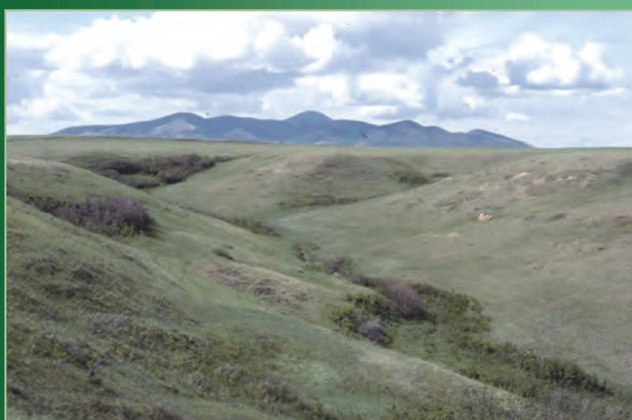
Recovery Strategies for Industrial Development in Native Prairie

for the

Mixedgrass



Sweetgrass Upland Ecodistrict

Natural Subregion of Alberta

Majorville Upland Ecodistrict
Natural Recovery

Cypress Upland Ecodistrict
Pipeline Construction

First Approximation

March 2014

Recovery Strategies for Industrial Development in Native Prairie

For The Mixedgrass Natural Subregion of Alberta

March 2014

First Approximation

Prepared for:

Range Resource Management Branch
Public Lands Division
Alberta Environment and Sustainable Resource Development

Petroleum Technology Alliance Canada

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In Association with:

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This manual is dedicated to the memory of Jennifer Richman, a valued colleague and collaborator, passionate about native prairie.

Cypress Upland Ecodistrict, Mixedgrass Natural Subregion

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Representatives from the Ranching Industry and the Reclamation Industry provided valuable input at two workshops. Review of the first draft was solicited from members of the Foothills Restoration Forum Technical Advisory Committee and others with experience in reclamation issues on native prairie including; Alberta Wilderness Association, Cheryl Bradley, Varge Craig, Ross Dahl, Peggy Desserud, Cathie Erichsen-Arychuk, Deb Everts, Simone Hagens, Kim Lutz, Susan McGillivray, Marshall McKenzie, David Novak, Ken Perl, Wilf Petherbridge, Jennifer Richman, and Dayle Soppet.

Thanks Team!

Marilyn Neville and Jane Lancaster

Preface

As the population and economy of Alberta expands, the extent and biodiversity of native prairie ecosystems is decreasing from the cumulative effects of agricultural conversion, energy development, transportation corridors and urban settlement. The Mixedgrass Natural Subregion of Alberta is rich in petroleum resources with a large and diverse development infrastructure in native prairie. Recently, development for wind energy is also taking place, resulting in extensive, long-term infrastructure in native prairie. The cumulative effects of multiple industries and fragmentation by many linear projects are degrading the overall health of native grasslands and their resilience to disturbance. Disturbance promotes the establishment of invasive species and reduces the ability of these ecosystems to recover.

As the demand for development has increased, so has public pressure to reduce the impact of industrial disturbance and the cumulative effects of multiple activities on native prairie ecosystems. The South Saskatchewan Regional Plan (Government of Alberta 2013) identifies the retention of biodiversity and healthy ecosystems as a key goal, including to:

- develop a regional biodiversity management framework;
- conserve critical habitats for species at risk;
- avoid, minimize or mitigate the conversion of native grasslands on public lands;
- apply integrated land management to minimize native vegetation loss; and
- coordinate land-use activities to reduce fragmentation by roads, access and facilities.

Effective recovery strategies are necessary to retain and maintain ecosystem biodiversity, health and resilience. A cumulative effects approach to land management will encourage restoration of existing footprint and minimize new footprint.

This manual has been developed for planners, land managers, land owners, reclamation practitioners and regulatory authorities to identify suitable strategies to minimize further impacts to Mixedgrass ecosystems. Construction, reclamation and restoration methods have evolved over time. Long-term monitoring data has been collected to assess the effectiveness of a number of practices. This document provides learnings from recent academic research, and from these field studies identifies strategies designed to provide the best chance at promoting successful retention and restoration of Mixedgrass ecosystems.

Reclamation practices following industrial disturbance in native prairie landscapes have been steadily evolving since the early 1980s. Over time the focus of reclamation practices in native prairie has shifted from controlling soil erosion and establishing sustainable grass cover to development planning with pre-disturbance assessment and implementation procedures designed to facilitate the restoration of ecosystem structure, health and function.

This need for a shift in focus from reclamation to restoration was acknowledged in the 2010 Reclamation Criteria for Wellsites and Associated Facilities in Native Grasslands (Alberta Environment 2011). The recovery strategies presented here have been developed to support the intent of the 2010 Criteria for Grasslands and to provide guidance for reclamation practitioners, contractors, landowners and Government of Alberta regulatory authorities. The strategies are not intended to be prescriptive, but rather strive to present options and pathways to enable selection of the most appropriate recovery strategy for the type of industrial disturbance on a site specific basis. Their purpose is to provide the expectations of what is required to reach the outcome of restoration over time.

The strategies build on existing guidelines and information sources such as *Restoring Canada's Native Prairies, A Practical Manual* (Morgan et al. 1995), *A Guide to Using Native Plants on Disturbed Lands* (Sinton Gerling et al. 1996), *Native Plant Revegetation Guidelines for Alberta* (Native Plant Working Group 2000), *Prairie Oil and Gas, A Lighter Footprint* (Sinton 2001) and *Establishing Native Plant Communities* (Smreciu et al. 2003). While these guides continue to be excellent information sources, this manual incorporates new knowledge sources and technical innovations that have been developed since 2003. The upstream oil and gas industry has made major changes to the way wellsites and associated infrastructures are developed in native prairie. Minimal disturbance best management practices are now the norm in native prairie. Realizing the reclamation challenges faced for development in native prairie and the benefits gained from minimizing the footprint of disturbance, other industries are modifying their construction practices.

This manual is presented as a first approximation recognizing that revision will be required as our knowledge of native prairie plant communities and their response to industrial disturbance increases. Revision will also be required as reclamation practitioners use this approximation and industry responds to the challenges of native plant community restoration with new technology designed to reduce the industrial footprint in native prairie landscapes.

The Natural Regions and Subregions of Alberta (Natural Regions Committee 2006) ecological classification and mapping assists practitioners with understanding the Natural Subregion context of restoration opportunities and limitations. The development of the Grassland Vegetation Inventory, Range Plant Community Guides and Range Health Assessment protocol by the Alberta Environment and Sustainable Resource Development (ESRD) Range Resource Management Program (RRMP) has greatly increased our understanding of native grassland ecosystems. These tools link native plant communities to soils and site characteristics and facilitate a more complete understanding of the ability of native plant communities to respond and adapt to natural disturbance regimes such as fire, grazing, drought, and insect predation. These tools are now being applied to assess and manage man-made disturbances. They are incorporated into pre-disturbance site assessment, development planning and reclamation certification for native grasslands, creating the need for an additional tool which provides guidance on appropriate recovery strategies for each Natural Subregion.

June Grass

The ongoing Recovery Strategies for Industrial Development in Native Prairie Project will eventually address all Natural Subregions within the Grassland Natural Region. Projects are underway through the partnership established between Alberta Environment and Sustainable Resource Development (ESRD) and Petroleum Technology Alliance Canada (PTAC) to capture the key experience and learnings that have accumulated over the past 10 to 20 year period since minimum disturbance practice was first established.

The Mixedgrass Natural Subregion is unique in the challenges it presents to restoring disturbance from industrial development. Much of the Mixedgrass native prairie has been lost to cultivation and fragmented by industrial activity and roads. The soils and climate of the Mixedgrass promote the spread of invasive non-native plants where soil disturbance has occurred. A restoration risk analysis is a critical step in assessing restoration strategies prior to and after disturbance. Minimal disturbance construction procedures, and natural recovery or assisted natural recovery where appropriate, are the most effective strategies for restoring native plant communities in the Mixedgrass. Alternate strategies for large disturbances not suited to natural recovery as well as severely degraded sites are defined and discussed in the context of new restoration tools and recent publications.

Cypress Upland Ecodistrict, Mixedgrass Natural Subregion

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Cypress Upland Ecodistrict - Pipeline Construction, Jane Lancaster, Kestrel Research Inc.

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Prairie Forbs, Cypress Upland Ecodistrict, Gaillardia, Crew Photo, June Grass, and Cypress Upland Ecodistrict, Jane Lancaster, Kestrel Research Inc.

1-A Shift in Focus to Restoration

Avoid Sensitive Landscape Features and Habitat, Image Courtesy Marilyn Neville, Gramineae Services Ltd.

Cumulative Effects: Cultivation, Road Ditch with Invasive Species, Cabin, Wellsite & Gravel Pit on Native Grassland, Jane Lancaster, Kestrel Research Inc.

2-Overview of the Mixedgrass Natural Subregion

Healthy Native Grassland, Transmission Lines, Cultivation and Wind Energy, Jane Lancaster, Kestrel Research Inc.

4-Promoting Native Plant Community Succession

Early Disturbance of Native Prairie, Steve Demkiw, Alberta Environment

Newly Broken Prairie, Jane Lancaster, Kestrel Research Inc.

Steam plough near Leavings, Alberta ca.1906 Glenbow Archives NA303-63

Stirling Lateral Branch, Alberta July 1904 Glenbow Archives PD-310-126

Early Pipeline Construction Glenbow Archives NA-711-27

Brome Invasion, Early Seral, Mid-Seral and Late Seral Community Examples, Cypress, Jane Lancaster, Kestrel Research Inc.

5-Preparing the Pathway

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Reduced Disturbance through Site Selection, Jamie Piccin, Dynamic Outlook Consulting

Two Strip Graveled Surface, Kevin Redden, Medicine Hat

Land Man Image and Mixedgrass Natural Subregion, Marilyn Neville, Gramineae Services Ltd.

6-Selecting the Recovery Strategy

Natural Recovery, Assisted Natural Recovery Reduced Disturbance Wellsite, Trained Operators, Temporary Access Using Interlocking Matting and Majorville Upland, Marilyn Neville, Gramineae Services Ltd.

Minimal Disturbance Wellsite, Annual Weeds Colonizing Exposed Topsoil and Wheat Grass Cover Crop, Jane Lancaster, Kestrel Research Inc.

Native Hay Cutting, Native Hay Crimped, Sweetgrass Upland, Trace Associates

Nursery Propagated Fescue Plugs, Donna Watt, CorPirate Services

Lentic Wetland and Lotic Wetland, Jane Lancaster, Kestrel Research Inc.

7-Implementing the Strategy

Selaginella in Sod Replacement on Ditchline; A Roughened Surface Retains Moisture, Marilyn Neville, Gramineae Services Ltd.

Kinsella Accu-Roller, Drill Seeding Equipment and Hydroseeding, Roger Didychuk, I.W. Kuhn Construction Ltd.

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Wild Harvest of Native Grass Seed, Donna Watt, CorPirate Services

Alternating Rows; Separating Seeds; Drying Seeds; Bagged and Ready for Storage, Marilyn Neville, Gramineae Services Ltd.

Wild Hay Harvester; mows and collects Native Hay; Wild Harvested Hay Spread on Pipeline RoW; Minimal Disturbance to Ground Cover, Ron Johnson, Prairie View Consulting

8-Maintaining the Pathway

Lentic Wetland, Jane Lancaster, Kestrel Research Inc.

Lodged Native Grass Cultivars Seeded on Remote Sump and Brome Invasion, Marilyn Neville, Gramineae Services Ltd.

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9-The Importance of Long Term Monitoring

Reclamation and Monitoring Research, Image Courtesy of Peggy Desserud

10-Future Research Required

Needle-and-thread Grass, Gaillardia and Crew Photo, Jane Lancaster, Kestrel Research Inc.

Abbreviations

ACIMS……Alberta Conservation Information Management System

ACIS……AgroClimatic Information Service

AER……Alberta Energy Regulator

AGRASID……Agricultural Region of Alberta Soil Information Database

cm……centimetre

EAP……Enhanced Approval Process

EBIPM……Ecologically Based Invasive Plant Management

EPP……Environmental Protection Plan

ERCB……Energy Resources Conservation Board

ESRD……Alberta Environment and Sustainable Resource Development

ESRRA……Ecological Site Restoration Risk Analysis

Express……Express Pipeline

FRF……Foothills Restoration Forum

FWMIS……Fish and Wildlife Management Information System

g……gram

GVI……Grassland Vegetation Inventory

ha……hectare

IL……Information Letter

IMP……Integrated Management Plan

kg……kilogram

km……kilometre

LAT……Landscape Analysis Tool

m……metre

MG……Mixedgrass Natural Subregion

MGPCG……Mixedgrass Range Plant Community Guide

NSR……Natural Subregion

NGO……non-government organizations

PLS……Pure Live Seed

PNC……Potential Natural Community

PNT……Protective Notation

PTAC……Petroleum Technology Alliance Canada

RPC……Reference Plant Community

SCA……Soil Correlation Area

1 A Shift in Focus to Restoration

Why is ecological restoration so important for supporting the cause of preserving native grassland ecosystems? To date much of the original native grasslands in the Mixedgrass Natural Subregion have been lost to cultivation. As such, it is critical to stress that these otherwise vibrant ecosystems are subject to ongoing risk from an increasingly large industrial footprint. The amount of industrial activity taking place in native grasslands has expanded dramatically since the early 1990s. If what remains of the native prairies is to be conserved for future generations, then it is critical to continue to improve reclamation practices and recovery strategies in native prairie landscapes. The focus must shift from reclamation to restoration.

There is an increasing public awareness of the remaining native grassland ecosystems and the ecological goods and services they provide for Albertans. The purpose of this document is to provide reclamation practitioners, landowners, land managers and regulatory authorities with a suite of recovery strategies for industrial disturbances in native grasslands. Developing effective recovery strategies is necessary to mitigate cumulative effects to native prairie by retaining and maintaining ecosystem biodiversity, health and resilience. A cumulative effects approach to land management will encourage restoration of existing footprint and minimize new footprint.

Avoid Sensitive Landscape Features and Habitat

Reclamation and Restoration Concepts

Ecological restoration is defined as "*the process of assisting the recovery of an ecosystem that has been degraded, damaged or destroyed*" (Society for Ecological Restoration 2004). While restoration cannot return an ecosystem to its exact original state, it can restore it to a similar historical trajectory, the general direction it may have as a result of natural causes.

Reclamation can have various outcomes and includes "revegetation, stabilization of the terrain, assurance of public safety, aesthetic improvement, and usually a return of the land to what, within the regional context, is considered to be a useful purpose" (Society for Ecological Restoration 2004). Returning land to a useful purpose may or may not be a return to its original state. For example, revegetation of a native grassland disturbance to a forage crop may result in a useful purpose, but no resemblance to native grassland.

Recovery is the redevelopment of structure, function and species composition and diversity which sets the disturbed site on a successional pathway towards the pre-disturbance plant community.

Interim reclamation is the application of mitigation to conserve soils and propagules until such time as the site is permanently abandoned and reclaimed. An important consideration of interim reclamation is to do no damage to the surrounding undisturbed plant communities, for example by allowing invasive plants to establish on exposed soils. Interim measures must also consider the eventual goal of restoration. For instance, seeding exposed soils to undesirable agronomic species will be difficult to correct later.

Linkage to the 2010 Reclamation Criteria

The recovery strategies documents are designed to dovetail with the *2010 Reclamation Criteria for Wellsites and Associated Facilities for Native Grasslands* (Alberta Environment 2011) by providing a pathway for decision making focused on choosing and implementing the recovery strategy that will restore ecological health, function and operability to the disturbed site. In the 2010 Grassland Criteria, there is emphasis on native grassland plant communities as indicators of equivalent land capability. Equivalent Land Capability is defined in the 2010 Criteria "*as the condition in which ecosystem processes are functioning in a manner that will support the production of goods and services consistent in quality and quantity as present prior to disturbance*". The bar has been raised and now we must meet the challenge.

Restoring ecological health, ecosystem function and land operability

Trajectory and Timing

In practice, activities undertaken to promote the eventual restoration of a disturbance are reclamation activities. For reclamation to be considered successful and meet the 2010 Reclamation Criteria, there must be evidence of a positive trajectory towards restoration. The timing for actual restoration of a healthy, functioning plant community that supports species typical of the biodiversity of the area may take many years. Studies indicate it may take 10 to 20 years to redevelop healthy late seral plant communities (and groundcover components like moss, lichen and selaginella may need 25+ years to re-establish) (Lancaster et al. 2012). Waiting 10-20 years to be assured that restoration is occurring is not practical. Therefore confidence must be established that a recovering site is on a positive trajectory at the time of reclamation certification, with the expectation that recovery will continue unassisted towards restoration over time. On non-challenging, well maintained sites, reclamation certification should be possible in about 5 years. However, on sites where there are protective notations (PNT) for rough fescue, reclamation certification could take much longer (e.g. 10+ years). Use of the Landscape Analysis Tool (LAT) to avoid native prairie and site project disturbances in more resilient plant communities can significantly reduce restoration challenges and the time required to achieve reclamation certification.

Reducing Cumulative Effects

The most important factors in reducing the cumulative effects of industrial disturbance in native prairie landscapes include:

- avoidance of native prairie through pre-development planning;
- where avoidance is not possible, reducing the footprint of impact to prairie soils and native plant communities through pre-disturbance site assessment;
- implementing the best available technology, construction practices and equipment to reduce the disturbance to soils and native plant communities; and
- understanding the important role timing plays in the outcome of development activities in native prairie and the timeline required to achieve restoration.

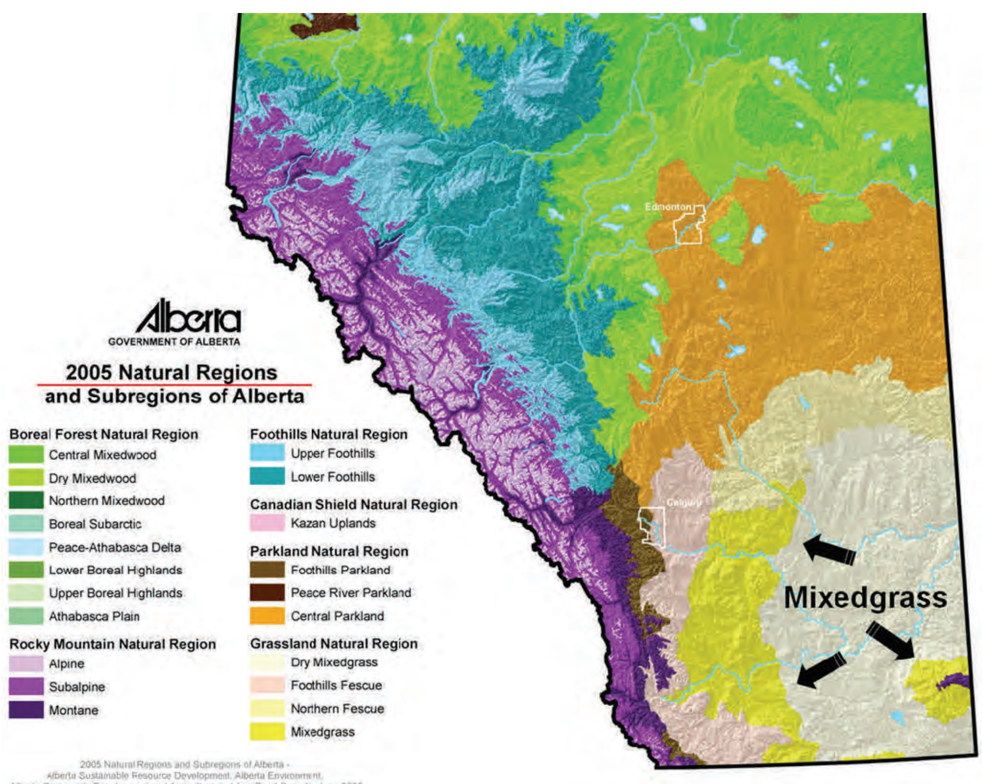
Cumulative Effects: Cultivation, Road Ditch with Invasive Species, Cabin, Wellsite and Gravel Pit on Native Grassland

2 OVERVIEW OF THE MIXEDGRASS NATURAL SUBREGION

The first step in restoration planning requires an understanding of Alberta's regional ecological land classification system. The Natural Regions and Subregions of Alberta provide the provincial ecological context within which resource management activities have been planned and implemented since the 1970s. The current revision entitled "*Natural Regions and Subregions of Alberta*" (Natural Regions Committee 2006) builds on two previous classifications: *Ecoregions of Alberta* (Strong and Leggat 1992) and *Natural Regions and Subregions and Natural History Themes of Alberta* (Achuff 1994). Copies of the current revision are available at: http://www.tpr.alberta.ca/parks/heritageinfocentre/docs/NRSRcomplete%20May_06.pdf

It is important to understand the ecological diversity of the Grassland Natural Region and the unique restoration challenges offered in each Natural Subregion. The Natural Subregion dichotomy is the first level of ecological classification in Alberta and assists practitioners with the understanding of restoration opportunities and limitations within the Subregion context. This publication focuses on the Mixedgrass Natural Subregion.

Figure 1 - Natural Subregions of Alberta



Physiography, Climate, Soils and Vegetation of the Mixedgrass Natural Subregion

The Mixedgrass Natural Subregion (Mixedgrass) occurs in five geographic areas extending north from the United States border to the Red Deer River (Figure 1, Figure 3). The largest area occurs on the plains to the east of the Foothills Fescue Natural Subregion and to the west of the Dry Mixedgrass Natural Subregion. This plain borders the Northern Fescue Natural Subregion to the north. This area includes the Lethbridge Plain, the Vulcan Plain, the Blackfoot Plain and the Standard Plain ecodistricts[1]. Smaller areas of Mixedgrass occur in four highland ecodistricts. The Majorville Upland occurs east of and adjacent to the plains to the north of the Lethbridge Plain. The Cypress Upland surrounds the Cypress Hills Escarpment and Plateau. The Sweetgrass Upland occurs as a band along the lower slopes of the Sweetgrass Hills along the United States border, and the Milk River Upland occurs along the eastern portion of the Milk River Ridge (Adams et al. 2013, McNeil 2004). It is important to understand the differences between the ecodistricts that occur in the Mixedgrass (Figures 4 through 8). Topography, elevation, soils and climate have played a major role in the development of sustainable native plant communities unique to each ecodistrict.

Healthy Native Rangeland

[1]Ecodistricts are based on distinct physiographic and/or geologic patterns. They are distinguished by similar patterns of relief, geology, geomorphology and genesis of parent material.

The Mixedgrass accounts for 19.8% of the Grassland Natural Region Area and 2.9% of the area of Alberta (ASIC 2001). The soils of the Mixedgrass are very productive. Hence, since settlement, the prairie has been highly fragmented by cultivation. Approximately 31% of the original 4.6 million acres of Mixedgrass prairie remain today (Adams et al. 2013). The plains are mostly cultivated with scattered remnant prairies. More extensive native rangelands occur at higher elevations on the slopes of the Cypress Hills, and the Sweetgrass, Milk River and Majorville Upland Ecodistricts (Natural Regions Committee 2006).

The boundaries of the Mixedgrass correspond closely to the boundaries of the Agricultural Regions of Alberta Soil Information Database (AGRASID) Soil Correlation Areas (SCAs) 2 and 3 (ASCI 2001). The plains portion of the Mixedgrass, including the Majorville Upland, is correlated with SCA3, while the Cypress Hills, and the Sweetgrass and Milk River Uplands are in SCA2 (Adams et al. 2013).

Strong, warm, westerly winds are a significant factor influencing restoration potential once the native prairie vegetation has been removed

The Mixedgrass is dominated by Dark Brown Chernozemic soils. Parent materials are dominantly glacial till with lesser occurrences of glacio-lacustrine, glacial-fluvial and eolian parent materials. Topography in the plains ecodistricts is dominantly undulating to hummocky. Topography in the highland ecodistricts is hummocky to inclined (Adams et al. 2013).

Winter thawing of frozen soils presents challenges for operating heavy equipment on native prairie vegetation

The climate of the Mixedgrass is characterized by short summers with warm days and cool nights. Mean summer temperatures are about 15^{o}C and mean annual temperature is about 5^{o}C (Adams et al. 2005). The Mixedgrass has slightly moister and somewhat cooler summers and milder winters than the Dry Mixedgrass Natural Subregion to the east. Climatic data and comparisons with the surrounding Natural Subregions can be found in the Mixedgrass Range Plant Community Guide (Adams et al. 2013). Even cooler and moister conditions prevail at higher elevations in the Mixedgrass highland ecodistricts. The milder winters, particularly in the western portion of the Mixedgrass, are due to the influence of Chinook winds. These strong, warm, westerly winds are a significant factor influencing restoration potential once the native prairie vegetation has been removed. Winter thawing of frozen soils presents challenges for operating heavy equipment on native prairie vegetation. The potential for soil loss due to wind erosion is a significant factor that must be considered in development planning. The fertile Dark Brown Chernozemic soils, combined with adequate average annual precipitation, provides the opportunity for non-native plants to invade and colonize disturbed soils, especially in areas fragmented by cultivation.

The potential for soil loss due to wind erosion is a significant factor that must be considered in development planning

The native grassland plant communities of the Mixedgrass are strongly influenced by regional factors. In the Mixedgrass, elevated regional landforms rising above broad plains, combined with soils and climatic factors related to differences in elevation, produce unique and varied native grassland plant communities. The plains ecodistricts of the Mixedgrass (Lethbridge, Vulcan, Blackfoot and Standard Plains) support native plant communities similar to the Dry Mixedgrass, typically dominated by needle-and-thread grass (*Stipa comata*), blue grama grass (*Bouteloua gracilis*), and northern wheat grass (*Agropyron dasystachyum*). In the Majorville Upland, western porcupine grass (*Stipa curtiseta*) replaces needle-and-thread grass as the dominant species. The lower slopes of the Cypress Hills Upland are dominated by June grass (*Koeleria macrantha*), northern and western wheat grass (*Agropyron smithii*), and needle-and-thread grass. Higher elevations are dominated by plains rough fescue (*Festuca hallii*), western porcupine grass, and sedge (Carex species). The Milk River Upland and the slopes of the Sweetgrass Upland are dominated by northern wheat grass, June grass, sedge communities and Idaho fescue (*Festuca idahoensis*), northern wheat grass, sedge communities. It is important to note that plains rough fescue plant communities can also occur in the transition areas between the Mixedgrass and the Northern Fescue Natural Subregion to the north, and the Foothills Fescue Natural Subregion to the west. Plains rough fescue and foothills rough fescue (*Festuca campestris*) plant communities should be avoided as they are very difficult to restore. A more detailed description of the Mixedgrass is provided in the Mixedgrass Range Plant Community Guide (Adams et al. 2013). The most current approximation can be found on the Alberta Environment and Sustainable Resource Development (ESRD) website at:
http://srd.alberta.ca/LandsForests/GrazingRangeManagement/documents/Mixedgrass-RangePlantCommunityGuide-Apr2013.pdf

Plains rough fescue and foothills rough fescue plant communities should be avoided as they are very difficult to restore

Types of Industrial Activity

There are numerous types of industrial activities operating in the native grassland ecosystems of the Mixedgrass. Currently, oil and gas production and the associated infrastructure is an important industry within the Mixedgrass. Exploration and development has occurred on both private and public lands, and on cultivation as well as native prairie. Several large diameter pipeline corridors cross extensive tracts of Mixedgrass native grassland. Coal is strip-mined to generate electricity and gravel is extracted to construct and maintain transportation corridors. Agriculture is the dominant land use. Large tracts of land are under cultivation for both dry land and irrigated crop production. The ranching industry continues to utilize native grasslands for livestock production.

Recently the quest to develop renewable forms of energy has resulted in development of wind farms and upgrading of electrical transmission corridors in the Mixedgrass. The cumulative effects of industrial activity in the Mixedgrass are significant, and the long-term impact of surface soil disturbance on the ecological integrity of these grasslands is not well understood.

The cumulative effects of industrial activity in the Mixedgrass are significant

Managing Surface Disturbance

The importance of managing surface disturbance and maintaining the integrity of native plant communities during industrial development in native prairie has been formally recognized since 1992. The following information letters, principles and guidelines have been developed by collaborative stakeholder working groups for the Alberta Energy Regulator (AER).

IL 92-12 (ERCB IL92-12) (Rescinded and replaced by ERCB IL2002-1)

This information letter informed industry that agronomic grasses such as crested wheat grass could not be used in reclamation seed mixes in native prairie.

IL 96-9 Revised Guidelines for Minimizing Disturbance in Native Prairie (ERCB IL 96-9); and

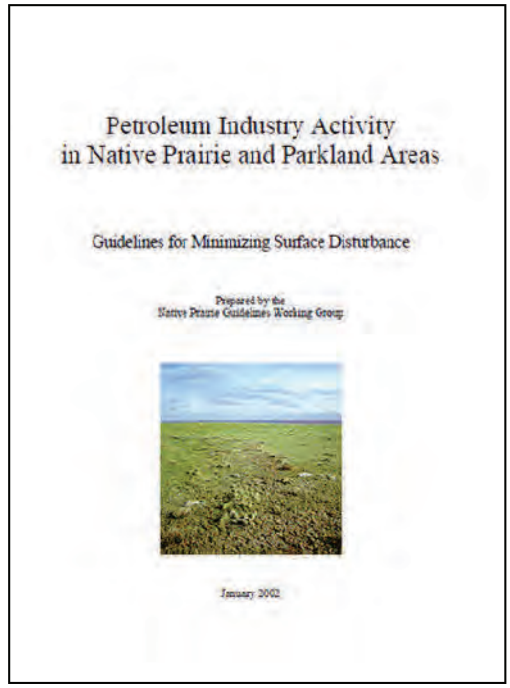
IL 2002-1 Principles for Minimizing Surface Disturbance in Native Prairie and Parkland Areas (ERCB IL 2002-1)

These information letters informed industry of the importance of native prairie and parkland areas and the need to minimize surface disturbance through all phases of development activities when undertaking development in these areas. IL 2002-1 recognizes the importance of the Parkland Natural Region and is available online at: http://www.aer.ca/document/ils/pdf/il2002-01.pdf

Petroleum Industry Activity in Native Prairie and Parkland Areas, Guidelines for Minimizing Surface Disturbance (Native Prairie Guidelines Working Group 2002)

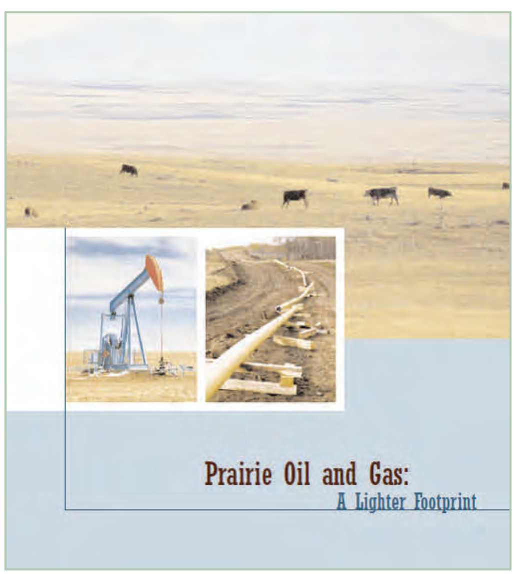
This document was prepared by a working group comprised of representatives from government agencies having jurisdiction over petroleum industry activities in native prairie and parkland areas. It provides specific direction for all phases of petroleum development activity including seismic and geophysical programs. Key general guidelines include:

- avoidance of native prairie and parkland landscapes if at all possible;
- the use of previously disturbed areas such as existing access roads and prairie trails;
- indicates the requirement for special planning measures, field based environmental assessments, minimal disturbance construction techniques and the use of native plant materials or natural recovery during site reclamation; and
- the importance of weed control is emphasized and environmental monitoring is recommended.



