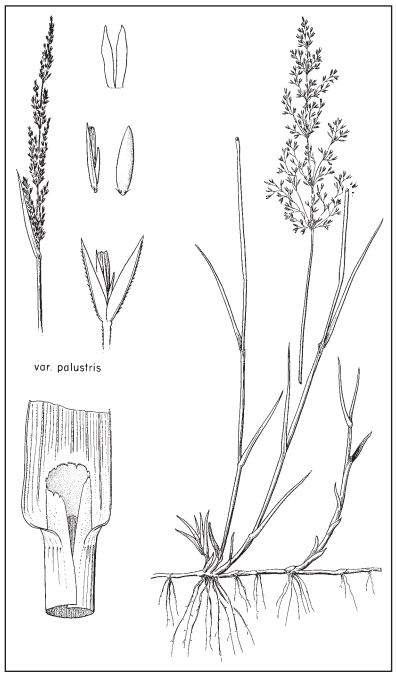
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Photo credit: Percy Folkard, (BC FLNR).



Redtop

Scientific name:
Agrostis gigantea Roth

Type:
Agronomic grass

General description:
Redtop is a long-lived, perennial tufted grass with common names like bentgrass or ticklegrass. Several closely related species of this bentgrass group are discussed in the literature including redtop (*Agrostis gigantea* Roth or *Agrostis stolonifera* - introduced), and hair bentgrass (*Agrostis scabra* - native). The common name ticklegrass can refer to any of these species. Redtop was introduced and has become naturalized throughout British Columbia. It is abundant following disturbance, especially in the northeastern part of British Columbia.

Its roots are tough and extensively branched with scaly rhizomes. This species was formerly combined with *Agrostis stolonifera* under the name *Agrostis alba*, but it is distinguished from *Agrostis stolonifera* by its underground rhizomes and tolerance of drier areas. Redtop forms a dense sod, but not as compact as bluegrasses.

Its stems grow 20 to 120 cm (8 to 47 in.) high. Leaves are smooth, 4 to 10 cm (1.5 to 4 in.) long and 3 to 8 mm wide.

Seed heads form open panicles with spikelets that are awnless or rarely with short awns. Redtop reproduces from both seeds and rhizomes.

Origin:
Introduced from Europe.

Distribution:
Naturalized throughout British Columbia.

Habitat and climate:
Grows on dry to wet roadsides, fields, or waste areas in lowland and montane areas.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Ponderosa Pine
Interior Douglas-fir
Interior Cedar–Hemlock
Engelmann Spruce–Subalpine Fir
Sub-Boreal Pine–Spruce
Sub-Boreal Spruce
Boreal White and Black Spruce

Annual precipitation minimum (mm): 450

Uses:
Introduced initially for use in lawns and turf grasses. Used for erosion control in riparian areas and wetlands, and rehabilitation of disturbed sites with high acidity or heavy metal contamination. There has been some use for pasture and hay in higher elevation wet meadows in western states.

Recovery after use (rating): Low
Tolerant of grazing because of semi-prostrate growth and generally low palatability.

Forage yield (rating): Low

Palatability/nutritional value: Low
Cattle prefer most other agronomic species over redtop. When it is available it is preferred by cattle and horses in spring and summer, preferred by sheep in spring, and desirable in summer.

Longevity (rating): High

Persistence (rating): High

Invasiveness (rating): High
Very aggressive even on very acid soils.

Erosion control (rating): High

Drought tolerance (rating): Moderate

Soil texture preference (rating): Fine
Grows well on poor, clayey soils, on poorly drained soil and on soils with low fertility. Not suited to limestone based soils.

Flooding tolerance (rating): Moderate

Salinity tolerance (rating): Low

Acidity tolerance (rating): High
Grows well on very acid soils.

Fire tolerance (rating): Medium

Seed size: Small

Seeds per kg: 10,670,000

Ease of establishment (rating): Moderate
When established from seed, plants can have low vigour resulting in poor stands. However, once established plants will readily spread.

Application requirements:
Early spring seeding is recommended to allow establishment before onset of drier conditions. Broadcast seeding with light harrowing is suitable. Soil compaction over seed may cause crusting which can be impenetrable to emerging seedlings.

Suggested mixtures:
Seldom seeded alone and forage quality is improved when seeded with species such as timothy and/or clover species.

Management considerations:
This species should not be seeded where native vegetation is desired, and readily hybridizes with other Agrostis species. Pasture mixes will need to be grazed closely to allow for palatable regrowth on wetter and sub-irrigated sites.

Typical seeding objectives:
Erosion control
Soil improvement
Forage enhancement

References:
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Photo credit: Percy Folkard, (BC FLNR).



Timothy

Scientific name:
Phleum pratense L.

Type:
Agronomic grass

General description:
Timothy is a widely adapted, cool season perennial bunchgrass. It is considered hardy and reliable, but does not tolerate drought well.

Roots are wide spreading, shallow and fibrous with heaviest concentration of roots within top 7.5 cm (3 in.) of soil. Swollen bulbs or corms develop just below the surface and store nutrients for winter survival and regrowth after cutting or grazing.

It has strong tall stems up to 120 cm (47 in.) tall. Leaves are hairless and rolled during the bud stage. They are relatively wide, up to 12 mm, and flat.

The seed head is a spike of densely packed, bristle-like spikelets, each producing a tiny, dark brown seed.

Origin:
Originated in Europe. Most introductions of timothy into Canada came from United States.

Distribution:
This introduced species is common throughout British Columbia.

Habitat and climate:
Best adapted to cooler, higher rainfall regions or wetter areas.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Ponderosa Pine
Interior Douglas-fir
Interior Cedar–Hemlock
Engelmann Spruce–Subalpine Fir
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce

Annual precipitation minimum (mm): 400

Annual precipitation maximum (mm): 600

Uses:
Used in pasture, domestic and export hay, seed production in the Peace and Creston areas of British Columbia. It has some use for erosion control in post-wildfire rehabilitation, but only when seeded in mixtures.

Optimal time of grazing use:
Early in summer for most livestock. It should not be grazed too early or too closely, due to the locations of the growing point for elongation.

Recovery after use (rating): Low
Regrows slowly if cut or grazed in late summer. Because timothy is not sod producing, it is intolerant of grazing hoof damage. Leave at least 10 cm (4 in.) of grassy residue to aid in regrowth. Fall grazing should be light as food reserves are accumulated for winter. Once the plant is dormant, timothy stands can be grazed in late fall and winter, but it does not hold its feed quality.

Forage yield:
Three year average dry matter yield at Prince George, B.C., was 4,606 kg/ha (4,112 lb/acre).

Palatability/nutritional value:
If used early in the season before flowering, timothy has good quality, 11% crude protein, and 61% digestibility. At later growth stages, quality and nutritional value decline rapidly.

Longevity (rating): High
4 to 10 years.

Persistence (rating): Moderate
Can persist under careful management. Some stands managed for seed production in the Peace Region have been established for 18 years or more.

Competitiveness (rating): Moderate
Poor to moderate competitiveness while establishing, weeds must be managed, though of moderate competitiveness once established.

Invasiveness (rating): Low
Timothy can co-exist with native species where it is well adapted, but it generally is not considered invasive.

Weed resistance (rating): Low
There are less weed control tools or herbicides that can be used on timothy than with many other grasses, so weed control can be challenging.

Erosion control (rating): Moderate
Provides moderate erosion control in wetland upland areas when seeded with other species.

Drought tolerance (rating): Low
Generally poor drought tolerance. Although some varieties have some drought hardiness, most timothy cannot tolerate short periods of moisture stress.

Winter hardiness (rating): High
Winter hardiness is increased with adequate snow cover.

Soil texture preference (rating): All
Timothy is well adapted for all soil textures, especially in Gray or Black soils.

Flooding tolerance (rating): High
Timothy grows well on moister soils and can withstand 1 to 2 weeks of spring flooding. There are differing views in the literature on its tolerance to flooding later in the growing season.

Salinity tolerance (rating): Low

Acidity tolerance (rating): High
Tolerates soil pH as low as 4.5.

Fire tolerance (rating): Low

Pest and/or disease threats:
Disease threats include purple eyespot and leaf streak. New stands are susceptible to grasshopper, wireworm, or glassy cutworm infestations. European skippers feed on timothy leaves and also perennial ryegrass, meadow fescue, and orchardgrass. Silvertop is a threat for seed producers of timothy, fescues, bluegrasses, wheatgrasses, and bromegrasses.

Seed size: Small

Seeds per kg: 2,712,000

Ease of establishment (rating): Moderate
Relatively easy to establish, because the seeds germinate quickly. Timothy must be seeded shallow to get good establishment.

Suggested mixtures:
Mix with legumes such as alfalfa, alsike clover, or birdsfoot trefoil.

Typical seeding objectives:
Forage enhancement
Erosion control

References:
Aasen, A. and M. Bjorge. 2009. Alberta forage manual. 2nd edition. AB Agric Agdex 120/20-1, Edmonton, AB. www.agriculture.alberta.ca/publications.

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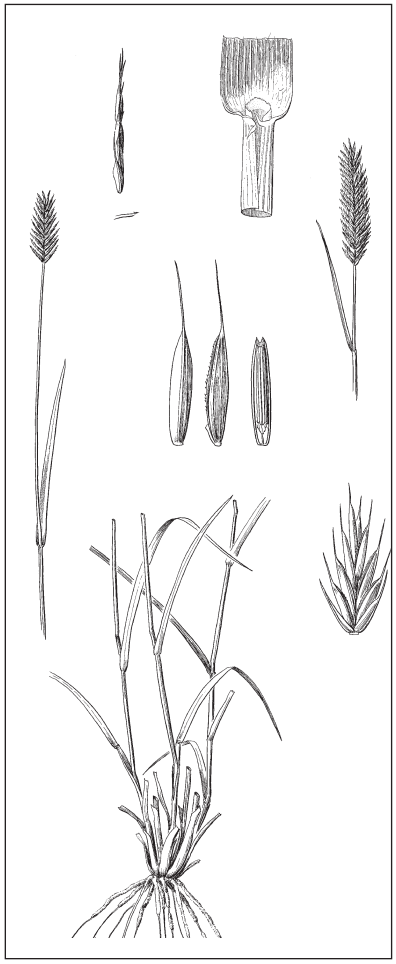
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Photo credit: Kimberley Will (BC AGRI).



Crested Wheatgrass

Scientific name:
Agropyron cristatum sens. lat (L.) Gaertn.

Type:
Agronomic Grass

General description:
Crested wheatgrass is a hardy, perennial, agronomic bunchgrass with fibrous roots. The *Agropyron* species (*A. cristatum, A. desertorum*) occurring in British Columbia hybridize readily when growing together, forming morphologically intermediate plants. Some cultivars are also intermediate, being derived from hybrids.

Stems are erect 50 to 100 cm (20 to 39 in.) tall or more, and usually softly hairy below the spike. The leaves are green to slightly blue-green with rough margins and upper surface veining. The leaf sheaths are open, and the lower sheaths smooth to somewhat hairy and sometimes purple in colour. The blades are flat, 1.5 to 6 mm wide and softly hairy on the upper surfaces, with ear-shaped lobes at the leaf-bases that are slender, and about 1 mm long.

The flat, comb-like seed heads or spikes are very distinctive. The spikes are up to 7 cm (23/4 in.) long and 2.5 cm (1 in.) wide, with a dense, oblong, flattened shape. The spikelets are closely overlapping, less than 1 mm apart, spreading at an angle of 30 degrees or more. They are mostly 5 to 7 flowered, and cross pollinated. Diploids (*A. cristatum*, Fairway-Parkway types) have smaller seeds, finer leaves and stems, and are less drought tolerant than the tetraploid (*A. desertorum*, Nordan/Summit) type.

Origin: Siberia

Distribution:
A widely adapted introduced species, crested wheatgrass is frequent in south-central and southeastern British Columbia.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Bunchgrass
Ponderosa Pine
Interior Douglas-fir
Montane Spruce
Engelmann Spruce–Subalpine Fir
Sub-Boreal Pine–Spruce

Annual precipitation minimum (mm): 200

Annual precipitation maximum (mm): 450

Uses:
Most often used for early spring pasture and occasionally for hay. Crested wheatgrass was used extensively in historic rehabilitation efforts on western rangelands.

Optimal time of grazing use:
Very early to early spring.

Recovery after use (rating): Moderate
Good forage in early spring, and has a high tolerance for close grazing but requires additional moisture and rest for regrowth.

Forage yield (rating): Low
Forage yields in the dry Bunchgrass zone can range between 300 and 1,000 kg/ha. (168 and 893 lb/acre). Yields of over 3,000 kg/ha (2,679 lb/acre) are possible under better soil and moisture conditions.

Palatability/nutritional value:
This grass provides palatable, productive, and nutritious forage in May and June. It is most palatable to all classes of livestock in the spring. Use by wildlife can vary. Crested wheatgrass seedings are heavily used by elk and bighorn sheep, but may be less favoured by mule deer. Palatability declines rapidly as it matures.

Longevity (rating): High
Long-lived, especially in dry areas, does not persist as long in northeastern British Columbia or the central interior.

Persistence (rating): High
Crested wheatgrass can persist for longer than 30 years in dry areas where it is well adapted. It produces many more seeds than bluebunch wheatgrass and seed production decreases little in dry years.

Invasiveness (rating): Low
Invasion of crested wheatgrass into native grasslands has been documented in some areas (Idaho, Oregon, and southern Alberta). Invasion into adjacent native range in southern British Columbia is less evident.

Competitiveness (rating): Moderate
Seedlings can be vigorous but are sensitive to competition. However, crested wheatgrass can resist competition from cheatgrass better than other grasses. Once established, crested wheatgrass is very competitive.

Weed resistance (rating): High
Once established, crested wheatgrass is very competitive with weeds where it is well adapted. Weed resistance may be lower under more moist conditions.

Erosion control (rating): Moderate
Crested wheatgrass has value for erosion control on semi-arid sites where species choices are limited.

Drought tolerance (rating): High
Crested wheatgrass is very drought tolerant.

Winter hardiness (rating): High
One of the most cold-hardy forage grasses on the Canadian Prairies.

Soil texture preference (rating): All
Crested wheatgrass can grow in a wide range of soil textures from sandy to clay.

Flooding tolerance (rating): Low

Salinity tolerance (rating): High

Acidity tolerance (rating): Moderate

Seed size: Medium

Seeds per kg: 480,000

Ease of establishment (rating): Moderate
Establishes quickly when conditions are suitable, and establishes satisfactorily if conditions are not ideal. In dry conditions it may take three to six years for plants to fully develop and for the stand to become free of weeds.

Application requirements:
A seeding rate of 4 kg/ha for the diploid types and 6 kg/ha for the tetraploid types will usually produce a satisfactory stand if seedbed conditions are good.

Suggested mixtures:
Alfalfa can be added to a mix at a rate of 1.25 to 2.5 kg/ha to improve forage quality where precipitation permits.

Management considerations:
Stands can be heavily used without reducing the long term yield.

Typical seeding objectives:
Forage enhancement
Invasive plant suppression

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Photo credit: Percy Folkard, (BC FLNR).

Intermediate/ Pubescent Wheatgrass

Scientific name:
Thinopyrum intermedia (Host) Barkw. and D.R. Dewey

Type:
Agronomic Grass

General description:
Intermediate wheatgrass is an erect, tall, perennial grass. Pubescent wheatgrass is currently considered to be a type of intermediate wheatgrass, although originally it was considered a separate species.

It appears to be a bunchgrass but some varieties have stronger, longer creeping rhizomes than others. It forms deep, extensive fibrous roots. Stems are 50 to 150 cm (20 to 60 in.) tall. Leaves are blue-green to green and 2 to 10 mm wide with thickened and hardened margins.

The seed heads are about 5 to 25 cm (2 to 10 in.) long in a narrow-shaped spike. There is one spikelet per node, attached alternatively, with 2 to 6 flowers. Intermediate wheatgrass produces large seed by cross-pollination.

Origin:
Intermediate wheatgrass is native to central Europe, the Balkans, and Asia minor and was introduced into North America in the 1930s. Early varieties into Canada came from Russia, or through the United States from Russia.

Distribution:
Intermediate wheatgrass is distributed throughout most of western North America.

Habitat and climate:
Dry roadsides and forests in the montane zone.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Bunchgrass
Ponderosa Pine
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Engelmann Spruce–Subalpine Fir
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce

Annual precipitation minimum (mm): 330

Annual precipitation maximum (mm): 1,120

Uses:
Intermediate wheatgrass is used for pasture forage, hay, and stockpiled grazing. With its extensive root system, it is also used for erosion control and the stabilization of disturbed soils. Pubescent wheatgrass was used extensively in rangeland rehabilitation seeding.

Optimal time of grazing use:
Intermediate wheatgrass is best utilized in spring and early summer. Plants should be allowed to reach a height of 20 cm (8 in.) before grazing, but it is best grazed before stem elongation. If used as a stockpiled forage, intermediate wheatgrass should be grazed early in the season to maintain quality.

Recovery after use (rating): Low
Intermediate wheatgrass is slow to regrow following clipping or grazing, especially if close or frequent. Grazing or cutting intermediate wheatgrass more than once per year will reduce stand vigour and persistence in the stand. A grazed stubble height of 10 cm (4 in.) is recommended. Its ability to form a sod increases its ability to withstand trampling.

Forage yield:
Intermediate wheatgrass can provide higher forage yields than other species in pasture situations where it is well adapted. In a trial on Gray zone soils near Prince George, intermediate wheatgrass produced a dry matter yield of 4,274 kg/ha (3,816 lb/acre).

Palatability/nutritional value:
Intermediate wheatgrass is highly palatable to livestock and wildlife. Typically intermediate wheatgrass has crude protein of 12–15% at haying, and protein may be as high as 11% later in the season. Intermediate wheatgrass matures later than other grasses, providing a high quality hay when it is grown in a mixture with alfalfa.

Longevity (rating): Moderate
Intermediate wheatgrass is relatively short lived.

Persistence (rating): Moderate
Intermediate wheatgrass persists less than 6 years in grazed pastures, but will persist as long as 10 years when used in a single crop hay situation. It is apparent that persistence is highly related to individual site conditions. In a U.S. Forest Service planting established in 1939 in southern Idaho, intermediate wheatgrass persisted for 52 years.

Invasiveness (rating): Low
Intermediate wheatgrass is not considered invasive, although in some situations it has been known to increase from sites where it is planted.

Competitiveness (rating): Moderate
Competitiveness has been variable depending on site conditions, and is thought to be less competitive than western wheatgrass. Its lack of competitiveness makes it a good candidate for mixing with legumes like alfalfa.

Weed resistance (rating): Moderate
When intermediate wheatgrass densities are high, it is expected to have moderate weed resistance.

Erosion control (rating): High
Intermediate wheatgrass is effective for erosion control. It produces a dense root system, especially on more moist sites. Root production will be reduced on drier sites.

Drought tolerance (rating): Moderate
Intermediate wheatgrass has good drought tolerance, but less tolerance than crested wheatgrass or Russian wildrye.

Winter hardiness (rating): High
Intermediate wheatgrass has good winter hardiness.

Soil texture preference (rating): Fine-Medium
Intermediate wheatgrass prefers well drained fine- to medium-textured soils.

Flooding tolerance (rating): Low
Intermediate wheatgrass does not tolerate flooding, but can withstand submergence for about 1 week in the spring.

Salinity tolerance (rating): Moderate
Intermediate wheatgrass has moderate salinity tolerance.

Acidity tolerance (rating): Moderate
Intermediate wheatgrass tolerates soil pH as low as 5.6.

Fire tolerance (rating): High

Seed size: Large

Seeds per kg: 194,000

Ease of establishment (rating): High
Intermediate wheatgrass establishes easily.

Suggested mixtures:
Intermediate wheatgrass is often combined with alfalfa for hay production.

Management considerations:
Intermediate wheatgrass is not suited to continuous grazing. It should be rested for at least 4 weeks in higher production rotational systems.

Typical seeding objectives:
Forage enhancement
Invasive plant suppression
Erosion control

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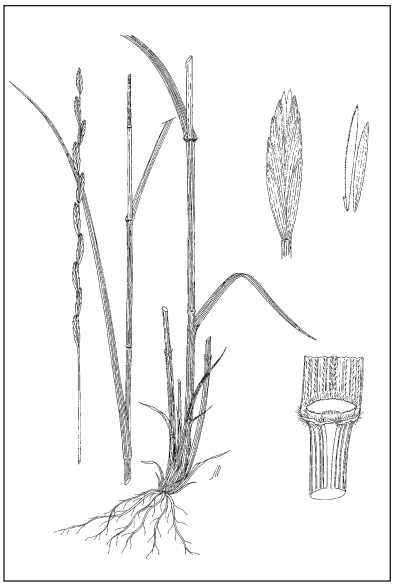
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Tall Wheatgrass

Scientific name:
Thinopyrum ponticum (Podp.) Z.W. Liu & R.R.-C. Wang OR *Elytrigia elongata* (Host) Nevski

Type:
Agronomic grass

General description:
Tall wheatgrass is a long-lived, tall, perennial bunchgrass introduced to North America from Russia. It is often used for rehabilitation of saline areas. It has an extensive fibrous root system that can grow 300 cm (118 in.) into the soil. Plants form a "bunch" that increases in size with age.

Stems are coarse and grow 100 to 300 cm tall (39 to 118 in.). Leaves are 2 to 6.5 mm with short hairs that make them scratchy to the touch.

The seed heads can be over 30 cm (12 in.) in length and form a stiff narrow spike, with long gaps between spikelets. Each spikelet has 5 to 11 cross-pollinated flowers. Seeds are large and do not shatter easily.

Origin:
Saline meadows of southern Russia.

Distribution:
Dry roadsides and saline areas.

Habitat and climate:
Dry roadsides, slopes, and open forests in grasslands and lower montane zones.

Regions:
Cariboo – Fraser-Fort George
Kootenay
Thompson – Okanagan

Typical BEC range:
Bunchgrass
Ponderosa Pine
Interior Douglas-fir

Annual precipitation minimum (mm): 300

Annual precipitation maximum (mm): 550

Uses:
Tall wheatgrass is used primarily for rehabilitation of saline areas, and is sometimes used for hay and forage. It has some value as nesting cover and food supply for birds.

Optimal time of grazing use:
Tall wheatgrass is best suited to early season rotational grazing.

Recovery after use (rating): Moderate
Tall wheatgrass should have up to 4 weeks of rest following grazing. It is best grazed rotationally with control over frequency and grazing height.

Forage yield (rating): Moderate
It yields well for hay but becomes very coarse as it matures. It also yields well in pastures but regrowth is slow.

Palatability/nutritional value:
Tall wheatgrass is less palatable and has lower nutritional value than other species because of its coarse stems and tough leaves.

Longevity (rating): High
Tall wheatgrass is long lived under ideal growing conditions, but dry conditions shorten its life.

Persistence (rating): Moderate
Tall wheatgrass has moderate persistence on sites where it is well adapted.

Invasiveness (rating): Low
Tall wheatgrass is not considered invasive.

Competitiveness (rating): Low
Tall wheatgrass would not be considered very competitive except on sites where it is very well adapted.

Weed resistance (rating): Low
Tall wheatgrass has little impact on invasive plants.

Erosion control (rating): Moderate
Tall wheatgrass is used for roadside stabilization, but may be less effective than other species for erosion control on steep slopes.

Drought tolerance (rating): High
It has high drought tolerance but it is less drought tolerant than slender wheatgrass.

Winter hardiness (rating): Moderate
Tall wheatgrass is extremely winter hardy. However, it is not as winter hardy as Kentucky bluegrass, creeping red fescue, and some of the other wheatgrasses such as western, slender, or crested wheatgrass.

Soil texture preference (rating): Fine-Medium
Tall wheatgrass prefers fine- to medium-textured moist soils, and can tolerate high water tables.

Flooding tolerance (rating): Moderate
Tall wheatgrass can withstand 5 weeks of flooding in spring. It has good tolerance for excess soil moisture.

Salinity tolerance (rating): High
Tall wheatgrass has the highest salt tolerance of all introduced agronomic grass species.

Acidity tolerance (rating): Low
Tall wheatgrass can tolerate soil pH as low as 6.6.

Seed size: Large

Seeds per kg: 174,000

Ease of establishment (rating): Low
Tall wheatgrass is slow to germinate and seedlings do not compete well with weeds. Two years are recommended for establishment before use.

Application requirements:
Seeding rates of 10 pounds pure live seed (PLS) per acre on non-saline soils and 15 pounds per acre on saline soils is recommended.

Suggested mixtures:
Should be seeded with other saline-tolerant species such as slender wheatgrass in rehabilitation projects.

Management considerations:
Effective weed control may be necessary for establishment. Irrigation and fertilization can enhance production.

Typical seeding objectives:
Forage enhancement
Erosion control

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Photo credit: Percy Folkard, (BC FLNR).

Dahurian Wildrye

Sientific name:
Elymus dahuricus Turz. ex Grieseb.

Type:
Agronomic Grass

General description:
Dahurian wildrye is a short-lived, shallow-rooted perennial bunchgrass native to Siberia, Mongolia, and China. "James" and "Arthur" are two varieties developed and registered for use in Canada.

It is a shallow-rooted bunchgrass with fibrous roots. The stems of Dahurian wildrye are erect and can grow to 100 to 150 cm (39 to 60 in.) high. The leaves are 11 to 15 mm wide with prominent veining, and lax with long (130 to 235 mm or 5 to 9 in.) leaf sheaths and internodes. The seed spikes (130 to 150 mm or 5 to 6 in.) are borne on culms 100 to 150 cm (39 to 60 in.) long. There are 2 to 4 spikelets per node but 3 are most common. Each spikelet may contain 3 to 5 florets. The seed is generally longer and wider than that of Russian wildrye, *Psathyrostachys juncea* (Fisch. Nevski), and frequently has awns 10 to 20 mm (.4 to .8 in.) in length.

Origin:
Siberia, Mongolia, China. Canadian varieties to date have originated from China.

Distribution:
Not native to British Columbia.

Habitat and climate:
Dahurian wildrye has been grown on a wide range of soil types in both northern and southern regions of Saskatchewan. It was one of the successful species in the Vaseux Fire Restoration Demonstration project initiated in the southern Okanagan, and was recommended for application in the final report (see Atwood 2009).

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Bunchgrass
Ponderosa Pine
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce

Annual precipitation minimum (mm): 300

Annual precipitation maximum (mm): 600

Uses:
It is used primarily for short-term pasture or hay forage, but because of its adaptability, ease of establishment, and shorter life span, it may have some application in restoration. It can establish and stabilize soil very quickly.

Optimal time of grazing use:
Dahurian wildrye begins growth early and should be grazed before it gets coarse. It can be used in the year of establishment, especially under moister site conditions.

Recovery after use (rating): High
Dahurian wildrye is quick to regrow and can be grazed 2 to 3 times within the season.

Forage yield (rating): Moderate
Forage yield is comparable to crested wheatgrass on sites in the southern prairie zone. On darker soils, yield may be as high as 5,534 kg/ha (4,941 lb/acre). It has good yield as long as it persists.

Palatability/nutritional value:
Dahurian wildrye is quite palatable and has good forage quality when it is growing. Unlike Russian wildrye, it does not cure well standing, although when cut at the immature stage hay quality may be as good as for crested wheatgrass.