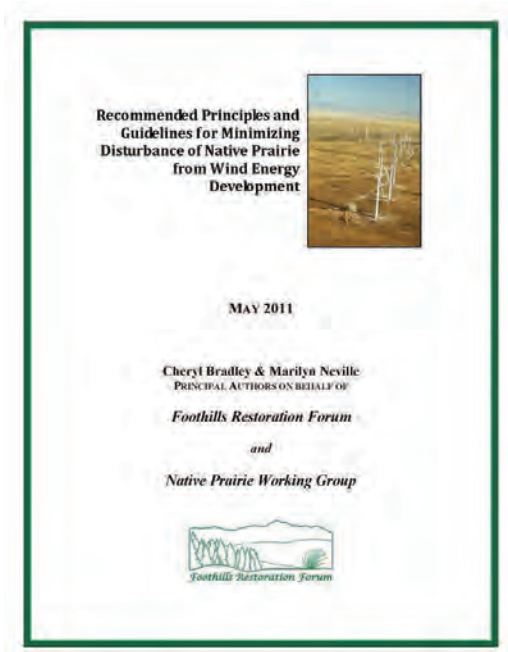
Prairie Oil and Gas: A Lighter Footprint (Sinton 2001)

This booklet provides information, photos and illustrations about best development practices to reduce the impacts of oil and gas activities on prairie and parkland landscapes. It focuses on a "cradle to the grave" approach that ensures care taken during one phase of development is not undone at another stage. The document is available in pdf format at: http://environment.gov.ab.ca/info/library/7150.pdf



Recommended Principles and Guidelines for Wind Energy Development in Native Prairie (Foothills Restoration Forum Technical Advisory Committee 2011)

This document proposes recommended principles and guidelines for wind energy developments similar to the principles and guidelines developed by the petroleum industry. The document was developed by a multi-stakeholder working group co-ordinated by the Foothills Restoration Forum and is available at: http://www.foothillsrestorationforum.ca/



Recommended Principles and Guidelines for Minimizing Disturbance of Native Prairie from Wind Energy Development

MAY 2011

Cheryl Bradley & Marilyn Neville
PRINCIPAL AUTHORS ON BEHALF OF

Foothills Restoration Forum

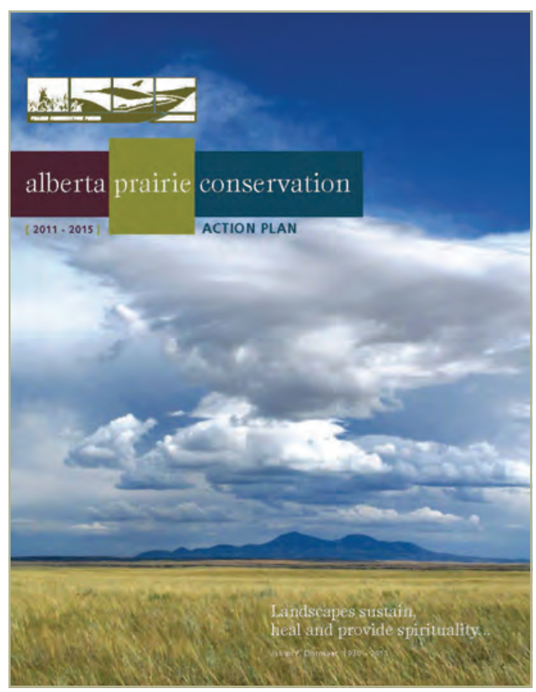
and

Native Prairie Working Group

Alberta Prairie Conservation Forum Action Plan 2011 to 2015

The vision embedded in the 2011 to 2015 Action Plan is to ensure the biological diversity of Alberta's prairie and parkland ecosystems is secure through the thoughtful and committed stewardship of all Albertans. To achieve the vision, three important long term outcomes are the focus of the PCF Action Plan.

- Maintain large prairie and parkland landscapes.
- Conserve connecting corridors for biodiversity.
- Protect isolated native habitats.



To reduce the footprint and the cumulative effects of industrial development in the prairie landscape these three important outcomes must be considered early in any development planning process. The 2011 Action Plan and valuable further information on the importance of prairie conservation is found on the Alberta Prairie Conservation Website at: http://www.albertapcf.org/

3 Tools for the Restoration Toolbox

Implementing improved recovery strategies involves not just practice change on the ground but also utilizing many new tools designed to understand site characteristics and plant communities linked to landforms and soils (Figure 2). These tools, described below, will improve project planning, reclamation best practices and restoration potential at all stages of development from pre-development planning through long-term monitoring to evaluating reclamation and restoration success. The timing of their use in developing a site -specific recovery strategy is described in Section 5: Preparing the Pathway.

Figure 2 - Standardized Grassland Assessment Tools

Plant Community Guide

GVI Site Types Defined on Landscape

Example of GVI Site Type Mapping

Range Health Assessment Workbook

Grassland Vegetation Inventory

The Grassland Vegetation Inventory (GVI) is the Government of Alberta's first comprehensive biophysical, vegetation and anthropogenic inventory of the Grassland Natural Region. Developed by ESRD, the GVI provides mapped information of landscape scale soil/landform features and vegetation cover for use in planning and management of rangelands, fish and wildlife, wetlands, land use and reclamation. It also includes a coarse hydrological feature layer. GVI is comprised of ecological range sites based on landform, soils and vegetation information for areas of native vegetation and general land use for non-native areas (agricultural, industrial, and urban areas). Tables correlating soils and ecological range sites can be found in the Mixedgrass Range Plant Community Guide (Adams et al. 2013).

A user manual entitled "*Grassland Vegetation Inventory (GVI) Specifications Data 5th Edition*" (Alberta Sustainable Resource Development and LandWise Inc. 2011) is available on the web at:

http://www.albertapcf.org/rsu_docs/grassland-vegetation-inventory-specifications-5th-edition--june-29-2010-revised---november-9-2011.pdf

GVI data is available either by contacting the Resource Information Management Branch Data Distribution (within ESRD) or obtaining website information from:

http://www.srd.alberta.ca/MapsPhotosPublications/Maps/ResourceDataProductCatalogue/ForestVegetationInventories.aspx and http://www.albertapcf.org/

Additional site-specific resources for soils mapping information are the Agriculture Region of Alberta Soil Information Database Version 3.0 (AGRASID) on-line database (ASIC 2001) and regional soils maps.

Figure 3 - Mixedgrass Natural Subregion Vegetation Inventory

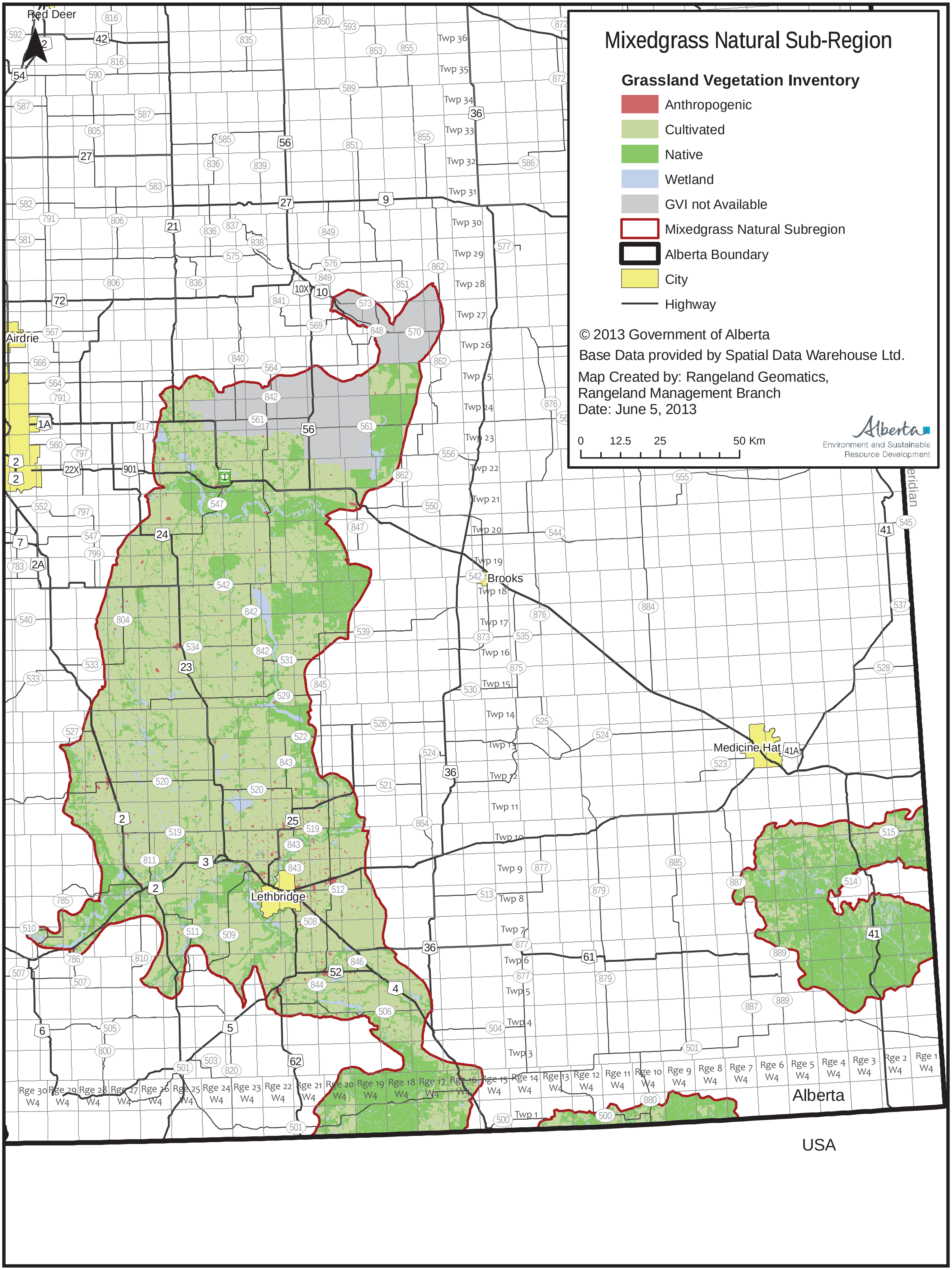


Figure 4 - Lethbridge and Vulcan Plains Ecodistricts Grassland Vegetation Inventory

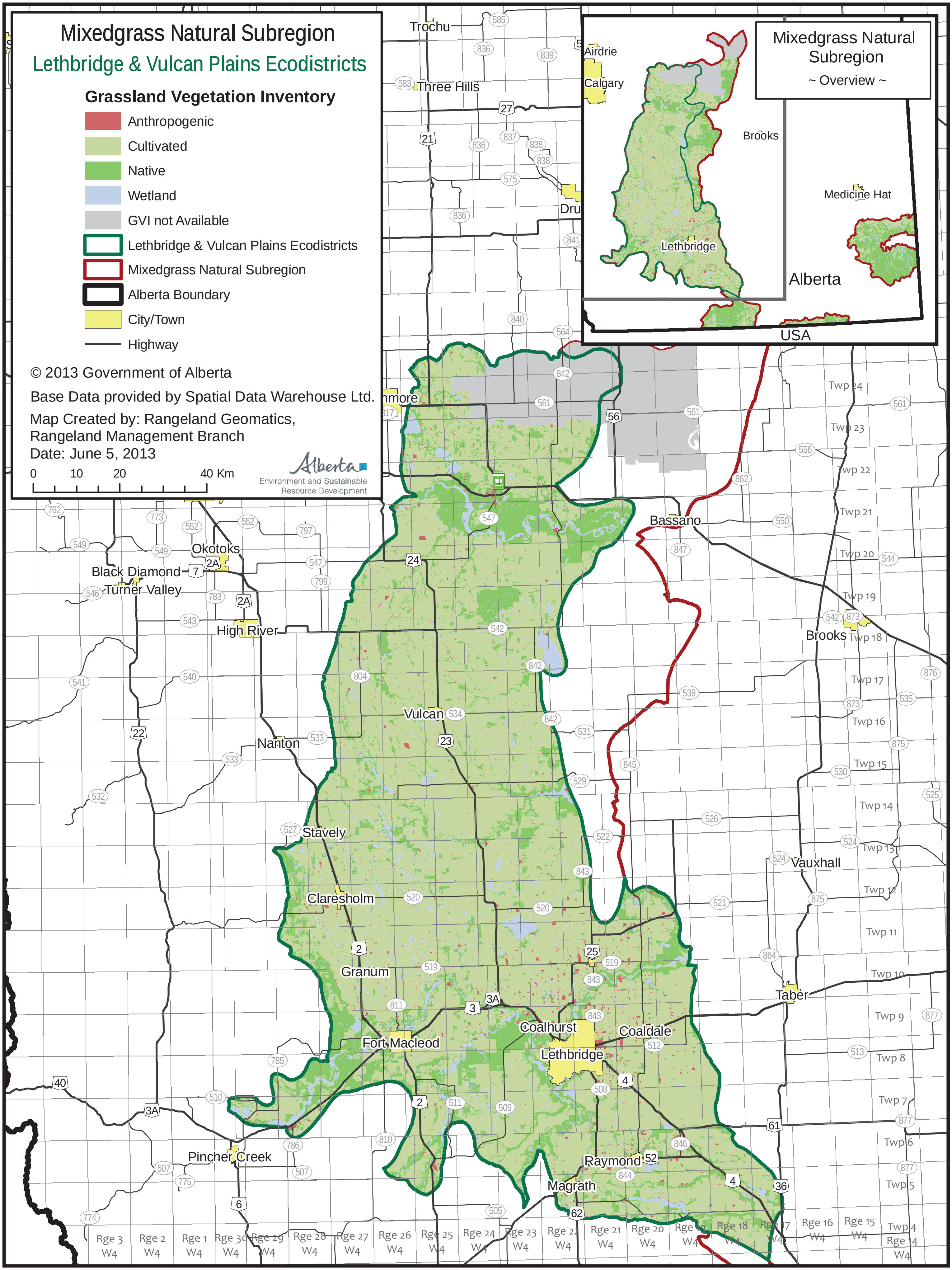


Figure 5 - Majorville Upland Ecodistrict Grassland Vegetation Inventory

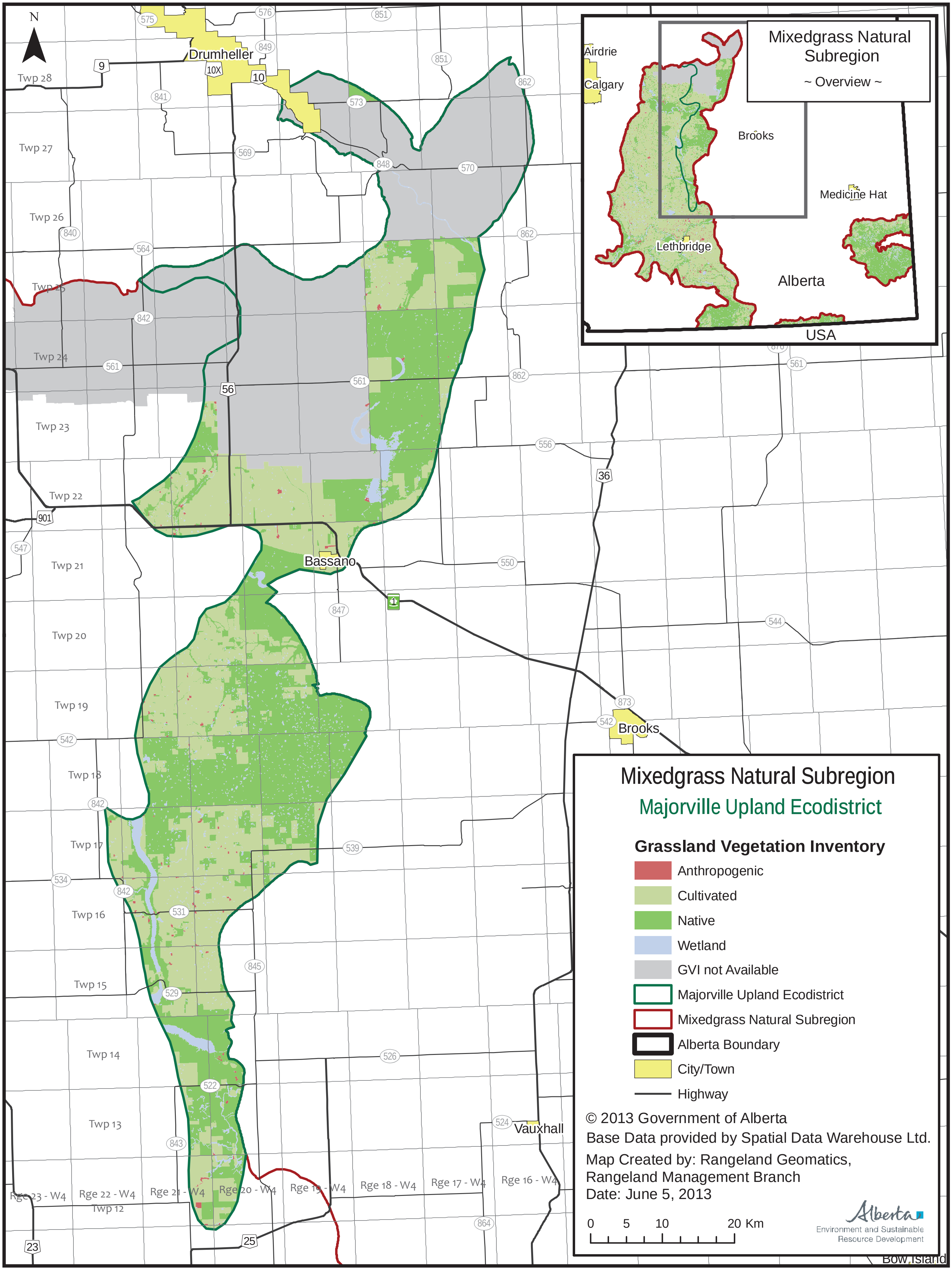


Figure 6 - Cypress Hills Upland Ecodistrict Grassland Vegetation Inventory

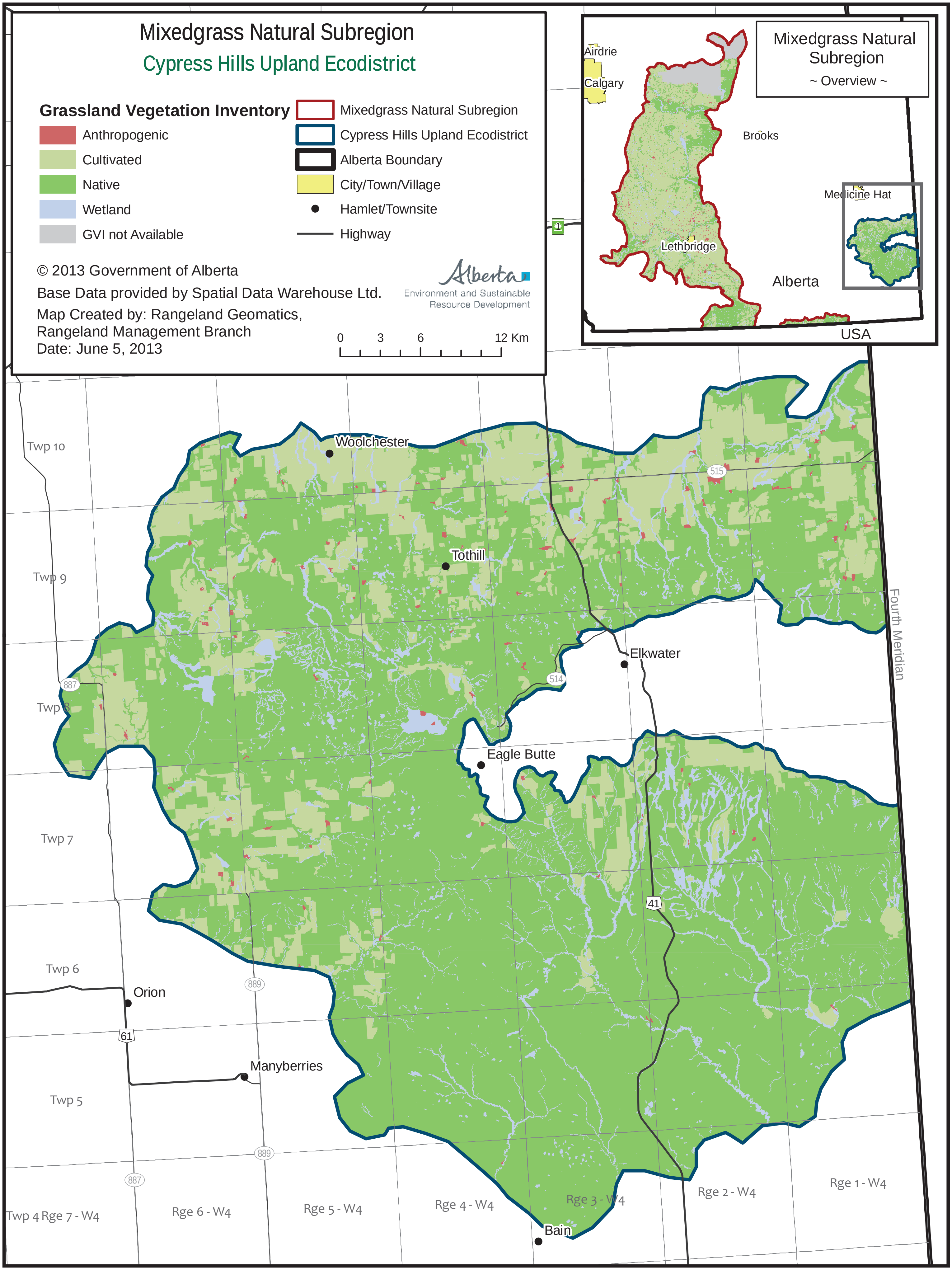


Figure 7 - Sweetgrass Upland Ecodistrict Grassland Vegetation Inventory

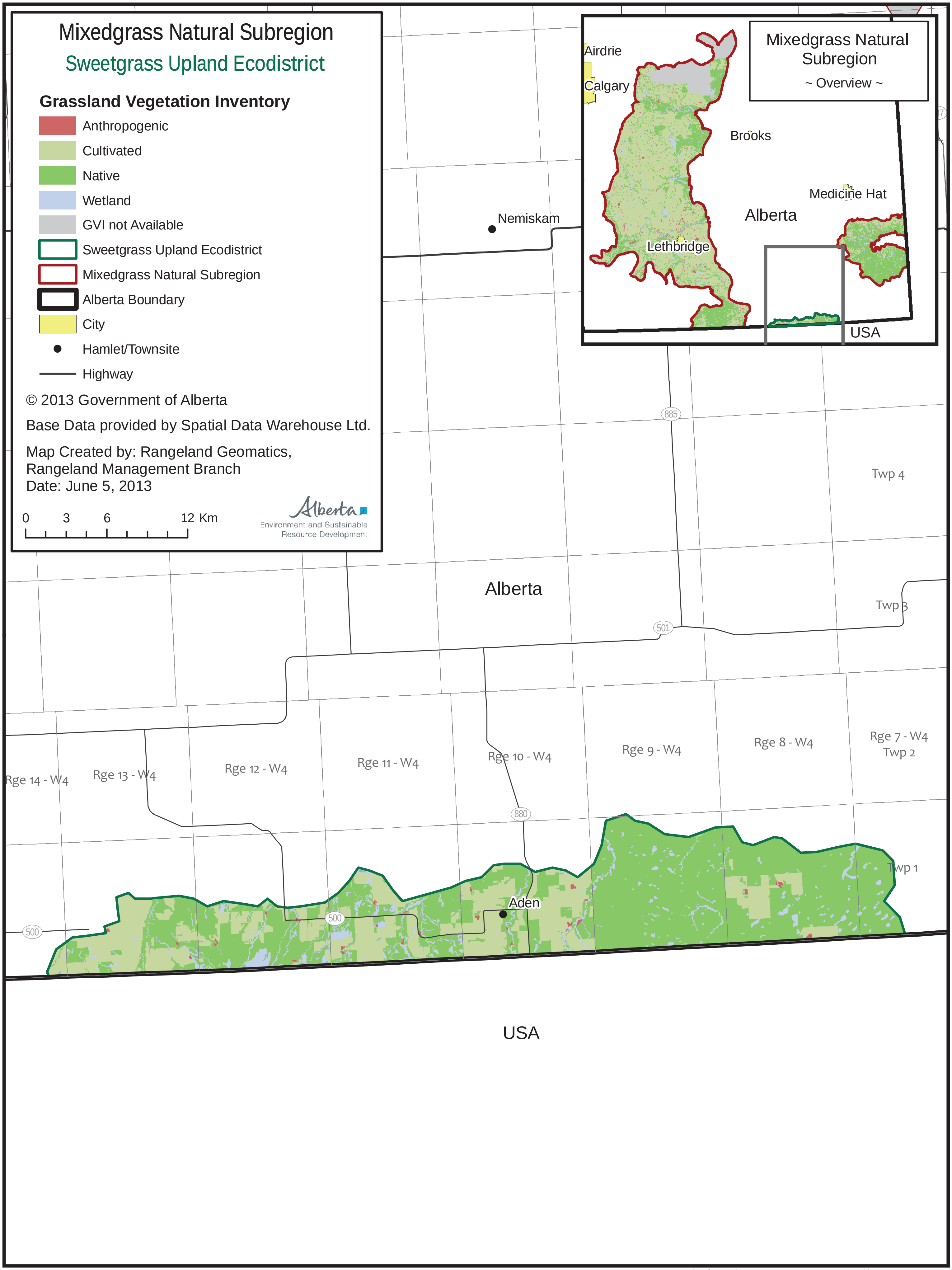
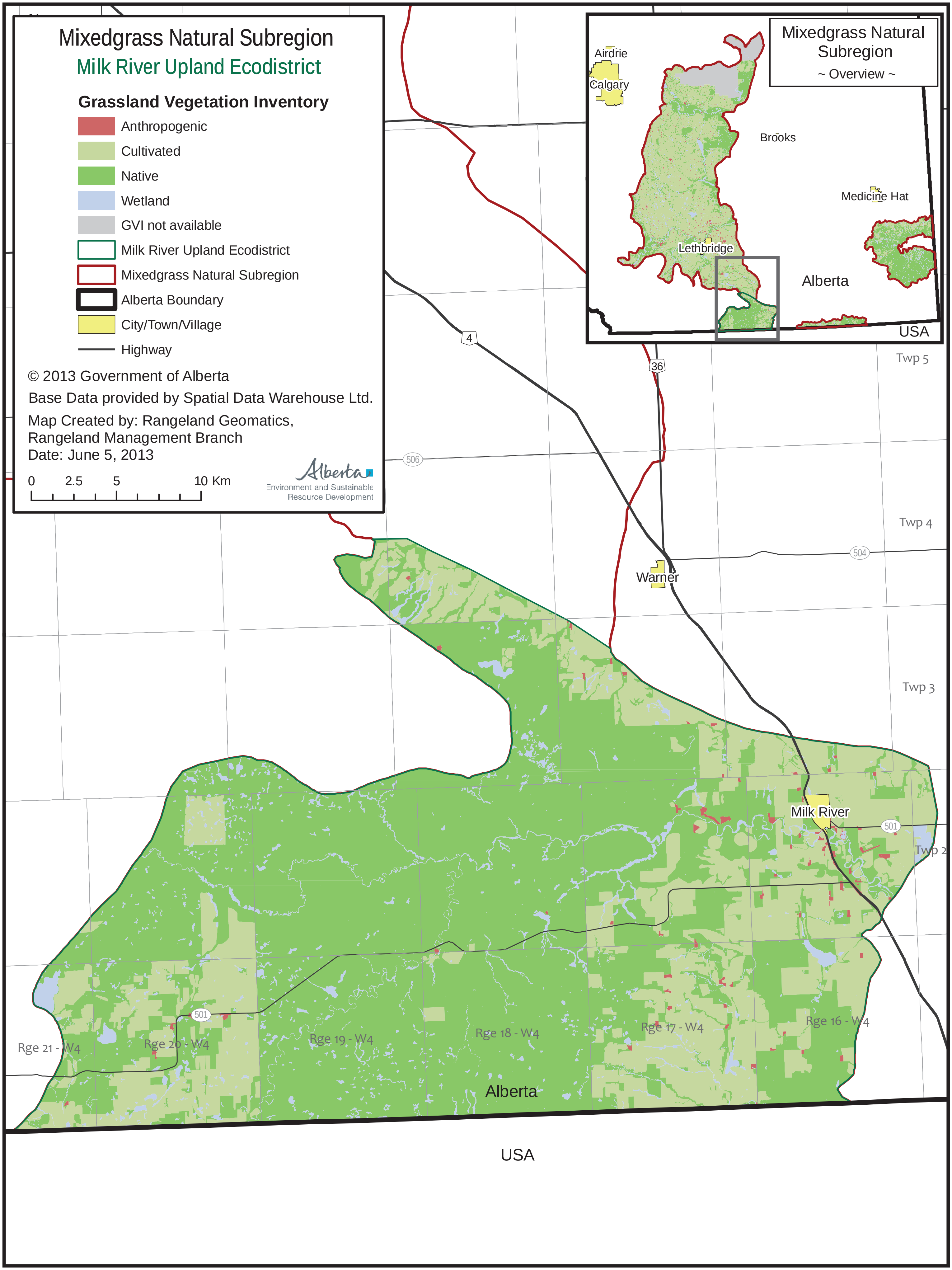
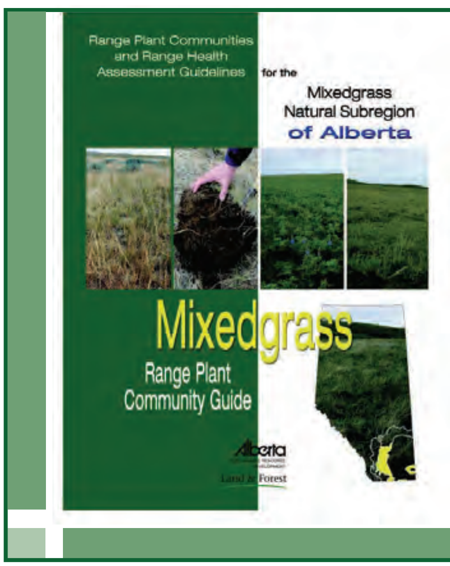


Figure 8 - Milk River Upland Ecodistrict Grassland Vegetation Inventory



Range Plant Community Guides

The Mixedgrass Range Plant Community Guide is an essential reference for identifying common plant communities and conducting range health assessments in the Mixedgrass Natural Subregion of Alberta. The guide provides descriptions of common plant communities linked to ecological range site and ecodistrict. Ecological range site is identified in the GVI mapping product. Range plant communities are reported in three categories including reference, successional and modified communities depending on the level of grazing disturbance. The plant community that is an expression of site potential is referred to as the reference plant community (RPC) since it represents the natural community that develops without disturbance or stress. This potential community is described as healthy for comparison in range health assessment. The plant community guides have been compiled from data collected from detailed vegetation inventories and the extensive system of reference areas established across the province by the ESRD Range Resource Management Program. The guides are available on the ESRD website and are updated on a regular basis as new data is gathered which can be linked to the GVI mapping.



2ND APPROXIMATION AVAILABLE AT:

http://srd.alberta.ca/LandsForests/GrazingRangeManagement/documents/Mixedgrass-RangePlantCommunityGuide-Apr2013.pdf

Navigating the Mixedgrass Range Plant Community Guide

The Mixedgrass Range Plant Community Guide (MGPCG) contains vital information to determine which ecodistrict your project is located in and common range plant communities found in each ecodistrict. Key steps to finding information for your project area are:

1. Identify the ecodistrict the project area is located in (MGPCG Figure: Ecodistricts in the Mixedgrass NSR).

2. Identify the major soil series and associated ecological range sites found in the ecodistrict (MGPCG Table: Major Soils and their Associated Ecological Range Sites by Ecodistrict). The ecological range site will be mapped at a landscape scale in the GVI data layer (this needs to be ground truthed). The soil series and the ecological range site will help determine which range plant communities may be found in the project area.

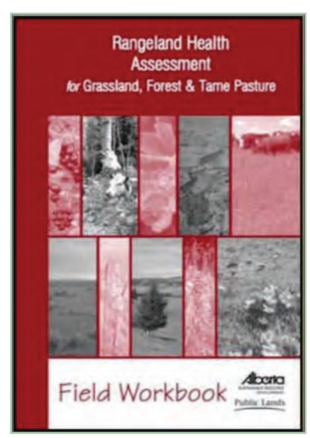
3. Then find MGPCG Table: Ecological Range Sites and Reference Plant Communities in the Mixedgrass Natural Subregion), which links ecodistricts with ecological range site and reference plant communities (or the potential native plant community under light disturbance).

4. Check MGPCG Tables to identify successional and modified communities associated with the reference plant communities. This will show the suite of range pant communities potentially present in the project area under different grazing pressure.

5. Once you are standing on the site, read through the descriptions of the range plant communities identified in MGPCG Tables.