Longevity (rating): Low
Dahurian wildrye is relatively short lived especially on drier sites (1 to 3 years). On more moist sites longevity is increased (3 to 5 years).

Persistence (rating): Low

Invasiveness (rating): Low
Dahurian wildrye is not considered invasive.

Competitiveness (rating): Moderate
Dahurian wildrye is very competitive in the year of establishment but becomes less competitive as the stand ages.

Weed resistance (rating): Low
Weed resistance is low where weeds are persistent.

Erosion control (rating): Low
Though Dahurian wildrye can provide cover because it establishes readily, its shallow roots make it unsuitable for erosion control.

Drought tolerance (rating): High
Has good drought tolerance.

Winter hardiness (rating): Moderate
Dahurian wildrye has moderate to high winter hardiness in most situations, although it can winter kill in very severe winters.

Soil texture preference (rating): All
Dahurian wildrye can be grown on a wide range of soil textures.

Flooding tolerance (rating): Moderate
Dahurian wildrye will withstand up to 4 weeks of flooding in the spring.

Salinity tolerance (rating): High
Young stands have a high salinity tolerance, but this appears to decrease as the stand ages.

Acidity tolerance (rating): Moderate
Dahurian wildrye has some tolerance to soil acidity.

Seed size: Large

Seeds per kg: 192,000

Ease of establishment (rating): High

Dahurian wildrye is easily established, has excellent seedling vigour, and is very competitive with other crops such as legumes.

Application requirements:
Dahurian wildrye is suitable for broadcast applications.

Suggested mixtures:
Suitable for mixtures, but should be limited to 25% of the mix to reduce competition with species that are slower to establish.

Management considerations:
Dahurian wildrye is sometimes seeded in wide or perpendicular rows with other longer-lived perennials to provide additional forage in the first year of establishment.

Typical seeding objectives:
Forage enhancement

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Photo credit: Curtis Bjork.

Russian Wildrye

Scientific name:
Psathyrostachys juncea (Fisch.) Nevski

Type:
Agronomic grass

General description:
Russian wildrye is a large, cool season, introduced, long-lived, perennial bunchgrass. It is well suited for pasture and stockpiled grazing. The roots are fibrous and may establish to a depth of 1.9 to 2.6 m (6 to 8 ft.). However, about 75% of the roots are in the surface 15 to 60 cm (6 to 24 in.). Russian wildrye roots have an extended horizontal spread and may draw heavily on soil moisture for a distance of up to 1.3 to 1.6 m (4 to 5 ft.). Its long season of growth and its vigorous soil-feeding habit make this species an excellent competitor with weeds once the grass is well established.

It has an abundance of long, dense, basal leaves that are from 15 to 45 cm (6 to 18 in.) long and up to 0.6 cm (¼ in.) in width. Plants vary from light to dark green, with many shades of blue-green. The erect, leafless reproductive stems are about 75 to 100 cm (30 to 39 in.) tall.

The seed head is a short dense, erect spike with two or more short-awned spikelets clustered at axis joints. The seed shatters readily at maturity. The seed is about the same size as crested wheatgrass seed.

Origin:
Siberia

Distribution:
Currently not widely distributed in British Columbia.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Bunchgrass
Ponderosa Pine
Interior Douglas-fir
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce

Annual precipitation minimum (mm): 200

Annual precipitation maximum (mm): 450

Uses:
A versatile forage for dryland pastures. The bulk of its forage production remains close to the ground, making it unsuitable for hay production.

Optimal time of grazing use:
Well suited to spring, fall, and winter grazing. Spring growth is somewhat later than crested wheatgrass.

Recovery after use (rating): Moderate
Adequate rest (at least 60 days) following early spring use is recommended. Fall regrowth is typically better than crested wheatgrass.

Forage yield:
Information is limited on dryland yields for new varieties in British Columbia. Recent 1-year results on a trial in the Cariboo near Micocene (elev. 3,400') produced 2,564 kg/ha (2,289 lb/acre). Reported 4-year average yields were approximately half those of crested wheatgrass for two very dry sites (Tranquille and Cache Creek) in the Thompson – Okanagan region. The 4-year average yields on these two sites ranged from 150 to 210 kg/ha (134 to 188 lb/acre).

Palatability/nutritional value:
Most palatable in the spring and fall, Russian wildrye cures well on the stem and maintains good nutritional value into the winter making it useful as a stockpiled pasture forage. Its higher digestibility and wider season of use may compensate for a lower forage yield.

Longevity (rating): High
Long-lived once established.

Invasiveness (rating): Low
It is not known to spread from where it is established.

Competitiveness (rating): High
Russian wildrye is very competitive once established.

Erosion control (rating): Low
Russian wildrye is not suitable for erosion control.

Drought tolerance (rating): High
Russian wildrye has excellent drought tolerance once established similar to crested wheatgrass.

Winter hardiness (rating): High
Russian wildrye has excellent winter hardiness.

Soil texture preference (rating): Fine-Medium
Russian wildrye is best suited to loamy to heavy clays soils. It can be productive on coarse-textured soils, once established.

Flooding tolerance (rating): Low
Russian wildrye has a low tolerance to flooding and can be used where soils are saturated for no longer than 1 week in spring.

Salinity tolerance (rating): High
Russian wildrye has good salinity tolerance.

Acidity tolerance (rating): Moderate
Russian wildrye tolerates soil pH as low as 6.4.

Pest and/or disease threats:
It is subject to attack by grasshoppers, cutworms, and other insects and no troublesome diseases have been noted.

Seed size: Medium

Seeds per kg: 358,472

Ease of establishment (rating): Low
Russian wildrye is extremely difficult to establish. For this reason it has not been commonly recommended for rangeland applications in British Columbia.

Application requirements:
Well prepared seedbed, firm and weed free, drill seeded in rows to a depth of 0.6 cm (1/4" in.) will help ensure establishment. Wider row spacings up to 45 to 90 cm (18 to 35 in.) have higher forage production.

Suggested mixtures:
Alfalfa is a suitable mix species, although it should be seeded in a separate operation with rows at 90 degrees to the Russian wildrye to reduce competition between the two species.

Management considerations:
Russian wildrye has a relatively low yield response to fertilizer. Proper grazing management is recommended to keep stands productive.

Typical seeding objectives:
Forage enhancement
Grazing season extension

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Alfalfa



Photo credit: Percy Folkard, (BC FLNR).



Scientific Name:
Medicago sativa L.

Type:
Agronomic legume

General description:
Alfalfa is the most widely used perennial, cool season agronomic legume, and is adapted to many regions and uses. It is palatable for livestock but can cause bloat if not managed carefully.

Alfalfa can have very deep tap roots and a woody crown. There are different types of root systems with different types of alfalfa. The Flemish type has a narrow crown, taproot, and few lateral roots; Siberian has a deep set crown and widely branching roots; variegated types can have roots and crowns like either Flemish or Siberian, or intermediate. Creeping-rooted types have some ability to spread from rhizomes that grow horizontally from primary roots. Shoots may survive as independent plants. Alfalfa crowns are deeper set than most other legumes (except for sweet clover), which increases winter hardiness and survival.

Each alfalfa shoot develops many branches. Flemish types have erect stems and wider leaves, while Siberian types have finer, less upright stems and narrower leaves. Each leaf has 3 leaflets with finely toothed margins from midway to the point of the leaflet. Multi-foliate types may have more than 3 leaflets on each leaf.

Flowers form from buds at the base of branches, which continue to grow. Up to 20 flowers are attached to a stalk. Flower colour varies with the type of alfalfa. Flemish: purple; Siberian: yellow; variegated types: purple, blue, green, cream, or yellow. Alfalfa is cross-pollinated and leaf cutter bees are often required to achieve successful pollination. Seeds per pod vary from 3 to 10, depending on the type of alfalfa.

Origin:
Europe, Middle East, Siberia

Habitat and climate:
Alfalfa is adapted to a wide range of soils and environments.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Bunchgrass
Ponderosa Pine
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Engelmann Spruce–Subalpine Fir
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce
Spruce–Willow–Birch

Annual precipitation minimum (mm): 300

Annual precipitation maximum (mm): 600

Uses:
Alfalfa is used for hay and pasture, and as stockpiled forage (although quality is limited by frost). It also is used for wildlife habitat and forage and has had some use in post-wildfire and range rehabilitation.

Optimal time of grazing:
Cut alfalfa at 10% bloom to optimize both quality and quantity of harvested forage, and to maintain stand productivity. Frequent early cutting will reduce root reserves, potential for growth, and stand longevity. After cutting, alfalfa can be stockpiled for fall grazing after the first killing frost. Grazing can begin at bud stage, but there is a high risk of bloat. Do not graze to less than 10 cm (4 in.) tall. Tolerance to frequent grazing is highly dependent on the variety and health of plant crowns.

Recovery after use (rating): Moderate
Allow growth to bud stage before first grazing or regrazing, and allow at least 40 days for plant recovery. Avoid use for 6 weeks before killing frost to reduce winter injury. Alfalfa can be stockpiled for later grazing, but quality declines rapidly.

Forage yield (rating): High
Provides the highest yield of all agronomic legumes. Yields range from 3,556 kg/ha (3,175 lb/acre) in the Brown soil zone to 6,352 kg/ha (5,671 lb/acre) in the Gray and Black soil zones. Yields can be as high as 7,101 kg/ha (6,340 lb/acre) in the Dark Brown soil zone.

Palatability/nutritional value:
Highly palatable to livestock. Crude protein can be as high as 21% and digestibility is 71%. Can cause bloat with the greatest risk during peak plant growth periods.

Longevity (rating): High
Can live from 3 to 20 years. Creeping rooted alfalfa survives for longer in some regions, whereas taprooted types survive better in northern regions. Longevity affected by management, fertility, timing of grazing by livestock and wildlife, winter hardiness, disease resistance, soil moisture, and pH.

Persistence (rating): Moderate
Persistence is highly variable and very dependent on crown health.

Invasiveness (rating): Low

Not considered invasive, although it has shown some spread from roadsides into native plant communities in the southern interior.

Competitiveness (rating): Moderate
Can be competitive once established, but stand may thin due to winter injury or other stresses, with an increase in grasses or weeds. Creeping rooted alfalfa types are more competitive, and spread by developing new shoots from creeping rootstocks. Established plants with tall stature may cause snow press on tree seedlings if left ungrazed.

Weed resistance (rating): Low

Erosion control (rating): Moderate

Drought tolerance (rating): High
Deep root system allows alfalfa plants to access subsoil moisture more effectively than many other types of forage. It can avoid the effects of drought for up to a year, and will survive longer-term drought by going dormant.

Winter hardiness (rating): Moderate
Difficult to rate hardiness as it is highly variable, dependent on cultivar, type of rooting, snow cover, fall weather conditions, age of stand, nutrient management, type of grazing, and other stresses.

Soil texture preference (rating): All
Prefers well-drained soils of all textures.

Flooding tolerance (rating): Moderate
Can withstand 1 to 2 weeks of spring flooding and waterlogged soils before spring growth. Waterlogging in fall reduces winter hardiness.

Salinity tolerance (rating): Moderate
The effects on growth of alfalfa begins at 2 deciSiemen per metre (dS/m). Growth is fair between 4 to 8 dS/m, but there is no growth above 16 dS/m. (Low tolerance would indicate interrupted growth at 4 dS/m or less.)

Acidity tolerance (rating): Low
Tolerates soil pH as low as 6.2.

Fire tolerance (rating): Low

Pest and/or disease threats:
Insect pests affecting alfalfa include pea aphid, spotted alfalfa aphid, alfalfa weevil, clover leaf weevil, alfalfa curculio, lygus bugs, alfalfa plant bug, alfalfa seed chalcid, alfalfa looper, alfalfa caterpillar, alfalfa blotch leafminer, alfalfa webworm, leafhoppers, two spotted mite, flower thrips, and grasshoppers. Disease threats include brown root rot, crown rot, winter crown rot, seedling blight, downy mildew, spring black stem, yellow leaf blotch, verticillium wilt, and bacterial wilt.

Seed size: Medium

Seeds per kg: 441,000

Ease of establishment (rating): High
Establishes readily, because seedlings emerge early and vigorously to compete with companion crops. Autotoxicity can be a problem between established older alfalfa plants and young seedlings, resulting in stunted plants.

Suggested mixtures:
Include alfalfa with a grass forage such as crested wheatgrass, meadow bromegrass, timothy, intermediate wheatgrass, smooth bromegrass, and orchardgrass.

Management considerations:
Inoculate with *Rhizobium meliloti* before seeding. In acidic soils, root nodulation and nitrogen fixation can be impaired. Responds well to fertilizing with phosphorus and sulfur, and sometimes responds well to micronutrient amendments. Avoid close grazing or cutting during the critical fall period 6 weeks before frost.

Typical seeding objectives:
Forage enhancement
Soil improvement

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Photo credit: Reg Newman, (BC FLNR).



Birdsfoot Trefoil

Scientific Name:
Lotus corniculatus L.

Type:
Agronomic legume

General description:
Birdsfoot trefoil is a perennial legume that does not cause bloat in grazing ruminant animals. It is highly adapted to grow in a range of challenging conditions including infertile soils, soils with high acidity or poor drainage, and poorly prepared seed beds.

It has a wide crown and taproot, intermediate in depth between alfalfa and red clover. Roots sometimes develop from older stems that have soil contact. It requires its own specific *Rhizobium loti* inoculant to fix nitrogen.

The plant produces many fine stems or branches from the crown, which can grow up to 75 cm (30 in.) long. Plants can be erect or prostrate. Birdsfoot trefoil has compound leaves with paired leaflets up the stalk and a single leaflet at the tip.

Flowers initially form on lower branches and continue up the stem. Flowers are a brilliant yellow and found in clusters of 2 to 8. After cross-pollination, each flower produces a cylinder-shaped pod 4 cm (11/2 in.) long with 10 to 20 seeds in each pod. The name is derived from the way the pods form at right angles to the stem, looking like a bird's foot.

Origin:
Native to Europe, North Africa, and parts of Asia. Canadian varieties of birdsfoot trefoil were developed and selected for winter hardiness, mainly from European and Russian sources.

Distribution:
Not widely distributed in British Columbia except where it has been introduced for use on pasture. It has become naturalized in parts of the United States.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Interior Cedar–Hemlock
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce

Annual precipitation minimum (mm): 400

Annual precipitation maximum (mm): 600

Uses:
Can be used for hay but better suited for pasture, especially in higher rainfall areas. Has had some minor use for soil improvement in forestry contexts, and for roadside revegetation.

Optimal time of grazing use:
A full canopy of leaves and ground cover must be produced before spring grazing. Cut or graze birdsfoot trefoil once per year during early bloom to balance optimum quality and quantity of forage yield.

Recovery after use (rating): Moderate
Requires 4 to 6 weeks' recovery following grazing. If continually grazed, grazing may damage crowns. Should be rested in late summer and fall, and allow some seed to set at least every 2 to 3 years to allow for seed production and ensure stand replacement.

Forage yield (rating): Moderate
Yields a lower quantity of forage than alfalfa, but of a higher quality longer into the growing season. Birdsfoot trefoil retains its quality longer into later maturity stages because of better leaf retention and indeterminate growth (i.e., response to current season's growing conditions).

Palatability/nutritional value:
Very palatable and non-bloating for ruminants. Crude protein at full bloom is about 9%.

Longevity (rating): Moderate
In pasture situations, stands may be productive for 2 to 4 years; however, some individual plants can be long lived.

Persistence (rating): Moderate
Persistence depends on crown survival. Snow cover improves winter survival. Stand persistence is improved by building up a seed bank or letting the forage set seed every couple of years. Birdsfoot trefoil has persisted for as long as 18 years in a mixed pasture in the Peace River region.

Invasiveness (rating): Low
Not considered invasive in British Columbia, but is considered weedy or invasive in some regions of the United States.

Competitiveness (rating): Low
May be more competitive under adverse conditions such as acidity or low fertility.

Erosion control (rating): Low
Has limited use for controlling erosion, but is well suited to grow on poor soils.

Drought tolerance (rating): Moderate
Has fair drought tolerance, because of its deep taproot.

Winter hardiness (rating): Low
Winter survival is improved by deep snow cover and adequate rest before frost.

Soil texture preference (rating): Fine-Medium
Adapted to moist sandy loam to clay soils. Adapted to waterlogged soils or conditions of poor fertility.

Flooding tolerance (rating): High
Can tolerate up to 4 weeks of flooding, and tolerate wet soils throughout the year.

Salinity tolerance (rating): High
Has good tolerance to salinity.

Acidity tolerance (rating): High
Can tolerate soils with pH as low as 5.0, but it is more productive with pH 6.0 to 6.5.

Shade tolerance (rating): Low
Sensitive to shade

Seed size: Medium

Seeds per kg: 827,000

Ease of establishment (rating): Low
Birdsfoot trefoil can be slow to establish. Seedlings can have weak roots that are sensitive to shade.

Application requirements:
Seed 1/4 inch in depth or less due to small seed size. Apply seed without a cover crop as birdsfoot trefoil seedlings are poor competitors.

Suggested mixtures:
Best seeded alone, or with less competitive or lower growing grasses (e.g., timothy) and legumes.

Management considerations:
Inoculate seed to enhance nitrogen production. To improve establishment and longevity, do not graze or cut before full bloom in the first year of establishment. Leave 7 or 8 cm (3 in.) stubble after grazing. Do not graze too early in spring or in late summer, 6 weeks before first frost, and allow to set seed every 2 to 3 years. Birdsfoot trefoil is a great species choice to improve soil conditions without causing bloat in grazing livestock.

Typical seeding objectives:
Forage enhancement
Grazing season extension
Soil improvement

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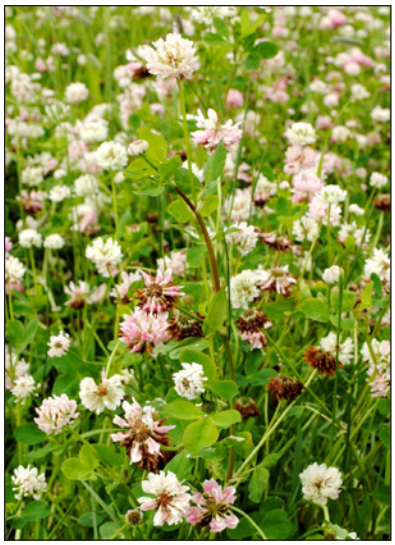
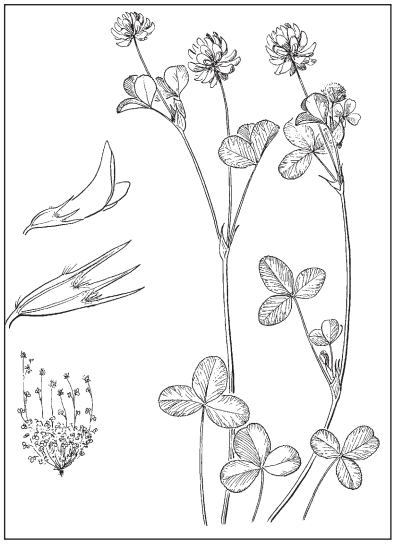


Photo credit: Percy Folkard, (BC FLNR).



Alsike Clover

Scientific name:
Trifolium hybridium L.

Type:
Agronomic legume

General description:
Alsike clover is a fast-growing, short-lived perennial clover, intermediate between white and red clover. Most commonly, diploid varieties are grown in Western Canada, but there are also tetraploid types (double the number of chromosomes with taller plants, larger leaves, and flowers).

The plant has semi-erect, slender, weak stems that grow to 60 cm (24 in.). These stems are indeterminate and may become quite long. Both the stems and leaf are hairless. The leaflets are finely toothed with 3 attached at a single point. It can often be distinguished from other clovers by the lack of the water mark (very prominent on leaves of red clover) and the character of the leaf and flower attachment to the stems.

Alsike clover has well-developed crowns and non-creeping taproots. It has compact flower heads that form at leaf axils that are pink to white. Alsike produces oblong pods with 2 to 4 small green, yellow, or black seeds per pod.

Origin:
Native to northern Europe, and cultivated in Sweden in the mid-1700s.

Habitat:
Alsike clover needs adequate growing season moisture, and moderate summer temperatures. These conditions limit alsike clover to irrigated areas or moist microsites at low elevations in southern British Columbia.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Interior Cedar–Hemlock
Montane Spruce
Engelmann Spruce–Subalpine Fir
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce
Spruce–Willow–Birch

Annual precipitation minimum (mm): 400

Annual precipitation maximum (mm): 600

Uses:
Used for hay, silage, pasture, and green manure. Used for site rehabilitation and soil improvement in forestry contexts and in areas with moist, acidic soils.

Optimal time of grazing use:
Good tolerance to frequent, close grazing, but poor tolerance to animal traffic. Optimal grazing ideally follows the growth of a full canopy of leaves. Requires rest periods of 4 weeks or more. Should not be grazed in the last 6 weeks of the growing season.

Recovery after use (rating): High
Rest or regrowth period of 4 weeks or more is recommended.

Forage yield (rating): Moderate
Yields are lower than alfalfa or red clover. Quality of forage is good, and longer lasting than red clover.

Palatability/nutritional value:
Very palatable, but can cause bloat, especially in vegetative stages. The risk to cause bloat in grazing livestock is lower than alfalfa and similar to red clover. Can cause photosensitization and clover poisoning in cattle, sheep, and especially horses, a common problem in the Peace Region.

Longevity (rating): Low
Not long lived (2 to 3 years).

Persistence (rating): Moderate
Well adapted to cool, moist areas of northern or high altitude areas. With crown survival or seed set, can be persistent.

Competitiveness (rating): Moderate
Vigorous and grows well with less competitive grasses, such as timothy.

Erosion control (rating): Moderate

Drought tolerance (rating): Low

Winter hardiness (rating): High
Alsike is winter hardy but if crowns are damaged it can winterkill.

Soil texture preference (rating): Fine
Alsike does especially well on moist clay soils, and it can do well on both peaty (organic) and inorganic soils.

Flooding tolerance (rating): Moderate
Can tolerate flooding for several days, and can grow in excess moisture conditions or on soils with poor drainage.

Salinity tolerance (rating): Low

Acidity tolerance (rating): High
Tolerates acidity as low as pH 5.0 and tolerates high alkaline soils as well.

Shade tolerance:
Fairly good shade tolerance

Fire tolerance (rating): Low

Pest and/or disease threats:
Casebearers, clover seed weevils, kesser clover seed weevils, clover root curculio, grasshoppers, leaf hoppers.

Seed size: Small

Seeds per kg: 1,544,000

Ease of establishment (rating): High
Easy to establish but must be seeded shallow. Minimal land preparation required. Volunteer establishment can occur.

Suggested mixtures:
Can be mixed with less competitive grasses such as timothy.

Management considerations:
Grazing livestock must be monitored for photosensitization and clover poisoning, especially horses and for bloat, especially with cattle. Inoculate with *Rhizobium trifolii* for best nodulation and nitrogen fixing.

Typical seeding objectives:
Forage enhancement
Erosion control
Soil improvement

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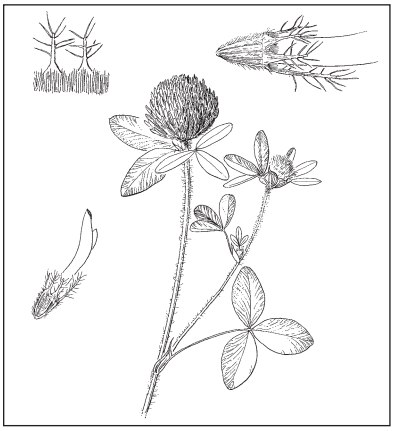
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Photo credit: Percy Folkard, (BC FLNR).



Red Clover

Scientific Name:
Trifolium pratense L.

Type:
Agronomic legume

General description:
Red clover is an introduced, commonly grown, tap-rooted, short-lived perennial legume. It can thrive in cooler temperatures and more acidic soils than alfalfa. It has deep tap roots that develop from a shallow, narrow crown, though not as deep as alfalfa, therefore reducing its drought tolerance.

Each crown produces many branched, hairy stems, which grow to 75 cm (30 in.) in length. Leaves are made up of 3 hairy leaflets attached at one point and often have white water markings on the green leaflets. Red clover produces globe-shaped, purple, cross-pollinated flowers. Seed pods are about 3 mm (1/8 in.) long with 1 to 2 yellow to purple hard seeds per pod.

Origin:
Originally from Europe and Turkey, although the commonly grown Altaswede variety was selected from Sweden.

Habitat:
Red clover needs adequate growing season moisture, and moderate summer temperatures. These conditions limit red clover to irrigated areas, or moist microsites at low to mid elevations in southern British Columbia.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Engelmann Spruce–Subalpine Fir
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce
Spruce–Willow–Birch

Annual precipitation minimum (mm): 400

Annual precipitation maximum (mm): 600

Uses:
Red clover is used for grazing, stockpiled forage, hay, silage, and green manure. It is palatable but can cause bloat. However, the risk of bloat is lower than for alfalfa. It is used for soil improvement in site rehabilitation in a variety of contexts.

Optimal time of grazing use:
Grazing should be delayed until a full canopy of leaves has developed. Experience with some custom graziers found that leaving red clover (and alfalfa) until full bloom before grazing prevented bloat and increased the stand persistence.

Recovery after use (rating): Moderate
Recovery after use may be mixed depending on the site and management. Some sources indicate red clover recovers well after mid-season cutting and can be left for fall grazing. Other sources say using red clover twice a season can reduce longevity. Still others advise against its use for grazing because of its inability to resist traffic from grazing animals. Recovery may depend on where the growing tip is in relation to cutting or defoliation from grazing. It is also dependent on available moisture and management history. It is recommended to leave at least 10 cm (4 in.) to allow for regrowth.

Forage yield:
Can yield 4,300 kg/ha (3,839 lb/acre) in the Grey or Black soil zones (e.g., areas of northern British Columbia). In drier regions, yield will be lower (e.g., 2,420 kg/ha [2,160 lb/acre]).

Palatability/ nutritional value:
Red clover is highly palatable and may be grazed preferentially. When red clover is cut or utilized at 25% bloom: crude protein can be 19% and dry matter 65 to 70%.

Longevity (rating): Low
Red clover is relatively short lived (i.e., 1 to 3 years).

Persistence (rating): Low
Persistence tends to be low, limited to 2 to 3 years. Because crowns and roots are close to the surface and break down naturally, crowns are more easily damaged. However, it can be more persistent if rotationally grazed.

Invasiveness (rating): Low
Not invasive.

Competitiveness (rating): High
Red clover tends to be vigorous and a good competitor with companion crops like timothy.

Erosion control (rating): Moderate
Red clover has value for soil improvement in erosion control seeding.

Drought tolerance (rating): Moderate
Red clover is more drought tolerant than alsike clover but less than alfalfa.

Winter hardiness (rating): Moderate
Winter hardiness depends on varieties, with single-cut red clovers having higher winter hardiness than double-cut types. Red clover tolerates colder temperatures than alfalfa.

Soil texture preference (rating): All
Prefers wet, fertile soils of any texture.

Flooding tolerance (rating): Moderate
Withstands 1 to 2 weeks of excess moisture, early in growing season; but intolerant of flooding during its actively growing period.