6. Understanding the ecological range site and range plant communities within a proposed project site is vital to conducting an ecological risk assessment for project planning.

Range Health Assessment



The Range Health Assessment protocol and the Range Health Assessment Field Workbook developed by the ESRD – RRMP have been used to assess, monitor and manage Alberta's rangeland since 2003. The field workbook is available on the web at:

http://www.srd.alberta.ca/LandsForests/GrazingRangeManagement/documents/RangelandHealthAssessmentforGrasslandForestTamePasture-Revised-Apr2009.pdf

The assessment approach builds on the traditional range condition concept that considers plant community type in relation to site potential, but adds new and important indicators of natural processes and functions. The methodology provides a visual system that allows users to readily see changes in range health and to provide early warning when management changes are needed. Understanding range health is an important component of a restoration risk assessment. In the context of reclamation after disturbance, it is a measure of ecosystem recovery.

Range health is defined as the ability of rangeland to perform certain key functions. These functions include: net primary production, maintenance of soil/site stability, capture and beneficial release of water, nutrient and energy cycling, and functional diversity of plant species. Workbook Table 1 (reproduced below) from the Range Health Field Workbook describes the functions of healthy rangelands and why they are important.

Table 1 – Functions of Healthy Rangelands

Rangeland Functions	***Why Is the Function Important?***
Productivity	• Healthy range plant communities are very efficient in utilizing available energy and water resources in the production of maximum biomass • Forage production for livestock and wildlife • Consumable products for all life forms (e.g. insects, decomposers etc.)
Site Stability	• Maintain the potential productivity of rangelands • Protect soils that have taken centuries to develop • Supports stable long-term biomass production
Capture and Beneficial Release of Water	• Storage, retention and slow release of water • More moisture available for plant growth and other organisms • Less runoff and potential for soil erosion • More stable ecosystem during drought
Nutrient Cycling	• Conservation and recycling of nutrients available for plant growth • Rangelands are thrifty systems not requiring the input of fertilizer
Plant Species Diversity	• Maintains a diversity of grasses, forbs, shrubs and trees • Supports high quality forage plants for livestock and wildlife • Maintains biodiversity, the complex web of life

The range health assessment questions detailed in the field workbook are indirect measures of the following indicators:

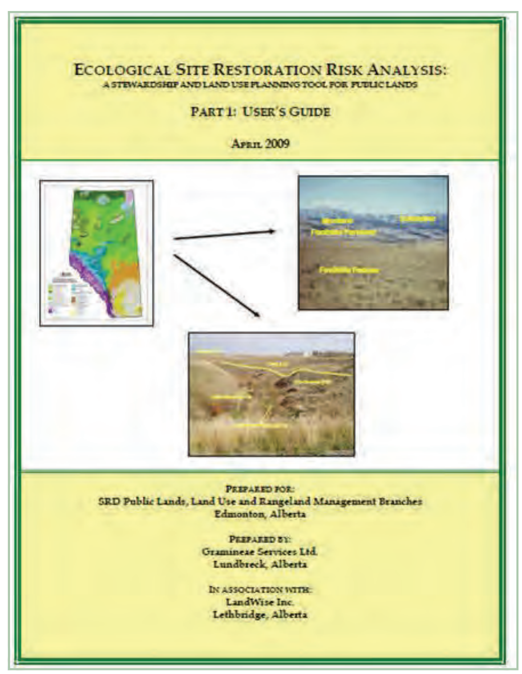
1. ***Integrity and Ecological Status*** – on native or modified grassland, based on species composition
2. ***Community Structure*** – vertical and horizontal
3. ***Hydrologic Function and Nutrient Cycling*** – litter cover and distribution
4. ***Site Stability*** – erosion, bare soil, moss and lichen cover
5. ***Noxious Weeds***

An evaluation of each indicator using the methods and scoring system detailed in the field workbook indicates whether these important ecological functions are being performed. A range health score is calculated as a percentage value, classified into one of three categories; unhealthy (0% to 49%), healthy with problems (50% to 74%) and healthy (75% to 100%).

Range health assessment is an important tool for monitoring the management of the multiple use activities taking place on grasslands. The use of a common assessment method for all man-made impacts on grasslands could facilitate more accurate cumulative effects assessment and lead to further improved land management and communication in the future. Range health assessment is an important component of the 2010 Reclamation Criteria for Grasslands and annual training programs for reclamation practitioners are being offered through the Foothills Restoration Forum. Reclamation Criteria training is also supported annually by the Alberta Institute of Agrologists.

Ecological Site Restoration Risk Analysis

The Ecological Site Restoration Risk Analysis (ESRRA) is a pathway for determining the ability of the components of an ecological range site to recover from the direct impact of industrial activity. This involves an understanding of the characteristics of the site, soils, landscape type, moisture regime and associated plant community. The ESRRA report, prepared by ESRD –RRMP in consultation with ESRD Rangeland Agrologists and Land Use Specialists can be found in the information portal on the Foothills Restoration Forum website at http://ww.foothillsrestorationforum.ca/


ECOLOGICAL SITE RESTORATION RISK ANALYSIS:
A STEWARDSHIP AND LAND USE PLANNING TOOL FOR PUBLIC LANDS

PART 1: USER'S GUIDE

APRIL 2009

PREPARED FOR:
SRD Public Lands, Land Use and Rangeland Management Branches
Edmonton, Alberta

PREPARED BY:
Gramineae Services Ltd.
Lundbreck, Alberta

IN ASSOCIATION WITH:
LandWise Inc.
Lethbridge, Alberta

Restoration Risk will Affect the Potential Restoration Outcome

In the Mixedgrass Natural Subregion the following factors affect restoration potential:

Ecosystem Restoration Challenges are Linked to Climate

1. Climatic processes such as available moisture and temperature during the critical periods of germination and emergence. In the Mixedgrass, elevation plays an important role in seasonal precipitation accumulation and mean temperature. Cooler and moister growing conditions prevail in the upland ecodistricts compared to the lower elevation plains.

2. The resistance the site can afford to non-native plant invasion. Non-native plants of concern include Prohibited Noxious and Noxious Weeds listed under the Alberta Weed Control Act and aggressive agronomic plants such as smooth brome (*Bromus inermis*), crested wheat grass (*Agropyron cristatum, A. sibiricum*), Kentucky bluegrass (*Poa pratensis*), sheep fescue (*Festuca ovina*) and sweet clover (*Melilotus spp*.). Aggressive non-native grass species such as downy brome (*Bromus tectorum*) and Japanese brome (*Bromus japonicus*) are of particular concern in the Sweetgrass and Milk River Uplands due to their adaptation to semi-arid conditions and disturbed soils.
   Within the Grassland Natural Region the potential for non-native plant invasion on disturbed upland soils decreases as soil fertility, topsoil depths and soil moisture decreases. For example, the Black Loamy soils of the Foothills Fescue Natural Subregion are much more prone to non-native plant invasion than the drier climatic conditions and Dark Brown soils of the Mixedgrass Natural Subregion. The same characteristics of soils, landscape type, moisture regime and associated plant community can be applied to assess vulnerability at the ecological range site level. For example within the Mixedgrass, Overflow ecological range sites are more prone to non-native plant invasion than Sands or Blowout range sites. In general, restoration may be more successful in drier ecosystems, e.g. Mixedgrass or Dry Mixedgrass Subregions, than in moist ecosystems such as Foothills Fescue or Central Parkland Subregions. Similarly, moister ecological range sites, e.g. Overflow or Sub-irrigated sites may create more challenges for restoration.

3. The total area of the development footprint, the amount of development related soil disturbance and the extent that the native plant communities are fragmented within the footprint are interrelated factors which affect restoration potential.

4. The potential for accelerated soil erosion beyond what would normally occur under undisturbed conditions varies according to the soil and landscape characteristics of the ecological range site. Factors include soil texture, landscape position, slope and the amount of bare soil present in the reference plant community.

5. Some ecological range sites are more adapted to soil disturbance than others. For example, wind erosion is a physical process inherent to the reference plant communities of Choppy Sand Hills ecological range sites. Coarse textured soils, significant amounts of bare soil and plants uniquely adapted to colonizing the bare soil are essential factors which maintain the habitat for many species of concern or at risk. Natural recovery facilitates the ecological recovery processes. Seeding can deter these processes and alter the plant community composition.

6. Adjacent land use also affects restoration potential. Remnant native prairie areas in highly fragmented landscapes are of particular concern. Close proximity to transportation corridors or tame pasture seeded to invasive non-native agronomic plants such as crested wheat grass, Kentucky bluegrass, smooth brome, sheep fescue or sweet clover can limit restoration potential. Industrial disturbances that are invaded by weeds and non-native invasive plants can also limit restoration potential and require complex recovery strategies.

7. The range health of the rangeland plant communities surrounding the disturbance plays an important role in restoration potential.

8. The grazing intensity both long-term and present on pastures affected by industrial development must be factored into the restoration potential.

Factors which indicate site sensitivity to development impacts and restoration potential should be used in the ecological risk analysis to determine:

- **if avoidance is the best strategy; or**
- **the most appropriate mitigation to reduce the impact of development through minimal disturbance and best management practices designed to reach the expected outcome of restoration over time.**

4 Promoting Native Plant Community Succession

Reflecting on Past History

Prior to the European settlement of the Canadian prairies, a number of key ecosystem processes shaped the native prairie landscape (Bradley and Wallis 1996). Chief among these were recurring drought, grazing and fire. These naturally occurring ecosystem processes were in balance, each providing a specific function that maintained a cycle of adaptation and renewal within the system over time.

Early Disturbance of Native Prairie

Human development activity since the early 1900's has resulted in increased levels of surface soil disturbance due to cultivation for agricultural crop production. Cultivation was not a feature of the natural system.

Following the extensive cultivation and abandonment of prairie landscapes, Canadian plant ecologist Robert Coupland observed recovery of native plant communities in approximately 20 years depending on the size of the cultivated area, distance to the supply of native seed stock, the degree of aridity of the years following, and duration of tillage (Coupland 1961). However, the recovery of the groundcover structural layer composed of moss and lichen in the Dry Mixedgrass and Mixedgrass appears to take much longer. Large areas of south eastern Alberta, especially in the Special Areas, have recovered to native grasslands, having once been abandoned cultivation during the dustbowl conditions of the 1920s and 1930s.

Newly Broken Prairie

Periods of Reclamation History

The history of reclamation in the grasslands of Alberta can be divided into four periods:

Pre- 1972

There was little in the way of policy and regulation. Soil handling was not defined and most disturbances were allowed to recover naturally.

Steam Plough Near Leavings, Alberta ca.1906

Stirling Lateral Branch, Alberta July 1904

Early Pipeline Construction

Influence of Manmade Disturbance

1972 to 1985

Early reclamation practices were developed, the emphasis was placed on soil conservation and seeding with agronomic grasses such as crested wheat grass and smooth brome to provide reliable vegetative cover to prevent soil erosion.

Invasion of Smooth Brome along a Seeded Pipeline

1985 to 1993

During this period reclamation practices focused on improving soil handling and erosion control. To facilitate precision in soil handling procedures, the area of surface soil disturbance required for projects drastically increased. This led to increased loss and fragmentation of native plant communities and increased the risk of aggressive non-native plant invasion. Use of agronomic species such as crested wheat grass was not permitted in Special Areas jurisdictions, a practice that later was adopted throughout the province in native grasslands.

1993 to the Present

During this period, the importance of the native grassland plant communities' role in ecological function has been recognized. The focus of reclaiming industrial disturbances has shifted towards minimizing the footprint of industrial disturbance and where that is not possible, revegetating disturbed soils with native plant cultivars[2]. However, there are issues associated with the use of native plant cultivars. Some cultivars are more robust in stature than the same species exhibits in the wild, resulting in altered plant community structure. The genetic source of many cultivars originates in climates and ecosystems far from Alberta's Grassland Natural Region. Some cultivars delay the process of succession because they display a competitive advantage over the wild species and are very persistent in the stand.

[2] A cultivar is a plant variety which has undergone genetic restriction through selection by plant breeders, and which has been registered by a certifying agency. Cultivars for several native grasses are available in Canada and have been widely used in the reclamation industry. Examples include: Walsh western wheat grass (*Agropyron trachycaulum*), Elbee northern wheat grass (*Agropyron dasystachyum*), and Lodorm green needle grass (*Stipa viridula*).

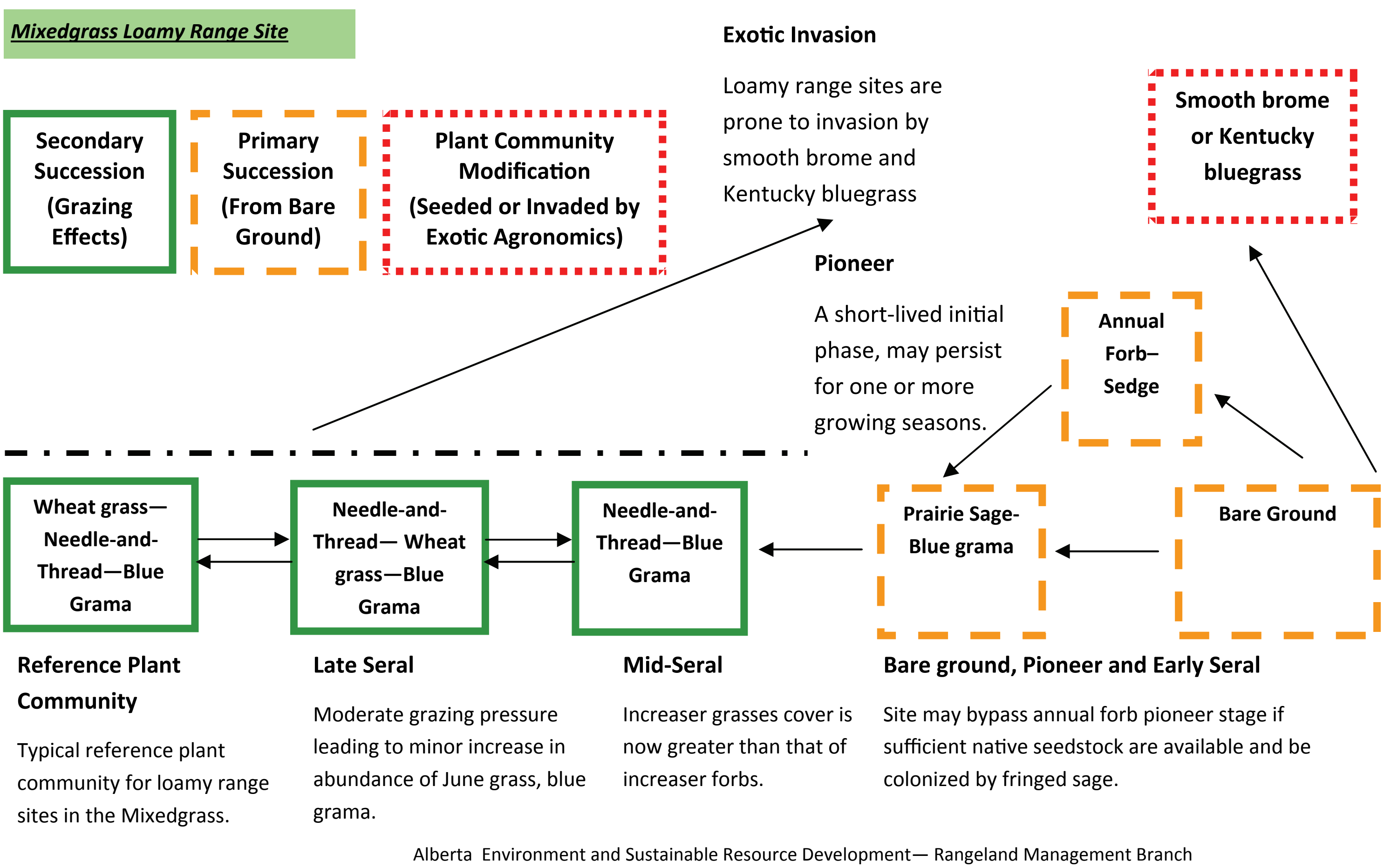
Understanding the Process of Succession

Native plant communities are not static, but rather constantly adapting to changes in the local environment over time. The 2010 Grassland Reclamation Criteria recognizes the importance of change over time. This process is referred to as succession. The Range Health Assessment Field Workbook (Adams et al. 2009) provides an overview of the process of succession. The workbook provides "Some Important Ecological Concepts". These concepts include:

- **Plant communities** are mixtures of plant species that interact with one another.
- **Succession** is the gradual replacement of one plant community by another over time.
- **Successional pathways** describe the predictable pathway of change in the plant community as it is subjected to different types and levels of disturbance over time.
- **Primary Succession** is the process of plant community development from bare soil, starting with pioneer species then progressing through the seral stages listed below.
- **Secondary Succession** is the process of plant community development after an established plant community is subject to additional disturbances like fire and grazing. The level of disturbance does not eliminate vegetation cover.
- **Seral stages** are each step along a successional pathway.
- Seral stages begin at the pioneer stage of **early seral** and progress upward in succession to **mid-seral**, then **late seral** and finally **potential natural community (PNC)** which is used as the "reference" for comparison.
- **Reference plant community (RPC)** is the term used for the potential natural plant community.
- An **ecological site** is a distinct kind of land with specific physical characteristics that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation.
- **Ecological status** is the degree of similarity between the present plant community and the reference plant community. Plant communities are **modified** when the disturbance has altered them to non-native species (like smooth brome, timothy (*Phleum pratense*) or Kentucky bluegrass) with a relative composition of greater than 70% non-native species. Note: The relatively high threshold composition of 70% non-native to define a modified community was selected as our general scientific knowledge of plant community recovery is still quite limited and further study is necessary to better establish a hard tipping point towards a permanent shift of the plant community to a non-native state.

Figure 9 is an example of a successional pathway diagram that serves to capture our understanding of how plant communities respond to disturbance based on current knowledge. The **green boxes** highlight the portion of grassland succession that we currently know the most about, namely secondary succession and the effects that light, moderate and heavy grazing have on native plant communities. The **brown boxes** illustrate the area of current and future research emphasis to better understand the pathway of primary succession of plant communities from bare soil. The **red boxes** illustrate dramatic changes that may occur when invasive species subvert the path of recovery. The **arrows** illustrate trajectories that may or may not be reversible. We know much less about the dimensions of plant succession from disturbed topsoil and so have reduced confidence in predicting outcomes. Nonetheless, this successional tool provides a foundation for capturing and sharing key learnings and for using this knowledge to improve our development practices.

Figure 9 – Successional Pathways and Seral Stages



It is important to note that the pioneer, early and mid-seral stages in Figure 9 can contain non-targeted species that still function for erosion control and moisture retention such as Russian thistle or fringed sage. They stabilize the soils and help facilitate the process of succession over time.

Establishing a Positive Trajectory Following Disturbance

The challenge for restoration following disturbance is to establish a positive successional trend towards the plant communities present on site prior to disturbance. The process typically takes many years (e.g. 10-20 years for rough fescue communities). The goal is to recognize a trajectory towards recovery (and negative trajectories) with confidence that recovery will continue unassisted towards restoration over time.

The challenge for restoration following disturbance is to establish a positive successional trend towards the plant communities present on site prior to disturbance

The current paradigm of only two or three years being required to achieve a reclamation certificate is not long enough to recognize a trajectory towards restoration of native grasslands. The actual trajectory toward climax plant communities as found in adjacent, non-disturbed areas will not be immediately evident in the 2 year period nominally used to assess (re)vegetation success.

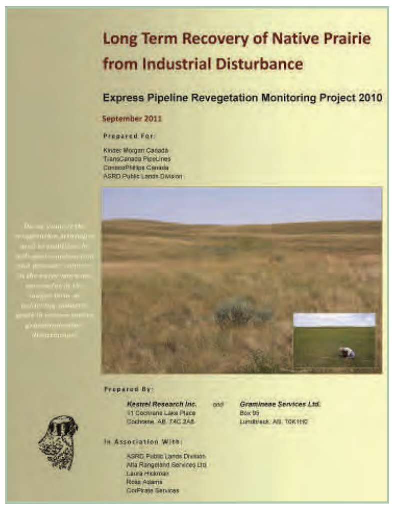
Expectations for the level of responsibility and the timeframe required to ensure sites are recovering is increasing. On non-challenging, well maintained sites in the Mixedgrass Natural Subregion, reclamation certification should be possible in about 5 years. However, on sites where there are invasive species issues, poor range health or protective notations (PNT) for rough fescue, reclamation certification could take much longer (e.g. 10+ years) and ongoing adaptive management during operations may be required.

Expectations for the level of responsibility and the timeframe required to ensure sites are recovering is increasing

The timeframe required for the process of succession to take place may not be recognized by land owners and reclamation practitioners. Industry needs to recognize their ongoing responsibility to ensuring restoration of their disturbances on native grassland. Patience is required to reach the restoration outcome.

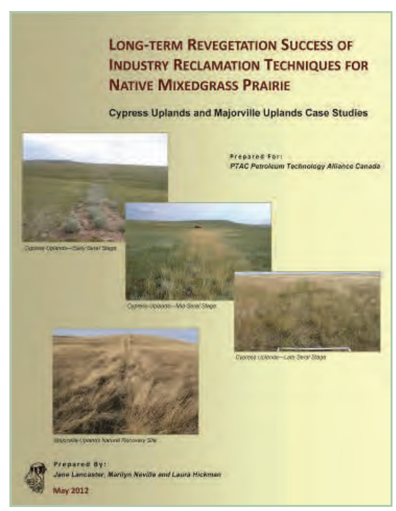
Industrial Disturbance and the Process of Plant Community Succession

Understanding successional stages for recovering plant communities is critical to having confidence that recovery is occurring on disturbed sites. Long-term monitoring data has been collected from several reclamation projects in the Mixedgrass. These studies are relevant to the Mixedgrass and to the understanding of succession after disturbance.



"Long-term Recovery of Native Prairie from Industrial Disturbance, Express Pipeline Revegetation Monitoring Project 2010" (Kestrel Research Inc. and Gramineae Services Ltd. 2011)

"Long-term Revegetation Success of Industry Reclamation Techniques for Native Mixedgrass Prairie" (Lancaster et al. 2012)



The complete reports are posted in the Information Portal on the Foothills Restoration Forum website at http://www.foothillsrestorationforum.ca

The definition of successional stages for a series of recovering plant communities on disturbed topsoil following pipeline construction was a key learning from the Express Pipeline case study data (Table 2). Pipeline construction practices included topsoil stripping, grading and trenching. Examples of plant community succession following topsoil disturbance in the Mixedgrass NSR are illustrated in both case studies documents: *Long-term Recovery of Native Prairie from Industrial Disturbance, Express Pipeline Revegetation Monitoring Project 2010* (Kestrel Research Inc. and Gramineae Services Ltd. 2011) and *Long-term Revegetation Success of Industry Reclamation Techniques for Native Mixedgrass Prairie* (Lancaster et al. 2012).

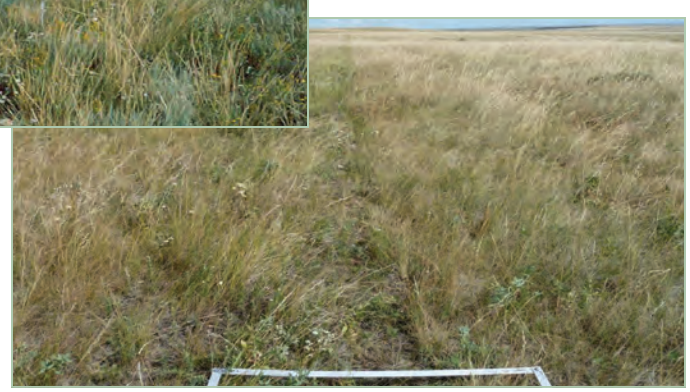
Patience is required to reach the restoration outcome

The role pioneer species play in the continuum of succession may not be recognized by landowners and reclamation practitioners. During the pioneer stage (Figure 9 and Table 2), annual forb species, often referred to as nuisance weeds, play an important role in site stabilization and moisture retention. Examples are Russian thistle (*Salsola kali*), flixeed (*Descurainia sophia*), grey tansy mustard (*Descurainia richardsonii*), peppergrass (*Lepidium spp*.) and the goosefoots (*Chenopodium spp*.).

It is also important to note that the pioneer, early and mid-seral plant communities (Figure 9 and Table 2) can contain non-targeted species that still function for erosion control and moisture retention such as the annual species listed above or pasture sagewort or fringed sage (*Artemisia frigida*). They stabilize the soils and help facilitate the process of succession over time.

Early Seral Community Example—Cypress

Mid-Seral Community Example—Cypress



Late Seral Community Example—Cypress

Table 2 – Successional Stages of Recovering Plant Communities Following Topsoil Disturbance

Seral Stage	Description
Bare ground	< 5% cover of live vegetation.
Pioneer	Site dominated by annual weeds and/or native forb species, a cover crop or first year seeded colonizing grasses such as slender wheatgrass.
Early seral	Site dominated by disturbance forbs such as pasture sagewort and other species such as low sedge. Seeded species and colonizing grasses such as spear grasses also establishing.
Mid-seral	Cover of grasses greater than that of disturbance forbs such as the sageworts; decreaser grasses present as a small component of the cover.
Late mid-seral	Cover of grasses greater than that of disturbance forbs such as the sageworts; decreaser grasses occupy about 50% of the cover; infill species present.
Late Seral - native	Cover of long-lived grass species expanding; native species cover from the seed bank established; slower establishing infill species present; decreaser grasses dominant; no more than one structural layer missing.
Late Seral - cultivars	Cover of long-lived grass species expanding; seeded cultivars clearly still dominant; slower establishing species such as fescues present; decreaser grasses dominant; no more than one structural layer missing.
Reference	Community closely resembles the ecological site potential natural community under light disturbance described in the Range Plant Community Guides.
Trending to Modified *	A primarily native plant community where non-native species are increasing over time and occupying > 5% of the total live cover; the succession time scale is as little as 5 and as many as 20 years or more.
Modified	> 70% cover of non-native species.

* Invasive non-native plants that are known to replace native species and establish permanent dominance in grassland communities include crested wheat grass, Kentucky bluegrass, smooth brome and sheep fescue in the Mixedgrass NSR.

5 PREPARING THE PATHWAY

Planning to Reduce Disturbance

Pre-disturbance planning is the first step in identifying the footprint of industrial development in native grassland ecosystems. It provides the opportunity to avoid disturbance to native grasslands by locating development on cultivation and previously disturbed lands dominated by non-native vegetative cover. Alberta Energy and Utilities Board, Information Letter IL 2002-1 (ERCB IL2002-1); *Principles for Minimizing Surface Disturbance In Native Prairie and Parkland Areas* alerts and directs industry regarding the importance of avoiding disturbance in native prairie, and the need to minimize disturbance should avoidance not be possible. The principles apply to all industrial activity in native prairie. Guidelines have been developed for petroleum industry activity (Native Prairie Guidelines Working Group 2002) and have been implemented widely and successfully by the industry. Other industries are encouraged to develop industry specific guidelines.

Minimal Disturbance – No Strip Pipeline Construction Operates on Frozen Ground Conditions, Majorville

Natural Recovery Pipeline, Majorville

Pre-Disturbance Site Assessment

Pre-disturbance site assessment is the decision-making process that enables productive and cost effective development planning (Figure 10). In the Mixedgrass, this sequential process is key in determining the location of the proposed industrial site and associated facilities with the least amount of impact to native grasslands. An example of how GVI pre-disturbance planning can optimize placement of development to minimize disturbance is illustrated in Figure 11.

Guidelines for pre-disturbance site assessment include:

Initial project notification: Engage qualified environmental professionals with experience in native grassland ecosystems and the challenges faced for industrial development. Determine the size and scope of the project, including the infrastructure necessary for full development.

Delineate local study area boundaries on the most recent air photo or fine scale satellite imagery available. This is the area surrounding the proposed target(s) that will be directly affected by development activity. The area should be large enough to include the maximum allowable movement of the proposed target(s) on the landscape. Conduct land titles searches and Surface Land Searches (available through Government of Alberta agencies) to determine if any instruments, protective notations, or conservation easements are in place.

If public lands are involved, the ESRD Enhanced Approval Process (EAP) will apply[3]. Consult the Enhanced Approval Manual available online and use the Landscape Analysis Tool (LAT) to determine landscape sensitivities and base features associated with the proposed project. Available online at: http://www.srd.alberta.ca/FormsOnlineServices/EnhancedApprovalProcess/Default.aspx

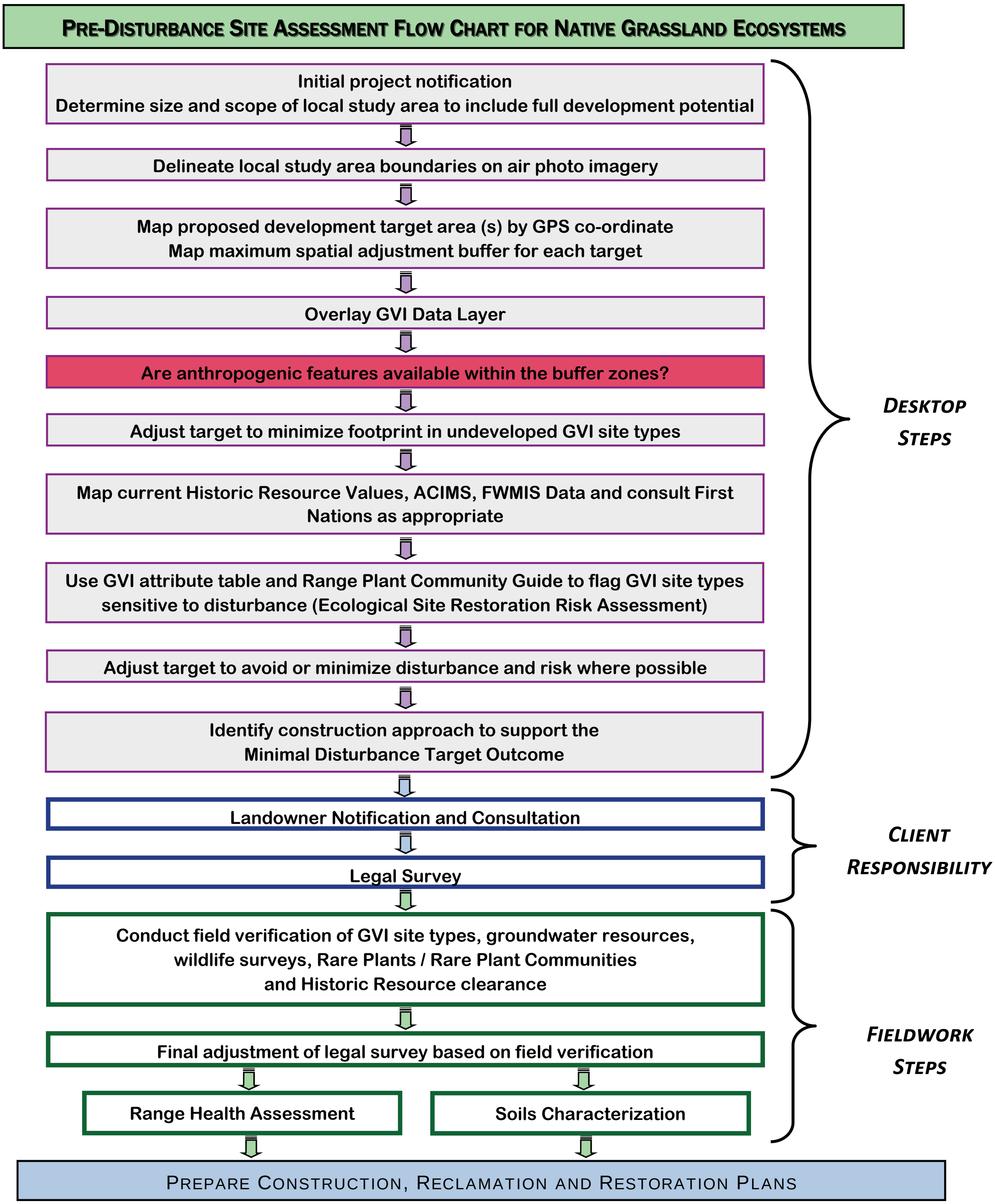
LAT provides linkage between landscape sensitivities, the proposed location and activity, and the applicable sensitivity section approval standards and operating conditions. The search may indicate Protective Notations (PNT) which alert industry to specific sensitivities where additional conditions and a non-routine application will apply.