Salinity tolerance (rating): Low

Acidity tolerance (rating): High
Tolerates pH levels as low as 5.0 but yield is reduced significantly. Prefers pH of 6.0 to 7.0.

Shade tolerance:
Good shade tolerance, and seedlings can compete with companion crops.

Fire tolerance (rating): Low

Pest and/or disease threats:
Red clover casebearer insect, clover mite, red clover thrip, and lesser clover leaf weevil.

Seed size: Medium

Seeds per kg: 606,000

Ease of establishment (rating): High
Very easy to establish.

Application requirements:
Can be applied with a variety of methods, including drill seeding, direct or sod seeding, and broadcast seeding. It can also be seeded by feeding directly to grazing animals in a salt mixture. (See page 39 for discussion).

Suggested mixtures:
Normally grown with less competitive grasses such as timothy.

Management considerations:
Seed should be inoculated with *Rhizobium trifolii* for better nodulation and nitrogen fixing. Stands may respond to fertilization. Red clover is short lived.

Typical seeding objectives:
Forage enhancement
Soil improvement

References:
Aasen, A. and M. Bjorge. 2009. Alberta forage manual. 2nd ed. AB Agric Agdex 120/20-1. Edmonton, AB. www.agriculture.alberta.ca/publications.

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Photo credit: Reg Newman, (BC FLNR).



White Clover

Scientific Name:
Trifolium repens L.

Type:
Agronomic legume

General description:
White clover is widely distributed, especially in cool temperate climates. The plant has stolons or creeping stems near the soil surface. Leaves, flowers, and roots grow directly from these stolons. It is a relatively short plant with indeterminate growth, although taller types can grow up to 25 cm (10 in).The common or white Dutch is small and low growing, while the large type (e.g., Ladino) can be four times larger than the common type. Intermediate types have characteristics that are a mix of the two forms, and are commonly used for pasture.

There are 3 leaflets attached at a single point, and are dark green, often with a white watermark. Leaflets are finely toothed, hairless, and nearly round, up to 3 cm (1 1/4 in.) wide.

Seedling plants develop a taproot, but older plants have threadlike, fibrous roots growing from detached stolons. White clover has one of the lowest root-to-shoot ratios of the legumes. Flower heads can have up to 100 flowers, which are cross-pollinated. Seed pods develop hard, yellow to red seeds.

Origin:
It is generally accepted that white clover has Mediterranean origins, and was brought to North America by settlers. Some have suggested the true ancestral forms originated in North America, and then migrated to Eastern Asia and on to the Mediterranean.

Habitat:
White clover needs adequate growing season moisture and moderate summer temperatures. These conditions limit white clover to irrigated areas, or moist microsites at low elevations in southern British Columbia.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Engelmann Spruce–Subalpine Fir
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce
Spruce–Willow–Birch

Annual precipitation minimum (mm): 400

Annual precipitation maximum (mm): 600

Uses:
Used in pastures and will often fill in with overgrazing, especially by sheep and horses. White clover has been used extensively for seeding after timber harvest in forestry contexts for both forage and soil improvement. White clover is also used in grass mixes for erosion control.

Optimal time of grazing use:
Later in the spring, once the plant has reached full height and leaf canopy. Tolerates frequent grazing and can be grazed repeatedly throughout the season.

Recovery after use (rating): High
Low growing points make white clover well adapted to use in continuous, closely grazed systems. Taller types benefit from rotational grazing.

Forage yield (rating): Low
It's low growing form makes white clover lower yielding than other legumes, but quality remains high throughout the growing season and after grazing. Intermediate and tall types have greater forage yields.

Palatability/nutritional value:
Palatable for livestock, especially sheep who may select for it. Increased risk of bloat due to high digestibility.

Longevity (rating): Low

Persistence (rating): Moderate
Survival of stolons affects persistence. Stands persist from seed set and surviving stolons; small types can sometimes persist in patches on drier sites.

Invasiveness (rating): High
Small volunteer types can invade continuously grazed pastures, under moist conditions.

Erosion control (rating): Moderate
White clover has value in erosion control mixes to produce nitrogen for grasses. Can provide reasonable erosion control on moist fertile slopes, but will be patchy on drier sites.

Drought tolerance (rating): Low
Yield is negatively affected by short drought periods. Small types tend to be more drought tolerant.

Winter hardiness (rating): Low
Large types are the least winter hardy. Intermediate and small types have some winter hardiness.

Soil texture preference (rating): Fine-Medium
Prefers clay and silty loam textured soil, but will grow on coarser sandier soils if moisture is adequate.

Flooding tolerance (rating): Moderate
Tolerates excess moisture but not flooding or water logging for extended periods of time during the growing season.

Salinity tolerance (rating): Low

Acidity tolerance (rating): High
Can grow in pH 5.0, but prefers 6.0 to 6.5.

Shade tolerance:
Low shade tolerance.

Fire tolerance (rating): High

Pest and/or disease threats:
Clover seed weevils, lesser clover weevils, casebearers (Coleophora mayrella), leafhoppers.

Seed size: Small

Seeds per kg: 1,764,000

Ease of establishment (rating): High
Establishes easily if moisture conditions are favourable.

Application requirements:
Can be applied with a variety of methods (e.g., drill seeding, direct or sod seeding, and broadcast seeding). Can be seeded by feeding directly to grazing animals in a salt mixture. (See page 39 for discussion.)

Suggested mixtures:
Intermediate types work well with Kentucky bluegrass, meadow bromegrass, or orchardgrass with frequent use to keep stands short.

Management considerations:
Inoculate with *Rhizobium trifolii* for better nodulation and nitrogen fixing. Grows best on fertile, moist soils. Can tolerate a shorter rest period than other legumes in a grazing system, but grazing should be light enough not to damage stolons. Should not be grazed during the last 6 weeks of the growing season, but can be grazed later in the fall. It is important to monitor for bloat with grazing animals.

Typical seeding objectives:
Forage enhancement
Soil improvement
Erosion control

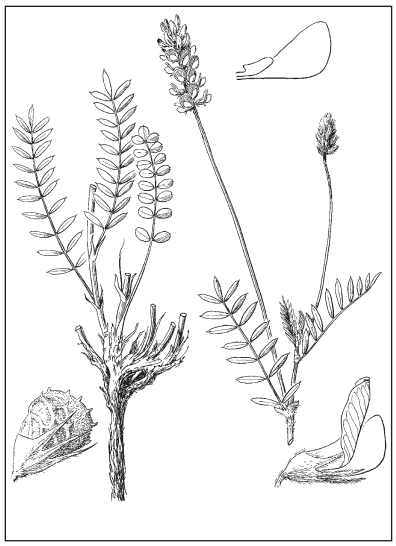
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Photo credit: Percy Folkard, (BC FLNR).



Sainfoin

Scientific Name:
Onobrychis viciifolia Scop.

Type:
Agronomic legume

General description:
Sainfoin is a drought tolerant, relatively short-lived, deep-rooted, non-bloating perennial legume. It can be useful in grazing systems because it is non-bloating and maintains good forage quality for late-season grazing or stockpiling. It may have a place in site rehabilitation and reclamation situations as it will grow on high pH, alkaline, thin, or gravelly soils. It is resistant to several diseases that threaten alfalfa productivity.

It has deep taproots with many branches of lateral roots, and a stout branched crown. Sainfoin's erect, hollow stems can reach up to 100 cm (39 in.) tall. Stems are very succulent and palatable in spite of their coarse appearance. There are 11 to 29 paired leaflets on each compound leaf.

Seed heads are wide at the base and narrow at the top, with up to 80 pink flowers attached to a common stalk. Cross pollination produces fibrous seed pods. Pods are kidney shaped and detach easily from the plant. Seed pods do not easily open to detach their greenish brown to dark brown seeds. Seed is often used with the pods.

Origin:
Origins in Europe, Russia, Turkey, and parts of Asia. Improved varieties were developed in Montana and southern prairies. It is also called saintfoin or holy clover.

Habitat:
Adaptation similar to alfalfa with somewhat less drought tolerance.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Ponderosa-Pine
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Engelmann Spruce–Subalpine Fir
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce
Spruce–Willow–Birch

Annual precipitation minimum (mm): 300

Annual precipitation maximum (mm): 600

Uses:
Used for pasture, hay, stockpiled forage. Also used in site rehabilitation and reclamation.

Optimal time of grazing use:
Graze in spring and early summer. Can be fall grazed after first killing frost. Sainfoin maintains its nutritive quality into full bloom.

Recovery after use (rating): Low
It has poor tolerance to close and/or frequent grazing, and is better suited to rotational rather than continuous grazing. To increase longevity, cut or graze leaving 30 cm (12 in.) stubble and do not use during last 6 weeks before frost, and normally allow a full season rest period after use. Sainfoin needs its leaves to photosynthesize and regrow as very few root reserves are stored during summer.

Forage yield (rating): Moderate
Yields are 80 to 90% of alfalfa, but the nutritive quality of sainfoin is maintained longer into the growing season than alfalfa. Yields of 1,800 kg/ha (1,600 lb/acre) in the Brown soil zone, 6,700 kg/ha (5,9820 lb/acre) in the Dark Brown soil zone, and 5,900 kg/ha (5,267 lb/acre) in the Black and Grey soil zones are possible.

Palatability/nutritional value:
Palatable with 18% protein during full bloom and 63% digestibility. Sainfoin is non-bloating for livestock, and its stems are more palatable than the stems of alfalfa. It is preferred over alfalfa by mule deer and other wildlife.

Longevity (rating): Moderate
Plants are moderately long lived (> 5 years).

Persistence (rating): Low
Stand persistence is very dependent on crown survival.

Invasiveness (rating): Low
Plants have become naturalized in some locations in the western United States, and may spread by seed under ideal conditions.

Competitiveness (rating): Low
Sainfoin is not competitive in many mixtures, but does well with bunchgrasses over the longer term. It can be competitive in the early years with mixtures such as intermediate wheatgrass or smooth bromegrass.

Weed resistance (rating): Low

Erosion control (rating): Moderate

Drought tolerance (rating): Moderate
Though sainfoin can grow in lower precipitation areas, it is not tolerant of prolonged drought and does not have sufficient drought tolerance to sustain production in semi-arid areas.

Winter hardiness (rating): High

Soil texture preference (rating): All
Sainfoin can grow on all soil textures, even on gravelly or thin soils.

Flooding tolerance (rating): Low
Can withstand 1 week of flooding or saturated soils in the spring.

Salinity tolerance (rating): Low

Acidity tolerance (rating): Low
Tolerates soil pH levels as low as 6.0.

Pest and/or disease threats:
Potential pests include alfalfa curculio, alfalfa plant bug, sainfoin seed chalcid, and webworms. Crown and root disease can be a problem for stand persistence, but the main threat is winter crown rot. Two major threats to alfalfa, bacterial wilt and alfalfa weevil, do not affect sainfoin.

Seed size: Large

Seeds per kg: 66,000

Ease of establishment (rating): Moderate
Sainfoin germinates well when planted into the soil, but establishes slowly but satisfactorily. Some sources state that scarifying seed improves germination.

Application requirements:
Sainfoin establishes best if it is seeded to a shallow depth (i.e., no more than 6 to 20 mm [1/4 to 3/4 in.] deep). Better establishment is achieved and if it is seeded alone, rather than with a nurse or companion crop.

Suggested mixtures:
Mixes well with bunchgrasses, such as Russian wildrye and crested wheatgrass, but is out-competed by grasses that are creeping rooted (produce rhizomes).

Management considerations:
Inoculate and scarify seed before establishing sainfoin. Sainfoin lacks a specific nitrogen-fixing bacteria and is sometimes not the highest nitrogen fixer. However, it is non-bloating for livestock.

Typical seeding objectives:
Forage enhancement
Soil improvement
Grazing season extension

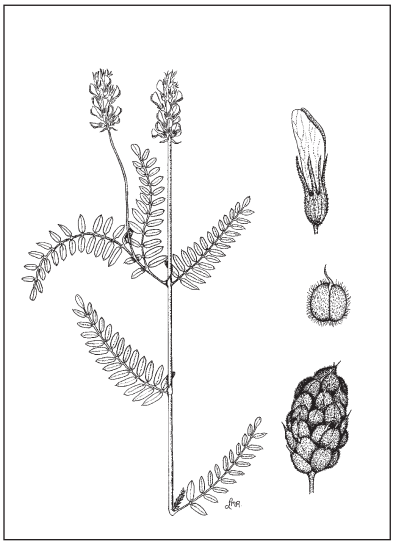
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Photo credit: anon (AGRI).



Cicer Milkvetch

Scientific Name:
Astragalus cicer L.

Type:
Agronomic legume

General description:
Cicer milkvetch is a palatable, non-bloating, perennial legume. The name comes from the belief that goat's milk supply was increased from eating vetches. It does not accumulate toxic levels of selenium, unlike many of the other milkvetches or "loco weed."

Deeply branched taproots and tough rhizomes develop from wide, winter-hardy crowns. Stems begin growing upright but soon fall or lodge. These hollow, succulent stems can be up to 120 cm (47 in.) long, growing to about half that in stand height. Compound leaves grow up to 15 cm (6 in.) long, and are made up of 13 to 27 hairy, paired leaflets.

Seed heads develop from buds on the stems, while leaves keep growing. There can be up to 40 pale yellow to white flowers attached to one stem. After cross-pollination, seed pods grow up to 15 mm (1/2 in.) long, turning black as they ripen. Each pod easily shatters to reveal up to 12 bright yellow to pale green seeds, which are hard and impervious to moisture.

Origin:
Native to Europe and Russia, it was brought from Sweden to the United States, and from Russia to Canada.

Distribution:
May be adapted to several regions, but infrequent and mostly limited to areas in British Columbia, where it has historically been seeded.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Ponderosa Pine
Interior Douglas-fir
Interior Cedar–Hemlock
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce

Annual precipitation minimum (mm): 350

Annual precipitation maximum (mm): 600

Uses:
Used mainly for pasture and stockpiling, orextending grazing season. It has been used for erosion control and soil stabilization.

Optimal time of grazing use:
Cicer milkvetch grows slower than alfalfa in the spring. With adequate rest, can be grazed early summer to fall. Since it holds its quality very well, it can be stockpiled for fall or winter grazing with good expected weight gains. When stockpiled it can still provide a maintenance feed before growth begins in early spring.

Recovery after use (rating): High
High recovery if not grazed to less than 10 cm (4 in.), and can be grazed frequently. Because of its rhizomes, it is tolerant to animal hoof action. Managed grazing improves the spread and fill of Cicer milkvetch in a stand. Cicer milkvetch should be allowed to set seed every 3 years to keep new plants in the stand.

Forage yield:
Yields less than alfalfa, but non-bloating and retains quality. 1,700 kg/ha (1,517 lb/acre) Brown soil zone, 4,300 kg/ha (3,839 lb/acre) in Dark Brown soil zone, and 5,300 kg/ha (4,732 lb/acre) in Black and Grey soil zones.

Palatability/nutritional value:
Crude protein values of 14.6% and digestibility of 61.5%. It has slightly higher protein levels and digestibility than alfalfa and red clover, but less than alsike and white clover. Cicer milkvetch maintains leaves and therefore quality late into the fall.

Longevity (rating): High
5 to 20 years.

Persistence (rating): Moderate
Once established, Cicer milkvetch's strong crowns and rhizomes give it excellent winter hardiness and stand persistence.

Invasiveness (rating): Low

Competitiveness (rating): Moderate
Competitive once established.

Erosion control (rating): High
Creeping roots are effective at controlling erosion.

Drought tolerance (rating): Moderate
Cicer milkvetch has moderate drought tolerance and goes dormant during dry periods.

Winter hardiness (rating): High

Soil texture preference (rating): All
Adapted to all soil texture types but prefers well-drained soils. It can tolerate soils with high water table.

Flooding tolerance (rating): Low
Although Cicer milkvetch will tolerate saturated soils in the spring up to 1 week, it does not tolerate more than brief periods of flooding during growing season.

Salinity tolerance (rating): Low

Acidity tolerance (rating): Low
Tolerates soil pHs as low as 6.0; but will also tolerate high pH, alkaline soils.

Fire tolerance (rating): High

Seed size: Large

Seeds per kg: 287,000

Ease of establishment (rating): Moderate
Many sources report that Cicer milkvetch is difficult to establish but newer varieties with increased seedling vigour have improved establishment characteristics. Cicer milkvetch can be established with the spread of seed by grazing animals. Delayed germination of seed may continue for up to 2 to 3 years.

Application requirements:
Seed may need to be scarified before planting. Grow without a nurse crop for best establishment. Cicer milkvetch needs good seed-to-soil contact to germinate.

Suggested mixtures:
Meadow bromegrass or bunchgrasses.

Management considerations:
Allow adequate time for good establishment (i.e., up to 2 growing seasons) before using Cicer milkvetch. Let this species set seed every 3 years to promote the recruitment of new plants in the stand.

Typical seeding objectives:
Forage enhancement
Grazing season extension
Erosion control

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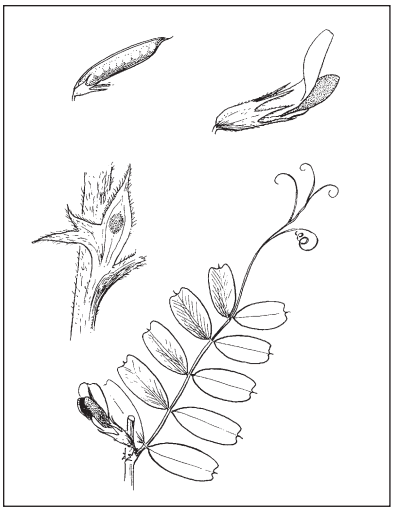
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Common Vetch

Scientific name:
Vicia sativa L.

Type:
Agronomic legume

General description:
Common vetch is a cool season, winter annual legume that is often used as a green manure crop or in pasture mixes. It is sometimes referred to as garden vetch. It has a taproot that can grow 100 to 175 cm (39 to 70 in.) deep, and prolific smaller roots in the upper 15 to 30 cm (6 to 12 in.) of the soil.

Common vetch produces a slender vine that grows along the ground from 60 to 180 cm (24 to 71 in.) in length. The leaves terminate in tendrils that can attach and climb up the stems of other grasses or crops in the mix. The leaves are very similar to hairy vetch with 4 to 10 leaflets, but the leaves are slightly larger and have a more distinct terminal point.

Common vetch can be identified by its unique inflorescence, which is unusual for forage plants. Flowers are larger than hairy vetch and develop where leaf axis joins the stem. Flowers are pinkish purple. Seeds pods are grown to gray, flat, elongated and have 8 to 10 seeds inside that are orange to cream in colour and oval to wedge shaped.

Origin:
Native to southern Mediterranean countries of Europe. Introduced to North America during 1800s.

Habitat and climate:
Found on roadsides and waste places, sometimes introduced into agriculture areas of southeast Vancouver Island, Lower Mainland, and rarely on the islands of Haida Gwaii. Perhaps some suitability to British Columbia's southern interior if introduced and seeded in spring, but use undocumented.

Regions:
Kootenay
Thompson – Okanagan

Typical BEC range:
Ponderosa Pine
Interior Douglas-fir
Interior Cedar–Hemlock

Annual precipitation minimum (mm): 310

Annual precipitation maximum (mm): 1,630

Uses:
Used commonly as a green manure, in pasture or for hay. It can also be used to improve wildlife habitat and protein sources.

Optimal time of grazing use:
Delay grazing until common vetch plants are 15 cm (6 in.) tall.

Recovery after use (rating): Moderate
Regrows well if lightly grazed, at least 5 cm (2 in.) is left and axillary buds below lowest leaf are left intact.

Forage yield (rating): Moderate
Can produce 4,480 to 6,720 kg/ha (4,000 to 6,000 lb/acre) when seeded alone in mid-west United States.

Palatability/nutritional value:
High quality hay and grazing but bloat is a risk.

Longevity (rating): Low
An annual legume.

Competitiveness (rating): Moderate

Persistence (rating): High
Common vetch can persist longer than its annual life cycle where it is adapted because of the hardness of its seed and its natural reseeding.

Invasiveness (rating): Moderate
Not on E-flora invasive list but considered to have some invasive potential due to its rapid spreading in open spaces with low fertility. Its seed is less hardy than hairy vetch, so reducing its risk as a problem weed.

Weed resistance (rating): High
Provides excellent spring weed suppression.

Drought tolerance (rating): Low

Winter hardiness (rating): Low
Less winter hardy than hairy vetch, so used as a spring annual in colder climates.

Soil texture preference (rating): All
Common vetch does not tolerate extremes in soil conditions as well as hairy vetch.

Flooding tolerance (rating): Low
Has low flooding tolerance but can tolerate short periods of saturated soils.

Acidity tolerance (rating): Moderate
Tolerates 5.5 to 8.2 pH but optimum is 6.5.

Shade tolerance:
Somewhat shade tolerant but not when inter-seeded with taller, robust crops like corn.

Pest and/or disease threats:
Insect pests may include pea aphids, cutworms, army worms, grasshoppers, lygus bugs, clover leafhopper, and potato leafhopper. Disease threats may include leaf spot, downy mildew, stem rots, root rots, rush, and anthracenose.

Seed size: Large

Seeds per kg: 15,400

Ease of establishment (rating): Moderate
Establishes well in the fall in areas with milder winters, or in the spring in areas with cooler winters. When seeded alone, common vetch is commonly seeded at 65 to 84 kg/ha (58 to 75 lb/acre) in Oregon or 27 to 33 kg/ha (24 to 27 lb/acre) in Nebraska. May have limited application in British Columbia's interior unless spring seeded.

Application requirements:
Establishes best if drilled into firm, prepared seedbed 0.6 to 1.2 cm. Can also be broadcast if seeding rate is increased. Fertilizing with phosphorus is often required at about 30 kg/ha (27 lb/acre) actual P.

Suggested mixtures:
For forage uses, mix with grasses like annual ryegrass or small grains. Is grown with other crops for improving soil or suppressing weeds.

Management considerations:
There are reported poisonings with livestock, horses and chickens, particularly if seed is ingested.

Typical seeding objectives:
Grazing season extension
Soil improvement
Forage enhancement

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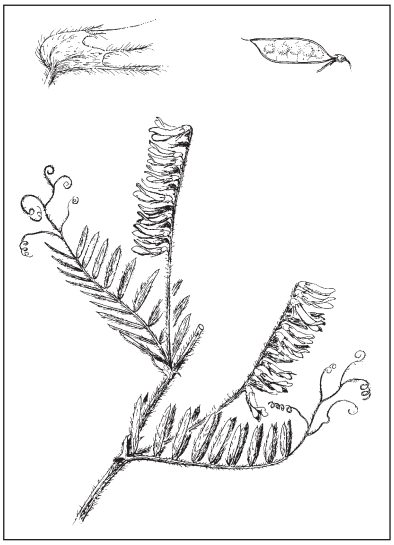
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Photo credit: Gordon Neish.



Hairy Vetch

Scientific name:
Vicia villosa Roth ssp *villosa*

Type:
Agronomic legume

General description:
Hairy vetch is an annual or biennial, hardy, cool season agronomic legume, also commonly referred to as fodder vetch, winter vetch, or sand vetch. It has a weak tap root that grows up to 60 to 90 cm (24 to 35 in.) with many side branches in the top 20 cm (8 in.), and is known as an excellent nitrogen fixer.

Hairy vetch has long trailing stems from 50 to 200 cm (20 to 79 in.) long. Stems are hairy and grow 1 to 3 cm (1/2 to 1 ¼ in.)long leaves on one side of the stem. There are 10 to 20 alternate, oblong leaflets per leaf, with branching tendrils at the ends.

It produces dense, pea-like flowers that range in colour from reddish purple to violet to white. Flowers develop into oblong seed pods, which produce small, black, round seeds that are irregular in size.

Origin:
Native to Europe and Asia. Now the most commonly used vetch in North America.

Distribution:
Common in extreme southern British Columbia. Potentially adapted to other areas where introduced.

Habitat and climate:
Mesic to dry roadsides and disturbed areas in the lowland, steppe, and montane zones.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Engelmann Spruce–Subalpine Fir
Sub-Boreal Spruce
Boreal White and Black Spruce

Annual precipitation minimum (mm): 450

Uses:
Can be used for hay or pasture, but consumption of seed can be poisonous to livestock. Hairy vetch is especially known for erosion control, bank stabilization, winter cover crop, and soil conditioning. It can be asuitable plant in organic and no-till pasture and cropping systems.

Forage yield (rating): High

Palatability/Nutritional Value:
High palatability. High crude protein values and very digestible.

Longevity (rating): Low
Annual or biennial.

Invasiveness (rating): Moderate
Can be invasive in some regions and situations if not managed properly.

Competitiveness (rating): High
Once established, hairy vetch can be aggressive and competitive.

Weed resistance (rating): High

Erosion control (rating): High

Drought tolerance (rating): High

Winter hardiness (rating): High
Winter hardy but dependent on good snow cover. Vetch seeded alone may be vulnerable to frost heave damage.

Soil texture preference (rating): Coarse
Prefers sandy soils, but is adapted to all soil textures.

Flooding tolerance (rating): Moderate.
Some flooding tolerance but not adapted to poorly drained soils.

Salinity tolerance (rating): Low

Acidity tolerance (rating): Low
Prefers pH 6.0 to 7.0. Low tolerance to low pH but moderate tolerance to high pH (alkalinity).

Shade tolerance: Low
Intolerant to shade

Seed size: Medium

Seeds per kg: 440,000

Ease of establishment (rating): High
Where adapted.

Application requirements:
Hairy vetch is normally planted in the fall. It can be broadcast or drill seeded.

Typical seeding objectives:
Erosion control
Revegetation (ground cover)
Soil improvement

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Fringe bromegrass



Photo credit: Percy Folkard, (BC FLNR).



Scientific name:
Bromus ciliatus L.

Type:
Native grass

General description:
Fringed bromegrass is a tall, loosely tufted, cool season, perennial native bunchgrass. It is effective for erosion control and valued in revegetation mixes for disturbed sites. This species is also very palatable for both ungulate wildlife and livestock throughout the growing season.

Fringed bromegrass is a bunchgrass with fibrous roots.

Stems grow to 60 to 100 cm (24 to 39 in.) tall, frequently with hairy nodes. Leaves are dark green, 10 cm (4 in.) wide and hairy at least on one side. The veining is prominent on both sides of the leaf. No auricles.

Seed heads form in open panicles that are 10 to 20 cm (4 to 8 in.) long with 4 to 10 flowers and long spikelets. Seeds are large and fuzzy when mature in mid-August.

Origin:
Native to both Canada and United States.

Distribution:
Distributed widely from Alaska and Yukon to Texas and Arizona, and from California to Newfoundland. Frequent in British Columbia and east of the Coast-Cascade mountains.

Habitat and climate:
Wet streambanks and lake margins, open coniferous or deciduous woodlands and meadows, especially mesic or moist areas in the montane zone.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Engelmann Spruce–Subalpine Fir
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce
Spruce–Willow–Birch

Annual precipitation minimum (mm): 400

Uses:
Used for reclamation and erosion control. Also excellent forage for both ungulate wildlife and livestock and holds its nutritional value throughout the growing season, so can be used to extend the grazing period.

Optimal time of grazing use:
Can be grazed throughout the season as it holds it palatability well.