Consult regional and municipal planning documents. Conduct a search for Environmentally Significant Areas, using the Provincial Update 2009 version available on the web. Map all possible constraints.

Map proposed development target area using standard cartographic coordinates. Map a maximum spatial adjustment buffer around the target(s). The buffer will provide the area on the landscape within which the target(s) can be moved and still remain effective.

[3] At the time of preparing this document, the Government of Alberta is in transition to a new, single regulator known as the Alberta Energy Regulator. Once operational, this change in regulatory jurisdiction and responsibility will be reflected in a future draft.

Figure 10 - Pre-Disturbance Site Assessment Flowchart for Native Grassland Ecosystems



Overlay the GVI data layer for the area on photographic imagery. The GVI attribute table which accompanies the data layer provides a coarse filter of biophysical, anthropogenic and land use features mapped as a series of polygons, lines, and points. Map existing anthropogenic features too small to be included in the GVI data layer, including well sites and flow lines.

Are anthropogenic features available within the target zones? If so, is shared use of the landscape feature possible? For example is moving a well site to cultivated lands, or shared access agreements for roads and trails possible?

Adjust target(s) to minimize footprint in undeveloped GVI site types (i.e. undisturbed and more or less intact native plant communities).

Map current documented ACIMS, FWMIS data, Historic Resource Values, and consult First Nations as appropriate. Consult the "*Recommended Land Use Guidelines for Protection of Selected Wildlife Species and Habitat within Grassland and Parkland Natural Regions of Alberta*" to determine any setback requirements for species at risk wildlife (Province of Alberta 2011). Highlight areas with potential habitat for Species at Risk.

Use GVI attribute table and Range Plant Community Guide to flag GVI site types sensitive to disturbance. Consult and incorporate soils information from AGRASID and regional soils maps where available. Implement desktop survey of groundwater resources.

Identify potential construction issues and explore possible options. Contour or digital elevation mapping is very useful at this stage.

Adjust target(s) to avoid or minimize disturbance where possible. Adjust to the defined outcome expectation of restoration that aligns with the 2010 Grassland Reclamation Criteria.

Notify and consult landowners/lease holders: Local knowledge and experience can be very important at this point in the planning process. Consultation provides the opportunity for education and information exchange. Landowner/ leaseholder concerns can be addressed and incorporated into the development plan at this stage.

Legal survey: Implementing the legal survey at this point in the planning process reduces the potential cost of multiple surveys by providing the opportunity to avoid sensitive environmental features through desktop analysis, and incorporating landowner concerns through the consultation process.

Conduct field verification of GVI site types, wildlife surveys, rare plant and plant community surveys and Historic Resource clearance. Determine the scope of the field verification to the size, type of development, landscape sensitivity and the timeframe when development takes place. Specific timeframes for wildlife and vegetation assessments will apply. In the Mixedgrass, a general timeframe to conduct field verification is May 15 to September 15. Document plant community types and dominant species to establish restoration goals. Establish a baseline for ground water monitoring if required.

Final adjustment to the legal survey based on field verification, environmental studies, construction constraints and continued landowner consultation.

Conduct Range Health Assessment and field characterization of soils within project footprint. Establish off site controls for comparison. Document local area weed and invasive plant concerns.

Reduce landscape impacts through reduced impact best management practices. Consider new development practices technologies that reduce the impact to soils, landscape, vegetation, water and wildlife resources.

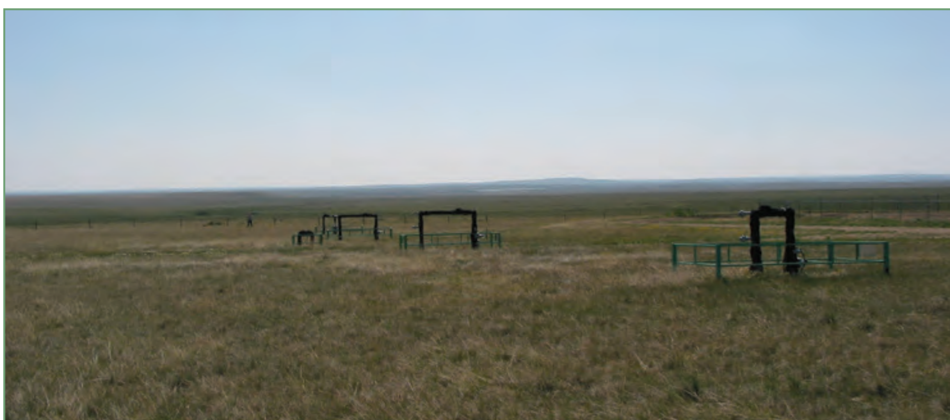
Prepare clearly defined reduced impact construction plans that incorporate minimal disturbance soil handling procedures, wildlife habitat constraints and the appropriate native grassland recovery strategy. Include Historical Resource mitigation where required. Clearly define reclamation procedures designed to reduce the impact of disturbance for each phase of development. Prepare site-specific native plant community recovery strategy(s) designed to enable the successional process to progress over time. Incorporate all plans into a detailed and site specific environmental protection plan (EPP).

Ensure the EPP, with construction, reclamation and restoration plans are incorporated into contract documents. Where appropriate to the development type and construction plan, include interim restoration planning to reduce the disturbance and bridge the gap between the operations phase and decommissioning.

Engage informed and experienced contractors committed to meeting the expected outcome of native prairie restoration.

Monitor to ensure contractual compliance.

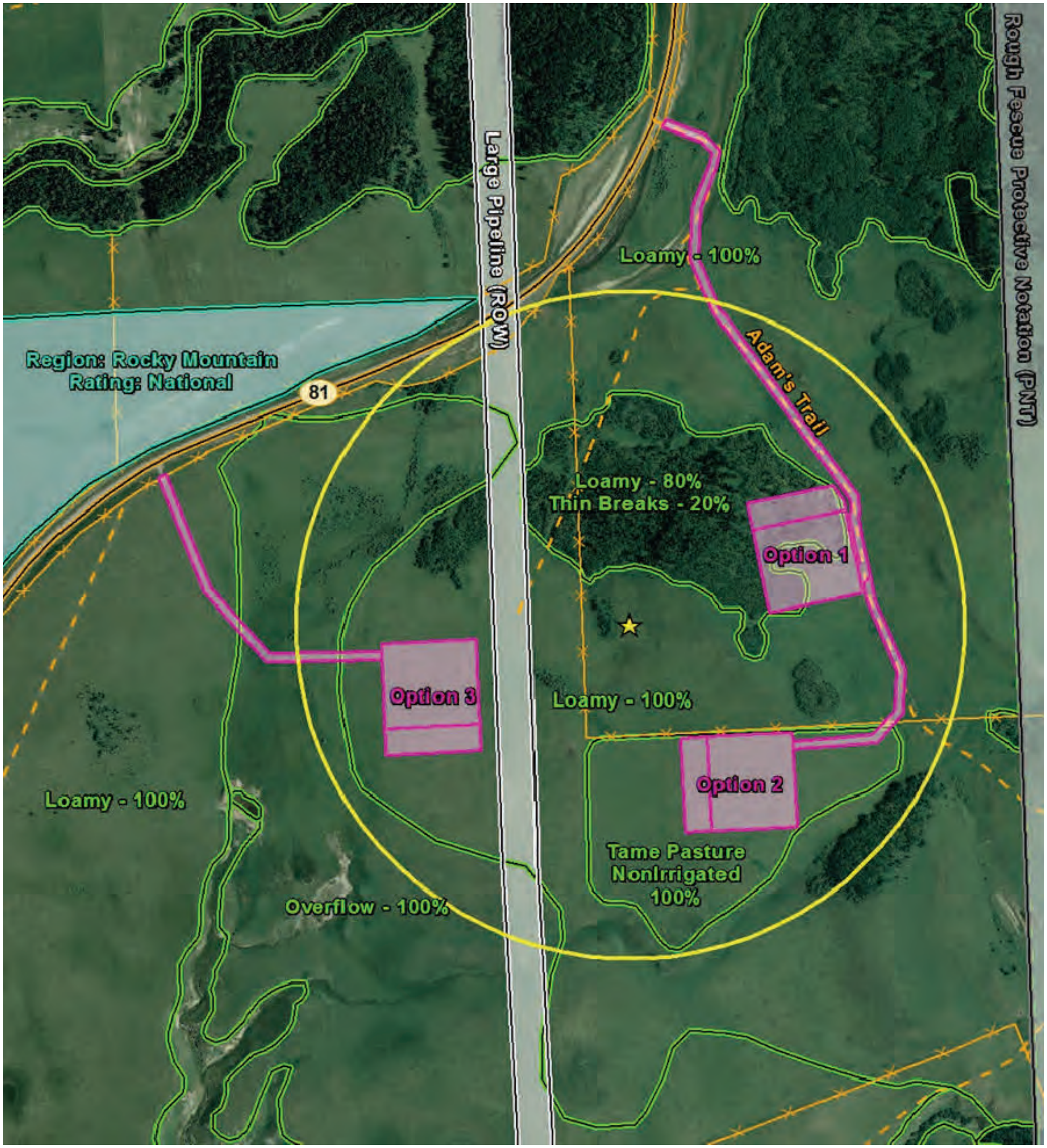
Communicates a progressive message to analyze, adapt and improve practices



Cluster Development: Multiple Flow Lines in a Common Corridor, Multiple Well Bores from a Single Well Pad, Cypress Hills

Reclaim and Reduce Disturbance During Operations: Two Strip Graveled Surface Minimizes Soil Disturbance and Provides Year Round Access

Figure 11 - Reduced Disturbance through Site Selection



GVI Mapping of Ecological Range Sites in a Development Target Area Facilitates Placement of Wellsite and Access to Minimize New Disturbance to Loamy Soils Supporting Rough Fescue Plant Communities

Incorporating Local Knowledge

Industrial development activity proposed in native prairie is often controversial within landowner, First Nations and environmental stakeholder groups who value the prairie landscape. Early notification and transparent communication with stakeholder groups is an essential component of pre-development planning.

The importance of local knowledge should never be underestimated

Notify and Consult with Landowners and/or Grazing Lease Holders

When working with landowners or grazing lease holders the following are some concepts that can facilitate the process.

- Communication is extremely important. Ranchers have learned from experience what works and what does not work on their land.
- Specific guidelines for notification and consultation are required on public land grazing leases and public lands grazing reserves. They are included in the Integrated Standards and Guidelines of the Enhanced Approval Process.
- When consulting private landowners incorporate the specific requests of the landowner within the limits of existing legislation.
- Healthy native grasslands are an important asset to the ranching industry.
- Industry must recognize the importance of water resources to the ranching industry.
- When planning industrial facilities it is important to recognize that sources of industrial noise such as compressor stations do impact cattle distribution within the fenced management unit.

To establish a positive successional pathway trend in plant communities, hope for a minimum of five years, but expect seven or more depending on moisture conditions

- Allow for settlement of soils over the trench when constructing minimal disturbance pipelines and flowlines. Subsidence over trenchline can be a safety concern and a pipe integrity issue if sinkholes develop over time.
- Depending on the type of industrial development and the extent of soil disturbance, the amount of available forage on the ranch may be reduced for many years. The rancher will have to adjust their management plan to compensate for the impact of the development. The recovering disturbance needs to be able to tolerate grazing as soon as possible. The developer needs to understand this and work with the rancher to reduce the impact.
- Climate and the timing of activity need to be considered to determine the timeframe for a positive plant community successional trend to be established on the disturbance. Hope for a minimum of five years, but expect seven years or more depending on moisture conditions.

- Confine disturbance to what is absolutely necessary.
- Access control and weed management are two key issues of concern. These issues extend beyond the initial development phase, to the operations phase and to decommissioning and abandonment.
- Reclamation fencing is often left in place well beyond when it is needed for vegetation establishment. The neglected fencing is often not maintained and becomes a liability for the rancher. Fencing must be removed to ensure the site can withstand grazing and to promote the process of plant community succession.
- Once vegetation is established, grazing is an important management tool.
- Concerns were expressed by workshop participants during the consultation process of this project that the Enhanced Approval Process (EAP) lacks sufficient checks and balances to ensure best management practices and minimal disturbance principles and guidelines are implemented during industrial development. There were concerns that the EAP eliminates vital communication with landowners and land managers.
- Maintain that vital communication link through the operations phase. Use respect!

Use Respect!

Ensure Compliance with Regional Land Use Policy

The Mixedgrass Natural Subregion encompasses a number of federal, provincial and regional policy directives regarding land use. Specific geographic areas where development in native prairie is managed under specific land use policy through legislation include the following.

- Alberta Environment and Sustainable Resource Development (ESRD) is the ministry that works with the municipalities to ensure land used for specified industrial activities ("specified land[4]") is reclaimed[5]. ESRD provides guidelines for reclamation and remediation, issues approvals for development activity, and is responsible for remediation and reclamation certification at decommissioning and abandonment.
- Special Areas Board Policy which includes specific requirements of the Environmental Review Program and Policy 06-06 provides specific direction regarding the expected outcome of development activity.
- The Public Lands Act and the ESRD Enhanced Approval Process (EAP) for upstream oil and gas development on public lands, specifically the Integrated Standards and Guidelines. Also, any historic terms and conditions specified in the development approval are grandfathered; compliance is required.
- Indian Oil and Gas Canada is the responsible authority for oil and gas exploration and development on specified First Nations Reserves. Exploration and development planning and activities are federally regulated and must be compliant with the Canadian Environmental Assessment Act.

Mixedgrass Natural Subregion

[4]See Glossary

[5]At the time of preparing this document, the Government of Alberta is in transition to a new, single regulator known as the Alberta Energy Regulator. Once operational, this change in regulatory jurisdiction and responsibility will be reflected in a future draft.

6 Selecting the Recovery Strategy

Selecting the most appropriate recovery strategy for the size and type of disturbance is key to restoration success in the Mixedgrass.

Industrial developments evolve in three phases.

Initial exploration and development activity required to access the resource. This can include the detailed planning, consultation and approval process, followed by the construction of the infrastructure required for oil and gas production, wind power development, mines, burrow pits or other related industrial activity. Incorporating the principles for minimizing disturbance to the native prairie ecosystem through detailed project planning with informed construction best practices and procedures are the most important recovery strategies at this phase.

Production which includes the construction of further infrastructure required to bring the product to market. This can include the construction of pipelines, pump stations, compressor stations, transmission lines, battery sites, access and associated infrastructure required to service the production of the resource. Typically this phase can last for many years. The focus should be to reduce the footprint of disturbance and wherever possible to set the stage for the process of recovery at decommissioning and abandonment. Interim reclamation planning for this phase should reduce the footprint of disturbance to the soils and native plant communities by reclaiming infrastructure no longer required, stabilizing and maintaining the integrity of the soils, and promoting the long-term recovery of the native plant communities that have been impacted by development activity. Think of it as a maintenance program that sets the pathway to reach the final outcome of ecological site restoration over time.

Decommissioning and abandonment is the final phase when resource production is either not commercially viable, or the development is at the "end of life". It is the process that precedes reclamation and remediation certification on "specified lands."

Figure 12 provides pathways for selecting the appropriate strategy for non-linear sites, including sites with ***reduced soil disturbance*** (for example less than 25% of the leased area has had the soil profile altered during development activity, while on 75% of the surrounding lease area the soils have remained undisturbed and the native grassland sod is intact). This guideline generally refers to shallow gas wells and associated infrastructure where much of the development activity takes place on unstripped soils.

Sites with ***significant soil disturbance*** encompassing more than 25% of the lease area (for example more than 3600m^2 within a lease area of 120 by 120 meters) refers to oil wells, oil production batteries, decommissioned sour gas wells, contaminated wellsites where soil remediation has taken place or topsoil has been imported, fully stripped wellsites, decommissioned compressor or pumping stations and reclaimed access roads. Other industrial sites such as mines, burrow pits, and turbine sites on wind farms fall into this category.

The shape of the soil disturbance and the edge to disturbance area ratio are important factors in determining the appropriate recovery pathways and strategies. For example, in the Mixedgrass natural recovery will be more successful on soil disturbances that are located in close proximity to and/ or surrounded by undisturbed native grassland. Figure 13 provides guidance for linear disturbances with significant soil disturbance. Examples are large diameter pipelines that have been stripped full width and graded, strip mines, and graded access roads.

Interim reclamation refers to sites where the surface soil disturbance has been reduced and reclaimed following initial development activity to stabilize the soils and facilitate the recovery of the native plant communities during the operational phase.

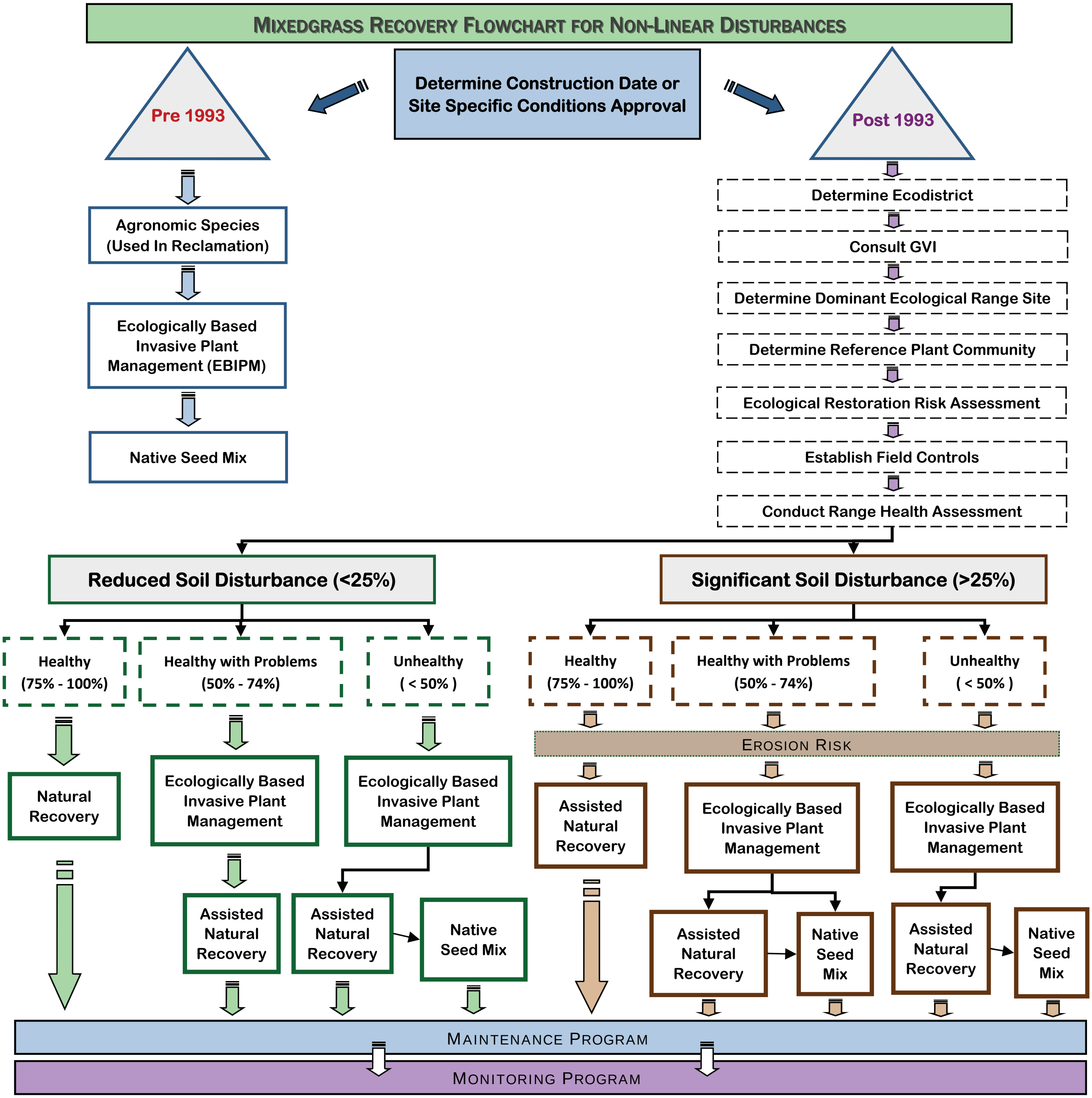
Recovery strategies for the Mixedgrass NSR include natural recovery, assisted natural recovery, and the use of native seed mixes.

The accompanying flow charts (Figures 12 and 13) for linear and non-linear disturbances provide a pathway for decision making when considering natural recovery, assisted natural recovery and native seed mixes.

Figure 12 Note: Reduced refers to small soil disturbances with a large surrounding edge where the native grassland sod has not been stripped for development activity. For example, approximately 25% of the leased area has had the soil profile altered during development activity, while on 75% of the surrounding lease area the soils have remained undisturbed and the native grassland sod is intact. Significant refers to soil disturbances with a small area (25%) where the native grassland sod has not been stripped for development activity surrounding a large area (75%) where the soil profile has been altered during development activity.

For the significance of the year 1993, refer to section 4, *Reflecting on Past History.*

Figure 12 - Mixedgrass Recovery Flow Chart for Non-linear Disturbances



Natural Recovery

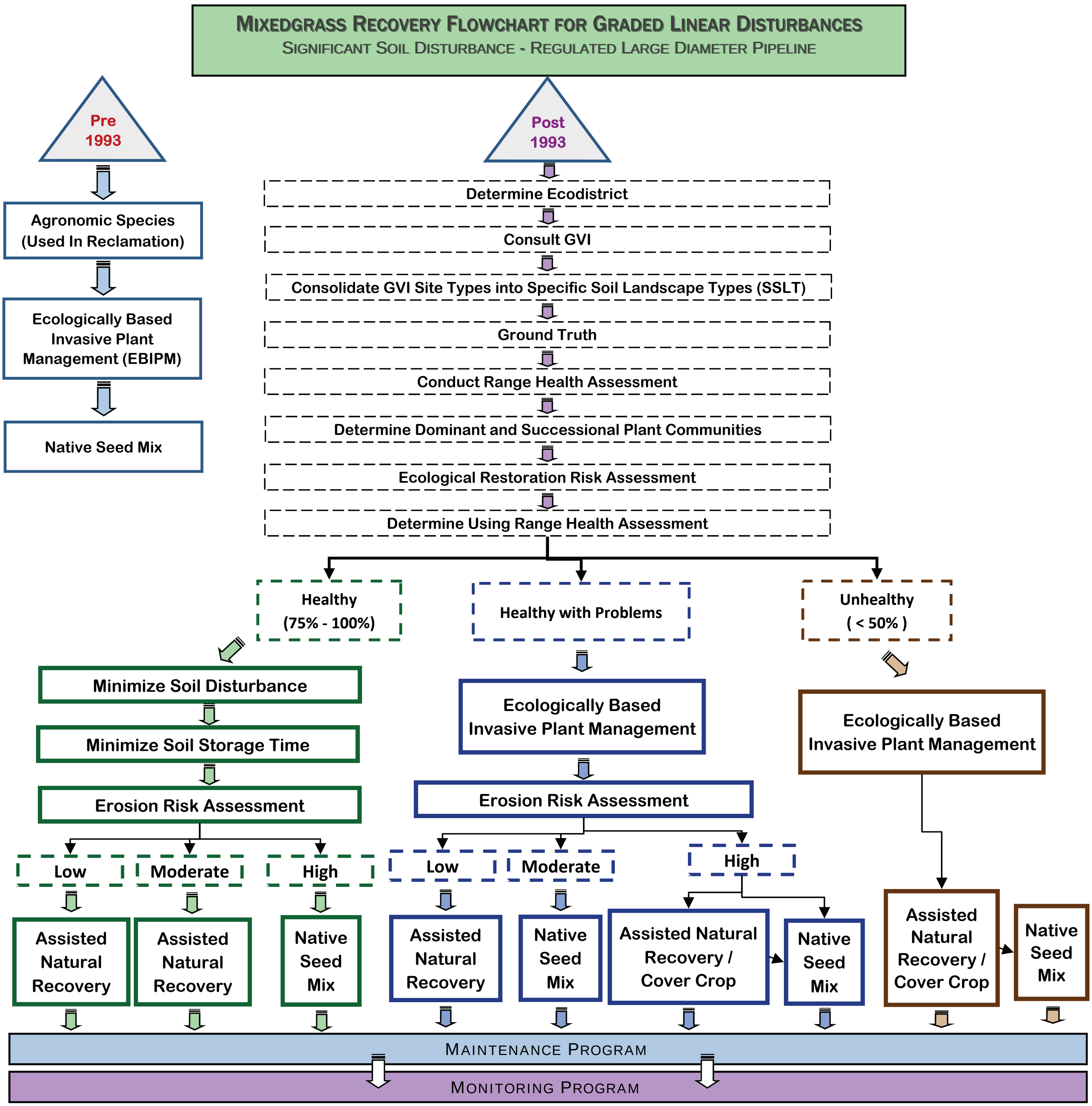
Assisted Natural Recovery

Native Seed Mix

Figure 13 Note: This chart applies to large areas of soil disturbance such as large diameter pipelines, strip mines, and graded access roads. Large diameter pipelines in this context are pipelines where topsoil salvage and grading is required on portions of the right-of-way due to topographic constraints or for safety requirements. These pipelines are regulated under the Environmental Protection and Enhancement Act and/or by the National Energy Board. They are generally greater than 20 inches in outside diameter.

For the significance of the year 1993, refer to section 4, *Reflecting on Past History.*

Figure 13 - Mixedgrass Recovery Flow Chart for Linear Disturbances



Natural Recovery

Natural recovery is defined as the "long-term re-establishment of diverse native ecosystems by the establishment in the short term of early successional species. This involves revegetation from soil seedbank and/or natural encroachment" (Alberta Environment 2010). No seed or other plant materials from beyond the disturbance are planted on the site during reclamation.

Natural recovery is a benefit of minimal disturbance industrial development procedures which minimize the disturbance to the soils and native vegetation.

Minimal Disturbance

Examples of minimal disturbance include shallow gas wells drilled and operated with the native sod and soils intact except for a small area at well center, and pipeline construction where the only soil disturbance is over the trenchline. Another example is the use of rig mats to minimize the compaction of unstripped native sod for temporary access or active areas within a site that require vehicles and equipment for construction or drilling. Monitoring soil moisture conditions and traffic control are essential factors for success when implementing minimal disturbance procedures and natural recovery. Heavy equipment and vehicle traffic over unstripped sod can cause compaction in the soils that can adversely affect the recovery of the native vegetation. Heavy traffic can also cause rutting and soil profile admixing which also affects recovery.

Some native plant communities in the Mixedgrass are particularly sensitive to soil handling and minimal disturbance practices are clearly advantageous to promote restoration. In an assessment of pipelines left to natural recovery, Desserud and Naeth (2013) concluded that in rough fescue dominated areas in the Mixedgrass NSR, it is important to retain sod as deep-rooted plains rough fescue will not tolerate soil stripping.

Pre-disturbance native vegetation recovers from minimal disturbance procedures providing the rangeland is healthy, the impact is short term, and development is conducted under dry or frozen ground conditions. This is the most important mitigation principle when implementing minimal disturbance and relying on natural recovery as the recovery strategy to promote restoration over time.

Natural recovery on disturbed soils relies on the native seedbank present in the uppermost layer of the topsoil, seed rain from the surrounding undisturbed native plant community, and native plant propagules (rhizomes and crowns) present in the disturbed soil to revegetate exposed soils. Examples of soil disturbance include: wellsites or access roads where topsoil stripping and grading has been necessary and pipeline construction where topsoil stripping has occurred.

Minimal Disturbance Techniques

Reduced Disturbance Wellsite Construction, Cypress Hills

Use of Barrier Fabric to Conserve Surface Vegetation, Trained Operators with Experience are Key to Success

Temporary Access Using Interlocking Matting

Ecological Risk Assessment

When considering natural recovery, it is important to conduct an ecological risk assessment (refer to Section 3) to determine the site specific risk factors that will affect the successional process. Does the native plant community have the resources to re-establish on the disturbed soils? Many species in the Mixedgrass are uniquely adapted to site conditions. Ecological range sites that are naturally adapted to disturbance like Sands demonstrate better success for natural recovery on large disturbances than Loamy range sites with large disturbances (Lancaster et al. 2012).

Is the landscape fragmented such that sources of invasive species nearby may also colonize the disturbance?

Are the key indicator species present with the sufficient vigour and reproductive capability to colonize the site?

Does the timing and intensity of grazing promote recovery or put it at risk? Clear communication with landowners or grazing leaseholders is necessary to understand their grazing management requirements and whether natural recovery is compatible.

Are non-native invasive plants present in the onsite community or in the surrounding area near the site? The fragmented native prairie landscape in the Mixedgrass presents additional challenges for invasive non-native plant management. In the Mixedgrass, the following invasive plants are known to invade bare ground and are very difficult to eradicate.

- ⃠ downy brome (*Bromus tectorum*)
- ⃠ Japanese brome (*Bromus japonicus*)
- ⃠ smooth brome (*Bromus inermis*)
- ⃠ Kentucky bluegrass (*Poa pratensis*)
- ⃠ crested wheat grass (*Agropyron cristatum, A. sibiricum*)
- ⃠ sheep fescue (*Festuca ovina*)
- ⃠ sweet clover (*Melilotus officinalis*)
- ⃠ alsike clover (*Trifolium hybridum*)
- ⃠ Canada thistle (*Cirsium arvense*)
- ⃠ common dandelion (*Taraxacum officinale*)
- ⃠ toad flax (*Linaria spp.*)
- ⃠ wormwood absinthe (*Artemesia absinthium*)
- ⃠ leafy spurge (*Euphorbia esula*)

Key Learnings from Case Studies

The following key learnings regarding the use of natural recovery in the Mixedgrass have been summarized from the case studies conducted for this project, *Long-term Revegetation Success of Industry Reclamation Techniques for Native Mixedgrass Prairie* (Lancaster et al. 2012).

Performance of Natural Recovery on Loamy and Limy Ecological Range Sites in the Majorville Upland Ecodistrict

Use of natural recovery as the strategy for narrow linear disturbances on Loamy and Limy ecological range sites in the Majorville Upland resulted in a positive successional trend towards the recovery of the disturbance over the trenchline. Range health scores have increased on all trenchline monitoring sites from four years to seven years post-construction indicating that the process of infill is occurring. Exposure of bare ground over the trenchline has decreased from year four to year seven and total vegetation has increased within the sample sites.

In the initial years of natural recovery (four growing seasons post-construction) western wheat grass, northern wheat grass , green needle grass (*Stipa viridula*) and sedge species (*Carex spp*.) play an important role in colonizing the bare soil. Pasture sagewort plays an important role in providing initial cover and shade for emerging graminoids.

Over the longer term (eleven years post-construction), western and northern wheat grasses increase in percent cover, stabilizing the soils with their ability to produce a network of rhizomes within the soil. Green needle grass also increases in cover as it is well adapted to disturbance. As the colonizing species provide initial structure over the soil surface, needle-and-thread grass seed rain from the adjacent undisturbed grassland is trapped within the bare soil spaces enabling the uniquely adapted seed to germinate, emerge and increase in cover over time. Pasture sagewort continues to play an important role in the forb component of the plant community but decreases in cover over time. Other disturbance related forbs including non-native species like goatsbeard (*Tragopogon dubius*) and common dandelion (*Taraxacum officinale*), continue to infill and the species composition varies over time depending on available moisture and site conditions in the area surrounding the disturbance.

Performance of Natural Recovery on Large Diameter Pipeline on Loamy Ecological Range Sites in the Cypress Upland Ecodistrict on Express Pipeline

Natural recovery was problematic on the Mixedgrass plains rough fescue natural recovery trial site conducted on Express Pipeline in the Cypress Upland (Lancaster et al. 2012). Exposed topsoil remained relatively bare for the first three years, lacking the flush of colonizing annuals typical of Dry Mixedgrass natural recovery trial sites. After 14 years, plains rough fescue is notably absent from the plant community. Although diverse, the plant community does not reflect the proportional cover of species in the reference plant community, nor the control site. There was an increase of undesirable non-native Kentucky bluegrass present in relatively low cover values on the control. This species is able to capitalize on disturbances and expand cover when it is present in undisturbed grasslands. The timing and duration of livestock grazing can also affect the success of natural recovery, particularly in plains rough fescue plant communities. Summer grazing has detrimental effects on seedling survival. This result highlights the additional challenge of re-establishing rough fescue on disturbed topsoil.

Majorville Upland Ecodistrict—Natural Recovery Pipeline

Performance of Natural Recovery on Minimal Disturbance Wellsites

Natural recovery is a largely successful strategy for recovery of native Mixedgrass range plant communities on range that has a health score of "healthy" or "healthy with problems" (Lancaster et al. 2012). Key observations for 2012 monitoring sites on Blowout range sites in the Sweetgrass Upland after ten years recovery are:

- cover of tall grasses, forbs and groundcover is reduced but recovering;
- total numbers of species are approaching off-site numbers;
- the number of native forb species is greater than 50% of the number on undisturbed grassland;
- litter values on undisturbed areas are double those found on the disturbance;
- introduced weeds are goatsbeard, common dandelion; and;
- disturbances may be targeted by grazers, (livestock or wildlife) which can affect recovery.

Well Managed Minimal Disturbance Wellsite

For loamy range sites in the Majorville, Lethbridge and Vulcan Plains ecodistricts, the Wheat grass - Needle-and-thread (MGA21) range plant community is a reference plant community (Adams et al. 2013). Key observations for natural recovery sites with health scores of “healthy” or “healthy with problems” are:

- sites tend to have comparable numbers or a few more species on disturbance and more native forbs on disturbance than on undisturbed sites;
- introduced species on disturbance include goatsbeard, common dandelion , flixweed (*Descurainia sophia*) and lamb's quarters (*Chenopodium album*);
- invasive species present at low cover values despite healthy range condition on undisturbed areas include crested wheat grass, and both crested wheat grass and Canada thistle on disturbances; and
- dominant natural recovery species are western wheat grass, needle-and-thread and blue grama (Lancaster et al. 2012).

Factors to consider in the risk assessment for minimal disturbance wellsites are the availability of native seed onsite related to grazing pressure, erosion risk and the proximity of sources of invasive species.

Site position and location can affect the success of natural recovery. For example, a wellsite situated in moderately grazed, healthy rangeland on thin Loamy soils on an upper west-facing slope experienced topsoil deflation in the five years since construction. The well site is in unhealthy range condition and is dominated by exposed crusted soil and annual weeds. This site is downwind of an intensive livestock operation which may contribute weed seed through wind transport.

Timing of Topsoil Stripping and Replacement

Where soil disturbance is necessary, the timing of topsoil stripping and replacement can have a dramatic effect on the success of the natural recovery revegetation strategy. Soil handling in the fall after the seed set of most species is more successful than at other times of the year. It is important to reduce the timeframe between topsoil stripping and replacement. It is also important not to re-disturb an area left to recover naturally. Ideally topsoil stripping and replacement should occur when the native vegetation is dormant (mid-summer to early winter in the Mixedgrass), within the same year and before the next growing season (Kestrel Research Inc. and Gramineae Services Ltd. 2011).

It is difficult to specify a timeframe for recovery. Depending on the type of disturbance, the native plant community and available moisture during the early years following soil disturbance recovery could take anywhere from 5 to 20 years or more. Note that full recovery or restoration is not a requirement for the issuance of a reclamation certificate under the 2010 Reclamation Criteria for Wellsites and Associated Facilities for Native grasslands. The criteria must show evidence of restoring ecological function and that the target plant community is on the trajectory to resemble the plant community in the control or adjoining undisturbed native grassland. It is important to recognize the role annual weeds and forbs play in stabilizing a site during the early years of recovery. The timeframe for indicator species to infill the site is dictated by on-going environmental site conditions. For example, extended periods of drought, salt laden soil, or above average moisture can affect the timeframe for recovery in a negative or positive way.

It is important to recognize the role annual weeds and forbs play in stabilizing exposed soils and retaining moisture during the early years of recovery

Annual Weeds Colonizing Exposed Topsoil

Assisted Natural Recovery

Assisted natural recovery uses short-term additions of materials to a disturbed site to modify site conditions such that they are more favourable for the re-establishment of vegetation from the resources naturally present on the site and in the surrounding area.

Cover Crops

Seeding soil disturbances with annual or short lived perennial species to stabilize erosion prone soils can facilitate the process of revegetation by natural recovery. In the Mixedgrass a combination of fall rye and flax at a light seeding rate (1/2 bushel per acre of each species) was used on a small diameter pipeline in the Cypress Upland (Lancaster et al. 2012) and on other industrial disturbances since the late 1990s. Winter wheat in place of fall rye has also been used. Other short lived perennial native cultivars such as Canada wild rye (*Elymus canadensis*) and slender wheat grass have been used as well. Applying the seed at low seeding rates is essential (3 to 5 kg per hectare depending on type of application) and a carrier (polished short grain rice or chick starter has been used) will be required to adequately disperse the seed. It is important to obtain Certificates of Seed Analysis before purchasing the seed and to ensure there are no Prohibited Noxious, Noxious weeds or undesirable invasive agronomic species such as crested wheat grass or sweet clover present in the seed. Retain the Certificates of Seed Analysis on file as they may be required during an environmental audit. Grazing management must be considered when using a cover crop. The combination of fall rye and flax is relatively unpalatable to livestock in pastures with healthy range health condition. Local knowledge and communication with the landowner/grazing leaseholder is very important when considering the implementation of this strategy.

Slender Wheat Grass Cover Crop

Wild Harvested Hay Mulch

Another method of assisted natural recovery involves mowing the native grasses and forbs adjacent to the area to be restored, chopping and spreading the mowed “native mulch” over the bare soil and leaving the site to recover naturally with no additional seed. To be successful the dominant grass species have to be in the mature seed set stage. Timing is essential to success. In the Mixedgrass NSR, the dominant species may be needle-and-thread, western porcupine grass or plains rough fescue, depending on the area. Note that plains rough fescue does not produce seed every year so availability for seed harvest is not guaranteed.

The advantage of this method is the potential to increase the amount and diversity of the seed source available to the disturbed soils. As well, the mulch conserves moisture and protects the surface of the soil from erosion. Also the procedure is very site specific as the plant material used is obtained from locally adapted seed within the same ecological range site as the disturbance.

The areas to be harvested must be free of invasive plants. For example, species such as crested wheat grass are prolific seed setters, and only a few plants in the harvest area could result in dominance by this invasive plant (see the Section "Guidelines for Wild Harvest Native Plant Materials" for details). Weather plays a role in successful native hay harvesting. Wind may affect successful cover of the disturbance. The chopped hay mulch is normally sprayed onto the disturbance and with wind, chaff and light-weight seeds could be carried away. The harvest area must be dry as wet grasses cannot be cut properly.

Choosing this strategy requires the same pathway for decision making as natural recovery. Rangelands show varying degrees of natural soil stability depending on climate, site, topography and plant cover. Assisted natural recovery may be appropriate where soil disturbance has occurred and there is potential for additional soil erosion based on soil properties and the action of wind and water. Examples include soil disturbances in Choppy Sand Hills or Thin Breaks ecological range sites. The addition of cover crops does delay the process of natural recovery. However, where erosion is a concern it does provide an option to native seed mixes if suitable native seed is not available.

Native Hay Cutting in the Sweetgrass Upland Ecodistrict

Native Hay Crimped into Exposed Topsoil in the Sweetgrass Upland Ecodistrict

Use of Native Seed Mixes

Long-term monitoring case studies conducted to prepare this manual (Kestrel Research Inc. and Gramineae Services Ltd. 2011; Lancaster et al. 2012) have illustrated the need for change in the way seed mixes are designed for native prairie. The native seed industry needs to evolve if the expected outcome is restoration. In the Mixedgrass, several of the native grass cultivars used in the past are too competitive to allow infill from the surrounding native plant community to occur. A reliable supply of native seed of the dominant species in the Mixedgrass plant communities such as needle-and-thread grass, western porcupine grass and plains rough fescue is essential. This will be achieved by changing the way native seed mixes are designed and develop a reliable supply of the required key native species.

The native seed industry needs to evolve if the expected outcome is restoration

Invasive non-native plant management is a component that must be considered for restoration planning in the fragmented native prairie of the Mixedgrass.

Industry has indicated a need for a standardized method of designing native seed mixes for large industrial disturbances not suited to natural recovery or assisted natural recovery in the Mixedgrass. These disturbances include:

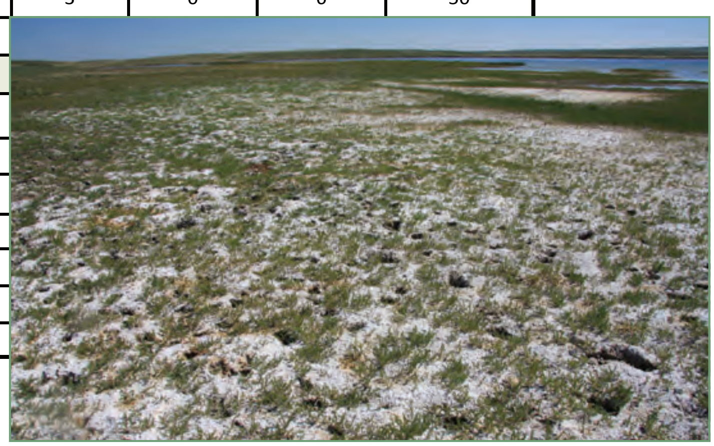
- decommissioned wellsites with significant soil disturbance due to contaminated soils, decommissioned full build out oil or gas wellsites, reclaimed access roads, large diameter stripped and graded pipelines, burrow pits and mines;
- large areas of disturbance with erosion and site stability concerns;
- areas of disturbance that require soil stabilization during the production phase (interim reclamation);
- large disturbances in rangeland where the surrounding native plant communities have low scores for plant community integrity and ecological status;
- disturbed sites where the surrounding native plant community does not have sufficient plant material resources to colonize the disturbance; and
- disturbances where seeding is required as part of an Ecologically Based Invasive Plant Management Plan (Rangelands SRM 2012).

The native seed industry and supply chain has also requested direction to facilitate growth within the industry in order to meet anticipated demand. Seed mix design methods used in this publication encompass the species list, plant communities and ecological range sites currently described in the Mixedgrass Range Plant Community Guide (Adams et al. 2013). The goal of the guidelines provided for seed mix design is to revegetate disturbances with species that will establish a mid- to late-seral plant community.

The current Range Plant Community Guide for the Mixedgrass (Adams et al. 2013) contains 38 native grassland plant community descriptions, seven modified native plant communities and six native shrubland plant communities. Given the diversity of ecological range sites and successional plant community types that can be encountered within a relatively small area on the prairie landscape, it is necessary to establish which ecological range sites have species in common based on the Agricultural Region of Alberta Soil Information Database (AGRASID) soil and landscape correlation. These groupings of ecological range sites with common dominant native grass species are referred to as **target recovering plant communities** (Appendix B). They are clearly not mature reference native plant communities but rather composed of the dominant native grass species that are drivers in the successional process. The goal of using native seed mixes is to establish the pathway(s) to restore the pre-disturbance plant community. Example native seed mixes are provided for each target recovering plant community. When seeded at the recommended low seeding rates, (8 kilograms per hectare for drill seeding and 15 kilograms per hectare for broadcast seeding), these dominant grass species will provide the vegetative cover to stabilize disturbed soils and facilitate the recovery of the plant community (including the native forb component) over time. Appendix B includes the specifics of the target recovering plant communities and examples of the expected outcome.

Figure 14 - Example Target Recovering Plant Community from Appendix B

Species	Common Name	Average % Cover	Minimum % Cover	Maximum % Cover	% Constancy
Grasses and Sedges					
Carex species	Undifferentiated sedge	25	15	34	100
Distichlis stricta	Salt grass	17	0	14	50
Agropyron smithii	Western wheat grass	7	0	14	50
Poa species	Undifferentiated bluegrass	6	2	10	100
Festuca hallii	Plains rough fescue	6	0	11	50
Puccinellia nuttalliana	Nuttall's Salt-Meadow grass	5	0	10	50
Koeleria macrantha	June grass	3	0	6	50
Muhlenbergia species	Undifferentiated Muhly	3	0	6	50
Spartina gracilis	Alkali cord grass				
Forbs					
Grindelia squarrosa	Gumweed				
Gutierrezia sarothrae	Broomweed				
Antennaria species	Undifferentiated everlastings				
Average Total Vegetation Cover					
Average Moss and Lichen Cover					
Average Exposed Soil					



Saline Lowland Ecological Range Site

Nursery Propagated Native Plant Materials

Nursery propagated native plant materials are used to promote the establishment of tree, shrub, forb, grasses, sedges and rushes on disturbed sites. They are used to establish species that are key components of ecological range sites that are difficult to establish by other strategies, to enhance diversity and infill and to create key habitat features for wildlife and /or rare plants. This strategy requires the engagement of suitably qualified and experienced practitioners and nurserymen to assess the site requirements, prepare the site design, and then collect, propagate, install and maintain the plant material. Plant material harvested for propagation should be sourced from the Mixedgrass NSR, the same ecodistrict and an equivalent ecological range site as the disturbed area to be restored. The plant material must be removed from the nursery and allowed to adapt to the site specific condition where they will be planted to prevent transplant shock and die-back. A monitoring and adaptive management program is required to maximize the success rate of this recovery strategy. Prairie conditions are harsh for young tender plants.

Many native plants have specific germination requirements to reduce seed dormancy and increase emergent survival. In undisturbed native grasslands the seed produced from native plants is subjected to a number of factors that promote germination. Examples include: freeze thaw cycles, scarification by coarse textured soils and acid treatment from being ingested by wildlife or livestock. Other factors include specific soil temperature, or moisture, or sunlight requirements. A very practical manual entitled *Cultivating Our Roots: Growing Authentic Prairie Wildflowers and Grasses* (Stewart 2009) provides detailed information on native seed collection and propagation of Mixedgrass native grasses and forbs.

Nursery Propagated Fescue Plugs

Considerations for Complex Sites

In many situations, native prairie in the vicinity of existing wellsites and associated facilities is no longer a uniform, undisturbed native plant community. Reclaimed old disturbances create a patchwork of well-established invasive plant communities (e.g. crested wheat grass) and native plant communities that create a challenge for restoration. Successful restoration strategies for these hybrid mixed sites can be complex. It is important to conduct a detailed vegetation inventory onsite, just offsite, and in undisturbed areas further away offsite. This can help determine the greatest factors of influence on a complex site (e.g. pipelines with shared rights-of-way, existing wellsites that have been redeveloped to reduce the impact to native grassland, or sites that have been impacted by heavy grazing or wind erosion).

Approaches to consider prior to further disturbance and during restoration when dealing with the tainted canvas include the following:

- pre-construction spraying of undesirable invasive species on site;
- raking accumulated litter thatch that may be reducing range health, harbouring undesirable seed or reducing opportunities for infill by native species;
- mowing the site while the natives are not actively growing;
- wiping out the old canvas completely and starting from scratch;
- seeding tough nurse crops lightly with a native cultivar mix (e.g. intermediate wheat grass, it is not long living but competes with invasives while native plants establish); and
- regular monitoring and timely management of re-establishing vegetation.

Well documented vegetation management plans (including weed and invasive species management plans) will help with providing data to understand successes and failures and apply to future research.

Considerations for Wetland Sites

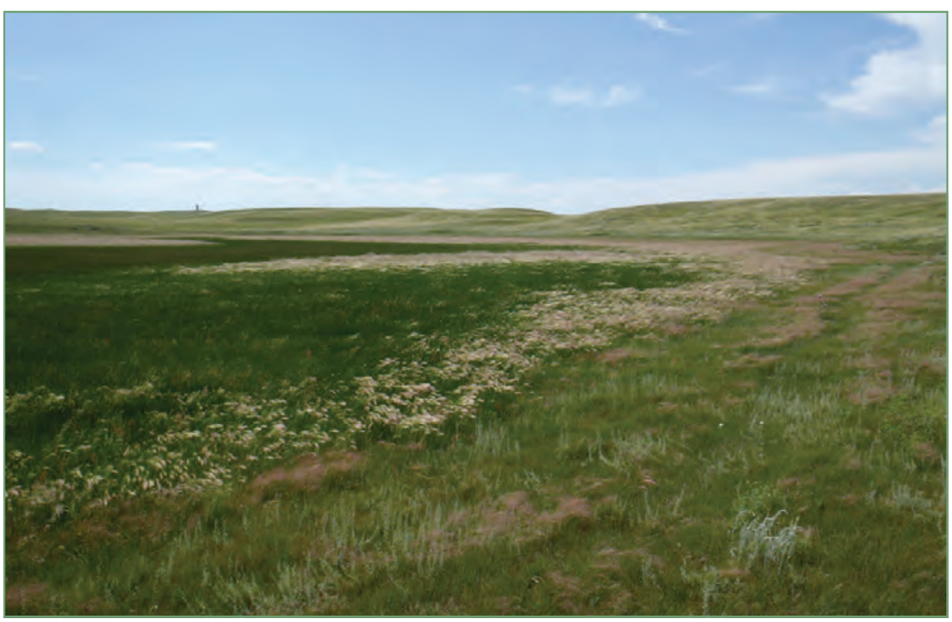
In most cases, government policy and regulations will strictly limit industrial activities which disturb lotic or lentic wetlands. When disturbance does occur, maintaining the health and function of all classes of water bodies is extremely important in the semi-arid landscapes of the Mixedgrass. Alberta's Wetland Policy provides specific direction regarding development activity near all classes of wetlands. The policy can be found on the web at: http://www.wetlandpolicy.ca/

There are off-set requirements for industrial disturbance near most classes of wetlands and water bodies and it is important that they are adhered to when planning industrial development. Details are provided in the Enhanced Approval Process found online at: www.srd.alberta.ca/FormsOnlineServices/EnhancedApprovalProcess/Default.aspx

Riparian Plant Communities of Southern Alberta; Detailed Site and Soils Characterization and Interpretation (McNeil 2008) is an important resource, providing practical information for development and mitigation planning near wetland (lentic and lotic) sites.

When decommissioning existing industrial infrastructure located in or near lentic (still water) or lotic (flowing water) sites, it is important to ensure remediation of all contamination issues (both soil and water) according to the current reclamation criteria (Alberta Environment 2011).

When industrial activity within a wetland occurs, as with upland native prairie vegetation communities, avoiding or minimizing disturbance to soil structure, soil layers and surface vegetation when frozen is likely to provide the most effective mitigation for wetland communities. Exposed moist wetland soils are vulnerable to colonization by invasive plants.



Lentic Wetland

During reclamation, replacing stripped subsoils and topsoil so that the original wetland contours are recreated is important to restore the hydrological regime of the wetland. This will permit natural circulation of water and redistribution of seed in the basin.

Natural recovery is usually the best restoration strategy for lentic (still water) prairie wetlands. Zonation patterns of wetland vegetation communities occur in response to dynamic seasonal moisture conditions. Prairie wetlands contain large sources of buried viable seed capable of responding to changing environmental conditions including disturbance (summarized in Keddy 2000). Seed is redistributed within wetlands during high water events.

Barriers to restoration of prairie lentic wetlands include:

- exotic weed invasion, particularly in vulnerable shallow low prairie and wet meadow wetland zones;
- drought;
- flooding of seed or seedlings in the wet prairie and sedge meadow zones, which serve as seed sources and can affect recruitment of plants;
- sedimentation, which can result in eutrophication of the wetland or burial of seed; and
- long-term storage of piled topsoils resulting in seed and propagule mortality.

Response to disturbance can be slower in saline wetlands; where seed densities are much lower (summarized in Keddy 2000). The majority of re-colonization of disturbance in saline wetlands occurs through spread of neighbouring rhizomatous species.

For riparian areas adjacent to rivers and streams, more intensive reclamation strategies may be required to control water erosion and promote restoration. Examples include: the use of erosion control fabric and geotextiles, hydro-mulching, nursery raised shrub and forb transplants, and soil bioengineering procedures such as live fachines or live staking. Riparian areas are associated with both lentic and lotic water bodies.

Lotic Wetland

7 Implementng the Strategy

The findings of the pre-disturbance site assessment and the size and type of disturbance will determine the most appropriate revegetation strategy for the site. Site preparation, timing and using the right equipment are three key elements to successful revegetation whether relying on natural recovery or planting a native seed mix. It is important to recognize that site preparation, soil handling and timing of activities need to be clearly defined for contractors. If native seed is required, begin the process of acquiring the seed well in advance of the time it is required. Large projects requiring large volumes of seed may require "forward contracting" native seed supply companies several years in advance to secure the appropriate native seed in the volumes required.

If native seed is required, begin the process of acquiring the seed well in advance, potentially one or more growing seasons in advance.

Salvaging Native Plant Material Resources

Assessing the pre-disturbance quality and quantity of the topsoil resource is a valuable component of restoration planning. The native seedbank, important for the recovery of native species diversity, is retained in the top 3 to 5 centimetres of soil. To conserve this valuable resource it is important to:

- consult the pre-disturbance site assessment to determine if pre-disturbance invasive plant management is required;
- reduce the amount of area disturbed;
- minimize the soil handling within the area disturbed;
- consider a two lift stripping procedure for areas with deep topsoil resources to prevent dilution of the native seedbank;
- minimize the timeframe between topsoil stripping and replacement; and
- avoid pulverizing and mixing the soils.

Site Preparation and Micro-Contouring

The native prairie is not flat. Micro-contouring facilitates seedling survival in the Mixedgrass. Retain the sod as intact as possible during stripping and replacement. Use equipment appropriate to the size of the disturbance and avoid overworking the topsoil during stripping. Do not harrow to break down the sod and pulverize the soil during replacement. Clumps of sod contain live plant material and the native seedbank that can re-establish, providing an important source of infill species and diversity within the recovering plant community. A roughened surface retains more moisture, provides shade and shelter for seedling growth, and reduces erosion potential. This is particularly important for natural recovery sites.

Selaginella in Sod Replacement on Ditchline

A Roughened Surface Retains Moisture

Recommended Timing of Restoration Activities

The Express project illustrated that natural recovery is most successful on sites where the soils were stripped in the late summer and replaced as quickly as possible in the fall of the same year before freeze up. This timeframe also avoids the sensitive breeding and rearing period for wildlife, (early spring to mid-summer) when timing constraints and/or conditions for industrial activity in native prairie may apply. Natural recovery was not as successful when topsoils were stored over winter and replaced in the summer of the following year.

Natural recovery is most successful on sites where the soils are stripped in late summer and replaced as quickly as possible in the fall of the same year before freeze up.

Late fall after the first hard frost or early spring as soon as the soils can be worked is the best time for seeding cool season grasses such as the native wheat grasses, needle-and-thread, western porcupine grass, and plains rough fescue. Ideally, warm season grasses should be seeded mid to late June. They need the soil to remain consistently warm for germination and emergence. Seeding is not recommended during the heat of the summer months when moisture is at a deficit. If seeding is required during mid-summer, use a cover crop (refer to section 6).

Selecting Equipment to Suit the Strategy

Native seed mixes usually contain a combination of large and small seeds which can lead to uneven seed dispersal and bridging in the seeding equipment. One solution to this problem is to have the small seeds blended and bagged separately from the large seeds. Most drill seeders used in reclamation such as the Great Plains, Truax or John Deere are specially designed with two seed boxes to accommodate large and small seeds. Another option is to drill seed the large-seeded species and broadcast, harrow and pack the small seeds. This method also facilitates more accurate seeding depth and reduces the competition for moisture between large and small seeded species. Whatever seeding method used, check the drill box or hopper frequently to determine if the seed is flowing or whether the drill rows may be plugged.

Some seed, such as wild harvested needle-and-thread, can also contain considerable amounts of inert material from the cleaning and de-awning process. The amount of inert material should be recorded on the Certificate of Seed Analysis. Seed containing unusually high amounts of inert material should be re-cleaned. Prairie Habitats Inc. has more than 20 years of experience in seeding wild harvested seed. Their website illustrates a complete line of wild harvesting and seeding equipment specially designed for restoration projects at: http://www.prairiehabitats.com/

Kinsella Accu-Roller

Drill Seeding Equipment

Hydroseeding

Native Grass Seed Cleaning Equipment and Grass Debearder

Guidelines for the Procurement of Native Seed

For projects that require native seed in the Mixedgrass NSR the following guidelines are recommended.

- For large disturbances such as large diameter pipelines, wind energy projects, mines, burrow pits or large plant sites it is important to plan at least two years in advance in order to ensure an adequate supply of the key species required for the project.

- Order plant material sourced from within the Mixedgrass.

- Ensure the seed lots of each species proposed are tested for purity and germination at an accredited laboratory prior to purchase from the vendor. Testing should be conducted within 12 months of the proposed planting date. Purity testing of large-seed species such as the native wheat grasses, needle-and-thread or western porcupine grass requires a minimum 50 gram sample size. Small seed species such as June grass require a minimum sample size of 10 grams.

- It may be necessary to contract a wild harvest of key species such as needle-and-thread grass, western porcupine grass or plains rough fescue to ensure an adequate supply for the project. Reputable and experienced companies are listed on both the Foothills Restoration Forum and Alberta Native Plant Council websites. Specify the ecological range sites from which the material should be harvested (i.e. Blowouts vs Loamy vs Sands and/or Choppy Sandhills). Obtain, review, approve and retain on file Certificates of Seed Analysis for each species harvested.

- When ordering native plant cultivars, order varieties produced specifically for the Mixedgrass by reputable research institutions such as the Alberta Research Council (now referred to as Alberta Innovates.) Consider forward contracting to ensure an adequate supply of appropriate species.

- Specify source identified seed grown within the Mixedgrass or the Mixedgrass Ecoregion of Saskatchewan. Purchase only from seed suppliers that can provide the necessary quality assurance. Obtain, review, approve and retain on file Certificates of Seed Analysis for each species.

- When ordering seed as well as the common name, include the scientific nomenclature and cultivar/variety or ecovar if applicable.

- There is zero tolerance of seed lots containing Restricted Noxious Weeds, Noxious Weeds such as downy brome, Japanese brome, and invasive agronomic species such as crested wheat grass, smooth brome, or Kentucky bluegrass (*Poa pratensis*) in the Mixedgrass. Seed lots containing quack grass (*Agropyron repens*) or foxtail barley (*Hordeum jubatum*) should also be rejected.

- Be aware that some private landowners and specifically certified organic producers will have specific requirements and specifications for seed mixes and weed control.

- Examples of Certificate of Seed Analysis and an explanation of interpretation are included in Appendix C.

Guidelines for Wild Harvested Native Plant Material

In order to obtain the plant material for the key dominant species required for restoration projects in the Mixedgrass, the material will have to be obtained through a process known as "wild harvesting". Wild harvesting should only be considered on sites that are in healthy range condition, free of Prohibited Noxious and Noxious weeds and invasive non-native agronomic species such as crested wheat grass, smooth brome, Kentucky bluegrass and sweet clover.

1. ***Use of specially designed equipment that harvests only the seed from the stems of select species*** such as needle-and-thread, western porcupine grass, June grass, blue grama grass, or plains rough fescue. The target species must be in the mature seed set stage. Care must be taken to ensure the collected seed is allowed to dry and cure following the harvest. The seed is then either spread directly on the area to be restored or sent away to be cleaned and marketed as a single species.
2. ***Wild harvested seed collection for field propagation and production.*** This could include field propagation of species such as needle-and-thread similar to the Ducks Unlimited Ecovar program or the Alberta Innovates (formerly Alberta Research Council) source identified program for ultimate commercial sale.
3. ***Seed collection of specific native grasses and forbs for nursery propagation of live plant material.*** The purpose is to install islands of live plant material that will create a seed source within the disturbed area.
4. ***A non-selective method is wild harvested hay.*** Specialized equipment is required. This method collects all species in seed at the time of cutting, and possibly early or prior-year seeds if ground litter is collected. Normally the hay is chopped and applied as mulch to the disturbance the same day it is harvested. The hay mulch is lightly crimped or harrowed and left on the surface.

The products of wild harvesting provide valued goods and services to the landowner or land manager. There may be a cost associated with obtaining wild harvest native plant materials. Negotiations to obtain permission should be conducted well in advance of the timeframe for the harvest.

Guidelines for Wild Harvesting Native Seed

The following guidelines have been established for wild harvesting on Public Lands. It is recommended that these guidelines be implemented when harvesting on private lands. Consult other jurisdictions such as First Nations Band Councils to determine if other guidelines are in place and/or if permits are required.

1. Obtain written consent from the grazing leaseholder for the area where seed harvesting is planned.
2. Only healthy range sites will be selected for seed harvest that are free of Prohibited Noxious, Noxious and invasive non-native species such as crested wheat grass, smooth brome and sweet clover.
3. The ESRD Range Agrologist responsible for the selected area must be notified to obtain approval for the site. A detailed sketch of the proposed location of the harvest must be provided. A Letter of Authority will be issued by the Range Agrologist to authorize the harvest.
4. Seed harvesting will be done using an alternating strip approach such that only half of the area is harvested.
5. Seed harvesting will not occur on the same site for a period of 7-10 years following the harvest (depending on climate and range health conditions).

Wild Harvest of Native Grass Seed

Alternating Rows to Conserve Seed on the Site

Separating Seeds

Drying Harvested Seeds

Seed Bagged and Ready for Storage

Guidelines for Harvesting Native Hay Mulch

Follow the guidelines for Collecting Wild Harvested Seed for site access permissions and site selection. Additional guidelines pertain to native hay cutting.

1. Native harvesters vary from small mowers that cut and collect native hay to larger modified combines, all equipped with specialized blades to handle hard native grasses. If a mower/collector is used, timing is essential as dominant grasses must have seeded. Some modified harvesters include a vacuum, which collects surface litter including seeds from earlier in the season or the previous year, in which case timing is less essential.
2. Native grassland should be cut in strips, leaving uncut strips to act as a seed rain source for the cut areas.
3. The amount of native grassland required for harvesting varies with Natural Subregions. In drier Mixedgrass NSR areas where needle-and-thread and blue grama dominate, the harvest area should be approximately 3 times the disturbance area. This includes sufficient area for un-cut strips. In moister rough fescue-dominant areas, roughly 2.5 times the disturbance area may suffice.
4. If the area is grazed, it is recommended grazing be suspended until after harvesting. Ideally, grazing should continue the following year, after the cut areas have had a chance to recover.
5. Native hay mulch harvesting will not occur on the same site for a period of 7-10 years following the harvest (depending on climate and range health conditions).
6. Wild harvested hay may be cut with a variety of equipment.

Finally, wild harvested native plant material is a precious resource. Before harvesting make sure there is a specific need and/or market for the material.

Never take more than is required to meet the need and ensure careful handling and storage of the plant material.

Wild Hay Harvester; mows and collects Native Hay

Wild Harvested Hay Spread on Pipeline RoW

Minimal Disturbance to Ground Cover

8 MAINTAINING THE PATHWAY

Most restoration projects will require a monitoring and adaptive management program for the first five growing seasons

Most restoration projects will require a monitoring and adaptive management program for the first five growing seasons. Notice that funds will need to be secured for this program early in the planning phase. The program should incorporate all of the relevant pre-disturbance site assessment information, details of the restoration plan, and documentation of specific issues encountered during the implementation of the plan. This information forms the basis of the program and facilitates the preparation of a work plan and budget.

Control of Restricted Noxious and Noxious weeds is required under the Alberta Weed Control Act (Province of Alberta 2010A). There are exceptions depending on the nature of the invader and target community. Compromises are usually required. Weed and invasive plant management is a specialized area of expertise and requires a Commercial Pesticide Applicator's license. Contractors hired should be familiar with the 2010 Reclamation Criteria for Native Grasslands, and the desired long-term outcome of native grassland restoration. Control of specific weed species at identified locations by spot spraying is preferred over a wide spectrum or broad application of herbicides. This approach will improve the chances for native forbs to establish and encourage the restoration of the plant community.

On private lands discuss invasive plant management with the landowner. Be aware that certified organic producers will have specific requirements and specifications for weed control.

Quite often there will be a flush of annual weeds and native forb species during the first couple of growing seasons following soil disturbance. This is a normal occurrence and should not cause concern. These species provide the "scab" that promotes the healing process by stabilizing the soil and retaining moisture. Where necessary, mowing annual weeds prior to seed set can reduce the competition for available soil moisture, reduce weed seed set and enhance seedling survival of desired species. However, where a lot of weed biomass is present (often the situation when mowing is desirable), care should be taken to either limit mowing height and just remove seed heads, or rake or swath/bale weeds to remove biomass.