Recovery after use (rating): Low
Considered a decreaser after grazing.

Forage yield (rating): Moderate

Palatability/nutritional value:
Excellent palatability for both ungulate wildlife and livestock from emergence through seed set. Plant protein levels average 20% in early June, 9% in July, and 3% in late August to October. In contrast, digestible carbohydrate increases over the growing season. Cattle will strip the leaves off the stems and sheep will seek out and graze the seed heads.

Longevity (rating): Moderate
Stand life is typically 4 years for seed production, but probably longer in forage and reclamation situations.

Persistence (rating): High
Long term revegetation potential is considered high.

Competitiveness (rating): High

Weed resistance (rating): Moderate

Erosion control (rating): High
Favoured in revegetation mixes for disturbed sites, especially in foothill and boreal forests. Very effective for erosion control.

Drought tolerance (rating): Moderate

Winter hardiness (rating): High

Flooding tolerance (rating): Low

Salinity tolerance (rating): Low

Acidity tolerance (rating): Moderate
Moderate tolerance for acidity (low pH) and but low tolerance for alkalinity (high pH).

Seed size: Medium

Seeds per kg: 300,000

Ease of establishment (rating): High
Easy to establish a good stand. 85% of seed germinates in 10 to 15 days.

Application requirements:
Seed at 0.6 to 1.2 cm (1/4 to 3/4 in.) deep. Seeding rate should be about 100 to 130 seeds per linear metre of row. Fringed bromegrass is best seeded with a seed carrier, unless the seed cleaning and processing have removed hairs to improve seed flow.

Typical seeding objectives:
Forage enhancement
Grazing season extension
Vegetation control
Erosion control
Native plant community

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Photo credit: NRCS Plant Materials Center, Pullman, WA.

Big Bluegrass

Scientific name:
Poa secunda (formerly *Poa ampla* Merr.)

Type:
Native grass

General description:
Big bluegrass is a native, cool season, long-lived, perennial bunchgrass that matures early in the growing season. It is part of what is referred to as the Sandberg bluegrass complex, which includes 8 species, including big bluegrass, Canby bluegrass, slender bluegrass, Alkali bluegrass, Nevada bluegrass, Sandberg bluegrass, and pine bluegrass. The differentiating characteristics within this complex of species often vary with environmental factors, making distinguishing amongst them very difficult. Big bluegrass is the most robust of this collection, and stands out for its large forage production and early spring growth. It has been used successfully for reseeding burned forest areas and is used by upland game birds for nesting.

Big bluegrass is a bunchgrass with a strong fibrous root system that sometimes develops short rhizomes. The rooting system is very effective in controlling soil erosion, thus this species is considered a good conservation grass. "Sherman" big bluegrass is a selection originating from seed collected from a native range site in Sherman County, Oregon. It has been successfully established in the Rocky Mountain regions of the United States above 2,100 m in elevation that receive above 360 mm (14 in.) of rainfall, and the Columbia Basin.

Stems grow to 30 to 130 cm (12 to 51 in.) in height. It has distinctly deep blue-green, abundant basal leaves. The leaf blades are folded in a keel-like tip typical of all bluegrasses. Leaves can grow up to 40 cm (16 in.) long and 1.5 to 3.5 mm (1/16 to 1/8 in.) wide.

Seeds develop in a large compact seed head with narrow panicle that is 20 cm (8 in.) long. The spikelets of big bluegrass (and the entire Sandberg bluegrass complex) differ from Kentucky bluegrass in that they do not have a web of hairs at the base of the seed callus.

Origin:
Big bluegrass is native to North America.

Distribution:
Occurs mainly in western North America with some specific populations in Quebec and Chile. The big bluegrass type of *Poa secunda* appears to be rare in British Columbia. The *Poa secunda* form known as Sandberg bluegrass is common.

Habitat and climate:
Big bluegrass occurs in sagebrush slopes, mid-elevation meadows, and openings in aspen stands.

Regions:
Cariboo – Fraser-Fort George
Thompson – Okanagan
Kootenay

Typical BEC range:
Bunchgrass
Ponderosa Pine
Interior Douglas-fir

Annual precipitation minimum (mm): 255

Annual precipitation maximum (mm): 610

Uses:
Big bluegrass is used for forage, dryland hay, and upland wildlife habitat. Upland game birds eat the seeds and use big bluegrass for nesting areas. It is also an important species for reseeding rangelands, stabilizing critical areas, reclaiming mine soils, and revegetating disturbed areas in aspen and conifer forests. Collections in Alaska have been used for erosion control, reclamation, and native plant community restoration.

Optimal time of grazing use:
Big bluegrass begins growing very early in the spring and up to 4 weeks earlier than crested wheatgrass. However, grazing on newly establishing stands should be deferred for 1 to 3 years.

Recovery after use (rating): High
Big bluegrass is considered an increaser species after grazing. It resists trampling very well as it goes dormant during summer and fall.

Forage yield (rating): Low
Forage production from big bluegrass varies, especially with rainfall and irrigation. Areas with at least 280 mm (11 in.) of rainfall can yield 630 to 1,360 kg/ha (562 to 1,214 lb/acre).

Palatability/nutritional value:
Palatable for livestock in spring and fall, for deer in the spring, and for elk in all seasons. As curing progresses over the summer, livestock preference for big bluegrass decreases.

Longevity (rating): High
The longevity of big bluegrass stands can exceed 30 years. This is partially due to seed shatter and the prolific "reseeding" of this plant species.

Persistence (rating): Moderate

Invasiveness (rating): Low
Seeds shatter but do not travel far from parent plant. Although big bluegrass seed can spread through feces, it is not considered aggressive or invasive.

Competitiveness (rating): High
It is often used as an early spring perennial grass that will compete well with annual weeds. Once established, big bluegrass, especially the Sherman variety, competes well with other weeds such as cheatgrass, Russian thistle, and prickly lettuce.

Weed resistance (rating): High

Erosion control (rating): High

Drought tolerance (rating): Moderate
Does not tolerate drought as well as other cool season grasses.

Winter hardiness (rating): Moderate
Big bluegrass is rated with excellent cold tolerance but this rating is from the lower Columbia Basin in the U.S. Pacific Northwest where winters are milder than in many parts of British Columbia.

Soil texture preference (rating): All
Thrives on a variety of soil textures from moderately coarse sands to dense clays.

Flooding tolerance (rating): Low
Although it will grow in moist conditions, it will not tolerate early spring flooding, poor drainage, or high water tables.

Salinity tolerance (rating): Low

Acidity tolerance (rating): Moderate
Sherman big bluegrass tolerates moderately acidic soils, thus it is a suitable species for reclaiming mine spoils. It can also tolerate weakly alkaline soils.

Shade tolerance: Moderate shade tolerance

Fire tolerance (rating): Moderate

Pest and/or disease threats:
Potential insect pests include grasshoppers, jackrabbits, and rodents. Disease threats include leaf rusts, stem rusts, and stem maggots.

Seed size: Medium

Seeds per kg: 926,000

Ease of establishment (rating): Moderate
Some varieties of big bluegrass shatter easily and grow from scattered seed, thus stands can improve and fill in over time.

Application requirements:
To ensure successful establishment of big bluegrass, perennial broadleaf weeds like Canada thistle and leafy spurge will have an impact on forage production and must be controlled before and after seeding.

If seeding a pure stand, seed at 1.7 kg/ha PLS or pure live seed (2.0 lb/acre PLS). If seeding in a native seed mixture, as is more commonly done, seed at 0.3 to 0.6 kg/ha PLS (1/2 to 1 1/4 lb/acre PLS). Spring seeding is best in Northern Great Plains while late fall seedings are suitable in areas with similar climate to the Great Columbia Basin.

Suggested mixtures:
Can be mixed with native fescues, wheatgrasses, and wildryes.

Management considerations:
When seeded with other native plants, big bluegrass is often a minor component of the mix. Management of the stand should consider major species in the mix and overall seeding objectives.

Typical seeding objectives:
Forage enhancement
Invasive plant suppression
Erosion control
Native plant community
Extending the grazing season

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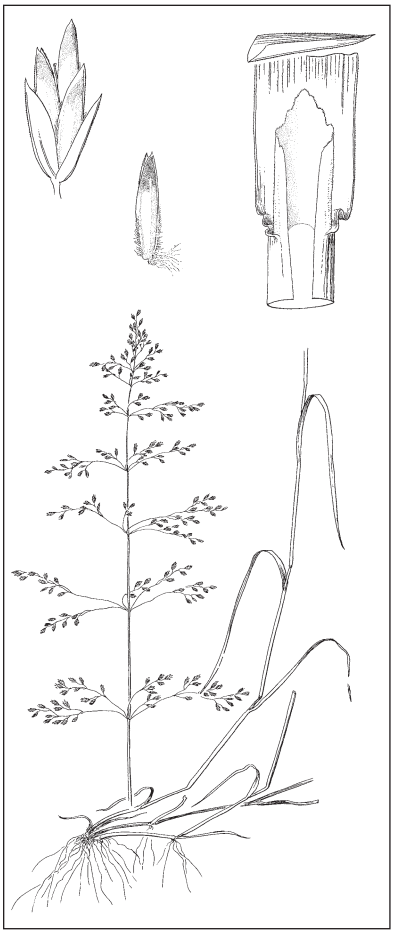
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Photo credit: Jamie Fenneman.



Fowl Bluegrass

Scientific name:
Poa palustris L.

Type:
Native grass

General description:
Fowl bluegrass is a loosely tufted, low growing, native, cool season, perennial bunchgrass. It is commonly a minor component in native grass seed mixes. It has fibrous roots and a tufted bunchgrass growth habit, but can form a weak sod.

It grows 40 to 122 cm (16 to 48 in.) tall. Stems are erect, purplish, and curved at the base. The leaves are greenish, flat or folded, and 1.5 to 3 mm wide with boat or keel-shaped tips.

The tiny flowers of fowl bluegrass are produced in mid-spring and are yellow. Seed heads are contained in an open panicle about 10 to 30 cm (4 to 12 in.) long with fine spreading branches. Lower branches have been described as cobwebby at the base. Seeds are small and brown. Fowl bluegrass reproduces from seed and tillers.

Origin:
Native to British Columbia.

Distribution:
Occurs commonly throughout northern United States, Alaska, and throughout all Canadian provinces and territories.

Habitat and climate:
Fowl bluegrass occurs commonly in wetter areas such as ditches, wetlands, moist forests, and clearings at low to medium elevations.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Engelmann Spruce–Subalpine Fir
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce

Annual precipitation minimum (mm): 450

Uses:
Used as a minor component in native grass reclamation mixes, and is considered an early- to mid-successional species. It has forage value and is used in pastures by both wildlife and livestock, where moisture is sufficient. The Chipewyan used fowl bluegrass to make vaccines or allergens to treat hay fever and to make hair rinses to revitalize hair.

Optimal time of grazing use:
Early in the spring.

Recovery after use (rating): Low
Slow recovery after clipping or grazing. This species can be either an increaser or a decreaser after grazing, depending on site conditions.

Forage yield (rating): Low

Palatability/nutritional value:
Low protein and low palatability for both browsing and grazing animals.

Longevity (rating): Moderate

Competitiveness (rating): Moderate

Invasiveness (rating): Moderate
Several of the native bluegrass species can be difficult for pedigreed seed growers to control in in other forage seed crops. Bluegrass seed is also difficult to separate from other grass seed crops.

Drought tolerance (rating): Low

Winter hardiness (rating): High
Can tolerate temperatures as low as –38°C.

Soil texture preference (rating): Fine-Medium
Adapted to medium-textured or loam soils to fine-textured or clayey soils.

Flooding tolerance (rating): Low
Although fowl bluegrass has a low tolerance to flooding, it is sometimes considered a wetland species indicator.

Salinity tolerance (rating): Low

Acidity tolerance (rating): High
Can tolerate high acidity levels of pH 4.9. Can tolerate some alkalinity up to pH 7.5.

Shade tolerance:
Moderate shade tolerance.

Fire tolerance (rating): High

Seed size: Small

Seeds per kg: 6,957,000

Ease of establishment (rating): Moderate
Fowl bluegrass has moderate seedling vigour.

Application requirements:
Seeds per gram should be verified when calculating seeding rate, as the seed weights reported in literature varied from 1.900 to 6.957 million seeds per kilogram.

Management considerations:
Several species of native bluegrasses such as fowl bluegrass can cause problems for pedigreed seed growers as these species are difficult to clean out of other grass seed crops.

Typical seeding objectives:
Erosion control
Native plant community

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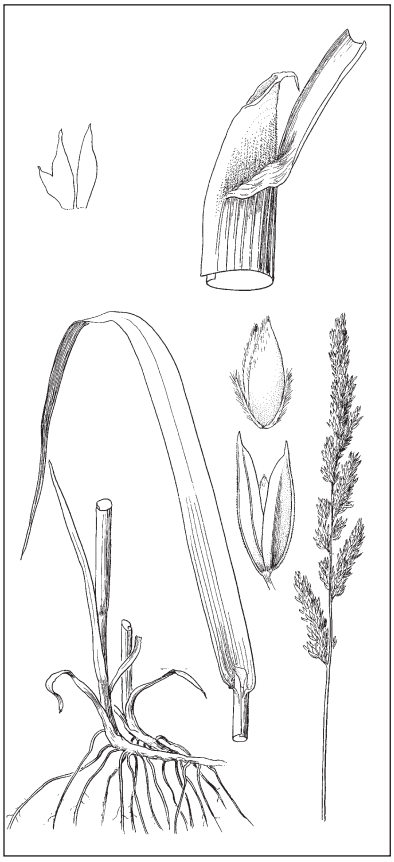
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Photo credit: A. Dobb.



Reed Canarygrass

Scientific name:
Phalaris arundinacea L.

Type:
Native grass (with introduced cultivars)

General description:
Reed canarygrass is a well-adapted, long-lived, cool season, perennial native grass. It grows well in wet areas but also can tolerate some drier areas.

Extensive sod-forming root systems are produced by crowns below the soil surface. The plant may appear to be bunched but actually produces large diameter, short rhizomes, which in turn produce new shoots and roots.

Stems are coarse and erect, growing up to 200 cm (79 in.) tall. Leaves are pale green, large, flat, and wide up to 20 mm (3/4 in.) wide.

The spikelets of the seed head cluster alternately up the stem, producing purplish flowers. Seeds are shiny, flattened, and small, about 4 mm long. Seed shatters very easily, and germination ability declines soon after being shed.

Origin:
Native to North America, including British Columbia, Europe, and Asia. Varieties introduced for pasture and other uses in Canada originate from both North America and Europe. It is thought the hybridization of introduced and North American types has produced aggressive plants in central and western North America.

Distribution:
This grass is common throughout southern British Columbia, in particular, the Coastal Douglas-fir and Sub-Boreal Pine–Spruce zones.

Habitat and climate:
This grass often grows on wet sites, and can indicate high soil moisture conditions where periodic flooding can occur for extended periods of time.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Bunchgrass
Ponderosa Pine
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce

Annual precipitation minimum (mm): 350

Annual precipitation maximum (mm): 600

Uses:
It is commonly used for pasture, hay—especially in wet meadows—and for erosion control. Reed canarygrass has also been grown for seed in the Peace Region. It was once used to weave mats for drying food and hats by the Okanagan people. A type of rope was also used to bind fishing weirs.

Optimal time of grazing use:
Young stands should not be grazed until they are well established and have developed a dense sod. Established stands can be grazed several times during the season, if kept in vegetative growth stages. As soon as reed canarygrass heads out, stems mature and become coarse causing a sharp decline in palatability.

Recovery after use (rating): High
If allowed to regrow to 30 cm (12 in.) before regrazing, reed canarygrass can be grazed 2 to 3 times during grazing season. Sod-forming stands resist animal traffic and hoof action.

Forage yield (rating): High
Yields 5,000 kg/ha (4,464 lb/acre) in northern prairie regions. Higher yields are possible on organic meadows in the B.C. interior with supplemental fertilization.

Palatability/nutritional value:
Crude protein of 12 to 15% and digestibility ranges from 55 to 65% early in the season, but protein and digestibility drop dramatically later in the season. Use alkaloid-free varieties registered in Canada to avoid problems with livestock grazing and alkaloid toxicity.

Longevity (rating): High

Persistence (rating): High

Invasiveness (rating): High
Invasiveness in many situations is considered moderate, but in southern British Columbia, and the U.S. Pacific Northwest it can escape from pastures and spread into riparian areas, waterways, and wetlands.

Competitiveness (rating): High
Low competitiveness in early years, but highly competitive and aggressive once it is established.

Erosion control (rating): High
Thick sod and high competitive ability make this a good candidate for erosion control, especially in waterways and wetter areas.

Drought tolerance (rating): Moderate

Winter hardiness (rating): High
Improved by allowing 4 weeks rest from grazing before killing frosts.

Soil texture preference (rating): Fine to Medium
Reed canarygrass is suited to loams, clays, and peat soils in floodplains, creeks, sloughs, and riparian areas.

Flooding tolerance (rating): High
Established reed canarygrass tolerates 5 to 8 weeks of flooding and grows well in waterlogged soils.

Salinity tolerance (rating): Low

Acidity tolerance (rating): High
Tolerates soil pH values as low as 5.0.

Seed size: Small

Seeds per kg: 1,175,000

Ease of establishment (rating): Low
Since the seedlings cannot tolerate flooding, late season seeding is optimal when soil moisture levels are lower and the chance of flooding is reduced. Stands can be thin in early years, but eventually fill in. When establishing new stands, use of pedigreed seed rather than common seed will reduce problems with alkaloids by ensuring that the alkaloid-free varieties are "true to variety".

Management considerations:
Older stands should be occasionally spiked, countered, or knifed to cut roots and rhizomes and stimulate new growth. Seek out newer, alkaloid-free varieties for forage uses, or carefully manage the grazing period to avoid alkaloid toxicity in animals. Fencing wetter areas with reed canarygrass separately can help ensure that these areas are grazed early enough for maximum palatability. Watch for alkaloid issues in stands established before the development of newer alkaloid-free varieties, especially in leaves regrown during drought stress.

Typical seeding objectives:
Forage enhancement
Erosion control

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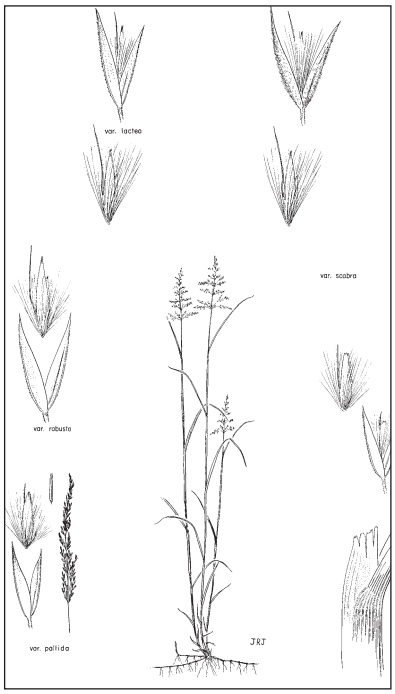
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Photo credit: Reg Newman, (BC FLNR).



Bluejoint Reedgrass

Scientific name:
Calamagrostis canadensis (Michx.) P. Beauv.

Type:
Native grass

General description:
Bluejoint is a robust, hardy, tall, tufted, perennial grass native to boreal forests. It gets its name from the purplish-blue nodes on its stems, and is also referred to as Canada bluejoint grass, reedgrass, marsh reedgrass, and Scribner's reedgrass. It provides good spring forage for livestock and native ungulates. When harvested as livestock feed from wet meadows that contain significant amounts of bluejoint reedgrass, it is referred to as "beaver grass."

The root system is fibrous and rapidly forms extensive creeping rhizomes. It can form extensive swards that can become competitive and problematic in some situations, inhibiting natural regeneration of tree seedlings.

Bluejoint stems can grow up to 200 cm (79 in.) tall. The panicle is up to 25 cm (10 in.) long and is often nodding or dropping. Numerous leaf blades alternate up the stem and grow up to 40 cm (16 in.) long. Leaf blades are flat and taper to a sharp tip. Seed heads form on loose, somewhat drooping, purple-tinged panicles with numerous spikelets. Flowering occurs June to August, and seeds are set mid-August to late September.

Origin:
Native to boreal forests in northern Canada.

Distribution:
Distributed widely across British Columbia and Canada on disturbed sites including roadsides, abandoned fields, logging landings, harvested forest sites and skid trails. This grass is present throughout mid to highelevations of the Ponderosa Pine, Interior Douglas-fir, Interior Cedar–Hemlock, Montane Spruce, Sub-Boreal Pine–Spruce, Sub-Boreal Spruce, Engelmann Spruce–Subalpine Fir, Boreal White and Black Spruce, and Spruce–Willow–Birch zones. Bluejoint can also occur on wetland and seepage sites in the Bunchgrass, Ponderosa Pine, Interior Douglas-fir, Montane Spruce, Engelmann Spruce–Subalpine Fir, Sub-Boreal Pine–Spruce, and Sub-Boreal Spruce zones.

Habitat and climate:
Bluejoint prefers moist to wet habitats, especially wetlands, shorelines, streambanks, and ditches. It also is found commonly in open meadows, and can occasionally be found on dry soils or rocky outcrops.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Bunchgrass
Ponderosa Pine
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Engelmann Spruce–Subalpine Fir
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce
Spruce–Willow–Birch

Annual precipitation minimum (mm): 360

Annual precipitation maximum (mm): 1,650

Uses:
Forage, revegetation, erosion control, and wildlife habitat.

Recovery after use (rating): Moderate
Decreases after heavy grazing and trampling in some areas. Otherwise, bluejoint is an increaser species and it readily reproduces through rhizomes and seed.

Palatability/nutritional value:
Fair nutritional quality that is generally higher in early spring. Livestock generally avoid the coarse stems but will eat the large leaves.

Longevity (rating): High

Persistence (rating): High
May persist for over 25 years, but often loses dominance in 10 to 20 years.

Invasiveness (rating): High
Bluejoint is used as an indicator species of biodiversity and ecosystem integrity northern interior regions. However, after large-scale disturbances it can become dominant on some sites and a problem weed species for forest stand establishment.

Competitiveness (rating): High
Can be highly competitive; mechanical or chemical control is required to control heavy swards to successfully establish tree seedlings.

Weed resistance (rating): High
Can become a weed in some situations.

Erosion control (rating): High
Rhizomes spread quickly in disturbed areas, and bluejoint can speed up recovery of soil properties like bulk density, organic matter content, and porosity. It has been used to lower water tables, but its competitive effect may outweigh the benefits. Bluejoint

has been used to stabilize streambanks, filter runoff, increase evapotranspiration to reduce flooding, rehabilitate wetlands, and revegetate oil spills (Sourdough variety). However, if the ultimate objective is to return to natural spruce regeneration, special management of bluejoint's highly competitive nature will be required.

Drought tolerance (rating): Moderate
Bluejoint can be very drought tolerant once established.

Winter hardiness (rating): High

Soil texture preference (rating): All
Often found on fine-textured soils with good water holding capacity, but can be found on sandy soils with high water table. Prefers very moist to wet soils with a moderate nutrient regime.

Flooding tolerance (rating): High
Bluejoint grows well on wet soils and has high tolerance to flooding.

Salinity tolerance (rating): Moderate
Can tolerate slightly brackish water.

Acidity tolerance (rating): High
Prefers pH levels of 5.0 to 5.9 but has a low tolerance for alkalinity.

Shade tolerance:
Considered a shade-intolerant species. Prefers open areas where it forms a distinctive understory to aspen or mixedwood stands.

Pest and/or disease threats:
There has been some study using biological control with fungal agents and deleterious rhizome bacteria to limit the spread of bluejoint reedgrass.

Seed size: Small

Seeds per kg: 5,000,000

Ease of establishment (rating): High
Establishes easily from wind-blown seed or from extensive underground rhizomes.

Application requirements:
Apply seed with site preparation to create a suitable seedbed.

Suggested mixtures:
Sometimes mixed with other grasses and legumes to reduce the competitiveness of bluejoint.

Management considerations:
Proactive management is required to limit bluejoint spread in some situations. Careful scalping or large inverted mounds are mechanical controls that have been tried. Herbicides and replacement vegetation might be considered depending on the situation and management objectives.

Sheep grazing with 2 grazing passes has also been used for successful control of bluejoint in the first season of tree establishment.

Typical seeding objectives: Erosion control
Invasive plant suppression
Native plant community
Vegetation control

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Photo credit: Percy Folkard (BC FLNR).



Pinegrass

Scientific name:
Calamagrostis rubescens Buckley

Type:
Native grass

General description:
Pinegrass is a native perennial adapted to dry woodlands and open slopes. This grass is erect, tufted, and often forms complete ground cover.

The root system forms fibrous roots and long, extensive, creeping rhizomes. Extensive roots form thick sod, therefore making pinegrass an important soil protection species.

Pinegrass stems grow erect, up to 100 cm (39 in.) tall. Leaf blades are long, drooping, and often hairy at the base. Seed heads form in dense panicles that often have a yellow-green or purplish tinge 6–15 (occasionally up to 25) cm (2-6 [occasionally up to 10 in.]) long. Spikelets are single-flowered.

Origin:
Pinegrass is native to western North America.

Distribution:
Pinegrass is often found in low to mid-elevation forests in the Ponderosa Pine and Interior Douglas-fir zones. At mid to high elevations, pinegrass can be found in the Interior Cedar–Hemlock, Montane Spruce, Engelmann Spruce–Subalpine Fir, Sub-Boreal Spruce, and Sub-Boreal Pine–Spruce zones.

Habitat and climate:
Relatively drought resistant and adapted to well-drained soils. It occurs on dry meadows, rocky slopes, and open forests from low to subalpine elevations.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Thompson – Okanagan

Typical BEC range:
Ponderosa Pine
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Engelmann Spruce–Subalpine Fir
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce

Annual precipitation minimum (mm): 400

Annual precipitation maximum (mm): 660

Recovery after use (rating): High
Pinegrass is very resilient against trampling and spreads rapidly by rhizomes.

Forage yield (rating): Low
In semi-open forest, production can be 273 kg/ha (243 lb/acre); it can be as high as 675 kg/ha in (603 lb/acre) open areas.

Palatability/nutritional value:
Fair palatability in the early spring but becoming harsh and tough by summer. Plant protein content is between 10 and 20% in the spring and drops to less than 5% by autumn.

Longevity (rating): High

Persistence (rating): Moderate
Persists or may increase in pioneer seral stages.

Competitiveness (rating): High

Erosion control (rating): High

Drought tolerance (rating): High
This species is tolerant to drought and high temperatures.

Winter hardiness (rating): Moderate
Pinegrass tolerates moderate winter temperatures and is fairly frost tolerant.

Soil texture preference (rating): Fine to Medium

Acidity tolerance (rating): High
Prefers pH levels of 5.5 to 8.0.

Shade tolerance:
Pinegrass is shade tolerant to very shade tolerant. It occurs naturally under forest canopies and reduction of forest cover stimulates increased flowering.

Seed size: Small

Seeds per kg: 8,730,000

Ease of Establishment (rating): Low
Pinegrass establishes itself readily after light to moderate forest disturbances like logging or fire. Primary form of establishment and reproduction is through vegetative spread. Natural seed production is low except when plants are exposed to light. Germination percentage of seed is also low (38% or less) and is unaffected by germination treatments.