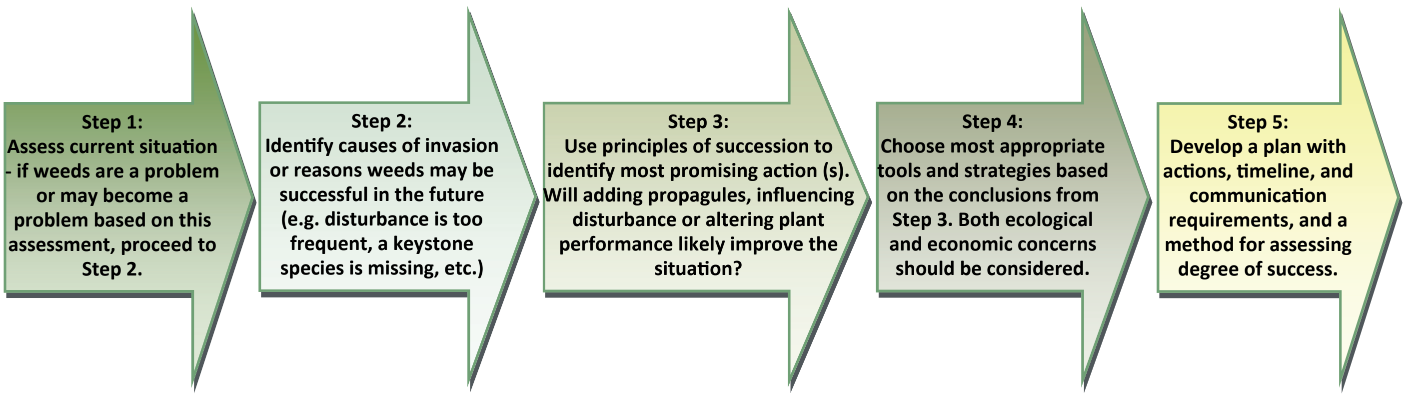
An Integrated Management Plan (IMP) to vegetation management is often the most successful and cost effective. Maintaining a database of areas where vegetation management is required and evaluating the success of the control methods implemented are important steps in a successful vegetation management program.

Ecologically Based Invasive Plant Management (EBIPM)

The December 2012 issue of Rangelands (Volume 34, Issue 6) is a special issue dedicated to a weed management system termed Ecologically Based Invasive Plant Management (EBIPM). EBIPM (www.EBIPM.org) is an approach to rangeland invasive plant management which applies scientific principles and management experiences in a step by step plan (Figure 15).

Figure 15 - The Step-by-Step Process of EBIPM from Rangelands

(Volume 34, Issue 6) (Svejcar and Boyd 2012)



Prior to applying EBIPM, it is important to understand the history of the area, especially locating and evaluating historical cultivation. Cultivation has been practiced in southern Alberta since the 1880's, with several million cultivated acres in the Mixedgrass NSR being abandoned following the drought and depression of the 1930's. Long-term effects of cultivation include soil compaction, reduced native seedbanks, and changes in soil nutrients and fertility, all potential causes of invasive plant succession. Knowing if an area has been cultivated will help identify causes of plant community change and which ecological processes are in need of repair.

Step 1: Assess the Current Situation

The Alberta Invasive Plant Council is an important source of information regarding new weeds of concern and methods of control. Their website is located at: http://www.invasiveplants.ab.ca/. The Association of Agricultural Fieldmen located at http://www1.agric.gov.ab.ca can direct you to the fieldman responsible for your project area. Incorporating their local knowledge of weeds of concern and effective methods of control is very useful in vegetation management planning. Also look south of the border to our neighbours in the United States. The USDA Agricultural Research Service has conducted considerable research in the field of vegetation management. A recent publication entitled *Revegetation Guidelines for the Great Basin: Considering Invasive Weeds* (Sheley et al. 2008) is a valuable source of information relevant to the Mixedgrass NSR of Alberta.

The Noxious Weeds section of the Rangeland Health Assessment, found at http://srd.alberta.ca/LandsForests/GrazingRangeManagement/RangeHealth.aspx, is a useful tool for identifying, not only noxious weeds, but also invasive plants. By applying the Density Distribution guide, you will be able to determine the extent of invasion and start planning the management process.

- Weed Score 2 or 3 – no or light infestation – no control required, or prevention if possible invasion from adjacent areas.
- Weed Score 1 – moderate infestation with some desired plants – control infestation and increase desired species – proceed to Step 2.
- Weed score 0 – heavy infestation without desired species – revegetation or restoration – proceed to Step 2.

Step 2: Identify Causes of Invasion or Reasons Invasive Plants May Be Successful in the Future

Treating invasive plants is often really only treating a symptom. Three ecological processes cause changes in plant communities and influence success of desired and invasive plants: site availability, species availability, and species performance.

Site availability is a disturbance that causes a pronounced change in an ecosystem and encourages invasive plants.

- Large-scale disturbances favour establishment of undesirable plants.
- Smaller-scale disturbances spread over time will be less likely to promote growth of invasive plants.
- Legacies of historical cultivation, which can last for decades to centuries, may affect site availability.

Species availability – presence or absence of viable invasive plant propagules brought in by external dispersal or present in the disturbed soil seedbank.

- Disturbances surrounded by native grassland will be less likely to be invaded than those adjacent to areas dominated by invasive plants, e.g. crested wheat grass.
- Disturbances in areas seeded or infested by invasive species in the past, may have those seeds in the seedbank, some lasting for many years, e.g. Kentucky bluegrass.

Species performance – how well invasive plants grow in disturbed environment conditions.

- Most invasive plants require more fertile or moist soil characteristics than native grasses. For example, smooth brome will thrive close to riparian areas.
- Special attention must be paid to areas that might promote the growth of invasive plants while waiting for ideal germination conditions i.e. soil disturbance exposes buried seeds.

Step 3 : Use Principles of Succession to Identify the Most Promising Actions

When invasive plant performance is controlled through herbicides, biological control, mowing, or other methods, niches are opened in the plant community allowing for native plant infill or for further weed invasion. Refer to section 4 for more information on succession processes. Use Figure 9 to determine the current stage of the invasive plant community.

Step 4: Choose the Most Appropriate Tools and Strategies Based on the Conclusions from Step 3

Invasive plants found in the Mixedgrass are identified in Table 3. The use of a particular management tool for control of invasive plants often depends on the life cycle of the target invasive plant or plants, as well as the life cycle of the desirable plants within the community.

- Livestock grazing can be one of the most useful tools to keep rangelands in good condition and maintain optimum production. Livestock remove litter, recycle nutrients, stimulate tillering of perennial grasses, and reduce seedbanks of competitive annual plants. Targeted grazing is an effective tool for invasive plant control, especially if managers exploit differences in plant phenologies, for example invasive plants may be more susceptible to grazing when green and when perennial grasses are brown and dormant. Table 3 indicates whether cattle grazing is an option for control. Browsers, including sheep and goats, will eat many weeds. Goats and sheep can digest toxins in weed plants that cows cannot. Goats are being used to manage toadflax in Alberta. Sheep are being used to control leafy spurge in the Porcupine Hills. This practice will increase in use in the future to control weeds and in some cases to control shrub growth (e.g. on ski hill runs). A good reference for toxicity of some plants for all livestock species is "*Stock-poisoning Plants of Western Canada*" (Majak et al. 2008).

- Applying herbicides is a common strategy to control invasive species, especially for perennial weeds, and may require repeated application over a long-term control time. Biennial weed species are best controlled before flowering stage of mature plants and also again in the fall to control rosettes of new growth (summer and fall spraying in 1 year). Alberta Agriculture provides information on all registered herbicides for the species in Table 3 at: http://www.agric.gov.ab.ca/app23/herbsel

- Mowing is effective for annual species, if done prior to seed setting. If infestations are low, hand pulling of taprooted species or spot herbicide applications may be effective.

Table 3– Invasive Plants Found in the Mixedgrass NSR with Grazing Responses

Common Name	Scientific Name	Growth Habit	Grazing Option
Forbs			
absinth wormwood	*Artemisia absinthium*	perennial, stems root	Poor – low forage value
clover, alsike	*Trifolium hybridum*	perennial, taproot	Good
clover, sweet	*Melilotus officinalis*	biennial, taproot	Spring grazing
Canada thistle	*Cirsium arvense* (noxious)	perennial, deep rhizomes	Poor – cattle avoidance
dandelion	*Taraxacum officinale*	perennial, taproot	Fair
goatsbeard	*Tragopogon dubius*	perennial, taproot	Fair
mayweed, pineapple weed	*Matricaria discoidea*	perennial, rhizomes	Poor – low forage value
leafy spurge	*Euphorbia esula (noxious)*	perennial, deep rhizomes	Poor – toxic to livestock
yellow toadflax	*Linaria vulgaris* (noxious)	perennial, rhizomes	Poor – cattle avoidance
Grasses			
barley, foxtail or wild	*Hordeum jubatum*	perennial, tufted	Poor – cattle avoidance
brome, downy	*Bromus tectorum (noxious)*	annual, tufted	Poor – injurious to cattle
brome, Japanese or chess	*Bromus japonicus (noxious)*	annual, tufted	Poor – injurious to cattle
brome, smooth	*Bromus inermis*	perennial, rhizomes	Good – very palatable
Kentucky bluegrass	*Poa pratensis*	perennial, rhizomes	Good – spring grazing
Russian wild rye	*Elymus junceus*	perennial, tufted, deep root	Good

Step 5: Develop a Plan with Actions, Timeline, and Communication Requirements, and a Method for Assessing the Degree of Success

An adaptive management cycle using the EBIPM framework is required to successfully manage invasive plants.

- Set measurable goals and objectives with the information obtained in Steps 1 to 4.
- Collect information on the proposed site and treatments on sites with similar climate, soils, and potential plant community to allow treatment alternatives design.
- Develop the adaptive management plan, defining the scale of the treatments, replication of sampling, study plot sizes, proper location of control areas, and protocols for data collection.
- Seek stakeholder input and incorporate stakeholder concerns.
- Adjust the plan to incorporate stakeholder comments. Widespread support for a management plan is key to its success.
- Implement the management plan, including a long-term perspective. The plan should be conducted for several years to be successful.
- Collect and analyse monitoring data, rigorously on a regular basis for several years.
- Draw conclusions. If vegetation passes the 2010 Reclamation Criteria (Alberta Environment 2011) apply for a Reclamation Certificate. If not, update the plan.

These steps should be repeated with each cycle, ultimately improving management, until the reclamation criteria are fulfilled.

Grazing Management

Native grasslands have evolved in association with grazing animals. Today, fences contain and restrict grazing animals and this factor must be considered in restoration planning. Consider the following guidelines.

- Early consultation with the landowner or leaseholder is important. Grazing management plans implemented to enhance recovery of industrial disturbances should incorporate local knowledge, be designed in consensus with the rancher and be well documented regarding the responsibilities of both parties, including who is responsible for removing fencing.
- Use the Range Health Assessment protocol and consultation with land manager to determine when temporary fencing might be appropriate (Adams et al. 2009). Restoration sites located in fields with unhealthy range health scores will require temporary fencing.
- Interim reclamation sites where topsoil resources have been stripped and stored may require fencing until vegetation is re-established. Once established the fencing should be removed.
- Industrial soil disturbances located in pastures rated as "healthy with problems" may require temporary fencing depending on which factors are affecting the range health scores. Also the timing and duration of grazing will need to be factored into the decision.
- The size and type of disturbance also determines the requirement for fencing. For example, reclaimed wellsites with more than 25% disturbance may require fencing. This will allow seeded areas at least one growing season for seed to germinate and establish a root system before grazing is allowed. If possible, allow the newly established plants a second year to set seed (usually by mid-summer) prior to removing the fence. This recommendation will result in livestock trampling a portion of the seed into the upper soil surface to further enhance infilling.
- Fencing can also restrict the movement and distribution of livestock and wildlife within the pasture surrounding the industrial development. Ensuring access to water is a primary concern. The physical presence of the fence may take quite a while for the animals to get used to, particularly when used on large diameter pipeline rights-of-way. Additional disturbance to the soils adjacent to the fencing has been observed as the animals try and find a way around the fencing. Salt and minerals can be used to lure animals away from the fencing and alter dispersal patterns.

- Ensure the temporary fencing is monitored and maintained. Maintenance is not the landowner's responsibility. Budget for maintenance.
- Ensure temporary fencing is removed when the plant community has reached the target and litter is at optimum rates for the Mixedgrass (figure 7, page 36 of the Range Health Assessment Field Workbook); (Adams et al. 2009). Fencing can have a negative effect on recovery if left in place too long. An excessive build-up of litter on the soil alters moisture conditions and reduces seed infiltration, which can negatively influence the process of plant community succession. Make certain there are adequate funds allocated for fence removal.

Fences Are Often Left Too Long

Fenced Remote Sump Site in Majorville Area: seeded native cultivars have become lodged, extensive litter buildup has altered surface moisture, and native encroachment is not occurring.

Monitoring Recovery

The purpose of monitoring is two-fold. In the first few years after disturbance, monitoring is a component of an adaptive management approach to maintaining a site to ensure that erosion, invasive species or grazing concerns do not inhibit revegetation by desirable species. In the long-term, monitoring is required to demonstrate a positive trajectory towards plant communities present prior to disturbance or towards a target native plant community. Reclaimed sites that are not monitored or managed can quickly deteriorate resulting in costly measures required to mitigate problems. Establishing a standardized method of monitoring industrial restoration projects and evaluating restoration success is required to allow us to communicate progress to stakeholders with increased confidence. Standardized methods will also assist in defining areas where improvement in the methods and strategies used are required. Monitoring should be approached with an adaptive management plan, incorporating goals for expected recovery with recurring monitoring. The following adaptive management plan guide is adapted from what Sheley et al. (2009) described in the December 2012 issue of Rangelands.

Reclaimed sites that are not monitored or managed can quickly deteriorate resulting in costly mitigation

Set Measurable Goals and Objectives

- The goal for restoration of native rangelands is to re-establish mature native plant communities on a disturbance that are suited to the ecological range site and equivalent in composition, structure and successional stage to the surrounding native grassland. The process of recovery evolves over time through initial establishment through several successional stages as ecosystem processes re-develop and species composition and structure matures (Kestrel Research Inc. and Gramineae Services Ltd. 2011).

- The 2010 Reclamation Criteria for Wellsites and Associated Facilities for Native Grassland (Alberta Environment 2011) provide established methods that can be used as a baseline for monitoring and targets for defining successful recovery.

- Collect information for the reclamation site such as climate, soils, and the potential plant community to help establish recovery targets and timeframes.

- Refer to the Mixedgrass Natural Subregion Range Plant Community Guide (Adams et al. 2013) to determine what the potential plant communities might be. http://srd.alberta.ca/LandsForests/GrazingRangeManagement/RangePlantCommunityGuidesStockingRates.aspx

- Alberta climate information is available at AgroClimatic Information Service (ACIS), providing historical Alberta Climate Maps and Alberta Weather Station Data and Graphs. You should be able to find weather stations in the vicinity of your sites. Tracking precipitation and temperature for the duration of monitoring will provide important information about potential and actual recovery success. http://agriculture.alberta.ca/acis/

- The timeframe for recovery will vary depending on the size of the disturbance, recovery strategy used and site specific conditions of the ecological range site where disturbance has occurred (climate, presence of invasive species, grazing pressure and range health). For example, if the surrounding area has a low range health score, the proposed site has a sensitive species such as rough fescue, or it is located in a moist/loamy range site, recovery may be slow (e.g. 15-20 years for rough fescue communities). Patience is required to allow natural successional processes to take place.

Establish a Monitoring and Adaptive Management Plan

Establishing Permanent Monitoring Sites

- Key to the reclamation criteria is establishing permanent monitoring sites that compare the recovering disturbed site with adjacent undisturbed control sites. Information collected over time from these sites can be used to adjust treatments, as required.
- Define replication of sampling, study plot sizes, proper location of control areas, and protocols for data collection.
- Establish the survey locations on lease and access and corresponding control points early in the establishment phase to assist the process of reclamation certification. Establish permanent photo reference points to capture the progress of restoration over time.
- Establish survey locations on pipelines to monitor the progress of restoration over time. Ensure that monitoring will include the diversity of different recovery strategies used for soil disturbances.
- Establish the frequency of monitoring events to allow timely and effective adaptive management and to track the process of succession towards the Target Recovering Plant Community over time.

Seek Stakeholder Input and Incorporate Stakeholder Concerns

- Stakeholders may include provincial land managers, ranchers, and non-government organization (NGO) representatives.
- Adjust the plan to incorporate stakeholder comments. Widespread support for a management plan is key to its success.
- Education of stakeholders may be required, especially to establish reasonable expectations regarding the expected timeframe of recovery.
- Communication with land managers and ranchers is paramount. Techniques such as timing of development activity, fencing and grazing rotation can be utilized to facilitate reclamation.

Collect and Analyse Monitoring Data

Assessing Recovery

The timeframe for recovery will vary depending on the size and age of the disturbance, the recovery strategy used and the site specific conditions of the ecological range site where disturbance has occurred (climate, presence of invasive species, grazing pressure and range health). Patience is required to allow natural successional processes to take place.

- The timeframe for recovery of key indicator species is variable and dependent on a number of interrelated factors. If plains rough fescue, a late seral species, is part of the target plant community, be aware that it is slow growing and susceptible to competition from faster growing species. It may require three to five years for seedlings to become established. Western porcupine grass may not appear until the early to mid-seral successional stage (Kestrel Research Inc. and Gramineae Services Ltd. 2011), but once germinated, it establishes quickly.
- It is not possible to estimate an accurate timeframe at this time. Drier areas of the Mixedgrass, dominated by needle-and-thread and blue grama, may recover similarly to the Dry Mixedgrass NSR. Observations made on Express pipeline indicate that in the Dry Mixedgrass a minimum of 3 years is required to establish a pioneer community on both seeded and unseeded sites. Recovery to a mid-seral plant community was as little as 3 and up to 14 years (Kestrel Research Inc. and Gramineae Services Ltd. 2011).
- Moister areas, such as those dominated by plains rough fescue, may recover more slowly. Assessments of pipelines in the Cypress Hills (Lancaster et al. 2012) concluded recovery to a late seral plant community required 10 to 12 years for relatively narrow, short term disturbances.

General Monitoring Guidelines

- The 2010 Reclamation Criteria for Wellsites and Associated Facilities for Native Grassland (Alberta Environment 2011) describe how to partition the disturbance for assessment, based on the disturbance size.
- Site visits should be targeted to efficiently gather the information needed to support an adaptive management plan. For example the number of site visits during the first two growing seasons may depend on the invasive non-native plant risk factor.
- Completing Rangeland Health Assessments at the established off site controls and onsite monitoring sites, using the standardized methods developed by ESRD, can determine if the disturbed site is on a positive successional pathway.

Monitoring in Years 1-3

- In the first years when seedlings are tiny, determining percent foliar cover of each species is not that important. Instead assess species composition and how it changes over time.
- Delineate a ¼ m^2 and count the young plants. Do this 10 times over the assessment area and average the count. Compare the plants to your seed mix. Low counts may require re-seeding (Hecker and Neufeld 2006). However, bare ground is normal in the first three years, allowing infill of native species from surrounding undisturbed areas.
- Perform Range Health Assessments within the first three growing seasons to identify possible problems on the disturbance that require remedial reclamation such as weed or non-native species issues (see EBIPM Section), soils or erosion issues.

Adaptive Management in Years 1-3

- Fencing to prevent grazing may be used in the first 1 to 3 years to allow plant germination and establishment (see Grazing Management Section).
- A flush of annual weeds and native forb species during the first couple of growing seasons following soil disturbance is normal. These species provide microclimate niches for small grasses, such as June grass, which may be sheltered by annual weeds until they become established. Spraying these so-called weedy species and re-seeding the site may promote aggressive colonizers and reduce the potential for native species infill. If infestations of annual weeds are heavy, mowing before seed set can be used to reduce competition while retaining the erosion mitigation they provide.
- Noxious weeds must be removed, by hand-picking or spot spraying herbicide application (see EBIPM Section).
- The longer the problems are allowed to go unattended the more difficult and costly it will be to achieve successful restoration.

Monitoring after Year 3

- Later as vegetation becomes established (years three and later) estimating the foliar cover that each species contributes to the plant community, and estimating the amount of bare soil becomes important as the recovering plant community matures.
- Delineate a ¼ m^2 area in a representative part of the restoration and estimate how much ground is being covered by the vegetative canopy. Identify which species were seeded to judge the success of the seed mix. For accurate results, sample ten replicate frames for an average (Hecker and Neufeld 2006). For sites with high species diversity, building a species area curve[6] will determine how many frames are sufficient to document the number of species on a site.
- Check vertical structure and plant layers, e.g. are there short, mid, and tall plants, bunch type plants and mat-like plants, and compare this to the expected plant community. This procedure is part of the range health assessment and reclamation criteria, which should be done at each monitoring site, both on the disturbance and the reference area.
- If vegetation cover complies with the 2010 Reclamation Criteria (Alberta Environment 2011), you may be able to apply for a Reclamation certificate. If not, continue with the Adaptive Management Plan.

Adaptive Management after Year 3

- Litter may start to build up, especially if the area has been fenced for too long a period. If necessary, mow or rake the excess litter and haul away grass thatch to simulate grazing and open up bare ground for grass seedlings to emerge and infill to occur.
- If most species are well established, remove fences and allow controlled grazing.
- Noxious weeds must be removed, by hand-picking or spot spraying herbicide application (see EBIPM Section).

[6]Species Area Curve – a plot of species number (x axis) versus sample area (y axis). Sufficient sampling to assess species diversity is the area at which the steeply increasing curve becomes almost horizontal (Mueller-Dombois and Ellenberg 2002).

Draw Conclusions and Update the Plan

- If vegetation passes the 2010 Reclamation Criteria (Alberta Environment 2011) apply for a Reclamation Certificate. If not, update the plan.
- These steps should be repeated with each cycle, ultimately improving management, until the reclamation criteria are fulfilled.
- Document the monitoring and maintenance program. Share successes and failures with colleagues through organizations such as the Canada Land Reclamation Association and the Foothills Restoration Forum.

The 2010 Reclamation Criteria – Native Grasslands (Alberta Environment 2011) shifts the focus from reclamation to restoration. As wellsites and associated facilities are assessed with the criteria our knowledge of the most successful recovery strategies on a site specific basis will increase.

9 THE IMPORTANCE OF LONG-TERM MONITORING

To conserve what remains of native prairie for future generations, recovery practices in native prairie landscapes must continue to be improved. In the past, equivalent land capability focused on salvaging soil. Today, equivalent land capability includes restoration of native plant communities in native rangeland. The focus must shift from reclamation to restoration.

There is very little information available on the long-term efficacy of various native grassland reclamation and recovery techniques in the Natural Subregions of Alberta. Long-term monitoring is needed to contribute to our understanding of whether restoration of native vegetation communities is possible, and if so, in what situations and over what timeframe. Additional data is required to fully understand and recognize native plant community successional pathways following industrial disturbance. Monitoring provides the opportunity to reflect on construction and reclamation procedures used in the past and make informed choices that will improve future restoration potential.

Valuable components of extended timeframe monitoring are as follows.

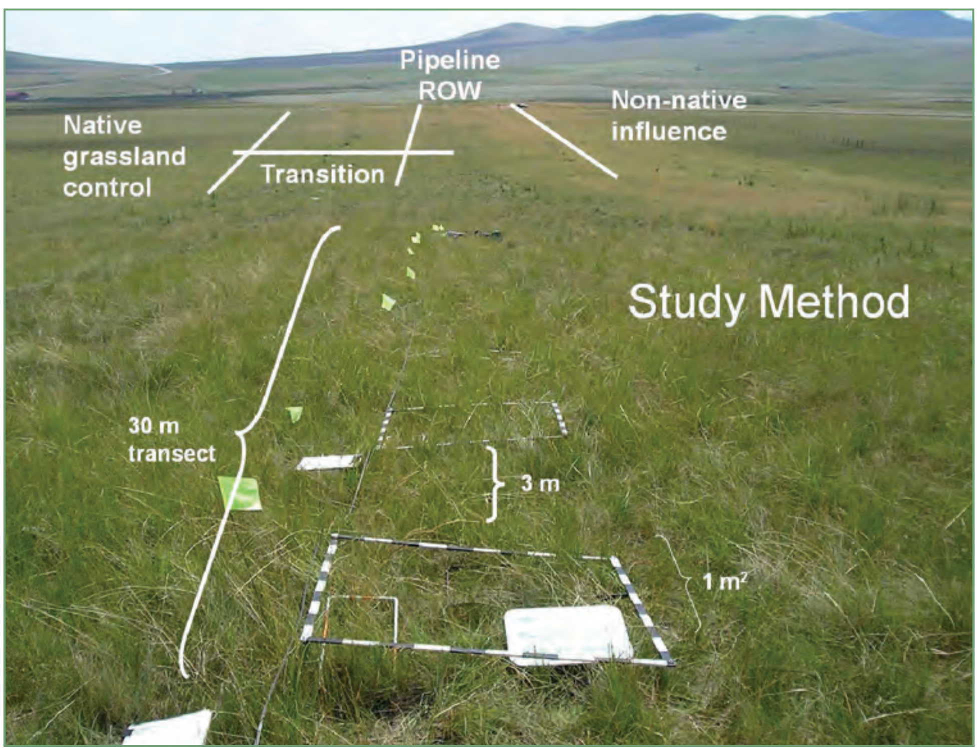
- Document construction, reclamation and reclamation maintenance procedures.
- Use standardized methods of data collection so results are comparable between projects. ESRD MF5 Range Survey Manual procedures and forms (ASRD 2007) provide a recognized method and easily transferrable data format that can be collected in the ESRD database.
- Repeat monitoring several times (e.g. years 3, 5, 7, 10, 15, 20) with enough time between monitoring events to allow successional shifts in structure, function and species composition to occur.
- Share the data with the Rangeland Management Branch of ESRD.
- Publish findings in journals and/or on publically accessible websites such as the Foothills Restoration Forum.

Monitoring provides the opportunity to reflect on construction and reclamation procedures used in the past and make informed choices that will improve future restoration potential.

Following are examples of some key learnings from recent case studies and research. These results provide direction for next steps.

- The results of the Express monitoring project 14 years after construction indicated that significant changes in the composition of recovering plant communities may occur after the first five years of reclamation both in positive and negative directions. Components of seed mixes performed differently over time, with some cultivars resulting in negative trajectories that will not achieve restoration. Ordinations of monitoring data collected over a series of year (1,2,3,5, and 14 years post -construction) were used to develop definitions of successional stages of recovering plant communities on disturbed topsoil (Kestrel Research Inc. and Gramineae Services Ltd. 2011).
- The Cypress and Majorville monitoring projects demonstrated the successful use of natural recovery and assisted natural recovery in healthy Mixedgrass rangelands to restore pipeline disturbances (Lancaster et al. 2012).
- Seeding experiments in Central Alberta indicate that seeding plains rough fescue as a monoculture resulted in better diversity on the site over time than seeding plains rough fescue with aggressive species, such as wheat grasses, in the seed mix (Desserud and Naeth 2013).

Reclamation practitioners, industry, regulators and scientists can all help further the knowledge base of tools and techniques to conserve and recover native grasslands. It is necessary to continue to develop best management practices and appropriate revegetation strategies for industrial disturbances in native prairie to promote industry stewardship on increasingly pressured prairie landscapes.



Reclamation and Monitoring Research

10 FUTURE RESEARCH REQUIRED

Stakeholder workshops were held during the preparation of this manual. Participants included experienced representatives involved in industrial development and reclamation of native prairie, the Mixedgrass ranching community, the native seed industry, conservation organizations and Government of Alberta regulatory authorities. One of the key issues discussed was the need for future research to improve restoration potential and expected outcomes for industrial disturbances in Mixedgrass prairie. We need to encourage and promote applied, ongoing, and coordinated research with the objective to catalogue and document trajectory of plant succession following disturbance over time. With a view to updating this document with a new approximation every 5 years, the Recovery Strategies Project is interested in receiving any results and ideas for new questions. Research priorities proposed by the stakeholders include the following.

- Does uneven distribution of replaced topsoil on a disturbance promote more species diversity?
- If grazing is used as a tool to promote restoration how can the stocking rate, timing and duration for grazing be determined on a site and issue specific basis?
- What is the effect of soil disturbance on soil microbes?
- What are the methods to stimulate seed production in healthy areas surrounding disturbance?
- Further study on the successful use of wild harvested hay to revegetate topsoil disturbances is required, including an assessment of infill. Development of guidelines is needed to ensure recovery of harvested areas. The potential for centrally located designated areas to supply native hay should be investigated.
- What role does soil compaction play in the recovery of unstripped minimal disturbance sites? Sites where soil compaction has taken place should be monitored and research questions defined. The Mixedgrass NSR is prone to Chinooks and poses increased risk for rutting and compaction of soils during winter construction and development activities. Mixedgrass loamy soils are more at risk than soils in the Dry Mixedgrass.
- What are the long-term ecological impacts of invasive species on linear and non-linear disturbances?
- What practices are available to remediate the impacts of invasive agronomic species?
- More monitoring and research is required to define appropriate seeding rates for sites that require seeding. More applied research in documenting native plant community succession over time is warranted.
- A system needs to be developed to set benchmarks to measure successful recovery or restoration.
- A system needs to be developed to capture reclamation monitoring and assessment data so others can access it in the future.
- What are the best methods to manage downy brome including: herbicidal products, alternatives to chemical treatment and the timing of chemical application or alternative treatments?

* What are the effects of soil disturbance on mycorrhizal populations and does inoculating disturbances improve restoration potential?
* What is the role of early colonizers in perennial establishment?
* What role do forbs play in plant community succession?
* Further research and monitoring is needed regarding the value of the two-lift stripping procedure to native plant community restoration.
* What is the success rate of planting of wild harvested native grasses without processing them first? An example would be marsh reed grass (*Calamagrostis canadensis),* which has very light seed and is very difficult to clean.
* How effective is planting nursery propagated native plant material (rooted seedlings) to introduce hard to establish species (e.g., shrubs, forbs) or, to establish native species on difficult sites (steep terrain, exposed areas, xeric sites)?
* What is the function of the awn and how can damage to the seed be reduced during processing to remove the awn, which can damage up to 50% of the seed, increasing the cost. We need to understand the function of the awn. Consider what are effective methods of applying seed mulch? Example, needle -and-thread grass, problem with awn, seeds fluffy, how to apply rather than clean it, seed mulch?

Needle-and-thread grass (Stipa comata)

Recovery Strategies Feedback

The creative process in the evolution of this manual has been a collaborative effort since the idea was conceived. We welcome comments and feedback as we continue with Revegetation Strategies for all the Natural Subregions and look forward to future research and technology that will yield a need for the Second Approximation of the Revegetation Strategies for the Mixedgrass Natural Subregion of Alberta.

If you have any questions, comments or require further information regarding the manual we can be contacted via the Foothills Restoration Forum website at: http://www.foothillsrestorationforum.ca/

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Appendix A Glossary of Terms

Blowouts: Ecological range sites with eroded surface pits reflecting the presence of abundant Solonetzic (hard pan) soils.

Chernozemic: Dominated by the accumulation of organic matter from the decomposition of grasses and forbs, typically of Grassland plant communities. Chernozemic soils have normal development of soil horizons (A, B, C) and the topsoil (Ah, Ap) is more than 10 cm thick.

Choppy Sandhills: Ecological range sites characterized by loamy sand and sand soils with a duned land surface.

Clayey: Ecological range sites with clayey textured soils including: silty clay, sandy clay, clay and heavy clay. Generally >40% clay.

Climax: The final or stable biotic community in a successional series; it is self perpetuating and in equilibrium with the physical habitat.

Cultivar: A plant variety which has undergone genetic restrictions through selection by plant breeders, and which has been registered by a certifying agency. **Native plant cultivars** in this report refer to cultivars produced from native grass species.

Decreaser: Highly productive, palatable plants that are dominant species in reference plant communities. They decrease in relative abundance as grazing pressure or disturbance related activity increases.

Ecodistricts: Geographic subdivisions of land based on distinct physiographic and/or geologic patterns. They are distinguished by similar patterns of relief, geology, geomorphology and genesis of parent material.

Ecological Range Site: A distinctive kind of land with specific physical characteristics that differs from other kinds of land in its ability to produce a distinctive kind and amount of vegetation. In a grassland environment, **range site** refers to a broader description of soil and landscape (e.g. loamy, clayey, sandy, choppy sand hills etc.), that might be further subdivided into ecological sites due to differences in plant community potential.

Ecological status: The degree of similarity between the present plant community and the **reference plant community**.

Ecovar: The offspring of native species that have been selected for their ability to survive and reproduce in specific ecological regions. Selection is done without emphasis on improving agronomic characteristics. Ecovars have greater genetic diversity than cultivars.

Equivalent Land Capability: The ability of the land to support various land uses after reclamation is similar to the ability that existed prior to any activity being conducted on the land, but the ability to support individual land uses will not necessarily be equal after reclamation. (Regulatory definition)

Forb: Primarily broad-leaved flowering plants with net-like veins. For the purpose of simplifying identification, the category can be broadened to include those parallel-veined plants with brightly colored flowers such as orchids or lilies.

Graminoid: Plants which have hollow, jointed stems and leaves in two rows (ranks). Flowers are usually perfect with seeds borne between two scales (palea and lemma). Commonly referred to as grasses and includes sedges.

Gravel: Ecological range sites dominated by gravels or cobbles (>50% coarse fragments). May be covered by a mantle with few gravels, up to 20 cm thick.

Grazing response: How the various kinds of plants on the range react when they are grazed. This may vary with soil and climate for any one species. Range plants are grouped as follows:

> **Grazing Response – Type 1 Species (Decreasers):** Species that decrease in relative abundance as disturbance increases. They tend to be palatable to grazing animals and are the dominant species in the reference plant community (climax vegetation). Highly productive, palatable plants that grow in the original climax vegetation stand. They are palatable to livestock, and will decrease on a range when exposed to heavy grazing pressures.
>
> **Grazing Response – Type 2 Species (Increaser – Type 1):** Species that normally increase in relative abundance as the decreasers decline. They are commonly shorter, less productive species and more resistant to grazing and other disturbances. Type 1 increaser species increase at first but may decrease later as grazing or other disturbance pressures continue to increase. The increaser plants are normally shorter, lower producing and less palatable to livestock.
>
> **Grazing Response – Type 3 Species (Invaders):** Invaders are introduced, non-native species and not normally components of the reference plant community (climax vegetation). They invade a site as the decreasers and increasers are reduced by grazing or other disturbances. Invaders may be annuals, herbaceous perennials, or shrubs and have some (or no) grazing value. They are never considered desirable or acceptable vegetation.
>
> **Grazing Response –Type 4 Species (Increaser – Type 2):** Species that normally increase in relative abundance as the decreasers decline. They are commonly shorter, less productive species and more resistant to disturbance. Type 2 increaser species continue to increase in abundance with increasing disturbance pressures. When increaser type 2 species occur on a disturbed wellsite, we limit the amount of this cover that is considered desirable vegetation. The amount considered acceptable would be equal to the cover of the species found in the control, or 5%, whichever is greatest.

Hardening off: A nursery process by which young plants are prepared for their final location outside by exposing them to a period of gradual change in water, light and temperature regimes (Dunster and Dunster 1996).

Increaser: Plant species that normally increase in relative abundance as the decreasers decline. They are commonly shorter, less productive species and more resistant to grazing and other disturbances.

Interim reclamation sites: Sites where the surface soil disturbance has been reduced and reclaimed following initial development activity to stabilize the soils and facilitate the recovery of the native plant communities during the operational phase.

Lentic: S*tanding* or *still water* (i.e. lakes, ponds, enclosed wetlands and sloughs).

Limy: Ecological range sites with eroded or immature soils with free lime ($CaCO^3$) at the soil surface. Soils pH generally 7.5.

Loamy: Ecological range sites with medium to moderately –fine textured soils.

Lotic: *Flowing water* (i.e. streams or rivers).

Minimum Disturbance: As defined in the 2010 Reclamation Criteria-Native Grassland, refers to minimum disturbance sites that have been reclaimed where construction practices have minimized the level of disturbance on the lease resulting in two different management zones (i.e. undisturbed meaning the soils have not been stripped and replaced and disturbed where the soils have been stripped and replaced).

Natural Subregion (NSR): Natural Subregions are subdivisions of a Natural Region, generally characterized by vegetation, climate, elevation, and latitudinal or physiographic differences within a given Region. There are 21 Natural Subregions in Alberta, four of which comprise the Grassland Natural Region.

Overflow: The ecological range site subject to water spreading and sheet flow. Typically on gentle inclines or terraces prone to stream overflow.

Ordination: Methods which graphically summarize complex species relationships by aligning observations in a pattern along multiple axes (dimensions) (McCune and Grace 2002).

Plant Community: An assemblage of plants occurring together at any point in time, thus denoting no particular successional status. A mixture of plant species that interact with one another.

Rangeland: Land supporting indigenous or introduced vegetation that is either grazed or has the potential to be grazed and is managed as a natural ecosystem.

Rangeland Health: The ability of rangeland to perform certain key functions. Those key functions include: productivity, site stability, capture and beneficial release of water, nutrient cycling, and plant species diversity.

Reclamation: The process of reconverting disturbed land to its former or other productive uses (Powter 2002). All practicable and reasonable methods of designing and conducting an activity to ensure:

(1) stable, non-hazardous, non erodible, favourably drained soil conditions, and

(2) equivalent land capability.

(3) The removal of equipment or buildings or other structures and appurtenances,

(4) The decontamination of buildings or other structures or other appurtenances, or land or water,

(5) The stabilization, contouring, maintenance, conditioning or reconstruction of the surface of land,

(6) Any other procedure, operation or requirement specified in the regulations. (Regulatory definition)

Reduced Soil Disturbance: Construction procedures and practices designed to reduce the area of impact to soil and native vegetation resources. It can refer to interim reclamation and recovery procedures which reduce the area of stripped and stored soils during the operational phase of an industrial development.

Reference Plant Community: The potential natural community or climax community. It is the plant community that is the expression of the ecological site potential under light disturbance. It is used in range health assessment as the basis for comparison, hence the term "reference".

Riparian: The transitional area between the aquatic part of a lotic or lentic system and the adjacent upland system.

Restoration: The process of assisting the recovery of an ecosystem that has been degraded, damaged, or destroyed (Society for Ecological Restoration 2004).

Sands: The ecological range site with very coarse textured soils that are not on a duned landscape.

Sandy: The ecological range site with sandy loam, moderately coarse textured soils.

Seral: Species or communities that are eventually replaced by other species or communities.

Shallow to Gravel: Ecological range sites characterized by soil with 20 to 50 cm of a sandy or loamy surface overlying a gravel or cobble-rich substrate.

Solonetzic: Dominated by hard-pan subsoil or B horizons that are hard when dry and a sticky mass of low permeability when wet. Solonetzic soils are high in sodium and typically have columnar or prismatic macro-structure.

Species Area Curve: A plot of species number (x axis) versus sample area (y axis). Sufficient sampling to assess species diversity is the area at which the steeply increasing curve becomes almost horizontal (Mueller-Dombois and Ellenberg 2002).

Specified land: For the purpose of the 2010 reclamation criteria, the term Specified Land, means land that is being or has been used or held for or in connection with the construction, operation or reclamation of a well, battery or pipeline (excerpt from the Conservation and Reclamation Regulation (115/93) of the Alberta Environmental Protection and Enhancement Act (Alberta Government 2000).

Succession: The gradual replacement of one plant community by another, over time.

Successional pathways: The predictable pathway of change in the plant community as it is subjected to types and levels of disturbance over time.

Seral stages: Each step along a successional pathway. Seral stages begin at the pioneer stage of **early seral,** and progress upward in succession to **mid-seral,** then **late seral** and finally the climax or **reference plant community.**

Thin Breaks: The ecological range sites with areas of bedrock at or near the surface; largely vegetated. May include thin, eroded or immature soils on gentle to steep landscapes.

APPENDIX B TARGET RECOVERING PLANT COMMUNITIES

Introduction

The Target Recovering Plant Communities are to be used as a companion to the Mixedgrass Range Plant Community Guide 2nd Approximation

Designing native seed mixes for industrial disturbances not suited to natural recovery or assisted natural recovery in the Mixedgrass Natural Subregion is as much an art as it is a science. The purpose of the native seed mix is to revegetate the disturbance with native grass species that will allow the process of succession to take place and to establish a mid- to late-seral plant community over time .

The Range Plant Community Guide for the Mixedgrass (Adams et al. 2013) provides a detailed discussion of plant community classification methods and the resulting plant community descriptions reported as one page summaries. Each plant community description provides the mean percent cover for each species, the range of percent cover in which the species occurs and the percent constancy of occurrence for each species within the dataset. The current Range Plant Community Guide for the Mixedgrass contains 38 native grassland plant community descriptions, seven modified native plant communities and six native shrubland plant communities. Data collected from the ESRD Range Reference Area Monitoring Program was used to compile the Guide. The Target Recovering Plant Communities have been developed from the *Mixedgrass Range Plant Community Guide 2nd Approximation* and is to be used as a companion document to the Range Plant Community Guide. For each plant community description the Mixedgrass Range Plant Community Guide provides detailed description of plant community composition linked to environmental variables including: ecological range sites, soils, elevation, soil drainage, slope and aspect.

Given the diversity of ecological range sites and successional plant community types that can be encountered within a relatively small area on the prairie landscape, it is necessary to establish which ecological range sites have species in common based on the Agricultural Region of Alberta Soil Information Database (AGRASID) soil and landscape correlation and common ecodistrict characteristics. These "clusters" of ecological range sites with common dominant native grass species are referred to as **target recovering plant communities**. They are clearly not mature reference native plant communities but rather composed of the average mean percent cover of the dominant native grass species that are drivers in the successional process. The mean percent cover of the combined native forb species has been provided as an average value. Mean percent cover for native shrub species, exposed soil, moss and lichen component and total vegetation is also provided to illustrate the components of the target recovering plant community at a mid- to late-successional stage. ESRD Range Resource Management Branch provided the dataset used to prepare the Mixedgrass Range Plant Community Guide for the preparation of the target recovering plant communities.

The specifics of the target recovering plant communities for each cluster of ecological range sites are presented in this appendix, accompanied by recommendations for seed mix design. The recommended native species will provide the initial vegetative cover to stabilize the disturbed soils and facilitate the recovery of the plant community (including the native forb component) over time. Reference material used to compile the recommendations include: the results of a literature review conducted for this project, the findings of the case studies described in *Long-term Revegetation Success of Industry Reclamation Techniques for Native Mixedgrass Prairie* (Lancaster et al. 2012), *Common Plants of the Western Rangelands Volume 1: Grasses and Grass-like Species* (Tannas 2003), *Manual of Plant Species Suitability for Reclamation in Alberta 2nd Edition* (Hardy 1989), *Native Plant Revegetation Guidelines for Alberta* (Native Plant Working Group 2000) *and Forage and Reclamation Grasses of the Northern Great Basin and Rocky Mountains* (Majerus 2009).

Examples of native seed mixes, based on the target recovering plant community are given as percent (%) Pure Live Seed by Weight. The value for each recommended species has been computed through an iterative process that converts the % foliar cover anticipated in the recovering plant community, to the % by weight of pure live seed required for each species in the seed mix. For example, how much northern wheat grass pure live seed is required in the seed mix to reach a target of 4 % foliar cover in the target recovering plant community?

It is important to note that this is only the first step in seed mix design. Further guidance for calculating seeding rates is provided in *Calculating Seeding Rates for Native Grassland Restoration Projects* (Tannas Conservation Services 2014). Examples of Reports of Seed Analysis accompanied by an explanation of how to interpret the reports have been provided by 20/20 Seed Labs Inc. (Appendix C). It is recommended that qualified professionals with experience in native prairie restoration be consulted for native seed mix design.

B.1 Target Recovering Plant Communities for the Cypress Upland Ecodistrict

Two distinct clusters of common native plant communities are encountered in the Cypress Upland Ecodistrict. Climate, soils and slope position appear to be key factors that define each target.

B.1.1 Cypress Upland: Loamy, Shallow to Gravel, Gravel and Thin Breaks Range Sites

The Range Plant Community Guide for the Mixedgrass lists the plant communities by ecological range site for the Cypress Upland Ecodistrict in Table 11 (Adams et al. 2013). The plant communities included in this cluster include: MGA1, MGA2, MGA30, MGA31, MGA7 and MGA8.

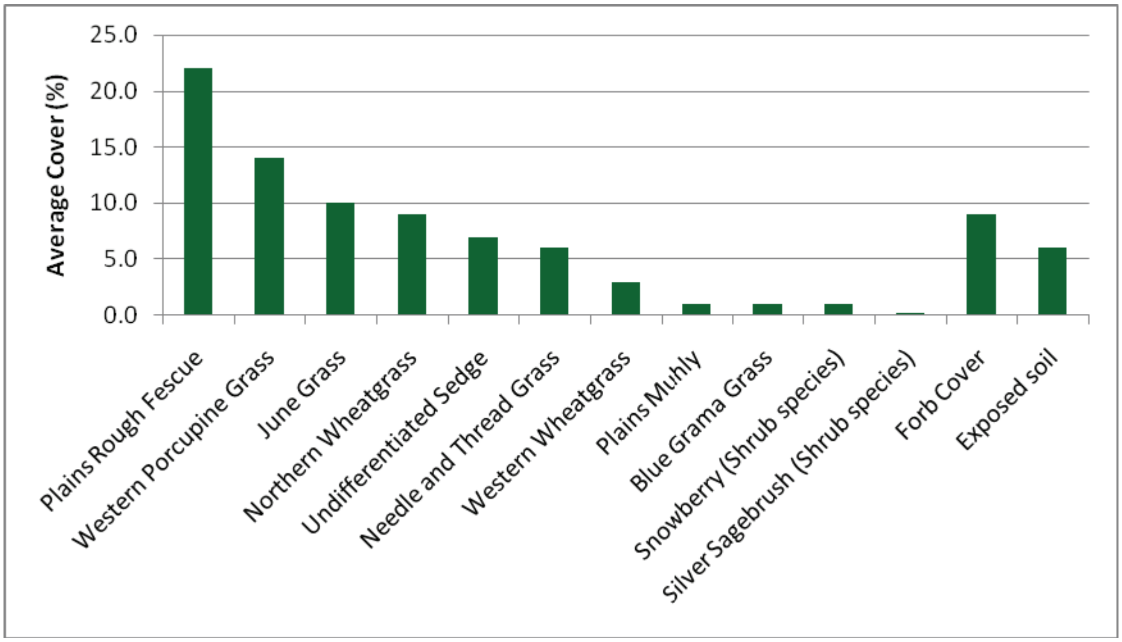
This cluster generally applies to the mid to upper slope positions in the Cypress Upland Ecodistrict. Native grasslands are largely intact under the stewardship of large ranching operations. In this area Plains rough fescue is a key indicator species common to loamy, shallow to gravel, gravel and thin breaks ecological range sites. The cluster includes mid- and late seral stage and reference plant communities found on loamy textured topsoils. Common dominant species include: plains rough fescue, western porcupine grass, June grass and northern wheat grass. This cluster is illustrated in Table B1 and Figure B1. The values in table percentages have been rounded to the nearest whole number.

Table B1 - Target Recovering Plant Community for Cypress Upland: Loamy, Shallow to Gravel, Gravel and Thin Breaks Range Sites

Species	Common Name	Average % Cover	Minimum % Cover	Maximum % Cover	% Constancy
Festuca hallii	Plains Rough Fescue	22	0	85	71
Stipa curtiseta	Western Porcupine Grass	14	0	74	91
Koeleria macrantha	June Grass	10	0	31	98
Agropyron dasystachyum	Northern Wheat grass	9	0	29	74
Carex species	Undifferentiated Sedge	7	0	29	97
Stipa comata	Needle-and-Thread Grass	6	0	37	53
Agropyron smithii	Western Wheat grass	3	0	22	60
Muhlenbergia cuspidata	Plains Muhly	1	0	14	3
Bouteloua gracilis	Blue Grama Grass	1	0	17	43
Symphoricarpos occidentalis	Snowberry (shrub species)	1	0	9	11
Artemisia cana	Silver Sagebrush (shrub species)	<1	0	7	4
Average Total Vegetation cover		**74**			
Average Forb Cover		**9**			
Average Moss and Lichen Cover		**40**			
Average Exposed Soil		**6**			

Plains rough fescue plant communities are difficult to restore. A slow growing, deeply rooted perennial species, rough fescue is slow to establish. It does not compete well with other species. Observations indicate restoration potential is greater on drier sites such as shallow to gravel or gravel range sites than loamy range sites that are more prone to invasion by non-native plants such as Kentucky bluegrass and smooth brome. Rough fescue seed must be wild harvested and the supply is often limited. Seed set is erratic and often seed is not available.

Figure B1 - Target Recovering Plant Community for Cypress Upland: Loamy, Shallow to Gravel, Gravel and Thin Breaks Range Sites



This information can then be used to design a native seed mix based on the common dominant species in the cluster and the performance of each species in the recovery process. Table B2 provides an example of the common dominant species recommended for inclusion in a native seed mix expressed as the portion required for each species in percent (%) Pure Live Seed (PLS) by weight. An example for this cluster could include:

Table B2 - Recommended Native Species for Cypress Upland on Loamy, Shallow to Gravel, Gravel and Thin Breaks Range Sites

Species	Proportion of Seed Mix % PLS by Weight	
Plains rough fescue	*Festuca hallii*	50%
Western porcupine grass	*Stipa curtiseta*	30%
Awned wheat grass	*Agropyron trachycaulum var. unilateral*	05%
Northern wheat grass	*Agropyron dasystachyum*	05%
June Grass	*Koeleria macrantha*	10%

Awned wheat grass has been added to provide initial cover and is expected to disappear from the stand in approximately 5 years, providing additional space for infill of the seeded species and encroachment from off site. Northern wheat grass has been selected to stabilize the soils and provide structure in the stand. The proportion of plains rough fescue has been increased based on results of the long-term monitoring projects conducted for this project and the proportion of the western porcupine grass has been increased to compensate for the variability in viable wild harvested seed. June grass has been selected to provide structure in the stand.

B.1.2 Cypress Upland: Low Elevation Dry Loamy and Blowout Range Sites

The Range Plant Community Guide for the Mixedgrass lists the plant communities by ecological range site for the Cypress Upland Ecodistrict in Table 11 (Adams et al. 2013). The plant communities included in this cluster include: MGA4, MGA5, MGA9, and MGC1.

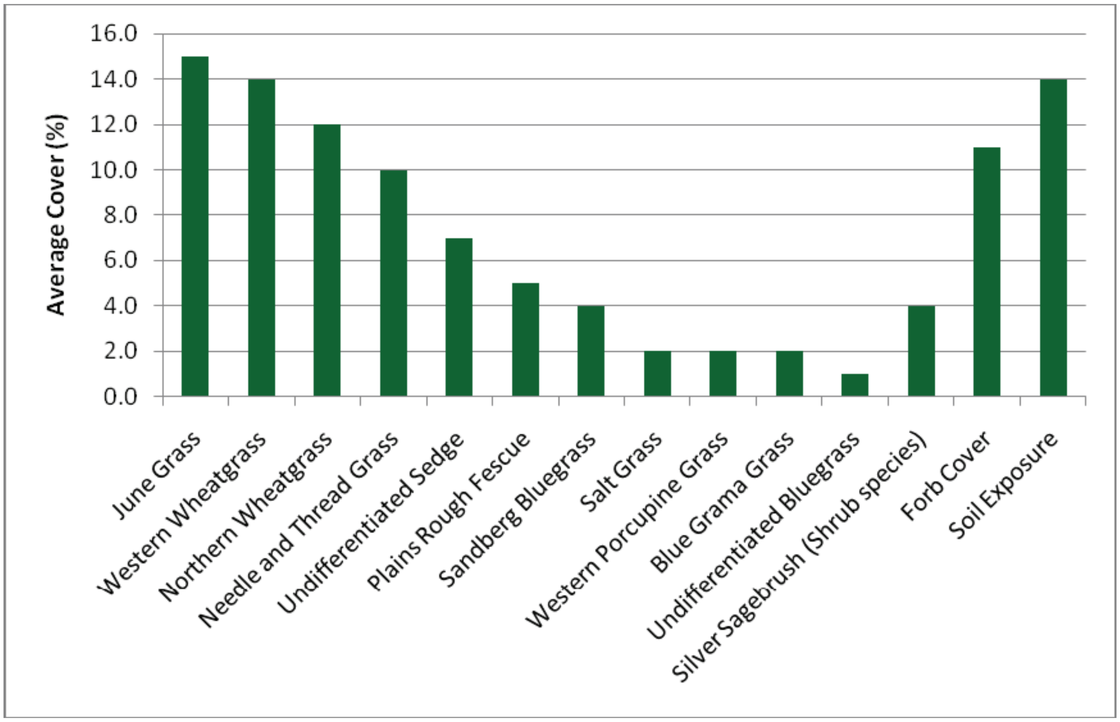
This cluster represents mid- to late seral plant communities found at lower elevations in the Cypress Upland on lower slope, terrace and level landform elements. The lower slopes tend to be more fragmented by cultivation. Drought tolerant species such as June grass, northern and western wheat grass and needle-and–thread grass are dominant. Plains rough fescue may be present at relatively low cover values. Soil exposure cover values reflect the characteristics of dry loamy to blowout range sites and soils of the Solonetzic Order.

Table B3 - Target Recovering Plant Community for Cypress Upland: Low Elevation Dry Loamy and Blowout Range Sites

Species	Common Name	Average % Cover	Minimum % Cover	Maximum % Cover	% Constancy
Koeleria macrantha	June Grass	15	8	27	100
Agropyron smithii	Western Wheat grass	14	5	26	100
Agropyron dasystachyum	Northern Wheat grass	12	0	37	73
Stipa comata	Needle-and-Thread Grass	10	0	17	45
Carex species	Undifferentiated Sedge	7	0	13	82
Festuca hallii	Plains Rough Fescue	5	0	11	9
Poa sandbergii	Sandberg Bluegrass	4	0	14	73
Distichlis stricta	Salt Grass	2	0	7	9
Stipa curtiseta	Western Porcupine Grass	2	0	12	18
Bouteloua gracilis	Blue Grama Grass	2	0	7	73
Poa species	Undifferentiated Bluegrass	1	0	11	9
Artemisia cana	Silver Sagebrush	4	1	15	73
Average Total Vegetation Cover		**61**			
Average Forb Cover		**12**			
Average Moss and Lichen Cover		**55**			
Average Exposed Soil		**14**			

Plains rough fescue plant communities are difficult to restore. A slow growing, deeply rooted perennial species, rough fescue is slow to establish. It does not compete well with invasive non-native plants. Rough fescue seed must be wild harvested and the supply is often limited. Seed set is erratic and often seed is not available. Moisture may be the limiting factor for restoration of rough fescue plant communities on the lower slopes of the Cypress Upland. The area is prone to periods of drought.

Figure B2 - Target Recovering Plant Community for Cypress Upland: Low Elevation Dry Loamy and Blowout Range Sites



This information can then be used to design a native seed mix based on the common dominant species in the cluster and the performance of each species in the recovery process. Table B4 provides an example of the common dominant species recommended for inclusion in a native seed mix expressed as the portion required for each species in % Pure Live Seed by weight. An example for this cluster could include:

Table B4 – Recommended Native Species for Cypress Upland: Low Elevation Dry Loamy and Blowout Range Sites

Species	Proportion of Seed Mix % PLS by Weight	
June Grass	*Koeleria macrantha*	10%
Western wheat grass	*Agropyron smithii*	10%
Northern wheat grass	*Agropyron dasystachyum*	15%
Needle-and-thread grass	*Stipa comata*	30%
Plains rough fescue	*Festuca hallii*	25%
Sandberg bluegrass	*Poa sandbergii*	10%

Western and northern wheat grass are early colonizers of disturbances and drivers in the successional process on blowout range sites in the Cypress Upland. Seed for these two species is available as native plant cultivars. The recommended % PLS by weight for both western and northern wheat grass is based on the competitive nature of the native plant cultivars and the relative weight of the seed (number of seeds per gram). Needle-and-thread grass and plains rough fescue are recommended at higher rates to compensate for wild harvested seed. June grass is an important structural component and Sandberg bluegrass is added for its drought tolerance.

B.1.3 *Cypress Upland: Saline Lowlands Ecological Range Sites*

The Range Plant Community Guide for the Mixedgrass lists MGA6 Salt grass – Sedge – Western Wheat grass as the late seral to reference plant community for saline lowland range sites in the Cypress Upland Ecodistrict (Adams et al. 2013).

Table B5 - Target Recovering Plant Community for Cypress Upland: Saline Lowland Range Sites

Species	Common Name	Average % Cover	Minimum % Cover	Maximum % Cover	% Constancy
Grasses and Sedges					
Carex species	Undifferentiated sedge	25	15	34	100
Distichlis stricta	Salt grass	17	0	14	50
Agropyron smithii	Western wheat grass	7	0	14	50
Poa species	Undifferentiated bluegrass	6	2	10	100
Festuca hallii	Plains rough fescue	6	0	11	50
Puccinellia nuttalliana	Nuttall's Salt-Meadow grass	5	0	10	50
Koeleria macrantha	June grass	3	0	6	50
Muhlenbergia species	Undifferentiated Muhly	3	0	6	50
Spartina gracilis	Alkali cord grass	3	0	5	50
Forbs					
Grindelia squarrosa	Gumweed	1	0	2	50
Gutierrezia sarothrae	Broomweed	2	0	3	50
Antennaria species	Undifferentiated everlastings	1	0	2	50
Average Total Vegetation Cover		**57**			
Average Moss and Lichen Cover		**26**			
Average Exposed Soil		**19**			

This range site and plant community is strongly influenced by discharge of groundwater and accumulation of salts, hence the dominance of salt grass and western wheat grass. The site may show a cyclic response to variation in total annual precipitation. Vegetation canopy cover will decline and bare soil increase during dry cycles, with a very strong cover of salt grass and western wheat grass during wet cycles. This community has a significant component of natural bare soil at about 19% (Adams et al. 2013). This range site is also at risk of invasion by non-native plants such as downy brome.

This information can then be used to design a native seed mix based on the common dominant species in the cluster and the performance of each species in the recovery process. Salt grass and western wheat grass are drivers in the process of succession and adapted to the cyclic moisture conditions.

Table B6 provides an example of the common dominant species recommended for inclusion in a native seed mix expressed as the portion required for each species in % Pure Live Seed by weight. An example for this range site could include:

Table B6 - Recommended Native Species for Cypress Upland: Saline Lowland Range Sites

Species	Proportion of Seed Mix % PLS by Weight	
Western wheat grass	*Agropyron smithii*	30%
Salt Grass	*Distichlis stricta*	25%
Nuttall's Salt-meadow grass	*Puccinellia nuttalliana*	15%
June grass	*Koeleria macrantha*	10%
Sandberg bluegrass	*Poa sandbergii*	20%

Sandberg bluegrass is included as it is drought tolerant and to provide initial cover. Nuttalls salt-meadow grass and June grass will provide diversity by establishing in niche areas within the site.

B.2 Target Recovering Plant Communities for the Sweetgrass and Milk River Upland Ecodistricts

Three distinct clusters of common native plant communities are encountered in the Sweetgrass and Milk River Upland Ecodistricts. Soil texture and slope position appear to be key factors that define each cluster.

B.2.1 Sweetgrass and Milk River Upland Ecodistrict: Overflow Range Sites

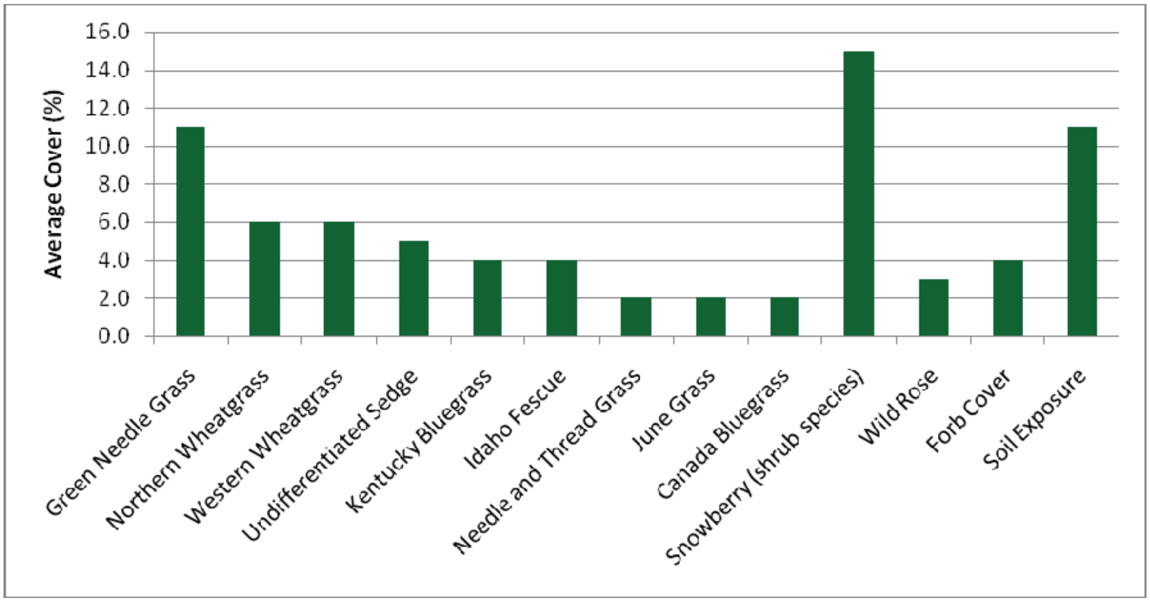
The Range Plant Community Guide for the Mixedgrass lists the plant communities by ecological range site for the Sweetgrass and Milk River Upland Ecodistricts in Table 11 (Adams et al. 2013). The plant communities included in this cluster include: MGB2, MGC7, and MGC2.

Table B7 - Recommended Target Recovering Plant Community for Sweetgrass and Milk River Upland: Overflow Range Sites

Species	Common Name	Average % Cover	Minimum % Cover	Maximum % Cover	% Constancy
Stipa viridula	Green Needle Grass	11	2	22	100
Agropyron dasystachyum	Northern Wheat grass	6	1	12	100
Agropyron smithii	Western Wheat grass	6	0	15	64
Carex species	Undifferentiated Sedge	5	0	11	82
Poa pratensis	Kentucky Bluegrass	4	4	16	45
Festuca idahoensis	Idaho Fescue	4	0	14	27
Stipa comata	Needle-and-Thread Grass	2	0	8	91
Koeleria macrantha	June Grass	2	0	3	73
Poa compressa	Canada Bluegrass	2	0	7	36
Symphoricarpos occidentalis	Snowberry (shrub species)	15	10	31	100
Rosa woodsii	Wild Rose (shrub species)	3	1	16	100
Average Total Vegetation Cover		**88**			
Average Forb Cover		**4**			
Average Moss and Lichen Cover		**2**			
Average Exposed Soil		**11**			

This cluster represents native plant communities found in areas subject to water spreading and sheet flow. Overflow sites are found in aprons, fans and draws where overland flow enhances site moisture conditions. Green needle grass, northern and western wheat grasses are well adapted to these overflow range sites. Idaho fescue and needle-and-thread grass are also adapted to the fluctuations in moisture from dry to moist and back to dry. The soils and moisture conditions of these range sites increase the risk of invasion by non-native plants when the soils are disturbed.

Figure B3 - Recommended Target Recovering Plant Community for Sweetgrass and Milk River Upland: Overflow Range Sites



Ecologically based invasive plant management will be very important when restoring disturbances in this cluster. Kentucky bluegrass, an invasive non-native plant is present in this cluster at an average mean cover of 4%. However, the plant community description for MGB2 (range 34-42%) illustrates the potential for this species to become dominant resulting in classification as modified plant community.

This information can then be used to design a native seed mix based on the common dominant species in the cluster and the performance of each species in the recovery process. Table B8 provides an example of the common dominant species recommended for inclusion in a native seed mix expressed as the portion required for each species in % Pure Live Seed by weight. An example for this cluster could include:

Table B8 - Recommended Species for Sweetgrass and Milk River Upland: Overflow Range Sites

Species	Proportion of Seed Mix % PLS by Weight	
Green needle grass	*Stipa viridula*	15%
Northern wheat grass	*Agropyron dasystachyum*	20%
Western wheat grass	*Agropyron smithii*	10%
Idaho fescue	*Festuca idahoensis*	15%
Needle-and-thread grass	*Stipa comata*	30%
June grass	*Koeleria macrantha*	10%

Green needle grass, northern and western wheat grass are available as native plant cultivars. The cultivars are aggressive and well adapted to overflow site conditions. They have been included to provide competition to site invasion by Kentucky bluegrass. However it is advisable to keep the percentages relatively low to avoid suppression of the other components of the seed mix. Idaho fescue and needle-and-thread grass are included as they are drought tolerant and well adapted to fluctuations in moisture conditions. June grass is common to these plant communities and adds structure to the stand.