Typical seeding objectives:
Erosion control
Native plant community

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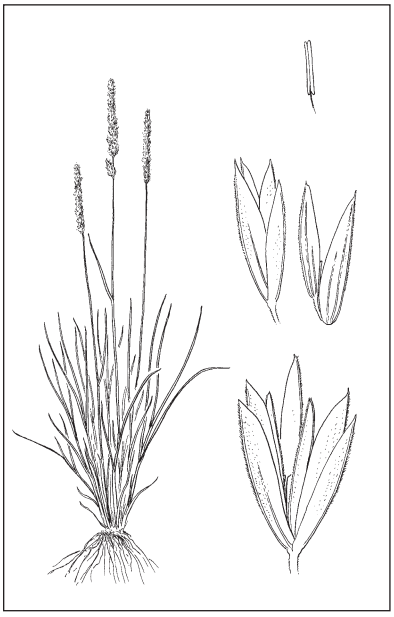
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Photo credit: Percy Folkard, (BC FLNR).



Junegrass

Scientific name:
Koeleria macrantha (Ledeb.) Schult.

Type:
Native grass

General description:
Junegrass is a widely distributed, long-lived, strongly-tufted, cool season, native perennial bunchgrass. It is considered an early- to mid-successional species and can be co-dominant in some late successional plant communities. It tends to increase with overgrazing. Junegrass is a highly variable species, adapting to various environmental conditions with different growth forms. For example, there are variations in hairiness or hairlessness, and on drier sites, plants are shorter with more basal leaves. Its fibrous roots grow to 50 cm (20 in.) with its feeder roots extending to 75 cm (30 in.).

Stems are smooth to softly hairy, 30 to 60 cm tall (12 to 24 in.). It produces leaves with sheath margins usually not overlapping, the collars often with long, straight hairs 1 to 1.5 mm long. Leaf blades are 1 to 4.5 mm wide, 2 to 6 cm (1 to 2½ in.) long, sometimes flat, but usually folded to in-rolled with prow-like tips. They are usually rough to densely hairy or short stiff-hairy or both, rarely smooth, often greyish.

The inflorescence is a spike-like panicle, 4 to 13 cm (1½ to 5 in.) long, the short branches spreading at flowering, with spikelets 2 to 4 flowered; unawned or rarely awned. The lower branches are 3.5 mm long, while the upper ones are 4 to 6 mm long. Flowers are yellow and produced in late spring. Junegrass is a prolific seed producer with brown seeds.

Origin: native

Distribution:
Widely distributed from montane and foothill grasslands to prairie and parkland environments.

Habitat and climate:
Occurs in grasslands and openings in northern boreal forests of Sub-Boreal Pine and Spruce and Sub-Boreal Spruce zones. In British Columbia, this grass is common in the Bunchgrass, Ponderosa Pine, and Interior Douglas-fir zones.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan.

Typical BEC range:
Bunchgrass
Ponderosa Pine
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Engelmann Spruce–Subalpine Fir
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Spruce–Willow–Birch

Annual precipitation minimum (mm): 300

Annual precipitation maximum (mm): 500

Uses:
Recommended in many native seed mixes and used in reclamation and rehabilitation as a pioneer or early successional species on disturbed sites.

Optimal time of grazing use:
Livestock prefer to graze in early spring or late fall after curing on the stem, as this is when it is most palatable. Wildlife prefer to graze it in the summer (deer) and in the spring and summer (elk).

Recovery after use (rating): Low
An increaser species and often used as an indicator of overgrazing. Junegrass requires a full growing season to recover from grazing.

Forage yield (rating): Moderate

Palatability/nutritional value:
Protein content is 20% in early spring but by late fall drops off to 4%. Plants cure well on the stem so can provide some feed for fall and winter grazing.

Longevity (rating): Moderate

Competitiveness (rating): High

Persistence (rating): Moderate to High
Thought of as an early-mid successional species on many sites but can be co-dominant with late successional species in some grasslands.

Invasiveness (rating): Low
It is not considered invasive but can spread to adjoining communities under ideal environmental conditions.

Weed resistance (rating): Moderate

Erosion control (rating): Moderate
May contribute to erosion control once established.

Drought tolerance (rating): High

Winter hardiness (rating): High

Soil texture preference (rating): Medium-Coarse
Prefers medium to coarse soil textures and mesic to dry soil moisture conditions.

Flooding tolerance (rating): Moderate

Salinity tolerance (rating): Low

Acidity tolerance (rating): Low
But tolerates higher pH levels and calcareous soils.

Shade tolerance: Moderate

Fire tolerance (rating): High
Junegrass has high fire tolerance and can increase after fire.

Seed size: Small

Seeds per kg: 3,448,000

Ease of establishment (rating): Low
Germination percentages can be low; seedling vigour can be low, and stands are slow to establish, often requiring 2–3 years.

Application requirements:
Seed often needs to be scarified and a seed carrier is necessary. If drill seeded, row spacing of 20 to 60 cm (8 to 24 in.) (Black and Grey soils) or 20 to 90 cm (8 to 35 in.) (warmer, drier areas) and shallow seeding no more than 0.6 cm (1/4 in.) is recommended. Spring seeding preferred.

Suggested mixtures:
Often associated with hairy wildrye and reedgrasses in forest openings in northern British Columbia and with bluebunch wheatgrass, rough fescue, and Sandberg's bluegrass in grassland communities in southern British Columbia.

Typical seeding objectives:
Native plant community

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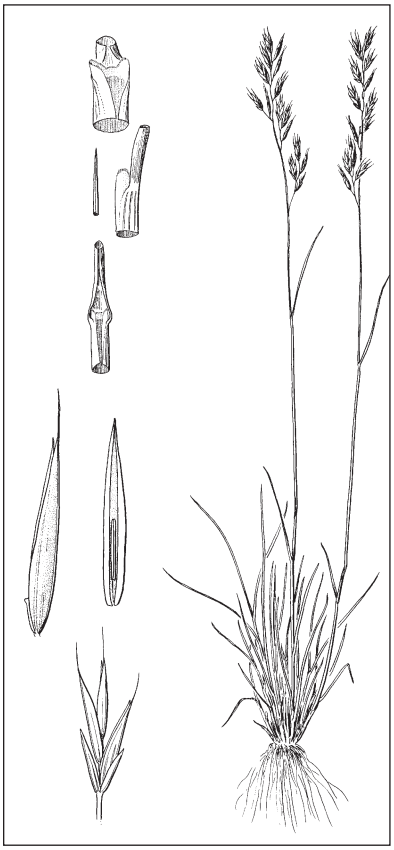
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Photo credit: Percy Folkard, (BC FLNR).



Rocky Mountain/Alpine Fescue

Scientific name:
Festuca saximontana Rydb./ *Festuca brachyphylla* Schultes

Type:
Native grasses

General description:
Rocky Mountain fescue is a densely tufted, low-growing, perennial bunchgrass with dense fibrous roots. Alpine fescue is very similar in growth habit but slightly shorter in stature. Both are cool season native grasses. There has been some variety development research in the last 10 years by Alberta Research Council researchers in Vegreville, Alberta.

The stems grow 10 to 60 cm (4 to 24 in.) tall. The leaves of Rocky Mountain fescue are very fine, yellowish-green to rarely purple, while the Alpine fescue leaves are commonly purple. Both have leaves that are about 0.5 to 1.0 mm wide, thread-like, and roll inwards.

The seed heads form 2- to 5-flowered spikelets in Rocky Mountain fescue compared to 3- to 4-flowered spikelets in Alpine fescue. Both have short awns on the seed. In native stands, flowering and seed maturity is highly variable. In cultivated stands, seeds shatter easily when mature. Alpine fescue has slightly smaller seeds (up to 2 mm difference in length). Flowering and seed maturity vary depending on altitude and latitude. In the northern prairies and boreal regions, seed matures in mid-June; in alpine regions, seed matures by early to late August. The seed shatters easily and provides plant recruitment for the revegetation of sites.

Distribution:
Circumpolar distribution. In North America, from Alaska and Yukon through southern British Columbia to California.

Habitat and climate:
Rocky Mountain fescue grows in grasslands, dry hillsides, open woodlands, sandy soils in moister areas, and exposed sites up to the tree line. It is a component in late successional grasslands in the southern Interior. Alpine fescue grows mainly in arctic and alpine areas (alpine and higher elevation BEC zones).

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Engelmann Spruce–Subalpine Fir
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce
Spruce–Willow–Birch
Boreal Altai Fescue Alpine

Uses:
Used in reclamation mixes as a pioneer species in harsh environments. Also used for erosions control and for restoring Rocky Mountain sheep habitat. Also appropriate for grassland restoration.

Optimal time of grazing use:
Early spring and early summer, but also late fall.

Recovery after use (rating): Moderate
Where Rocky mountain fescue is a co-dominant in late successional grasslands, in the Interior Douglas-fir zone it decreases with overgrazing. At higher elevations, Rocky Mountain and Alpine fescue can remain in mid-successional grazed alpine plant communities.

Forage yield (rating): Low
Less palatable than Idaho fescue and low forage production but important forage for wildlife. Stays green until late fall. Has also been reported to be fairly good forage for livestock.

Palatability/nutritional value:
Palatability is low but an important source of food for Rocky Mountain sheep and for elk in spring and summer.

Longevity (rating): High
Rocky Mountain fescue is long lived.

Competitiveness (rating): Low
These are non-competitive species considered compatible with other native species.

Persistence (rating): Moderate

Erosion control (rating): High
The fibrous roots of these grasses and their adaptation to sandy, gravelly, infertile soils make them useful for erosion control and rehabilitation of disturbed sites.

Drought tolerance (rating): High
Both are drought tolerant and are noticeably absent from wetter areas.

Soil texture preference (rating): Medium-Coarse
Prefers well drained sandy to loam soils.

Acidity tolerance: Low to moderate

Salinity tolerance: Low

Flooding tolerance (rating): Low
Not common in areas where water pools.

Shade tolerance:
Alpine fescue is shade tolerant.

Seed size: Small

Seeds per kg: 1,041,000

Ease of establishment (rating): High
Germinates better in cooler soils.

Application requirements:
Clear site of all weeds, as these species are not overly competitive. Use narrow spacing if drill seeding. Seed early in spring. Suggested seeding depth is 0.6 to 1.2 cm (1/4 to 1/2 in.).

Suggested mixtures:
Best blended with junegrass, alpine bluegrass, or other native species.

Typical seeding objectives:
Erosion control
Native plant community
Cultural and/or aesthetic

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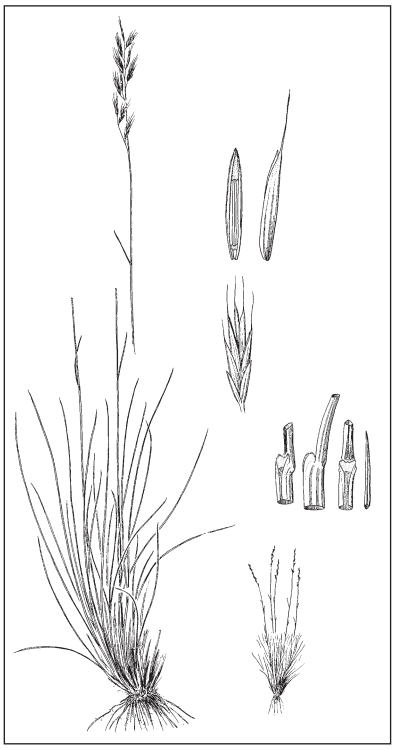
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Photo credit: Percy Folkard (BC FLNR).



Idaho Fescue

Scientific name:
Festuca idahoensis Elmer

Type:
Native grass

General description:
Idaho fescue is a densely tufted, native perennial bunchgrass. It is an important component of late successional upper grassland plant communities in southern British Columbia, and is common throughout the U.S. Pacific Northwest. The recognition of Idaho fescue as separate species is questioned by some authors, who consider it a variety of *Festuca occidentalis* (western fescue). However, it is closely related to the *Festuca ovina* complex and has long been identified as a separate species.

Roots are fibrous and not rhizomatous. Stems are 30 to 100 cm (12 to 39 in.) tall, densely tufted, and somewhat rough with nodes exposed. Leaf blades are numerous, 15 to 30 cm (6 to 12 in.) long, and stiff when dry. The seed head is narrow, and 10 to 20 cm long (4 to 8 in.). Spikelets are 5 to 7 flowered. Florets have an awn 2 to 4 mm long.

Origin:
Idaho fescue is native to British Columbia.

Distribution:
Idaho fescue occurs mostly in south-central and southeast regions of the province. It also is found in Alberta, Saskatchewan, and most western states.

Habitat and climate:
Dry to moist grasslands and open forests.

Regions:
Cariboo – Fraser-Fort George
Kootenay
Thompson – Okanagan

Typical BEC range:
Bunchgrass
Ponderosa Pine
Interior Douglas-fir
Montane Spruce
Engelmann Spruce–Subalpine Fir

Annual precipitation minimum (mm): 305

Annual precipitation maximum (mm): 510

Uses:
Idaho fescue is an important forage for livestock and native ungulates. It has some potential for rehabilitation and erosion control.

Optimal time of grazing use:
Idaho fescue can be grazed in all seasons. Most of its growth occurs in spring, but it cures well and is palatable to cattle and native ungulates well into fall. It is not preferred by sheep once it matures.

Recovery after use (rating): Moderate
Idaho fescue can withstand grazing of up to 50% of its annual production, but it should not be grazed at the same time each year. It should not be grazed closer than 8 cm (3 in.) to the ground. Complete rest every 2-4 years, or a lower level of utilization (30%) will help maintain vigour and range condition.

Palatability/nutritional value:
Idaho fescue is considered excellent forage for cattle and good forage for sheep, maintains its forage value late into the season, and is good forage for native ungulates in winter.

Longevity (rating): High
Idaho fescue is long lived.

Persistence (rating): High
Idaho fescue is persistent if grazing is managed.

Invasiveness (rating): Low
Idaho fescue is not invasive.

Competitiveness (rating): Moderate
Moderately competitive once established. Does not compete well with aggressive introduced grasses.

Weed resistance (rating): Low
Weed resistance is dependent on germination. Where germination is satisfactory, Idaho fescue can emerge earlier than some annual weeds although seedling vigour is considered low.

Erosion control (rating): Moderate
Extensive root system makes it suitable for erosion control once established.

Drought tolerance (rating): Moderate
Drought tolerance is similar to that of hard fescue.

Winter hardiness (rating): High

Soil texture preference (rating): Medium
Prefers silt loam or sandy loam soils.

Flooding tolerance (rating): Low
It is intolerant of flooding.

Salinity tolerance (rating): Moderate
Tolerant of weakly saline conditions.

Acidity tolerance (rating): Moderate
Tolerant of weakly acidic conditions.

Shade tolerance:
Has moderate shade tolerance

Fire tolerance (rating): Moderate
Moderate tolerance of fire in the fall, but needs requires 2 to 3 years to recover from burning.

Pest and/or disease threats:
Primary pests are rodents, grasshoppers, and fungi.

Seed size: Medium

Seeds per kg: 425,000 to 460,000

Ease of establishment (rating): Low
Idaho fescue can be difficult to establish and requires 2–3 years to reach a mature stand phase. Germination can be variable, especially with native seed collections. Two cultivars of Idaho fescue (Joseph and Nezpurs) have been developed at the University of Idaho using 3 phases of phenotypic recurrent selection. The population base for the cultivars came from 89 native ecotypes collected from the northwestern U.S. and Canada. Both exhibit better germination and establishment characteristics than the source collections.

Application requirements:
Germination will be enhanced with drill seeding, but this may not be practical or desirable depending on the context. Late fall seeding is recommended.

Suggested Mixtures:
Normally recommended as a component in seed mixtures with other native species.

Management considerations:
Idaho fescue decreases with overgrazing. Deferred grazing is beneficial for maintaining Idaho fescue and can provide late fall and winter forage for wildlife.

Typical seeding objectives:
Erosion control
Native plant community
Sociocultural and/or aesthetic

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Photo credit: Rick Tucker, (BC FLNR).



Rough Fescue

Scientific name:
Festuca campestris Rydb.

Type:
Native grass

General description:
Rough fescue is a densely tufted, native perennial bunchgrass, and an important component of British Columbia's native grasslands. The name rough refers to the rough edges of the leaves and stems.

It has fibrous roots and is rarely rhizomatous. Plants spread from tufts growing at the edges of the crowns.

Stems are 40 to 90 cm (16 to 35 in.) tall with no exposed nodes. Leaf blades may be flat or folded 10 to 60 cm (4 to 24 in.) long and 1.2 to 3.2 mm wide when flat. Dense basal leaves are dark green and produce large amounts of forage, while taller leafless stems produce the seed heads. Seed heads are mature in 90 to 95 days from the first growth in spring.

Origin:
Rough fescue is native to British Columbia.

Distribution:
Rough fescue is a common dominant bunchgrass in grassland associations of south central and southeast British Columbia, and southern Alberta. It also occurs in Washington, Idaho, Oregon, Montana, and Colorado.

Habitat and climate:
It occurs on moist to dry grasslands and forest openings in the steppe to subalpine zones.

Regions:
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Bunchgrass
Ponderosa Pine
Interior Douglas-fir
Montane Spruce
Engelmann Spruce–Subalpine Fir
Spruce–Willow–Birch

Annual precipitation minimum (mm): 350

Annual precipitation maximum (mm): 610

Uses:
Important forage for both wildlife and livestock. Used in grassland restoration and site rehabilitation.

Forage yield (rating): Moderate
Rough fescue is one of the highest yielding of British Columbia's native grasses. Yields on excellent condition grasslands where it is dominant average more than 1,100 kg/ha (982 lb/acre) and can be as high as 2,700 kg/ha (2,411 lb/acre).

Recovery after use (rating): Low
Can be managed with proper utilization and periodic year-long rest. Continued defoliation during the latter part of the spring growth period can be detrimental to rough fescue.

Palatability/nutritional value:
Rough fescue has fairly good palatability and is readily grazed. Rough fescue has different forage and palatability levels in different regions. It cures on the stem but early frosts may interfere with the curing process.

Longevity (rating): High
Rough fescue is long lived.

Persistence (rating): Moderate
Good persistence once established, and when managed appropriately.

Invasiveness (rating): Low
Not invasive.

Competitiveness (rating): High
It is competitive when well established in naturally occurring native plant communities.

Weed resistance (rating): Low
Low weed resistance when it is being established. Established stands have much higher weed resistance.

Erosion control (rating): Low
Can provide high protection from erosion once established. Slow establishment limits use in critical erosion control situations.

Drought tolerance (rating): Low
Rough fescue has low drought tolerance.

Winter hardiness (rating): Moderate
Rough fescue requires a frost free period of at least 90 days.

Soil texture preference (rating): Medium-Coarse
Rough fescue prefers medium- to coarse-textured soils.

Flooding tolerance (rating): Low
Rough fescue has low tolerance to flooding.

Acidity tolerance (rating): Moderate
Rough fescue can tolerate soil pH levels of 6 to 8.

Shade tolerance:
Rough fescue has intermediate shade tolerance.

Fire tolerance (rating): Medium

Seed size: Medium

Seeds per kg: 600,000

Ease of establishment: Low
Emergence is poor despite high germination rates. Rough fescue has moderate seedling vigour. Stand development is slow. Fourteen years after pipeline restoration in Alberta, seeded rough fescue cover is 50% of control sites.

Application requirements:
Broadcast seeding using the Kinsella Accuroller (roller and imprinter) was reasonably successful in a major pipeline restoration project in Alberta.

Suggested mixtures:
Suitable with early- to mid-succession native species.

Management:
Grazing management is required for rough fescue to establish and persist.

Typical seeding objectives:
Native plant community
Sociocultural and/or aesthetic

References:

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Photo credit: Doug Fraser, (BC FLNR).



Tufted Hairgrass

Scientific name:
Deschampsia cespitosa (L.) Beauv.

Type:
Native grass

General description:
Tufted hairgrass is a short-lived, tufted, cool season, native perennial bunchgrass. Roots are shallow, fibrous, and dense. A mass of deep green leaves covers the crown. Densely tufted and with numerous stems, this native grass is found throughout British Columbia. Seed production is important for stand maintenance. It is valuable as a range grass and fairly resistant to close grazing.

Each plant has 1 to 20 straw-coloured stems that are 20 to 120 cm (8 to 47 in.) in height. The seed head is feathery in appearance. It branches several times, and forms whorls of 6 to 10 at points 2 cm (1 in.) apart. Leaves are up to 5 mm wide, flat, folded, flexuous, and sharp-pointed, sometimes swollen at each end, and without auricles.

Seed heads are loose, open, often drooping or nodding panicles 10 to 25 cm in length (4 to 10 in.). Spikelets are mostly 2 flowered.

Distribution:
Found across North America and in Iceland. One of the most widely distributed grasses on earth.

Habitat and climate:
Found in sloughs, moist draws, wet meadows, on stream banks, poorly drained fertile areas, gravelly river bars, lakeshores, and even alpine tundra. Found in low to high elevations. Occupies moderately moist to seasonally flooded, and sunny to partially shaded environments in a wide variety of soil types.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Bunchgrass
Ponderosa Pine
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Engelmann Spruce–Subalpine Fir
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce
Spruce–Willow–Birch

Annual precipitation minimum (mm): 400

Uses:
Highly palatable, resistant to grazing, remains green throughout the summer, and good for pasture forage. This highly variable species can adapt to stressful environments, and is often recommended for reclamation and rehabilitation projects.

Optimal time of grazing use:
Grazing should be deferred until the stands are established.

Recovery after use (rating): High
High recovery if rotational grazing system is used. Despite this species' resistance to grazing damage, it will decline with continuous season-long grazing.

Forage yield (rating): Moderate

Palatability/Nutritional Value:
Very palatable early in the season with up to 20% protein content in early May.

Longevity (rating): Low
Generally considered a short-lived species.

Invasiveness (rating): Low
Rated low but it can be problematic in some forage crops.

Competitiveness (rating): Moderate
Rated moderate as it can dominate if it is seeded too heavily in a mixture, and it can be a serious competitor with trees.

Erosion control (rating): Moderate
Sometimes used to stabilize stream banks, canals, and shorelines. Tolerates heavy metal contamination.

Drought tolerance (rating): Low

Winter hardiness (rating): High

Soil texture preference (rating): All
Can be found in a wide variety of soil types from fine to coarse.

Flooding tolerance (rating): High
Can be found in seasonally flooded areas.

Salinity tolerance (rating): Moderate
Tufted hairgrass is generally considered to have low salinity tolerance; however, it grows in salt marshes and coastal estuaries so some tolerance to salinity is inferred.

Acidity tolerance (rating): Moderate
Tolerant to both acidity (low pH levels) and alkalinity (high pH levels).

Shade tolerance (rating): Moderate

Fire tolerance (rating): High
The crown of tufted hairgrass can survive all but the most severe or hottest fires.

Pest and/or disease threats:
Insect pests include aphids, billbugs, leafhoppers, and others. This species is host to number of diseases and pests such as ergot, rusts, stripe smut, blind seed, leafs spots, and turf disease.

Seed size: Small

Seeds per kg: 3,600,000

Ease of establishment (rating): Low
Tufted hairgrass will establish with adequate moisture. Seed selected from high elevations may have higher dormancy and is likely to germinate better in fall seeding applications. Seeds selected from low elevations have lower dormancy and thus can be planted in the fall or spring. Specific selections are often required for extreme soil conditions.

Suggested mixtures:
Where species diversity is a goal, mixtures with less than 0.3 to 0.6 kg/ha (approx.1/4 to 1/2 lb/acre) may be required.

Typical seeding objectives:
Forage enhancement
Erosion control
Revegetation (ground cover)
Native plant community

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Photo credit: Reg Newman, (BC FLNR).



Bluebunch Wheatgrass

Scientific name:
Pseudoroegneria spicata (Pursh) A. Love

Type:
Native grass

General description:
Bluebunch wheatgrass is a native, perennial, cool season bunchgrass with fibrous roots, sometimes forming clumps as wide as 150 cm (59 in.). Stems range from 60 to130 cm (24 to 51 in.) tall, with narrow leaves mostly originating from the stem.

Bluebunch wheatgrass reproduces primarily through seed, but may reproduce vegetatively with short rhizomes on wetter sites. Bluebunch wheatgrass is an important species in British Columbia grasslands, occurring mostly in the south, central, and southeast parts of the province. It has historical importance in the development of the livestock industry in British Columbia because of its value for fall and winter grazing. It is also an important indicator of good ecological condition.

There are two recognized forms or subspecies of bluebunch wheatgrass. The smooth or awnless form (*Pseudoroegneria spicata* ssp. inermis) is more common in British Columbia, although the awned form (*Pseudoroegneria spicata* ssp. *spicata*) is also found. These two subspecies differ by only one gene, and there is some question whether this merits the distinction of the two subspecies.

Origin:
Native to British Columbia

Distribution:
Found in a wide range of habitats throughout the province, but is common only in the southern interior regions.

Habitat and climate:
Occurs in dry, in open areas, on rocky slopes, and in forest openings.

Regions:
Cariboo – Fraser-Fort George
Kootenay
Thompson - Okanagan

Typical BEC range:
Bunchgrass
Ponderosa Pine
Interior Douglas-fir

Annual precipitation minimum (mm): 200

Annual precipitation maximum (mm): 500

Uses:
As an important native component in B.C. grasslands, bluebunch wheatgrass is an important species for consideration in reclamation and restoration. It provides valuable forage for wildlife and all types of livestock.

Optimal time of grazing use:
Bluebunch wheatgrass can support grazing in all seasons. Sufficient growth should be allowed before grazing bluebunch wheatgrass in the spring. At least 15 cm (6 in.) of growth or allowing plants to reach the 4-leaf stage of development is recommended. Spring use should be deferred, or alternated to fall use every 2–3 years. New stands should be well established (2–3 growing seasons) before grazing is allowed.

Recovery after use (rating): Low
Repeated defoliation during the spring growth period is likely to reduce plant vigour, and lead to plant mortality (see McLean and Wikeem 1985). Suitable regrowth is likely to occur with late summer or fall rain if proper utilization (40–50% of growth) is applied in the spring season.

Forage yield (rating): Moderate
Forage yield will vary depending on the location and composition of the stand. McLean and Bawtree (1982) reported a yield of 660 kg/ha (589 lb/acre) in a mixed native stand (with needle-and-thread grass) on a mid-elevation (850 m) (2,789 ft.) site near Kamloops, B.C.

Palatability/nutritional value:
Bluebunch wheatgrass is highly palatable to livestock and wildlife and provides good winter forage when rested during the growing season. Plants remain green well into summer. Crude protein of green leaf material sampled in May was 15%, and cured material sampled in November was 3% in the Kamloops area (McLean and Bawtree 1982).

Longevity (rating): High
Bluebunch wheatgrass is long lived.

Persistence (rating): Moderate
Bluebunch wheatgrass has good persistence once established and managed appropriately.

Invasiveness (rating): Low
Bluebunch wheatgrass is not invasive, but can spread into adjoining communities on sites where it is well adapted.

Competitiveness (rating): Moderate
Bluebunch wheatgrass is considered to be reasonably competitive when it is well established in naturally occurring native plant communities.

Weed resistance (rating): Low
Bluebunch wheatgrass has low weed resistance when it is being established. Cheatgrass infestations can inhibit

establishment on some sites. Established stands have higher weed resistance but can be susceptible to highly invasive species.

Erosion control (rating): Low
Bluebunch wheatgrass can provide some erosion control on dry, disturbed sites where native vegetation is desired.

Drought tolerance (rating): High
Bluebunch wheatgrass is very drought tolerant.

Winter hardiness (rating): Moderate
Bluebunch wheatgrass is cold tolerant.

Soil texture preference (rating): Medium-Coarse
Bluebunch wheatgrass does best on medium-coarse textured soils, but also can be found on heavy- to medium- to coarse-textured soils.

Flooding tolerance:
Bluebunch wheatgrass is not tolerant of high water tables, saturated soils, or flooding.

Salinity tolerance (rating): Low
Bluebunch wheatgrass will tolerate weakly saline conditions.

Acidity tolerance (rating): Low
Bluebunch wheatgrass does not grow on highly acidic sites.

Shade tolerance:
Bluebunch wheatgrass can tolerate some shade.

Fire tolerance (rating): High

Pest and/or disease threats:
Grasshoppers and other insects may damage stands.

Seed size: Medium

Seeds per kg: 331,000

Ease of establishment (rating): Low
Bluebunch wheatgrass is more difficult to establish than other native wheatgrasses. The viability of commercially available cultivars is questioned by some professionals, and locally collected seed is often used when maintenance of ecological integrity is desired. Whitmar was the first commercially available variety. It was selected from the awnless subspecies in the Palouse grasslands near Colton, Washington, in 1946. It was selected for forage production, seedling vigor and seed production and is best suited for areas with more than 300 mm (12 in.) of annual precipitation.

"Goldar" was released in 1989 and developed from an awned collection originating from a ponderosa pine woodland on the Umatilla National Forest near Anatone, Washington. A more recent (2001) awned variety called P-7 was created in an effort to increase adaptability using open pollination of 25 different populations from various states, including one from the Slocan Valley of British Columbia. There is little information on its full range of adaptation but it is expected to perform better under drier conditions than the older varieties. Anatone, released in 2003, is similar to Goldar but expected to establish and perform better in areas with 250 to 300 mm (10 to 12 in.) of precipitation.

Secar, a variety released in 1980, was promoted as bluebunch wheatgrass, but originated from a misidentified population from the Snake River Valley in Idaho and is now known as Snake River wheatgrass (*Elymus wawawaeinsis*). This variety is suited to lower precipitation areas 200 mm (8 in.). Discovery, another Snake River wheatgrass (not known to occur naturally in British Columbia), was released in 2008.

Application requirements:
Seedbed preparation followed by drill seeding at depths of 0.6 to 1.27 cm (1/4 to 1/2 in.) produce the best results, but this method is likely to be unsuited to most projects and site conditions found in British Columbia. When seeded in pure stands, a seeding rate 260 PLS (pure live seed) per square metre (24 PLS per square foot) is recommended. Broadcast seeding is likely to be more applicable, but establishment may be slow and results mixed. Some B.C. restoration practitioners have used vegetative or plug plantings. Broadcast seeding rates for pure stands should be 150–200% of the drilled seeding rate. Hay seeding using locally sourced plant materials was applied with marginal results on a restoration project in the South Okanagan.

Suggested mixtures:
Bluebunch wheatgrass should be seeded with other suitable native species, rather than with more competitive introduced species.

Management considerations:
Bluebunch wheatgrass does not tolerate heavy, continuous grazing. A rest or deferred rotation grazing system is recommended to keep this grass in a healthy and vigorous condition.

Typical seeding objectives:
Erosion control
Native plant community
Aesthetic and/or cultural
Extending the grazing season

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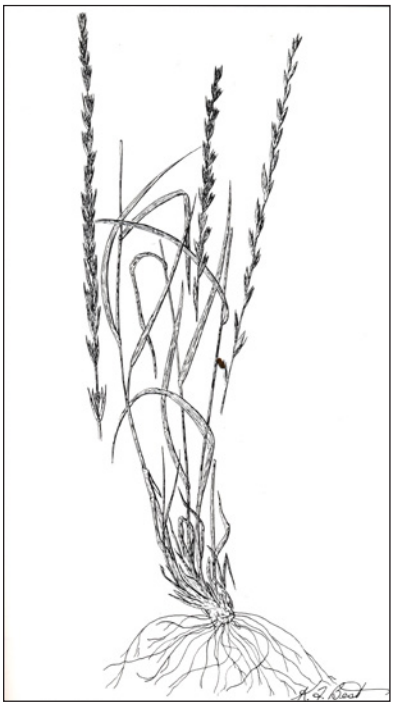
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Slender Wheatgrass



Photo credit: Percy Folkard, (BC FLNR).



Scientific name:
Elymus trachycaulus (Link) Gould ex Shinners ssp. *trachycaulus*

Type:
Native grass

General description:
Slender wheatgrass is a cool season, native perennial bunchgrass. Its roots are fibrous, sometimes with short rhizomes.

This grass has a wide geographic distribution throughout North America. Like bluebunch wheatgrass, two subspecies occur in British Columbia. The awned version, *Elymus trachycaulus* ssp. *subsecundus* (Link) A. Love & D. Love, occurs more frequently in southern British Columbia, while the awnless plant (*Elymus trachycaulus* (Link) Gould ex Shinners ssp. *trachycaulus*) is prevalent through most of the province.

Awnless slender wheatgrass was propagated for seed production by the 1920s on the prairies and was known as western ryegrass. It was an important forage species until the introduction of crested wheatgrass in the 1930s.

Stems typically range from 30 to120 cm (12 to 47 in.). It has leaves that are usually flat. Seed heads are slender and 8 to 20 cm (3 to 8 in.) long with overlapping spikelets. Spikelets are awned or awnless as noted in description above.

Origin:
Native to North America

Distribution:
Slender wheatgrass is common throughout British Columbia and much of North America.

Habitat and climate:
It occupies moderately moist to dry grasslands, meadows, forest openings, rocky ridges, and slopes throughout British Columbia and all vegetation zones.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Bunchgrass
Ponderosa Pine
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Engelmann Spruce–Subalpine Fir
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce
Spruce–Willow–Birch

Annual precipitation minimum (mm): 350

Annual precipitation maximum (mm): 600

Uses:
Slender wheatgrass is utilized by both livestock and wildlife. Under optimal conditions it may also be harvested for hay. It has been used widely in both restoration and reclamation situations, in part because seedling vigour is better than other native grasses. It is quick to germinate, so that it also has some application for erosion control. It has been used for post- wildfire restoration, mine reclamation, and seeding of roadside right-of-ways and other disturbances.

Optimal time of grazing use:
Slender wheatgrass can be grazed at the 4-leaf stage, but should be grazed only once per year. It maintains growth into summer, cures fairly well, and can be grazed in fall and winter.

Recovery after use (rating): Low
Slender wheatgrass is considered excellent forage but has low tolerance to heavy or repeated grazing.

Forage yield (rating): Moderate
Yield is variable depending on the site and establishment conditions. Yields of 5,170 kg/ha (4,616 lb/acre) can be expected in agronomic situations with good soil and moisture conditions.

Palatability/nutritional value:
Slender wheatgrass has average digestibility and crude protein ranging from 11% before heading to 9.5% at maturity.

Longevity (rating): Low
Slender wheatgrass is considered relatively short lived (3–4 years). In seeded applications it is sometimes used as an interim species in mixtures that include longer-lived, slower-establishing species.

Persistence (rating): Moderate
Seed production and drop should be allowed at least every other year, to increase persistence.

Invasiveness (rating): Moderate
In some regions slender wheatgrass has so well established that it is considered a vigorous persistent weed.

Competitiveness (rating): Moderate
Slender wheatgrass generally decreases in abundance, but because of early seedling vigour seeding rate should be limited to roughly 1 kg/ ha (around 1 lb of PLS per acre) in mixes where slower to establish species are used.

Weed resistance (rating): Moderate
Because it is quick to establish, slender wheatgrass may be useful for reducing weedy species if applied immediately after disturbance.

Erosion control (rating): Moderate
Because it is quick to establish and has

good seedling vigour, slender wheatgrass is often used in erosion control applications. Inclusion of longer-lived species is recommended for long-term stabilization.

Drought tolerance (rating): Moderate
Slender wheatgrass has fair drought tolerance.

Winter hardiness (rating): High
Slender wheatgrass has good winter hardiness.

Soil texture preference (rating): Fine-Medium
Slender wheatgrass prefers fine- to moderately-textured soils.

Flooding tolerance (rating): Moderate
Slender wheatgrass is well suited to drained low lying areas, but can stand spring flooding of 2–5 weeks.

Salinity tolerance (rating): High
Slender wheatgrass has good salinity tolerance and is often used for reclamation on saline soils.

Acidity tolerance (rating): Moderate
Slender wheatgrass can tolerate soil pH levels as low as 5.6.

Pests:
Slender wheatgrass is susceptible to head smut (Ustilago bullata) and stripe smut (U. striiformis) and may be susceptible to infestations of grass billbug.

Seed size: Medium

Seeds per kg: 320,000

Ease of establishment:
Slender wheatgrass establishes easily. "Adanac" and "Revenue" are two common Canadian varieties and were both developed in Saskatchewan by Agriculture Canada. The Alberta Environmental Centre released "AEC Hillcrest" in 1994. This variety originates from the awned subspecies, and is expected to be suited to more difficult site conditions and shorter growing seasons.

Application requirements:
In field situations, a firm weed free seed bed and a seeding rate of approximately 7 kg/ha (approx. 6 lb/acre of PLS or pure live seed per acre) are recommended. Seeding depth should be 0.6 to 2 cm (1/4 to 3/4 in.). In restoration and erosion control, or other broadcast seeded applications, a seeding rate of 1.5 to 2 times the drill seeded rate is recommended. Seeding rate should be reduced to 1 kg/ha (approx.1 lb PLS per acre) when combined with slower establishing native species to reduce seedling competition.

Suggested mixtures:
Slender wheatgrass is often included in seed mixes, with slower-establishing, longer-lived species.

Management considerations:
In situations where slender wheatgrass is grazed by livestock, rest or deferment every 2–3 years should maximize persistence.

Typical seeding objectives:
Erosion control
Native plant community
Invasive plant suppression

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Photo credit: Reg Newman, (BC FLNR).



Western Wheatgrass

Scientific name:
Pascopyrum smithii (Rydb.) A. Love

Type:
Native grass

General description:
Western wheatgrass is a native cool-season perennial grass that grows from conspicuous white rhizomes, and is strongly rhizomatous. Western wheatgrass is a sub-dominant in plant communities with bluebunch wheatgrass and Idaho fescue, and is dominant on many sites on mixed-grass prairie east of the Rockies. On clay sites it is usually found with green needlegrass (*Nassella viridula* (Trin.) Barkworth - syn. *Stipa viridula*).

The shallow roots of western wheatgrass extend to 25 cm (10 in.) deep whereas feeder roots can be 150 cm deep (59 in.). The roots are known to creep aggressively in some conditions.

Smooth stems grow to 20 to 100 cm (8 to 39 in.) tall and are very erect. The leaves are rigid, flat, 6 mm wide, glaucous, blue, and grow at a 45 degree angle to the stem. The leaves are also ridged, rough, and veiny. The auricles are often purple, giving the plant its common name. Seed heads are 7 to 15 cm long (3 to 6 in.) dense spikes with single spikelets at each node. Each spikelet is 6 to 10 flowered glumes that are 10 to 12 mm long. They are rigid and almost flat sided in the middle not broadened.

Seeds are 10 to 12 mm long; the lemma sometimes having a short awn. Western wheatgrass is cross-pollinating often via wind, and is self-incompatible.

Origin:
Western wheatgrass is native to the mixed-grass prairies of North America.

Distribution:
Western wheatgrass is found throughout British Columbia and the rest of North America except in the southeastern United States. It is locally common in northeastern British Columbia as part of the Peace River grasslands.

Habitat and climate:
Western wheatgrass is found on moist to dry slopes in grassland and montane zones. It can often be found where water pools in the spring.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Ponderosa Pine
Interior Douglas-fir
Engelmann Spruce–Subalpine Fir
Sub-Boreal–Spruce
Boreal White and Black Spruce

Annual precipitation minimum (mm): 300

Annual precipitation maximum (mm): 510

Uses:
Western wheatgrass is used for livestock and wildlife forage on native ranges. It is occasionally used as native hay on sites that might receive supplemental moisture. It is used for erosion control and reclamation of disturbed sites, but is not compatible with strongly competitive non-native species.

Optimal time of grazing use:
Western wheatgrass can be used in spring, summer, and fall and as stockpiled grazing as it cures on the stem.

Recovery after use (rating): Moderate
Annual spring use will usually cause western wheatgrass to decrease. It usually responds favorably to rest rotation or deferred rotation grazing systems. Western wheatgrass should be allowed to reach 15 cm (6 in.) of growth before grazing in spring.

Forage yield (rating): Low
Western wheatgrass has relatively low forage production compared to other species.

Palatability/nutritional value:
Western wheatgrass is considered good forage and is palatable to livestock and wildlife. In June digestibility is 60% with crude protein around 14%. By September digestibility is 50% and crude protein is 8.5%. Provides nutritious winter pasture and hay.

Longevity (rating): High
Western wheatgrass is long lived.

Persistence (rating): Moderate
Western wheatgrass has reasonable persistence if grazing is managed.

Invasiveness (rating): Low
Western wheatgrass is not considered invasive but can spread into adjoining areas under ideal conditions.

Competitiveness (rating): Moderate
Western wheatgrass can be competitive as it becomes established, spreading mostly by rhizomes. The percentage in mixtures should be kept low to prevent western wheatgrass from dominating stands.

Weed resistance (rating): Moderate
Under the appropriate site conditions western wheatgrass can provide good weed resistance once it is established.

Erosion control (rating): High
Western wheatgrass has excellent value for erosion control because of its spreading root system. However, full cover will be delayed as stands take several years to become fully established.

Drought tolerance (rating): High
Western wheatgrass has very good drought tolerance.

Winter hardiness (rating): High
Western wheatgrass has excellent winter hardiness.

Soil texture preference (rating): Fine-Medium
Western wheatgrass prefers fine- to medium-textured soils.

Flooding tolerance (rating): Moderate
Western wheatgrass can stand approximately 5 weeks of spring flooding.

Salinity tolerance (rating): Moderate
Western wheatgrass has moderate salinity tolerance.

Acidity tolerance (rating): Low
Western wheatgrass is not recommended for acidic soils.

Shade tolerance:
Western wheatgrass has moderate shade tolerance.

Pest and/or disease threats:
Primary pests include grasshoppers, ergot, and stem and leaf rusts.

Seed size: Large

Seeds per kg: 243,000

Ease of establishment (rating): Moderate
Western wheatgrass is relatively easy to establish, but seedlings tend not to be very vigorous. Germination is sometimes poor and stands can take several years to become fully established through rhizome development.

Application requirements:
Western wheatgrass is sometimes established from sod. Some form of minimal site disturbance after broadcast seeding is recommended.

Suggested mixtures:
Western wheatgrass works well in mixtures but creeps aggressively so should be kept to a low percentage.

Management considerations:
Proper grazing management is required to maintain the productivity of western wheatgrass. After approximately 5 years, stands may become sod-bound, making stand renovation necessary to maintain productivity.

Typical seeding objectives:
Erosion control
Native plant community
Extending the grazing season
Invasive plant suppression

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Photo credit: Percy Folkard (BC FLNR).



Blue Wildrye

Scientific name:
Elymus glaucus Buckl. ssp. *glaucus*

Type:
Native grass

General description:
Blue wildrye, also known as smooth wildrye, is a bluish-green, tall, tufted, native cool season perennial grass. The root system is fibrous and may have short rhizomes. The plant forms small tufts of a few stems between 50 to 150 cm (20 to 59 in.) tall. The stems have a waxy covering that contribute to the plant's bluish-green colour and name.

The leaves are flat and wide (5 to 15 mm), tapering to the tip. Leaf blades are roughened, above and below. The nodes are exposed, often with dense short hairs. Seeds occur on dense bearded spikes usually 5 to 15 cm (2 to 6 in.) long, that turn purplish as they ripen.

There are two recognized subspecies in British Columbia: subspecies *glaucus* has awns greater than 5 mm while subspecies virescens has awnless lemmas, or awns less than 5 mm. The seeds of blue wildrye were used as a food source by the Coast Salish peoples.

Origin:
Blue wildrye is native to British Columbia.

Distribution:
Blue wildrye is common throughout southern British Columbia and less frequent in the north. This grass occurs in dry forests of the Ponderosa Pine and Interior Douglas-fir zones, and moist forests in the Engelmann Spruce–Subalpine Fir, Montane Spruce, Sub-Boreal Spruce, Sub-Boreal–Pine Spruce, and Interior Cedar–Hemlock zones. Blue wildrye can also be found at high elevations in the Alpine Tundra and Spruce–Willow–Birch zones.

Habitat and climate:
Blue wildrye is widely distributed on moist to dry slopes, forests, and meadows from lowland to alpine zones.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Ponderosa Pine
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Engelmann Spruce–Subalpine Fir
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Spruce–Willow–Birch

Annual precipitation minimum (mm): 400

Annual precipitation maximum (mm): 1,500

Uses:
Native revegetation of disturbed or burned areas, erosion control for steep slopes. Wildlife habitat for mammals and birds.

Recovery after use (rating): Low
Does not tolerate heavy grazing. Close grazing in spring eliminates a stand of blue wildrye within 3 to 5 years.

Forage yield (rating): Low

Palatability/nutritional value:
Most palatable to wildlife and livestock in the early part of the season. Forage value declines with maturity. This grass is not readily eaten after the seed heads are formed.

Longevity (rating): Low
Blue wildrye is considered short lived (i.e., 3–8 years).

Persistence (rating): Moderate
Although short lived, blue wildrye is able to persist in plant communities with self-seeding.

Invasiveness (rating): Low

Competitiveness (rating): High
Considered highly competitive as it has high seedling vigour, establishes rapidly, and has good ground protection. It is also a good seed producer and reseeds readily.

Erosion control (rating): Moderate
A pioneer species with hardy fibrous root system has value in erosion control especially on steep sites with coarse soils.

Drought tolerance (rating): Moderate
Varies with ecotype. Some are adapted to dry grassland sites.

Winter hardiness (rating): Moderate
Variable with ecotype.

Soil texture preference (rating): All

Flooding tolerance (rating): Low
Low flooding tolerance, but will tolerate somewhat poorly drained soils.

Salinity tolerance (rating): Low

Acidity tolerance (rating): Moderate
Prefers moderately acidic to neutral soils, pH levels of 5.8 to 8.5.

Shade tolerance (rating): Moderate

Seed size: Large

Seeds per kg: 219,000

Ease of establishment (rating): High

Application requirements:
Cultivars and selected varieties have been developed. The genetic source should be identified before application. There is wide variation in this species, and outcrossing with local populations is possible.

Suggested mixtures:
Should be included in a mixture for revegetation seedings.

Typical seeding objectives:
Erosion control
Native plant community
Sociocultural and/or aesthetic

References:

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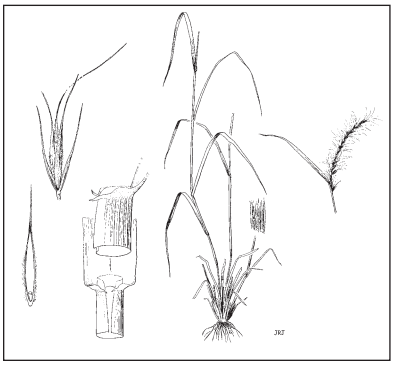
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Photo credit: Percy Folkard, (BC FLNR).



Canada Wildrye

Scientific name:
Elymus canadensis L.

Type:
Native grass

General description:
Canada wildrye is a tall, tufted, cool season, perennial bunchgrass. It is also known as nodding wildrye in some areas.

It grows from a deep, spreading root system, occasionally with short rhizomes.

Erect and leafy hollow stems grow to 60 to 150 cm (24 to 59 in.) in height. Leaf blades are flat and wide, waxy green, and sometimes curled. Its seed heads self-pollinate, with some cross-pollination.

Origin:
Native to British Columbia.

Distribution:
Canada wildrye is found throughout British Columbia, but is infrequent in the south-central and southeast parts of the province. It is found throughout North America, with the exception of the U.S. southeast, and the Great Plains.

Habitat and climate:
Canada wildrye is found on sandy or gravelly, dry to moist river bars and meadows in highland areas below the subalpine.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Engelmann Spruce–Subalpine Fir
Boreal White and Black Spruce

Annual precipitation minimum (mm): 500

Annual precipitation maximum (mm): 1,140

Uses:
Canada wildrye is used for habitat restoration and erosion control, and also as grazing and hay for livestock.

Optimal time of grazing use:
Canada wildrye grows rapidly in spring, and if grazed should be used in spring or early summer.

Recovery after use (rating): Low
Canada wildrye grows slowly after grazing or haying and should be rested for an entire growing season following use. It should only be grazed after it has reached a height of 13 cm (5 in.).

Palatability/nutritional value:
Canada wildrye is considered to be good forage early in the season, but is less desirable as it matures. Forage quality is poor when mature; although the energy value is relatively good, the protein value is very poor. Canada wildrye has fair to good palatability for wildlife.

Longevity (rating): Low
Canada wildrye is relatively short lived, with an expected productive life span of 3 to 5 years.

Persistence (rating): Low
Canada wildrye establishes rapidly and has high seedling vigor but is replaced by other species within 2–3 years.

Invasiveness (rating): Low
Canada wildrye is not considered invasive.

Competitiveness (rating): Low
Canada wildrye is not considered to be very competitive.

Weed resistance (rating): Low
Canada wildrye does not compete well with weedy species.

Erosion control (rating): High
Canada wildrye establishes quickly and has good seedling vigour providing quick stabilization on disturbed sites. It is particularly well suited for use in riparian areas. It is known for its rapid cover and site stabilization in mixtures for roadside, parks and recreational areas, prairie restoration, and critical areas.

Drought tolerance (rating): Moderate
Canada wildrye has moderate drought tolerance, but is better adapted to moist areas.

Winter hardiness (rating): Moderate
Canada wildrye has good winter hardiness.

Soil texture preference (rating): Medium-Coarse
Canada wildrye prefers coarse-textured soils.

Flooding tolerance (rating): Low
Canada wildrye is not adapted to flooded conditions.

Salinity tolerance (rating): Moderate
In some references, Canada wildrye has poor salinity tolerance; in others it is rated with good salinity tolerance.

Acidity tolerance (rating): Moderate
Canada wildrye tolerates soil pH levels as low as 5.0.

Shade tolerance:
Canada wildrye has fairly high shade tolerance which makes it suitable for use in riparian areas where there may be a tree or shrub canopy.

Fire tolerance (rating): Low

Seed size: Large

Seeds per kg: 250,000

Ease of establishment (rating): High
Canada wildrye is easily established.

Application requirements:
Canada wildrye is suitable for fall or dormant season seeding, and is suitable for broadcast seeding applications. "Manadan" (ND) is the predominant variety for northern regions and was released in 1946 by the USDA Northern Great Plains Research Laboratory at Mandan, North Dakota.

Management considerations:
Persistence of Canada wildrye is increased if plants are allowed to set seed and establish seedlings.

Typical seeding objectives:
Erosion control
Natural plant community (ground cover)

References:
B.C. Ministry of Forests. 1998. Knowing grasses and grasslike plants in British Columbia: self-study guide to identification of selected species mostly by vegetative characteristics. 3rd draft. Forest Practices Branch, Range Section, Victoria, B.C.

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Photo credit: Jamie Fenneman.



Fuzzy-spiked Wildrye (Hairy Wildrye)

Scientific name:
Leymus innovatus (Beal) Pilg.

Type:
Native grass

General description:
Fuzzy-spiked wildrye is sometimes called hairy wildrye, but is a different species than *Elymus hirsutus*, which is also commonly called hairy wildrye. Fuzzy-spiked wildrye is a tall, cool season, perennial tufted grass that is adapted to a wide range of soil conditions. It is sod-forming with a deep spreading root system and creeping scaly rhizomes. It is often used for native species site rehabilitation, as its rapidly spreading rhizomes are good for erosion control.

The stems can grow from 50 to 100 cm (20 to 39 in) tall with mainly basal leaves. Leaves can be up to 25 cm (10 in.) long and appear rolled at emergence. The leaves are somewhat hairy on the bottom side with prominent veins on the top side. Auricles are well developed and claw-like.

The inflorescences are dense, erect, purple or greyish. Spikes can be up to 12 cm (5 in.) long, and are very hairy. Spikelets usually occur in pairs and are 3- to 5-flowered. Lemmas are usually not awn-tipped, or may sometimes have awns 3 to 4 mm. Reproduction of this species occurs through rhizomes and seeds. It is an important native forage species for wildlife.

Origin:
Native to North America.

Distribution:
Fuzzy-spiked wildrye occurs throughout the northern region in the Sub-Boreal Spruce and Boreal White and Black Spruce zones.

Habitat and climate:
This species is most likely found in open forests and previously disturbed sites. Fuzzy-spiked wildrye is widely adapted to sandy or gravelly soils.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Northeast – Peace-Liard

Typical BEC range:
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce
Spruce–Willow–Birch

Annual precipitation minimum (mm): 400

Annual precipitation maximum (mm): 900

Uses:
An important native component to open forests, disturbed sites, and rangelands. It provides important winter forage for mountain sheep in the northern region.

Forage yield (rating): Low
Low to medium forage yield rating. It has been traditionally considered as poor forage value and poor palatability due to coarseness of the foliage. However, recent studies suggest cattle show good gains in pastures where fuzzy-spiked wildrye is prominent.

Palatability/nutritional value:
Low palatability due to its coarse, rough foliage.

Invasiveness (rating): Low

Competitiveness (rating): Low

Erosion control (rating): High
Rapidly spreading rhizomes make this species well used for erosion control.

Drought tolerance (rating): High

Soil texture preference (rating): Coarse
Commonly found on sandy and gravelly textured soils.

Flooding tolerance (rating): Moderate

Salinity tolerance (rating): Moderate

Acidity tolerance (rating): Moderate
Moderate tolerance to acidity (low pH) but low tolerance to alkalinity (high pH).

Shade tolerance:
This species is reported to be shade intolerant to moderately shade tolerant.

Seed size: Medium

Seeds per kg: 577,000

Ease of establishment (rating): Moderate
Fuzzy-spiked wildrye can be hard to grow from seed as germination can be low. One source reports suitable germination but slower seedling growth.

Typical seeding objectives:
Erosion control
Native plant community

References:

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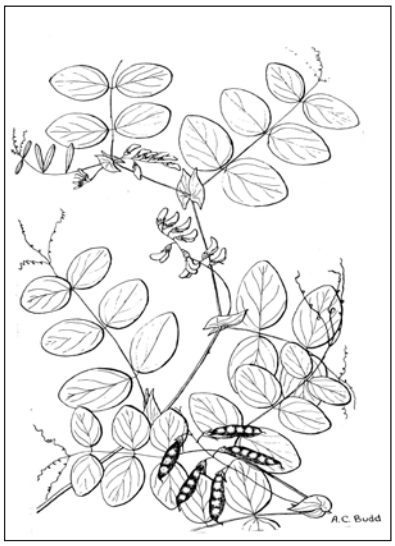
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Creamy Peavine



Photo credit: Percy Folkard, (BC FLNR).



Scientific name:
Lathyrus ochroleucus Hook.

Type:
Native legume

General description:
Creamy peavine is a climbing perennial legume. It is widespread in moist to dry open woodlands, especially deciduous or mixed-tree stands. It is sometimes confused with veined or purple peavine (*Lathyrus venosus*) when not in flower, but the leaves of the two species differ. Creamy peavine is an indicator plant of mesic moisture and average to above-average nutrient status in boreal and sub-boreal BEC classifications in British Columbia. It has been found to be an indicator of burned plant communities in Elk Island Park in northern Alberta. Its growth response after fire may be due to the legume seed dormancy being broken by the fire, and regrowth of from subsurface root material.

Its roots have creeping rhizomes and it is a nitrogen-fixing plant. It is erect to climbing with slightly angled stems that are 30 to 100 cm (12 to 39 in.) tall. It has alternate leaflets in 3 to 4 pairs that are 7 cm (3 in.) long with branched tendrils.

Flowers are white to yellowish white in terminal clusters of 6 to 15. Seed pods are hairless. Seeds can be toxic to humans and livestock, especially horses, and can lead to a condition of partial paralysis called "lathyrism."

Origin:
Native to British Columbia.

Distribution:
Creamy peavine is found as far north as Northwest Territories, east to Quebec, south to Ohio, and west in British Columbia.

Habitat and climate:
Creamy peavine occurs in continental boreal and wet cool temperate climates on moderately dry to fresh water-receiving sites. It is abundant in mesic or near mesic mature deciduous forests of the Boreal White and Black Spruce (BWBS) and Sub-Boreal Spruce (SBS) BEC zones. It is most prevalent on well to moderately well-drained sites, but will also grow on rapidly drained to imperfectly drained sites. In the Sub-Boreal–Pine Spruce (SBPS) zones southwest of Prince George in the Cariboo area, it grows on wetter than average sites with above-average nutrient status.

Regions:
Bulkley – Nechako
Cariboo – Fraser-Fort George
Kootenay
Northeast – Peace-Liard
Thompson – Okanagan

Typical BEC range:
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Engelmann Spruce–Subalpine Fir
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce

Annual precipitation minimum (mm): 400

Annual precipitation maximum (mm): 700

Uses:
Excellent forage value for wapiti (elk) and cattle. Some use in reclamation and restoration.

Recovery after use (rating): Low
Creamy peavine can have low recovery as it is preferentially grazed, although it can recover if protected from grazing.

Forage yield (rating): Moderate
Studies have shown decreased forage production after clipping or grazing. Yields are lower than common agronomic legume species.

Palatability/nutritional value:
Very palatable. Livestock and wildlife will selectively graze it.

Persistence (rating): High
Persists or may increase in abundance in pioneer and young seral stages in native plant communities.

Invasiveness (rating): Low

Competitiveness (rating): Low
Considered a poor competitor on disturbed sites.

Erosion control (rating): Low
Some erosion control value if established.

Drought tolerance: Low
Dependent on stand condition, tree canopy overstory, and litter layer.

Winter hardiness (rating): Medium

Soil texture preference (rating): Medium-Coarse
Prefers loamy to sandy loam textured soils.

Flooding tolerance (rating): Low
Most prevalent on well to moderately well-drained sites.

Salinity tolerance (rating): Moderate

Acidity tolerance (rating): Low

Shade tolerance:
Usually shade tolerant, but in some cases has been found to be shade intolerant.

Fire tolerance (rating): Moderate
Moderate fire tolerance, with some roots and rhizomes 1.5 to 5 cm below the mineral soil surface.

Seed size: Large

Seeds per kg: 61,000

Ease of establishment (rating): Low

Application requirements:
Fall planting may assist in breaking seed dormancy. Site needs to be free of weeds and rhizomatous grasses to reduce competition.

Typical seeding objectives:
Soil improvement
Native plant community

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Photo credit: Percy Folkard, (BC FLNR).



American Vetch

Scientific name:
Vicia americana Muhl. ex Willd.

Type:
Native legume

General description:
American vetch is a long-lived, cool season, native perennial legume. It has climbing or trailing tendrils; the name vicia is from the Latin vincio meaning to bind or climb. It is commonly found throughout British Columbia. Its common names include American vetch, wild vetch, stiffleaf vetch, and wild pea. Currently recognized subspecies are *Vicia americana* ssp. americana and *Vicia americana* ssp. *minor* Hook.

It has rhizomatous roots and forms symbiotic root nodules with nitrogen-fixing Rhizobium bacteria. It forms a single trailing or climbing stem 15 to 100 cm (6 to 39 in.) tall, and occasionally hairy. Leaves are simple with 8 to 18 leaflets each about 35 mm (1.4 in.) long.

Flowers are bluish purple to reddish purple and pea-like. They have 3 to 9 flowers in a loose terminal cluster. Seed pods are hairless.

Origin:
Native to British Columbia.

Distribution:
Found from Northwest Territories south to New Mexico, from British Columbia and California east to New Brunswick.

Habitat and climate:
Common in moist to mesic meadows and open forests. American vetch is common in fescue grasslands and mixedwood forest areas. It also grows along fence lines and road sides. It is listed as an indicator species in BEC classifications for northern British Columbia. It increases and persists with pioneer early-successional stands of deciduous and mixed stands, particularly in the Boreal White and Black Spruce zones. Creamy peavine is also found in association on sites in the Sub-Boreal–Spruce zone on dry to mesic sites with average to above-average nutrient status. This species is associated with medium nutrient status in medium to drier areas of the Sub-Boreal–Pine-Spruce zone.

Regions:
Bulkley – Nechako
Cariboo – Fraser Fort George
Kootenay
Northeast – Peace Liard
Thompson – Okanagan

Typical BEC range:
Bunchgrass
Ponderosa Pine
Interior Douglas-fir
Interior Cedar–Hemlock
Montane Spruce
Sub-Boreal Spruce
Sub-Boreal Pine–Spruce
Boreal White and Black Spruce

Annual precipitation minimum (mm): 230

Annual precipitation maximum (mm): 1,270

Uses:
American vetch is used as a nitrogen-fixing cover crop, as a legume in native seed mixtures for revegetating disturbed areas, and for wildlife and livestock grazing. First Nations used the leaves for poultices, and the pods and seeds for food.

Recovery after use (rating): Low
Not tolerant to heavy or continuous grazing; decreases with overgrazing.

Forage yield (rating): Low
Low yielding but valuable forage for grazing both wildlife (mule deer, grizzly bear, black bear, small mammals, game birds) and livestock (cattle, sheep, horses).

Palatability/nutritional value:
Highly palatable for mule deer, black or grizzly bears, small mammals, and game birds.

Longevity (rating): High
Long-lived.

Invasiveness (rating): Low
American vetch is noted as potentially invasive in some regions of the United States. It is not on the E-flora Invasive Plant List for British Columbia.

Competitiveness (rating): Low

Erosion control (rating): Low
Some erosion control value if established.

Weed resistance (rating): Low

Drought tolerance (rating): High

Winter hardiness (rating): Moderate
Considered winter hardy where it is adapted in the lowland, steppe, and montane zones.

Soil texture preference (rating): All
Prefers fine or clay soils to medium-textured or loamy soils. It prefers moist to dry soils and full sun.

Flooding tolerance (rating): Low

Acidity tolerance (rating): Low
Prefers a neutral range of pH levels from 5.9 to 7.2.

Salinity tolerance (rating): Moderate

Shade tolerance: Moderate
Shade tolerance varies from shade tolerant to intolerant.

Fire tolerance (rating): Moderate to High

Pest and/or disease threats:
The vetch bruchid (*Brachus trachialis*) is an insect pest that may negatively affect natural reseeding in pastures. Also susceptible to Botrytis fungus.

Seed size: Large

Seeds per kg: 72,230

Ease of establishment (rating): Low
Low seedling vigour

Application requirements:
Spring or fall seeding.

Suggested mixtures:
In pasture situations, can be mixed with a taller-growing grass or fall rye so that it can climb. Should be mixed with other suitable native species for native plant community restoration, or where native species are desired.

Management considerations:
Scarification (scratching or etching) of the seed will decrease the germination time from 14 to 7 days, but will not improve overall germination. Managed grazing is required to maintain American vetch in the plant community.

Typical seeding objectives:
Forage enhancement
Soil improvement
Native plant community

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APPENDICES

A. Economic Analysis

When seeding is required by regulatory revegetation obligations, determining the most cost effective option is relatively straight forward. Listing total costs associated with different methods, or suppliers, to accomplish the task is sufficient. However, when seeding is an optional consideration, the economic efficiency of the project requires a more critical evaluation. A selected project should be efficient—meaning that it yields positive net benefits.

The challenges of applying full cost-benefit analysis to projects on Crown land was explained in Chapter 2. For projects on private land, and for some situations on Crown land, where project impacts can be clearly linked to a specific enterprise like a ranch or a community pasture, cost–benefit analysis should be applied. Despite uncertainties around future revenues and other assumptions, cost–benefit analysis can help to clarify management alternatives, and lead to more financially sound decision making.

The purpose of this appendix is to provide a simple example of cost–benefit analysis for a pasture seeding project. The principles demonstrated here can be used to evaluate other types of projects in a variety of situations. This type of analysis, however, does not evaluate the overall profitability of a livestock enterprise or ranch. The example is hypothetical, and different results can be expected if different estimates and assumptions are used.

Net Present Value

For the purposes of this example, the cost–benefit analysis is based on the net present value (NPV) of the seeding project or project alternative. The NPV is the difference between the present value of the estimated benefits (revenues) and the present value of the costs:

$$NPV = PV(Benefits) - PV(Costs)$$

If only one project option is being considered and the NPV for the project is positive, then it is considered efficient and can go ahead. If more than one project alternative is being evaluated, then the project with the highest NPV should be selected.

Information required

In the pasture context, seeding projects are usually planned to increase and maintain forage production over a period of years. Costs associated with seeding are an investment to receive an annual return in the form of additional forage production, which increases revenues. There may also be annual costs created by the project that must be deducted from additional annual revenue. This aspect of the analysis is sometimes referred to as partial budgeting, since it considers only those parts of the enterprise's budget affected by the project. There is a general assumption with the analysis that the proposed project does not require a complete restructuring of the enterprise, and fits with the current management structure.

Costs

Costs can be variable and specific to the enterprise and location. For example, costs for land preparation can be lower than reported custom rates if older equipment is used.

Direct fixed costs would include:

- site preparation,
- seed,
- seed application,
- additional fencing or livestock water development.

Indirect fixed costs would include:

- risk associated with a failed seeding,
- non-use during establishment,
- future renovation requirements,
- interest on direct costs during the non-use period.

Annual use costs might include:

- fence maintenance or fence moving in the case of portable electric fence that is specific to the seeding alternative,
- water maintenance associated with the project.

Benefits

The expected benefits (revenues) from increased forage production can be challenging to estimate, and are dependent on site conditions, species and seasonal precipitation. NPV is especially sensitive to the forage production estimates used in the analysis. Research and local knowledge should be consulted to develop production estimates. The valuation method for the added forage production can vary as well. One approach is to consider how the forage might be valued in the local pasture rental or lease market in $/AUM. If the extra forage can be used to extend the grazing season for the livestock enterprise, it may have higher value than the general pasture lease rate.

Increased forage production can also be equated to additional livestock production; however, this approach is more complex and expands the amount of partial budgeting required for the cost-benefit analysis. The example presented here will use the pasture lease rate as the method for valuing the additional forage created by the seeding project.

Total herbage dry matter production in kg/ha or lbs/acre can be converted to AUMs by using an appropriate utilization factor (e.g., 50–70%), and a value for the forage consumption required by one animal unit for one month. This figure can vary depending on the size of the typical animal unit. Traditionally this value has been about 364 kg (802 lbs) based on a daily consumption of 12 kgs (26 lbs) for a 454 kg (1,000 lb) cow with her suckling calf. Larger frame crossbred cows can weigh as much as 545–636 kg (1,200–1,400 lbs), and these animals can consume as much as 14–27% more forage than the smaller 454 kg (1000 lbs) cow.

These differences should be kept in mind when determining the value of additional forage, especially when pasture lease rates and/or other estimates or conversion factors are used. The goal is to match the grazing with an appropriate pasture lease rate and the actual increase in forage created by the seeding. In the example presented here, production estimates in AUMs per acre were derived from a combination of reported stocking rates and herbage production. Browse production should also be considered if it is expected to be an important source of forage during the grazing season.

While all the investment costs of a seeding project are incurred in present values, revenues are realized annually over a period of years. These benefits received in the future are worth less than the same amounts received today, and therefore must be discounted to present value so they can be compared directly to costs (see net present value above).

Choice of discount rate can have a significant effect on the determination of the present value of benefits. The pasture lease rates used in this example are projected into the future and are not adjusted for inflation. Therefore, it is appropriate to use a "real" rather than nominal or inflation adjusted discount rate, or loan rate. Bank loan interest rates are typically composed of a real rate of return, and an expected inflation rate. In the example presented here, a base or real discount rate of 4% is assumed. An additional 4% discount is added to reflect a real rate of risk associated with the project. It is also acceptable to account for risk associated with seeding establishment, by adding the cost of re-seeding and additional project delay to the investment cost as noted above. However, in the example developed here, risk associated with the forage production projected over the longer term is perhaps more significant than establishment failure. The 4% added to 4% discount rate accounts for both types of risk, and provides a reasonably conservative analysis.

Example Pasture Development Options

The project options used in this example are based in the Northeast–Peace-Liard region approximately 30 km west of Dawson Creek. Recent aspen logging on 120 acres has created an opportunity to consider improving forage production with seeding. The life of each option is expected to be 15 years. The options are:

A) Piling of remaining logging slash and remaining stumps, followed by double discing (with heavy breaking disc), fixed-wing aerial broadcast seeding of agronomic species and floating. The land is already perimeter fenced. A single water trough will be installed and gravity

fed from an existing dugout. After the year of establishment, the pasture will be continuously grazed for a four month period on annual basis. This scenario is considered a conventional clearing and breaking treatment, and expected to minimize aspen regrowth for the life of the project. The expected production, expressed as a stocking rate, is 2.4 AUMs/acre.

B) There is no seeding after logging. Forage production is provided by the native plant community, and aspen regrowth is controlled with intensively managed grazing. To facilitate intensive stocking, a single high tensile smooth wire electric cross fence is installed. This wire is used to electrify a portable poly-wire electric fence which is moved to allow strip grazing. Water is provided by six gravity-fed troughs. The expected production is 0.6 AUMs/acre including use of aspen browse.

C) Logging slash and stumps are piled and burned, and the area is aerially seeded with a fixed-wing aircraft. Livestock are turned out for a brief period after seeding to provide some disturbance and increase seed-to-soil contact. Water development and electric fence are installed as in scenario B above, to manage grazing and potential aspen regrowth. Expected production is 3 AUMs/acre.

Pasture development option details and assumptions are summarized in Table A.1. Costs and benefits for each option are summarized in Table A.2.

Table A.1 Summary of pasture seeding options for cost–benefit analysis example.

	Option A	Option B	Option C
Details	Piling, discing and seeding, continuous grazing	No seeding, intensively managed grazing	Piling, seeding, intensively managed grazing
Pasture size	120 acres	120 acres	120 acres
Production	2.4 AUMs/acre	.6 AUMs/acre	3.0 AUMs/acre
Expected life	15 Years	15 Years	15 Years

Table A.2 Costs and benefits associated with pasture seeding options.

Costs	Rate	Option A	Option B	Option C
Piling (D7 or equivalent)	1.0 acre/hr x $175/hr x 120 ac.	21,000	0	21,000
Double disc	$25/acre x 2 x 120 ac.	6,000	0	0
Seed	$2.20/lb x 15 lbs/ac x 120 ac.	3,960	0	3,960
Aerial seeding	$7.50/acre x 120 ac.	900	0	900
Floating/rolling	$15.00/acre x 120 ac.	1,800	0	0
Electric fencing costs		0	2,500	2,500
Water - 1" poly pipe		250	1,000	1,000
Water tanks		300	1,500	1,500
Tank floats		50	300	300
One season lost use	72 AUMs @ $15 each	1,080	0	1,080
Interest during non-use	8% of direct costs	2,736	0	2,469
Total Investment		**$38,076**	**$5,300**	**$34,709**
Additional annual costs ($)				
Labour	40 hrs @ $15/hr	0	600	600
Additional annual revenues				
Total AUMs	AUMs/acre x 120 ac.	288	72	360
Revenue @ $15/AUM	Total AUMs x $15/AUM	$4,320	$1,080	$5,400
Net revenue @ $15/AUM	Annual revenue – annual cost	$4,320	$480	$4,800
Revenue @ $20/AUM	Total AUMs x $20/AUM	$5,760	$1,440	$7,200
Net revenue @ $20/AUM	Annual revenue – annual cost	$5,760	$840	$6,600

Annual labor costs are incurred for options B and C to support increased water development maintenance and movement of portable electric fence for intensively managed grazing. This decreases net revenues for those options. Net annual revenues are converted to present value for the 15 year period using a discount rate of 8% which includes a real discount rate of 4% and a risk allowance of 4%. Net present values can be calculated using the NPV financial function in Microsoft Excel. The present value of benefits and the NPV for each pasture development option is presented in Table A.3.

Table A.3 Summary of present value costs, annual net revenues, present value of benefits over 15 years, and NPV for pasture development options.

	Option A	Option B	Option C
Present value (Costs)	$38,076.00	$5,300.00	$34,709.00
Net revenue @ $15/AUM	$4,320.00	$480.00	$4,800.00
Present value (Benefits)[a]	$36,976.95	$4,108.55	$41,085.50
Net revenue @ $20/AUM	$5,760.00	$840.00	$6,600.00
Present value (Benefits)[a]	$49,302.60	$7,189.96	$56,492.56
NPV ($15/AUM)	-$1,099.05	-$1,191.45	$6,376.50
NPV ($20/AUM)	$11,226.60	$1,889.96	$21,783.56

[a] *Expected over the life of the project.*

When forage production is valued at $15/AUM, only option C, which involves partial development, seeding and intensively managed grazing, results in a positive NPV. This suggests option C should proceed over all others under the assumptions used in the analysis. Both options A and B have negative NPV values suggesting neither should be implemented. When forage is valued at $20/AUM all options have positive NPV, but again option C should be pursued over the other options as it has the highest overall NPV.

Option B provides an interesting point for discussion, as it might be considered the lowest cost option of the three. However, forage production remains low under this alternative and thus the present value of benefits (revenues) is also low. Additional annual labor costs for the intensively managed grazing under this alternative also have a negative effect on NPV. If this option were changed to continuous grazing, eliminating electric fencing, additional water troughs, and the annual labor, the expected life would be shortened to seven years because of expected aspen regrowth. With these adjustments, option B would almost rival option C when a forage value of $15/AUM is used (NPV = $5,023, not in table). However, at the higher forage value rate of $20/AUM, option C far surpasses the modified option B. To make modified option B fully comparable, the future cost of a rejuvenation treatment to control aspen regrowth at year seven should be incorporated to extend the life of the alternative to 15 years (see footnote).

The important message here is that increased forage production is the key to increased revenues, and if increased production can be achieved at a lower cost, net benefits (revenues) will be maximized. The main value of the cost-benefit analysis is that it allows full exploration of alternatives. Once the cost and revenue structure is set up in an Excel spreadsheet, any number of alternatives can be explored, and the most economically efficient alternative selected.

[2] *Options should be evaluated over the same discounting period so they have the same opportunity to accumulate costs and benefits. Alternatives with different time periods can be compared by converting the NPVs to an equivalent annual net benefit. This is accomplished by dividing the NPV of each alternative by an annuity factor that has the same term and discount rate as the project itself (i.e., the present value of an annuity of $1 per year for the life of the project discounted at the rate used to calculate the NPV). In the example above, modified option B (with continuous grazing, a seven year life, an 8% discount rate and $15/AUM forage value) has a NPV of $5,023. Its annuity factor (taken from a standard annuity table) is 5.206. Therefore the equivalent annual net benefit is $965 ($5,023 ÷ 5.206). The equivalent annual net benefit for alternative C ($15/AUM and 8% discount rate) is $745 ($6,376 ÷ 8.559). This assumes that modified option B could be rejuvenated at very low cost at the end of year seven, and this is an unrealistic assumption. To properly compare modified option B to other alternatives, the future cost of a rejuvenation to extend the pasture life to 15 years should be incorporated into the analysis.*

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B. Soil Erosion Assessment Key – Climatic Precipitation Factors

Table B.1 Cariboo forest region: Precipitation factors

Low	Moderate	High	Very high
all BG PPxh			
IDFxm IDFxw IDFdk	IDFmw		
MSxk	MSxc		
SBSdw SBSmc*	SBSmh SBSmc* SBSmw SBSwk		
SBPSxc SBPSdc	SBPSmc SBPSmk		
ESSFxv	ESSFwk*	ESSFwc ESSFwk	
ICHdk	ICHmk ICHwk*	ICHwk*	

**These subzones/variants encompass two precipitation factor ranges. Use local experience in deciding the appropriate precipitationfactor to apply in the keys.*

Table B.2 Kamloops forest region: Precipitation factors

Low	Moderate	High	Very high
all BG PPxh			
IDFxh IDFxw IDFdk IDFdm	IDFmw IDFww		
MSxk	MSdc MSdm MSmm		
SBSdh SBSdw	SBSmm		
SBPSmk			
ESSFxc	ESSFdc ESSFdv	ESSFwc ESSFmw	ESSFvc ESSFvv
	ICHmk ICHmw	ICHwk	ICHvk
		CWHds CWHms	

Table B.3 Nelson forest region: Precipitation factors

Low	Moderate	High	Very high
PPdh1 PPdh2			
IDFdm1 IDFdm2 IDFun IDFxh1			
	MSdk MSdm1		
	ESSFdc1 ESSFdk	ESSFwc1 ESSFwc2 ESSFwc4 ESSFwm	ESSFvc
	ICHdw ICHmk1 ICHmw1 ICHmw2 ICHmw3 ICHxw	ICHwk1	ICHvk1

Table B.4 Prince George forest region: Precipitation factors

Low	Moderate	High	Very high
SBSdh SBSdk SBSdw SBSmk1 SBSmc*	SBSmh SBSwk SBSmw SBSmk2 SBSmc*	SBSvk	
BWBSdk BWBSmw2 BWBSwc3	BWBSmw1 BWBSwc1&2		
	ESSFmm ESSFmv ESSFwk*	ESSFwc ESSFwk*	ESSFvc
	All SWB		
	ICHmc ICHmm ICHwk*	ICHvk ICHwk*	

** These subzones/variants encompass two precipitation factor ranges. Use local experience in deciding the appropriate precipitation factor to apply in the keys*

C. Seeding Rate Calculations [3]

Seeding recommendations often provide weight-based application rates, especially designed for growing agronomic or native species in field situations. They are frequently provided for broadcast methods as well, often with advice to double the rate normally suggested for drilled or direct seeding to compensate for sub-optimal seedbed conditions. Weight-based recommendations are fairly straight forward when species are seeded as a monoculture in a field, but are more complex for seed mixtures and when site conditions are less than ideal.

Seeding rates for agronomic species in ideal seedbed conditions are based on years of research and field trials. In situations that demand broadcast methods, site and seedbed conditions are highly variable and seeding rates are somewhat subjective. The number of suitable microsites for seed germination should also be a factor when developing broadcast seeding rates.

Appropriate seeding rates for a wide variety of seeding methods, seed mixtures and conditions can be developed independently using:

- a target plant density,
- the number of seeds per unit weight for the species,
- pure live seed (PLS) for the species in the seed lot,
- a percent establishment factor.

Determining seeding rate using target plant density

The target plant density is the number of plants of each species desired at the establishment stage when the plants are no longer reliant on food reserves in the seed and have sufficient root development to survive on the site. This is usually the number of plants established after the first growing season following seeding. In native plant communities, the target plant density will allow for the fact that many seedlings do not reach maturity, and that plant densities will be much lower at maturity (20–40% of established seedlings). For example, the target plant density for a native bunchgrass community may be 10 to 20 plants if a mature plant density of 4 plants/m^2 is desired. Adjustments to this approach are required for species that spread quickly by rhizomes or other means. Target plant densities for seeding native species can be estimated using reference plant communities.

Table C.1 provides target plant densities for forage (pasture) seeding in the prairie soil–climatic zones as a reference. The Gray Wooded zone has application to the Northeast–Peace-Liard region, and parts of the north central interior (Bulkley-Nechako and Cariboo-Fraser Fort George). The seedling density for the brown zone may have some application for drier southern interior locations, but local experience and knowledge should be consulted.

[3] Seeding rate calculation using target plant density adapted from A. Smreciu et al., Establishing Native Plant Communities (Edmonton, AB: Alberta Agriculture, Food and Rural Development, 2002). Seeding rate formula attributed to D. Walker.

Table C.1 Suggested seedling density for forage seeding (plants/m^2)

Soil zones	Legumes	Grass/Legume (50:50)	Grass
Black	80–100	80–100	100–160
Dark Brown	60–100	60–100	100–160
Brown	30–50	20–40	20–40
Gray Wooded	40–50	30–40	40–50
Irrigation	150–250	150–200	200–300

Source: "Perennial Forage Establishment in Alberta" (Alberta Agriculture and Rural Development, 2005), http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex9682/$file/120_22-3.pdf?OpenElement.

The number of seeds per unit weight for a species in a seed lot can be taken from book values (see species summaries – Chapter 8), it can be obtained from a seed analysis lab or it can be determined from weighing actual seed counts. There can be wide variation depending on the variety or ecotype, and this can influence actual seeding rates. The actual value for the seed being applied should be used whenever possible. The pure live seed for the species in the seed lot can be obtained from the seed analysis certificate (Figure 7.2).

The estimate of establishment after the first growing season is used to develop an establishment factor in percent. This factor recognizes that under field conditions only a certain number of seeds and seedlings will make it through the germination and establishment stages and survive the first growing season (see Figure 6.1). Potential establishment also depends on individual species response to competition from seedlings of the same species, and seedlings of other species included in the mix. This can be an important factor for native species. Early successional species can be tolerant of high plant densities, while mid- to late-successional species may not grow as well in high density situations.

Table C.2 Typical estimates of seedling establishment (% seedlings per pure live seed after one season)

Establish-ment	25–50%	15–25%	5–15%	0.1–5.0%
Species or type	crested wheatgrass smooth bromegrass timothy perennial ryegrass cereal grains	western wheatgrass northern wheatgrass slender wheatgrass Canada wildrye green needlegrass	alpine fescues red fescue cultivars sheep/hard fescues alfalfa clovers	tufted hairgrass junegrass Canada bluegrass many harvested native seeds

Seeding rate formula

Seeding rates for each species in a mix can be calculated with the formula below (see Example 1). If using target plant densities from Table C.1, the total suggested density should be apportioned to each species in the mix.

Target Plant Density		No. seeds per gram		Pure live seed %		Establishment %		Conversion g/m^2 to Kg/ha		
$\frac{plants}{m^2}$	x	$\frac{1\ gram}{no.\ of\ seeds}$	x	$\frac{1}{PLS\ \%}$	x	$\frac{1}{Estab.\ \%}$	x	$\frac{1\ kg}{1000\ g}$	x	$\frac{10{,}000\ m^2}{1\ ha}$

Example 1: Seeding rate calculation for Rocky Mountain fescue using target plant density

Target plant density chosen for species = 20 plants/m^2
Seeds per gram = 1,042 (from species summary pg. 112)
PLS % = 88
Establishment % = 10

$$\frac{20\ plants}{m^2} \times \frac{1}{1{,}042} \times \frac{1}{0.88} \times \frac{1}{0.10} \times \frac{1\ kg}{1{,}000\ g} \times \frac{10{,}000\ m^2}{1\ ha} = 2.2\ kg/ha$$

Each species in the mix can be calculated in this way. Increases in calculated rates may be required for broadcast applications, particularly when post seeding disturbance such as rolling, harrowing, or packing is not planned or is impractical.

Determining seeding rate using seed density

The seeding rate calculation and development of a seeding mix can be simplified by using recommended seeding densities in PLS/m^2. These recommendations are widely available for agronomic species seeded as monocultures, and are intended to achieve target plant densities that result in productive stands. These densities can be converted to kg/ha using the number of seeds per gram for the species and the same conversion factors used in the seeding rate formula above (see Example 2). For example, the recommended seeding density for wheatgrasses is 130–260 PLS/m^2. Smaller seeded species generally have higher seed density rates, to compensate for establishment factors (i.e., less food reserves than larger seeds; the recommended seeding rate for orchardgrass is 700-900 PLS/m^2, and white clover 750 PLS/m^2).[4] When combined in a seed mixture, recommendations can typically range from 300 – 1,500 PLS/m^2 depending on the species in the mixture, seeding method and context.

Example 2: Seeding rate calculation for slender wheatgrass as a single species using recommended seed density in PLS/m^2

Recommended density = 130–260 PLS/m^2 (200 PLS/m^2 chosen for this example)
Seeds per gram = 320 (from species summary page 112)
PLS = 88%

$$\frac{200\ PLS}{m^2} \times \frac{1}{320} \times \frac{1}{0.88} \times \frac{1\ kg}{1{,}000\ g} \times \frac{10{,}000\ m^2}{1\ ha} = 7.1\ kg/ha$$

A seeding rate calculator, drill seeding rates for various row spacing, and additional seeding rate information for commonly used agronomic species is available at on line: http://www.agric.gov.ab.ca/app19/calc/forageseed/forageseedintro.jsp

[4] *"Perennial Forage Establishment in Alberta" (Alberta Agriculture and Rural Development, 2005), http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex9682.*

Glossary

Aerate – To supply with, or expose to, air. Turning over or mixing soil by use of a plough, hoe or other agricultural implement are methods used to aerate soil.

Agronomic – A type of forage variety bred for applied agriculture and crop production.

Annual – A plant that establishes, produces flowers and seeds, and dies within one growing season.

Autotoxicity – The inhibition of growth of one plant on others of the same species.

Auxilliary bud – A growing point capable of forming a new shoot or flower(s) at the leaf axil along a stem.

Awn – A narrow, bristle-like appendage.

Berm – A narrow ledge or ridge. Berms are often used in erosion and sedimentation control to slow or divert overland water flow.

Biennial – A plant that establishes, produces flowers and seeds, and dies within two growing seasons. A biennial will often establish in the first year and produce flowers and seed in the second growing season.

Biological control – The use of an organism's natural predators to control its population.

Biological control can be considered either: (1) classical, where an organism is established to reduce pest populations and bring the pest into equilibrium with the surrounding environment; or, (2) inundative, where large numbers of predators are augmented to provide short-term suppression of pests. Classical biological control is the primary biological control method used for the management of invasive plants in British Columbia.

Bloat – Excessive accumulation of gases in the rumen. Primary ruminal tympany, or frothy bloat, is caused by the entrapment of normal gases of fermentation in a stable foam and is associated with succulent and quickly digested high protein forages. Secondary ruminal tympany, or free gas bloat, is caused by physical esophageal obstruction due to a foreign body (e.g. potato, turnip, beet).

Breaking – Term applied to the process of turning, cutting or ploughing land for the first time.

Bridging – The plugging of seed equipment (e.g., cups, opener tubes, seed hoppers) by species with large or irregular shaped seed.

Bulk density – A soil measure of dried weight per unit volume. Variation in bulk density is a result of the proportion and specific gravity of organic and inorganic particles, and the porosity of the soil.

Bunchgrass – A grass that grows in a clump or tuft, as opposed to a creeping or sod-forming mat.

Calibration – The process of ensuring accuracy compared to a standard. In seeding applications this means setting equipment so that the desired number of seeds/unit area are applied.

Callus – A hardened thickening at the base of a seed where it detaches from the lemma.

Canopy – The above-ground leaves and stems of a plant.

Carrier – An additive used during seeding to assist with the handling and/or delivery of applied seed.

Cloddy – A soil described as consisting of firm clumps, particularly in clay and loam soils.

Coated seed – Seeds that are encrusted with biological or other compounds to assist in handling and application, contact with the soil surface, and germination. Coated seeds are usually those that are especially small or irregularly shaped.

Competition – The negative interaction between organisms resulting from the extraction of resources from a common pool. Resources include water, nutrients, light, and shelter.

Competitiveness – The ability of a plant to establish, grow, and reproduce within a plant community sharing a common pool of resources.

Compound leaf – A leaf that is comprised of a central stem or point from which multiple leaflets are produced.

Creeping roots – Plant stems that grow horizontally underground to access resources and sprout new roots and above-ground shoots.

Cross-pollination – The transfer of pollen from one plant to another.

Crown – The permanent base of a perennial herbaceous plant.

Crude protein – An estimate of total protein based on nitrogen available in protein and non-protein sources.

Culti-packers – An agricultural implement used to crush soil clods, remove air pockets, and create a smooth, firm seedbed.

Cultivar – A group or variety of named plants selected and maintained through cultivation and maintained for desirable morphological, physiological, or chemical characteristics.

Cultivation – The act of mechanically mixing, overturning or tilling soil. Also refers to the application of agricultural practices to conserve and/or increase productivity.

Cutblock – A forest opening created following the harvest of trees from a site.

Decreaser – A plant that decreases in composition within a plant community over time following a repeated disturbance such as grazing.

Deferred grazing or deferment – Delaying the grazing period until a later date to allow for forage species to produce seed, establish new plants, restore vigour, and/or produce forage for grazing or haying at a later date within the same growing season.

Diploid – A plant with two sets of chromosomes inside each cell.

Disc – An agricultural implement consisting of parallel disc blades ganged together, used to till or overturn soil.

Disperse – An organism or reproductive part actively transporting itself, or relying on environmental or biological factors (e.g., wind,water, or animals), for transport to a new location.

Drag scarify – To expose mineral soil by pulling a heavy metal implement such as chains or drums with sharp teeth, behind a skidder or other power unit.

Drought – A prolonged shortage of water at a site in relation to normal patterns of water availability.

EcovarsTM (Trademark of Ducks Unlimited Canada) – Ecological cultivars that emphasize genetic diversity and adaptation, while still meeting a standard for certain adaptive characteristics for a specific ecological region.

Endophyte – A fungus or other micro-organism that lives inside a plant. The endophyte can be parasitic or mutualistic.

Ergot – A group of fungi that grow on the seeds of several cereal and grass species. The disease causes the replacement of a seed with a black mass of fungal structures.

Erosion – The process of wearing away rocks or soil by water, ice, wind, or earth movement.

Evapotranspiration – Sum of evaporation of water from the soil surface and transpiration, which is the loss of water vapour from plants.

Fertility – A measure of the soil's ability to supply nutrients required for plant growth.

Float – An improvised or designed drag implement pulled behind a tractor, skidder or other power unit used to firm and level the soil surface and break down large clumps.

Floret – An individual flower. In a grass, one or more florets are contained within a spikelet.

Forage – A crop grown as food for grazing animals.

Forest land – Lands comprised of trees that often form the natural climax vegetation.

Germination – The emergence of the plant from a seed.

Girdling – Removing a band of bark and cambium around the base of a tree.

Grassland – Lands that are dominated by a recognized plant community association of grasses and grass-like plants; forbs; and small, woody shrubs (e.g., big sagebrush). Trees and shrubs may form a small component (< 25% crown cover) of grasslands, or they may exist as pockets or openings within forest land.

Harrow – An agricultural implement pulled behind a tractor (or other powered unit) consisting of a frame with metal spikes and/or discs (as in disc harrow). It is used to break up ploughed ground, soil clods, tear vegetation and cover seeds.

Hay – Forage that is cut and dried, and usually bundled and stored, for use as animal feed.

Herbaceous – Vegetative growth without a woody component. Grasses are an example of herbaceous vegetation.

Hummock – A low mound or knoll.

Increaser – A plant that increases in composition within a plant community following a repeated disturbance such as grazing.

Inflorescence – The flowering part of a plant, also referred to as a seed head.

Inoculation – The introduction of micro-organisms or substances to the seed coat.

Invasive plant – A potentially detrimental and extremely aggressive plant species introduced to British Columbia, often referred to as a noxious weed.

Invasiveness – The ability of a plant to increase within a community to the detriment of surrounding vegetation.

Legume – A plant from the Fabaceae family. Legumes produce fruit in pods and fix nitrogen from the atmosphere using bacteria found in root nodules in the soil.

Lemma – In grasses, the lower of two bracts that surround the floret.

Lodge – In a forage crop, refers to plants falling over; not remaining upright.

Longevity – The expected lifespan of an individual plant.

Macronutrient – A chemical element essential for plant growth, usually found in soil at concentrations greater than one part per million.

Mechanical purity – Refers to the degree of freedom of a seed lot from seeds of other crop kinds, weed seeds and inert matter.

Microbiotic crust – A crust formed on the soil surface consisting of algae, bacteria, lichen, fungi and/or moss.

Micronutrient – A chemical element essential for plant growth, usually found in very low soil concentrations.

Microsite – A specific minute area with different environmental conditions than adjacent areas.

Mineral soil – A soil consisting of primarily mineral matter, generally containing less than 17% organic carbon.

Mulch – A covering of organic material such as leaves, straw, bark, and/or compost used to protect the soil surface from microbiotic crust formation and the effects of raindrops, wind, evaporation and temperature.

Mycorrhizae – Soil fungi growing in association with plant roots.

Native plant – A plant species occurring within its historic range.

Naturalized – A plant species not native to a region but which has adapted to form a stable component of a plant community.

Nitrogen fixation – The conversion of nitrogen into forms readily available for uptake by plants.

Node – The point on a stem from which branches or leaves originate.

Nutrient cycling – The ecological process of recycling organic and inorganic matter back into the production of living matter.

Palatable – Plant characteristics or conditions that stimulate a selective consumption response by animals.

Panicle – An inflorescence consisting of a branched cluster of flowers.

Pedigreed seed – Seed is recognized as having pedigreed status when derived from a pedigreed crop. Seed originating outside of Canada must be certified by a foreign certification agency recognized by the CFIA before being considered pedigreed seed in Canada.

Persistence – The ability of a plant to maintain its presence within a plant community and recruit new individuals by means of seed or vegetative reproduction and establishment.

pH – The degree of acidity or alkalinity of a soil expressed in the pH scale. Neutral conditions have a pH of 7.0; lower pH levels indicate increasing acidity and higher pH indicates increasing alkalinity.

Phenotypic recurrent selection – A method of plant breeding where the genetic composition of plant material is based on the reproductive offspring of parent plants, and offspring are crossed to develop the new populations of the selected plant.

Porosity – The ratio of the volume of air-space to the total volume of soil.

Potential Natural Community (PNC) – The natural grouping of plants expected to develop over time given the specific climate, soils, aspect and natural disturbance regime for a site.

Propagule – A portion of a plant that produces a new plant.

Pubescent – A plant or plant part covered with short hairs.

Pure live seed – A measure of the purity and germination of seed expressed in percent. Pure live seed (PLS) is calculated by the formula: PLS = % germination x % purity / 100.

Range – A land type supporting the production of forage for grazing.

Rangeland – Land on which the native ground cover or understory vegetation component is dominated by grass or grass-like plants, as well as forbs, shrubs, and trees, providing grazing for livestock and wildlife. This includes lands that have been converted and revegetated through management to provide grazing value.

Reclamation – The process of reconverting disturbed land to its former or other productive uses. Ecosystem function is retained, but the structure may be less complex than a restored condition. The ability of the land to support various uses after reclamation is similar to that of the land before reclamation, but individual uses will not necessarily be identical.

Rehabilitation – Implies that the land will be returned to a form and productivity in conformity with a prior land use plan, including a stable ecological state that does not contribute substantially to environmental deterioration and is consistent with surrounding aesthetic values. Results in an altered ecosystem, with different function and structure from the original system.

Restoration – The process of establishing the ecosystem that existed before disturbance. Depending on the site this may include the PNC, or a plant community that will transition to the PNC.

Rest – The removal of grazing from a plant community over a period of the growing season to allow for regrowth and maintenance of plant vigour.

Rhizome – A horizontal subsurface stem capable of producing roots and new stems; also referred to as a creeping root.

Riparian – A transition zone between aquatic and surrounding drier upland habitat that has a combined presence and abundance of water and vegetation that responds, requires and survives well with water and soils that are modified by stream or wetland processes and associated vegetation.

Ripper – A long, claw-like device attached to the back of a bulldozer and used to break up deep, hardened soil layers. Can be modified to produce different disturbance effects (see subsoiler).

Roller – A heavy implement used to break up soil lumps and level soil following cultivation.

Salinity – The relative proportion of dissolved salt within soils, lakes and oceans. Usually measured as the salt concentration of the soil solution in g/l or electric conductivity in dS/m (deci-siemens per metre).

Sediment – Organic or inorganic material that is transported by, and settles out of, water, wind, ice, or overland soil movement.

Seedbed – The soil prepared for the application of seed, potentially treated to increase plant germination and establishment.

Self-pollination – The transfer of pollen from the anthers (male pollen-producing structures) to the stigma (female portion of the ovary that receives pollen) within the same flower.

Semi-arid – Climate conditions resulting in regular annual periods of drought that limit vegetative growth. Evapotranspiration often exceeds precipitation, but moisture is higher than in arid areas.

Seral stage – A plant community formed during the development of an ecosystem.

Slash – Coarse and fine woody material remaining on a harvested site following logging operations.

Smut – A group of fungi that infect the reproductive system of plants in the grass family.

Sod – Matted roots and/or rhizomes holding together surface soil.

Soil texture – The relative soil proportions of sand, silt, and clay.

Species – A rank or classification below genus within hierarchical taxonomy.

Spike – Plant inflorescence consisting of a single stem with a terminal cluster of multiple flowers arranged linearly along an unbranched stalk.

Spikelet – A small terminal cluster or secondary spike in a plant inflorescence consisting of one to many flowers.

Stockpile – The accumulation of the growth of a forage crop left for grazing at a later date (e.g., ungrazed regrowth left for late fall or winter grazing).

Subsoil – The layer of earth below the topsoil but above bedrock.

Sub-soiler – An implement pulled behind a machine or tractor to break into hardened, deeper soil layers.

Succession – The process of ecosystem development identified by a sequence of plant and animal communities.

Swale – A low tract of land often characterized by increased soil moisture and serving as an occasional catchment for overland water flow.

Taproot – The main root axis from which smaller roots arise.

Tetraploid – A plant with four sets of chromosomes inside each cell.

Soil texture – The relative proportions of sand, silt and clay in soil.

Tiller – A lateral shoot growing from the base of the original stalk.

Topsoil – The upper soil layer consisting of a higher concentration of organic matter.

Trifoliate – Having three leaflets or leaf-like parts.

Tufted – A small, dense clump of shoots, considered to be much smaller than a mature bunchgrass.

Turf – A land cover type consisting of dense, sod-forming plants.

Turfgrass – A type of grass suitable for cultural uses in residential and commercial applications, playing fields, parks and public spaces.

Varietal purity – Trueness to type or characteristics associated with a variety.

Variety (see Cultivar) – A particular form of a plant species. Variety is often used to describe a selectively bred strain of a native or agronomic plant.

Weed – An unwanted nuisance or troublesome plant. A weed can temporarily alter or influence ecosystem development, but tends not to persist indefinitely within a robust plant community with managed disturbance (e.g., grazing).

Windrow – A pile of harvested or waste material formed into a long line to encourage drying or facilitate further treatment or use.

Winter hardiness – The ability of a plant to tolerate cold temperatures and survive over winter to complete its life cycle.

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Index

aeration, 41
Agropyron
  cristatum (see crested wheatgrass)
  desertorum (see crested wheatgrass)
Agrostis alba (see redtop)
  gigantea (see redtop)
  scabra (see redtop)
  stolonifera (see redtop)
alfalfa, 59, 95, 120, 123, 125, 130,
alfalfa, 61, 124, 131, 143, 146, 153, 155, 200
  auto toxicity, 39, 201
animal stocking rates, 36
annual cropping, 34
annuals, 61
aspen, 36, 38, 40, 93, 136, 260
Astragalus cicer (see cicer milkvetch)
average daily gain, 30
barley, 39
B.C. Forest Practices Code Soil Rehabilitation Guide, 67
biodiversity, 20, 21, 46, 53
biogeoclimatic zones, 52, 82, 102, 104, 106, 108, 110, 161
birdsfoot trefoil, 202
bloat, 200, 202, 204, 206, 208, 210, 214
bluejoint reedgrass, 226
bluegrass
  big, 220
  Canada, 61, 162
  fowl, 222
  Kentucky, 157, 164
  Sandberg's, 48, 146
bromegrass
  fringed, 218
  hybrid, 166
  meadow, 168
  smooth, 170
Bromus
  ciliatus (see fringed bromegrass
  inermis (see smooth bromegrass
  inermis x riparius (see meadow bromegrass)
Bromus riparius
browse, 27, 260-261
burn
  piles, 30
  severity, 31, 59, 62, 65, 90
burning
  by sled, 66
  prescribed, 13, 61
Calamagrostis
  canadensis (see bluejoint reedgrass).
  rubescens (see pinegrass)
campsites, 69
Canada Seeds Act, 141-142, 145, 147-148
carbon/nitrogen ratio, 71
chaining, 28
cheatgrass, 46, 61, 90, 176, 180, 221, 241
chipping wood, 56
cicer milkvetch, 212
clearcut, 26, 30, 36
clover
  alsike, 39, 126, 130, 204
  red, 39, 130, 143, 153, 156, 206
  white, 39, 129, 208
community pastures, 23, 34-35, 41
converted land, 35, 39, 96, 120
cost-benefit analysis, 21, 36, 93, 96, 258
creamy peavine, 254
cultural objectives, 11, 20, 98
Dactylis glomerata (see orchardgrass)
Dahurian wildrye, 196
Dalmatian toadflax, 46, 180
Deschampsia cespitosa (see tufted hairgrass)
deer mice, 26
disc trenching, 28
discount rate, 260, 262
drag scarifier, 35
Dilling and Production Regulation, 19
Ecological Reserve Act, 18
ecosystem, 12
  restoration, 52-57
economic factors, 20
Elymus
  canadensis (see Canada wildrye)
  dahuricus (see Dahurian wildrye)
  glaucus (see blue wildrye)
  trachycaulis (see slender wheatgrass)
  wawawaensis (see bluebunch wheatgrass)
Elytrigia
  elongata (see tall wheatgrass)
endophytes, 172, 178, 184
erosion, 36, 86
  control, 59, 66, 96
feces, 39, 42, 221
fertilizer, 38, 45, 71, 86
fescue
  chewings red, 172
  creeping red, 174
  hard/sheep, 176
  Idaho, 234
  Rocky Mountain/alpine, 232
  rough, 236
  tall, 178
  western, 234

Festuca
arundinacea, (see tall fescue
brachyphylla (see Rocky Mountain/ alpine fescue)
campestris (see rough fescue)
idahoensis (see Idaho fescue)
occidentalis (see Idaho fescue)
ovina (see hard and Idaho fescue)
rubra (see red fescue)
rubra ssp. *fallax* (see Chewings red fescue)
saximontana (see Rocky Mountain/ alpine fescue)
trachyphylla (see hard fescue)
fire
guards, 55, 59
hazard reduction, 53
suppression, 52
First Nations, 44, 52
floating, 46, 123, 126, 260
forage
annual, 96
enhancement, 31, 94
perennial, 39, 62
production, 30, 34, 62
quantity, 63
replacement, 62
requirements, 36
stockpiling, 166, 170, 178, 210, 212
yields, 46
forest
canopy cover, 53
encroachment, 53
fire-maintained, 53, 56
floor, 69
land, 24
management, 24, 67, 69
regeneration, 26, 28, 31, 63
thinning, 55
Forest and Range Practices Act, 18, 28
genetic
sources, 49
purity, 150
variability, 49-50
germination, 36, 87, 117-120, 123-134, 141-142, 146-151
grassland(s), 20, 45-46, 60, 62
ecosystems, 47
rehabilitation, 44-45
restoration, 44, 50, 53
semi-arid, 46
grazing, 24
deferred (see stockpiling)
intensive, 38, 136, 261
management, 26, 35, 40, 46, 49
season extension, 184, 198, 202, 210, 212, 216, 218
hard/sheep fescue, 176
harrowing, 39, 119, 123, 134
hay, 18, 42, 96, 119, 124
herbicide
regulations, 40
control, 40-41
hybrid bromegrass, 166
invasive plant(s), 16, 20, 46-47, 64
control, 40
infestations, 42
suppression, 11, 24, 31, 33, 51, 59-60, 94
Junegrass, 230
Koeleria macrantha (see Junegrass)
land clearing, 35-36
landings, 24, 30-31
Lathyrus ochroleucus (see creamy peavine)
Leymus innovatus (see fuzzy-spiked wildrye)
litter, 37
livestock distribution, 28, 63
lolitrum B, 184
Lolium
multiflorum (see Italian ryegrass)
perenne (see perennial ryegrass)
Lotus corniculatus (see birdsfoot trefoil)
meadow bromegrass, 168
Medicago sativa (see alfalfa)
mineral soil, 29, 53
exposure, 28, 66, 88
native
cultivars, 49, 145, 148, 160
plant community, 216, 220, 222, 226, 228, 230, 232, 234, 236, 238, 240, 244, 246, 248, 252, 254, 256,
seed, 50, 54, 69, 136, 140, 148, 163
natural
drainage, 59
succession, 37, 46, 54, 59
net present valuation, 258
nitrogen, 26, 36, 38, 71, 96
nutrient(s) and dynamics, 71
oats, 39
Oil and Gas Activities Act, 18
Onobrychis viciifolia (see sainfoin)
orchardgrass, 39, 180
packer, 45, 126
Pascopyrum smithii (see western wheatgrass)
pasture, 34
condition, 36, 39
rejuvenation, 36, 40
persistence, 64, 97, 127, 161
Phalaris arundinacea (see reed canarygrass)
Phleum pratense (see timothy)
pinegrass, 54, 62-63, 228

pipeline(s), 49, 66-68
Poa
compressa (see Canada bluegrass)
pratensis (see Kentucky bluegrass)
secunda (see big bluegrass)
potential natural community (PNC) 11-13, 36-37, 46, 81, 83-84
precipitation, 59, 79, 81
protected areas, 64
Psathyrostachys juncea (see Russian wildrye)
Pseudoroegneria spicata (see bluebunch wheatgrass)
pure live seed (PLS), 130, 146, 149, 269-270
rangeland
drills, 46
seeder, 46
reclamation, 12
redtop, 186
reed canarygrass, 224
rehabilitation, 12, 44-47
post-wildfire, 48, 58, 61, 66, 85, 90, 96
wildfire, 59-60, 64
restoration, 12-13, 19-20, 46, 49
gene pool ranking concept, 50, 64
of grasslands, 44-47
revegetation, 12, 18, 64, 67, 80, 87
natural, 46, 60, 62, 69, 90, 93
Rhizobium
leguminosarum, 128
loti, 129, 202
trifolii, 269, 272
ripping, 28, 71
roads, 24, 31
rodents, 26
rolling, 119, 123, 271
ryegrass
Italian, 182
perennial, 184
sainfoin, 210
seed
coat, 39, 133, 140
contact with soil, 35, 88, 161
native, 49, 69
propagation, 49
warehousing, 80
seedbed, 36, 62, 71, 86
preparation, 46
seeding
broadcast, 36, 59, 61, 87, 122, 126, 133, 161
density of plants, 129, 269
density of seed, 271
direct, 39, 123
effectiveness, 61
fed through cattle, 39
over-seeding, 39
rate calculations, 269
rotations, 39
sod, 39
shrubs, 46
silviculture, 27, 31, 88, 98
plans, 29
silvopasture, 24, 28, 32-33, 36, 80, 83
site
disturbance, 24, 26, 28, 39, 41, 46-47, 49, 52, 60, 64, 80, 87, 90, 96, 119, 136
preparation, 28-31, 35-36, 68
Sinorhizobium meliloti, 129
skid trails, 24, 30-31
slash, 53, 55-56, 260-261
snow press, 26, 63, 98, 200
soil
compaction, 27, 68, 86
conditioning, 216
contact with seed, 39
disturbance, 28, 46-53, 67
fertility, 38, 117, 134
improvement, 24, 26, 34, 96, 200, 202, 204, 206, 208, 210, 214, 216, 254, 256
microbial populations, 46
structure and rehabilitation, 71, 96
species
adaptation, 13, 46, 80
diversity, 37
selection, 79-80, 83, 86, 93, 97
weedy, 42, 49, 60
woody, 26, 36, 40
species at risk, 53
succession, 11-12, 26, 36-37, 46-48, 54, 59, 62, 83, 117
tall fescue, 178
temporary work sites, 69
tillage, 36, 41, 45, 69, 123
timber harvest, 24, 28, 55, 66, 94
timothy, 39, 48, 61, 188
topsoil, 68-72, 86, 88, 92, 126
transplants, 46, 54
tree seedling, 25, 63
establishment, 26, 67, 96
trampling and mortality, 26
trenching, 27
tufted hairgrass, 238
utility
corridor(s), 47, 66-67
vegetation
assessment, 60, 69, 83, 86
control, 24, 46, 69, 96, 98
native, 26, 30, 36, 59
understory, 40, 54, 62-63, 83

vetch
American, 256
common, 214
hairy, 216
voles, 26
weed(s), 94, 128, 134, 136, 141
and grazing, 49
control, 19, 49, 117, 134
during establishment, 117, 119-120, 123, 127, 130
seeds, 141, 146-149
Weed Control Act, 19
well sites, 66-67
wheatgrass
bluebunch, 46, 48-50, 51, 240
crested, 45-46, 190
intermediate/pubescent, 192
slender, 244
tall, 194
western, 61, 246
wildfire, 58-66
Wildfire Act, 18, 59
wildrye
blue, 248
Canada, 250
Dahurian, 196
fuzzy-spiked 252
Russian, 198
windrows, 31
woody debris, 28, 61, 69, 123, 136



ISBN 978-0-7726-6643-7