B.2.2 Sweetgrass and Milk River Upland Ecodistricts: Loamy, and Thin Breaks Ecological Range Sites

The Range Plant Community Guide for the Mixedgrass lists the plant communities by ecological range site for the Sweetgrass and Milk River Upland Ecodistricts in Table 11 (Adams et al. 2013). The plant communities included in this cluster include: MGA10, MGA11, MGA12, MGA13, MGB3, MGA20, MGC3, and MGA32.

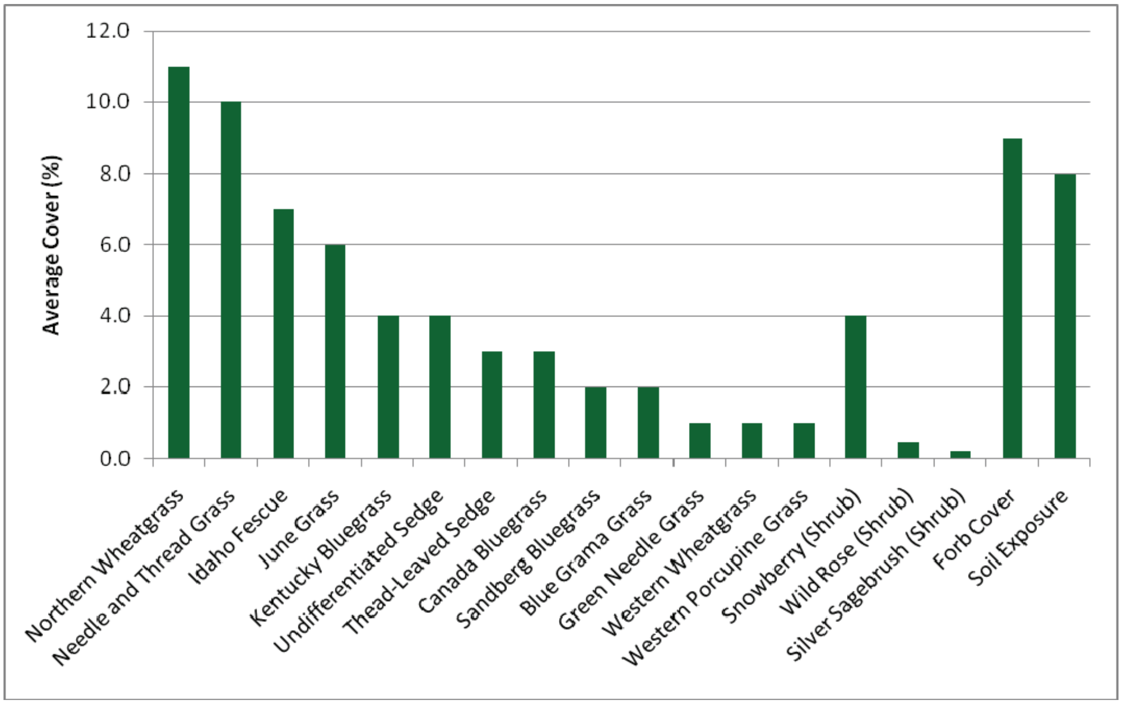
Table B9 - Target Recovering Plant Community for Sweetgrass and Milk River Upland: Loamy and Thin Breaks Range Sites

Species	Common Name	Average % Cover	Minimum % Cover	Maximum % Cover	% Constancy
Agropyron dasystachyum	Northern Wheat grass	11	0	64	99
Stipa comate	Needle-and-Thread Grass	10	0	71	82
Festuca idahoensis	Idaho Fescue	7	0	57	75
Koeleria macrantha	June Grass	6	0	27	97
Poa pratensis	Kentucky Bluegrass	4	0	45	46
Carex species	Undifferentiated Sedge	4	0	17	96
Carex filifolia	Thead-leaved Sedge	3	0	13	21
Poa compressa	Canada Bluegrass	3	0	5	1
Poa sandbergii	Sandberg Bluegrass	2	0	37	22
Bouteloua gracilis	Blue Grama Grass	2	0	20	21
Stipa viridula	Green Needle Grass	1	0	22	44
Agropyron smithii	Western Wheat grass	1	0	19	2
Stipa curtiseta	Western Porcupine Grass	1	0	23	37
Symphoricarpos occidentalis	Snowberry (shrub)	4	0	25	58
Rosa woodsii	Wild Rose (shrub)	<1	0	9	7
Artemisia cana	Silver Sagebrush (shrub)	<1	0	5	6
Average Total Vegetation Cover		**83**			
Average Forb Cover		**9**			
Average Moss and Lichen Cover		**13**			
Average Exposed Soil		**8**			

Dominant grass species in this cluster that drive the successional process include: northern wheat grass, needle-and-thread grass, Idaho fescue and June grass.

Ecologically based invasive plant management will be very important when restoring disturbances in this cluster. Kentucky bluegrass, an invasive non-native plant is present in this cluster at an average mean cover of 4%. However, the plant community description for MGB2 (range 34-42%) illustrates the potential for this species to become dominant resulting in classification as modified plant community.

Figure B4 - Target Recovering Plant Community for Sweetgrass and Milk River Upland: Loamy and Thin Breaks Range Sites



This information can then be used to design a native seed mix based on the common dominant species in the cluster and the performance of each species in the recovery process. Table B10 provides an example of the common dominant species recommended for inclusion in a native seed mix expressed as the portion required for each species in % Pure Live Seed by weight. An example for this cluster could include:

Table B10 – Recommended Species for Sweetgrass and Milk River Upland: Loamy and Thin Breaks Range Sites

Species	Proportion of Seed Mix % PLS by Weight	
Northern wheat grass	*Agropyron dasystachyum*	20%
Needle-and-thread grass	*Stipa comata*	30%
Idaho fescue	*Festuca idahoensis*	10%
June grass	*Koeleria macrantha*	10%
Sandberg bluegrass	*Poa sandbergii*	20%
Slender wheat grass	*Agropyron trachycaulum*	10%

Northern and slender wheat grass are available as native plant cultivars. The slender wheat grass has been included to act as a nurse crop to provide initial vegetative cover on steep slopes and to provide competition to invasive non-native Kentucky bluegrass. However it is advisable to keep the percentages relatively low to avoid suppression of the other components of the seed mix. Idaho fescue, needle-and-thread grass and Sandberg bluegrass are included as they are drought tolerant and well adapted to fluctuations in moisture conditions. June grass is common to these plant communities and adds structure to the stand.

B.2.3 Sweetgrass and Milk River Upland Ecodistricts: Clayey and Blowout Ecological Range Sites

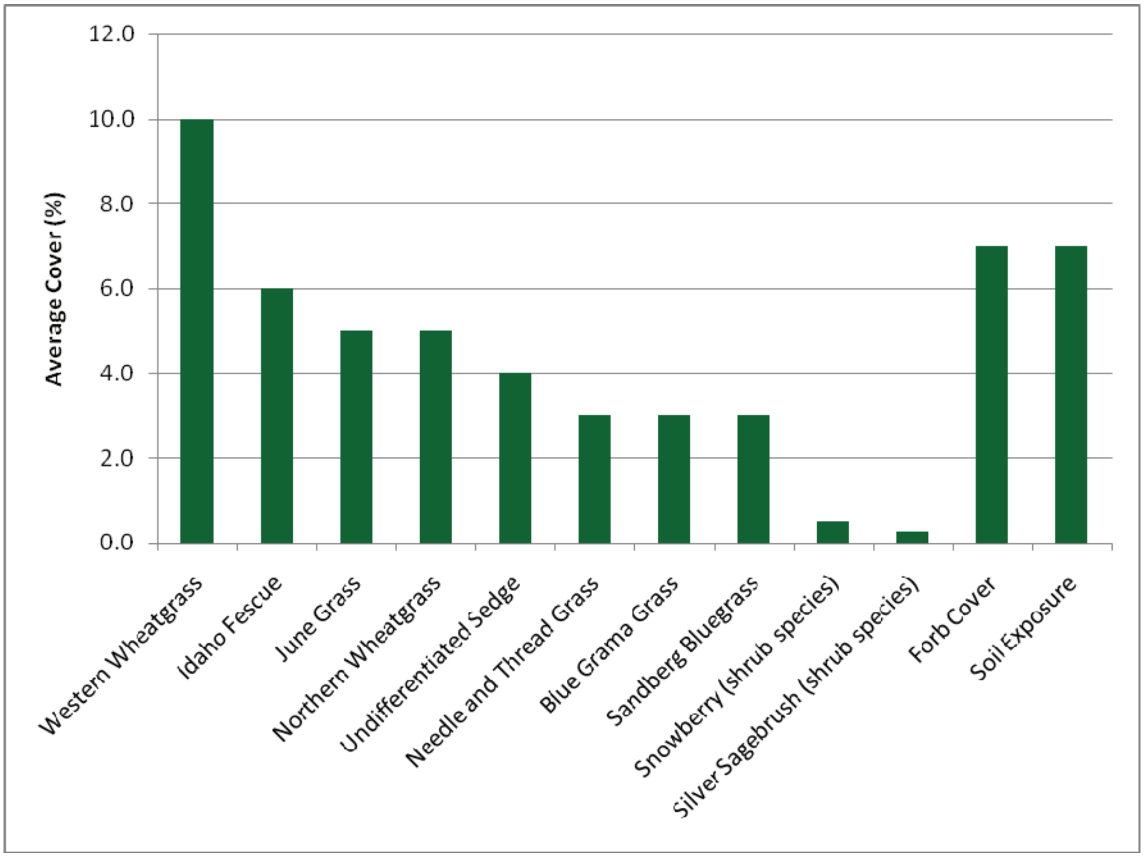
The Range Plant Community Guide for the Mixedgrass lists the plant communities by ecological range site for the Sweetgrass and Milk River Upland Ecodistricts in Table 11 (Adams et al. 2013). The plant communities included in this cluster include: MGA33, MGA34, and MGA35.

Table B11 - Target Recovering Plant Community for Sweetgrass and Milk River Upland: Clayey and Blowout Range Sites

Species	Common Name	Average % Cover	Minimum % Cover	Maximum % Cover	% Constancy
Agropyron smithii	Western Wheat grass	10	0	45	59
Festuca idahoensis	Idaho Fescue	6	0	24	59
Koeleria macrantha	June Grass	5	0	26	97
Agropyron dasystachyum	Northern Wheat grass	5	0	17	68
Carex species	Undifferentiated Sedge	4	1	12	100
Stipa comata	Needle-and-Thread Grass	3	0	21	85
Bouteloua gracilis	Blue Grama Grass	3	0	30	68
Poa sandbergii	Sandberg Bluegrass	3	0	15	32
Symphoricarpos occidentalis	Snowberry (shrub species)	<1	0	10	18
Artemisia cana	Silver Sagebrush (shrub species)	<1	0	4	6
Average Total Vegetation Cover		**90**			
Average Forb Cover		**7**			
Average Moss and Lichen Cover		**12**			
Average Exposed Soil		**7**			

Northern wheat grass, western wheat grass, Idaho fescue and June grass play an important role in the process of succession in this cluster. These species are adapted to the clay based soils of clayey and blowout range sites. Idaho fescue is dominant in the reference plant community MGA33 Idaho Fescue – Northern Wheat Grass. However, northern wheat grass, June grass and western wheat grass are drivers in the late to mid- seral successional stages. The rhizomatous wheat grasses fracture the clay soils, improving water infiltration. Drought tolerant Sandberg bluegrass is also an important component of the mid-seral successional stage.

Figure B5 - Target Recovering Plant Community for Sweetgrass and Milk River Upland: Clayey and Blowout Range Sites



This information can then be used to design a native seed mix based on the common dominant species in the cluster and the performance of each species in the recovery process. Table B12 provides an example of the common dominant species recommended for inclusion in a native seed mix expressed as the portion required for each species in % Pure Live Seed by weight. An example for this cluster could include:

Table B12 - Recommended Species for Sweetgrass and Milk River Upland: Clayey and Blowout Range Sites

Species	Proportion of Seed Mix % PLS by Weight	
Western wheat grass	*Agropyron smithii*	10%
Northern wheat grass	*Agropyron dasystachyum*	10%
Sandberg bluegrass	*Poa sandbergii*	10%
June grass	*Koeleria macrantha*	10%
Idaho fescue	*Festuca idahoensis*	15%
Needle-and-thread grass	*Stipa comata*	30%
Blue grama grass	*Bouteloua gracilis*	15%

B.2.4 Sweetgrass and Milk River Upland Ecodistricts: Sandy Ecological Range Sites

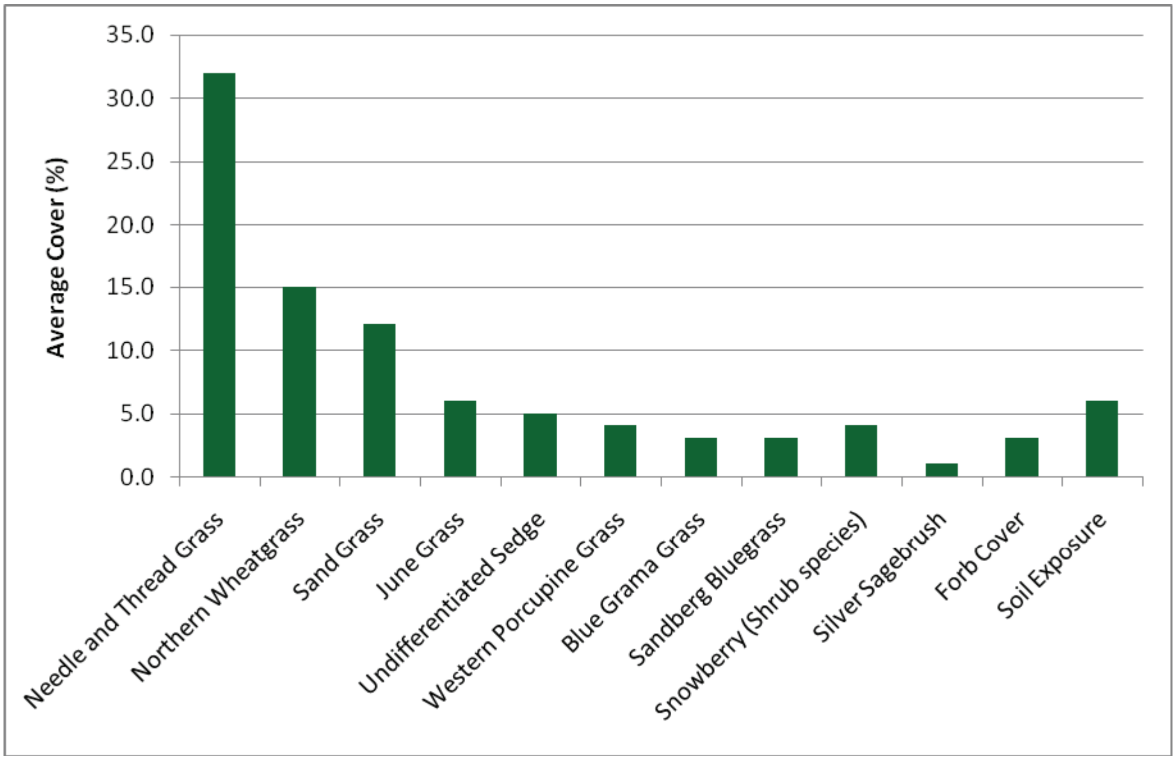
The Range Plant Community Guide for the Mixedgrass lists the plant communities by ecological range site for the Sweetgrass and Milk River Upland Ecodistricts in Table 11 (Adams et al. 2013). The plant communities included in this cluster include: MGA16 and MGB4.

Table B13 - Target Recovering Plant Community for Sweetgrass and Milk River Upland: Sandy Ecological Range Sites

Species	Common Name	Average % Cover	Minimum % Cover	Maximum % Cover	% Constancy
Stipa comata	Needle-and-Thread Grass	32	5	58	100
Agropyron Dasystachyum	Northern Wheat grass	15	1	41	100
Calamovilfa longifolia	Sand Grass	12	2	42	100
Koeleria macrantha	June Grass	6	1	18	100
Carex species	Undifferentiated Sedge	5	1	23	100
Stipa curtiseta	Western Porcupine Grass	4	0	25	57
Bouteloua gracilis	Blue Grama Grass	3	0	10	84
Poa sandbergii	Sandberg Bluegrass	3	0	12	78
Symphoricarpos occidentalis	Snowberry (shrub species)	4	0	19	57
Artemisia cana	Silver Sagebrush	1	0	5	24
Average Total Vegetation Cover		**74**			
Average Forb Cover		**3**			
Average Moss and Lichen Cover		**24**			
Average Exposed Soil		**6**			

Dominant species in this cluster are needle-and-thread grass, northern wheat grass and sand grass. MGB4 is a modified plant community which is dominated by smooth brome (*Bromus inermis*). If smooth brome is present in the pre-disturbance site assessment then ecologically based invasive plant management will be required.

Figure B6 - Target Recovering Plant Community for Sweetgrass and Milk River Upland: Sandy Ecological Range Sites



This information can then be used to design a native seed mix based on the common dominant species in the cluster and the performance of each species in the recovery process. Table B14 provides an example of the common dominant species recommended for inclusion in a native seed mix expressed as the portion required for each species in % Pure Live Seed by weight. An example for this cluster could include:

Table B14 - Recommended Species for Sweetgrass and Milk River Upland: Sandy Range Sites

Species	Proportion of Seed Mix % PLS by Weight	
Northern wheat grass	*Agropyron dasystachyum*	10%
Needle-and-thread grass	*Stipa comata*	50%
Sand grass	*Calamovilfa longifolia*	10%
June grass	*Koeleria macrantha*	10%
Sandberg bluegrass	*Poa sandbergii*	10%
Slender wheat grass	*Agropyron trachycaulum*	10%

Slender wheat grass has been included to provide initial cover and competition for smooth brome.

B.2.5 Sweetgrass and Milk River Upland Ecodistricts: Saline Lowlands Ecological Range Sites

The Range Plant Community Guide for the Mixedgrass lists MGA19 Salt grass – Western Wheat grass - Sedge as the late seral to reference plant community for saline lowland range sites in the Milk River Upland Ecodistrict (Adams et al. 2013).

Table B15 - Target Recovering Plant Community for Sweetgrass and Milk River Upland: Saline Lowland Range Sites

Species	Common Name	Average % Cover	Minimum % Cover	Maximum % Cover	% Constancy
Grasses and Sedges					
Distichlis stricta	Salt grass	29	12	60	100
Agropyron smithii	Western wheat grass	14	5	23	100
Carex species	Undifferentiated sedge	7	0	21	100
Stipa comata	Needle and thread grass	6	0	19	100
Agropyron dasystachyum	Northern wheat grass	6	0	17	50
Poa pratensis	Kentucky bluegrass	5	0	31	17
Stipa viridula	Green needle grass	4	0	9	50
Deschampsia cespitosa	Tufted hair grass	4	0	17	50
Koeleria macrantha	June grass	3	0	9	100
Forbs					
Artemisia species	Undifferentiated Artemisia	2	0	11	17
Haplopappus lanceolatus	Lance-leaved ironplant	1	0	2	50
Shrubs					
Symphoricarpos occidentalis	Snowberry	3	0	8	50
Total Vegetation		**76**			
Moss and Lichen Cover		**9**			
Soil Exposure		**15**			

This range site and plant community is strongly influenced by discharge of groundwater and accumulation of salts, hence the dominance of salt grass and western wheat grass. The site may show a cyclic response to variation in total annual precipitation. Vegetation canopy cover will decline and bare soil increase during dry cycles, with a very strong cover of salt grass and western wheat grass during wet cycles. This community has a significant component of natural bare soil at about 15% (Adams et al. 2013). If Kentucky bluegrass (invasive non-native plant) is identified in the pre-disturbance site assessment, ecologically based invasive plant management will be required.

This information can then be used to design a native seed mix based on the common dominant species in the cluster and the performance of each species in the recovery process. Salt grass and western wheat grass are drivers in the process of succession and adapted to the cyclic moisture conditions.

Table B16 provides an example of the common dominant species recommended for inclusion in a native seed mix expressed as the portion required for each species in % Pure Live Seed by weight. An example for this range site could include:

Table B16 - Recommended Species for Sweetgrass and Milk River Upland: Saline Lowland Range Sites

Species	Proportion of Seed Mix % PLS by Weight	
Western wheat grass	*Agropyron smithii*	30%
Salt Grass	*Distichlis stricta*	25%
Northern wheat grass	*Agropyron dasystachyum*	15%
June grass	*Koeleria macrantha*	15%
Tufted hair grass	*Deschampsia cespitosa*	15%

Western wheat grass and salt grass are included as they are drought tolerant and can tolerate salt laden soils and fluctuations in soil moisture. Northern wheat grass will provide initial cover and structure. Tufted hair grass and June grass will provide diversity by establishing in niche areas within the site.

B.3 Target Recovering Plant Communities for the Lethbridge and Vulcan Plains Ecodistricts

Two distinct clusters of native plant communities are encountered in the Lethbridge and Vulcan Plains Ecodistricts. Soil texture is the dominant factor determining the plant community. The remaining native grasslands of the Lethbridge and Vulcan Plains Ecodistricts are fragmented by cultivation. Invasion of disturbed soils by non-native invasive plants is a key limiting factor to restoration potential in these ecodistricts.

B.3.1 Lethbridge, Vulcan, Plain Ecodistricts: Loamy Ecological Range Sites

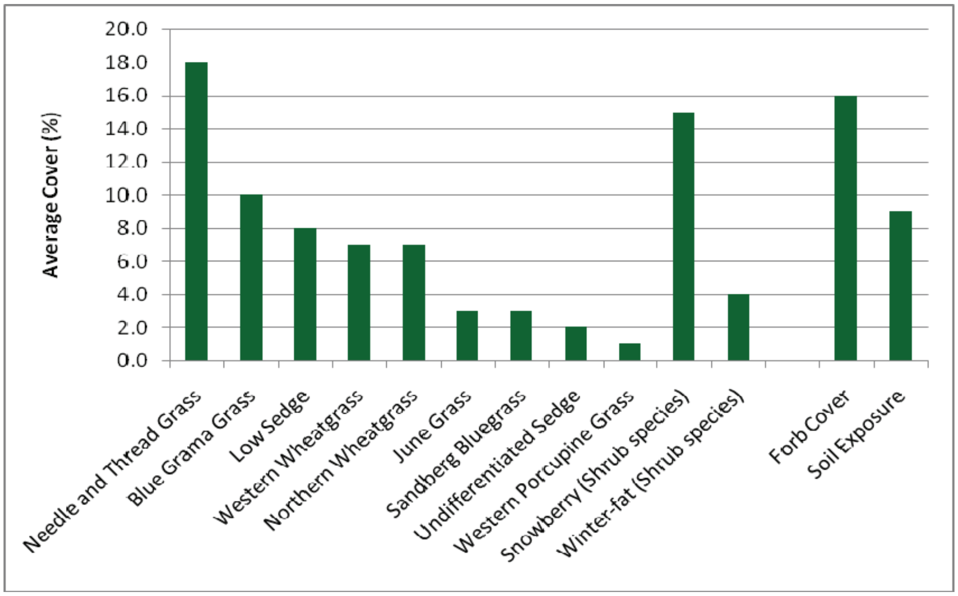
The Range Plant Community Guide for the Mixedgrass lists the plant communities by ecological range site for the Sweetgrass and Milk River Upland Ecodistricts in Table 11 (Adams et al. 2013). The plant communities included in this cluster include: MGA21, MGA22, MGC4, MGC5, MGC6.

Table B17 - Target Recovering Plant Community for Lethbridge, Vulcan Plain: Loamy Range Sites

Species	Common Name	Average % Cover	Minimum % Cover	Maximum % Cover	% Constancy
Stipa comata	Needle-and-Thread Grass	18	0	96	96
Bouteloua gracilis	Blue Grama Grass	10	0	66	64
Carex stenophylla	Low Sedge	8	0	45	77
Agropyron smithii	Western Wheat grass	7	0	64	22
Agropyron dasystachyum	Northern Wheat grass	7	0	38	83
Koeleria macrantha	June Grass	3	0	34	42
Poa sandbergii	Sandberg Bluegrass	3	0	44	25
Carex species	Undifferentiated Sedge	2	0	13	21
Stipa curtiseta	Western Porcupine Grass	1	0	19	3
Symphoricarpos occidentalis	Snowberry (shrub species)	15	0	63	69
Eurotialanata	Winter-fat (shrub species)	4	0	34	14
Average Total Vegetation Cover		**61**			
Average Forb Cover		**16**			
Average Moss and Lichen Cover		**11**			
Average Soil Exposure		**9**			

Needle-and-thread grass, blue grama grass, northern and western wheat grass are important drivers in the successional process in this cluster. Snowberry is an important shrub species providing significant cover in open shrublands along the Little Bow drainage. Kentucky bluegrass and Canada bluegrass are both invasive non-native plants found in MGC5. The moist loamy soils of this cluster are particularly sensitive to invasion by non-native plants.

Figure B7 - Target Recovering Plant Community for Lethbridge, Vulcan Plain: Loamy Range Sites



This information can then be used to design a native seed mix based on the common dominant species in the cluster and the performance of each species in the recovery process. Table B18 provides an example of the common dominant species recommended for inclusion in a native seed mix expressed as the portion required for each species in % Pure Live Seed by weight. An example for this cluster could include:

Table B18 - Recommended Species for Lethbridge, Vulcan Plain: Loamy Range Sites

Species	Proportion of Seed Mix % PLS by Weight	
Slender wheat grass	*Agropyron trachycaulum*	10%
Northern wheat grass	*Agropyron dasystachyum*	05%
Western wheat grass	*Agropyron smithii*	05%
Needle-and-thread grass	*Stipa comata*	40%
Blue grama grass	*Bouteloua gracilis*	25%
June grass	*Koeleria macrantha*	10%
Sandberg bluegrass	*Poa sandbergia*	05%

Ecologically based invasive plant management will be required if invasive plants are detected in the pre-disturbance site assessment. The moist loamy soils provide the nutrient and moisture requirements suited to non-native plant invasion of disturbed soils. Slender, northern and western wheat grasses are available as native plant cultivars. They can be quite competitive and should be seeded at low application rates. Slender wheat grass is included to provide initial cover and competition to invasive plants and is expected to disappear from the stand in approximately 5 years. Northern and western wheat grasses are important components but are seeded at low rates to allow space for the development of the needle-and-thread grass and the shrub and forb components. Blue grama is an important early successional species in this cluster. June grass and Sandberg bluegrass provide structure in the stand.

B.3.2 Lethbridge, Vulcan, Plain Ecodistricts: Sandy and Sands Ecological Range Sites

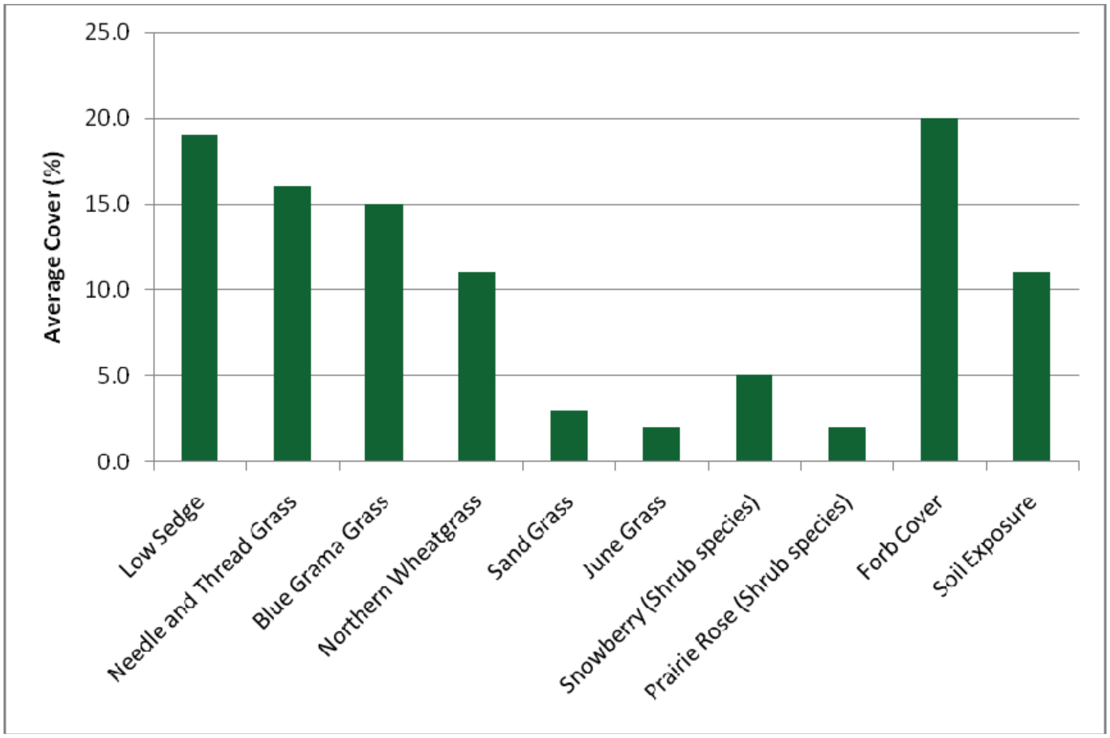
The Range Plant Community Guide for the Mixedgrass lists the plant communities by ecological range site for the Sweetgrass and Milk River Upland Ecodistricts in Table 11 (Adams et al. 2013). The plant communities included in this cluster include: MGA25, MGA24, MGA26, MGA27, MGA28.

Table B19 - Target Recovering Plant Community for Lethbridge, Vulcan Plain: Sandy and Sands Range Sites

Species	Common Name	Average % Cover	Minimum % Cover	Maximum % Cover	% Constancy
Carex stenophylla	Low Sedge	19	2	52	100
Stipa comata	Needle-and-Thread Grass	16	1	69	100
Bouteloua gracilis	Blue Grama Grass	15	0	55	90
Agropyron dasystachyum	Northern Wheat grass	11	0	42	98
Calamovilfa longifolia	Sand Grass	3	0	21	4
Koeleria macrantha	June Grass	2	0	21	65
Symphoricarpos occidentalis	Snowberry (shrub species)	5	0	18	56
Rosa arkansana	Prairie Rose (shrub species)	2	0	12	34
Average Total Vegetation Cover		**62**			
Average Forb Cover		**20**			
Average Moss and Lichen Cover		**3**			
Average Soil Exposure		**11**			

Low sedge is a significant species in the process of succession in this cluster. Needle-and-thread grass, blue grama and northern wheat grass are also prominent. The shrub component is also important with snowberry occurring at an average of 56% constancy. The forb component is also significant at an average of 20%.

Figure B8 - Target Recovering Plant Community for Lethbridge, Vulcan Plain: Sandy and Sands Range Sites



This information can then be used to design a native seed mix based on the common dominant species in the cluster and the performance of each species in the recovery process. Table B20 provides an example of the common dominant species recommended for inclusion in a native seed mix expressed as the portion required for each species in % Pure Live Seed by weight. An example for this cluster could include:

Table B20 - Recommended Species for Lethbridge, Vulcan Plain: Sandy and Sands Range Sites

Species	Proportion of Seed Mix % PLS by Weight	
Needle-and-thread grass	*Stipa comata*	35%
Blue grama grass	*Bouteloua gracilis*	30%
Northern wheat grass	*Agropyron dasystachyum*	10%
Sandgrass	*Calamovilfa longifolia*	05%
June grass	*Koeleria macrantha*	15%
Slender wheat grass	*Agropyron trachycaulum*	10%

Slender, northern and western wheat grasses are available as native plant cultivars. They can be quite competitive and should be seeded at low application rates. Slender wheat grass is included to provide initial cover and competition to invasive plants and is expected to disappear from the stand in approximately 5 years. Sandgrass is also available as a cultivar and should be seeded sparingly as it can be very competitive, forming thick mats from long, scaly rhizomes. If non -native invasive plants are detected in the pre-disturbance site assessment, ecologically based invasive plant management will be required.

B.3.3 Lethbridge, Vulcan, Plain Ecodistricts: Saline Lowlands Ecological Range Sites

The Range Plant Community Guide for the Mixedgrass lists MGA29 Salt grass – Foxtail Barley - Western Wheat grass as the late seral to reference plant community for saline lowland range sites in the Lethbridge, Vulcan Plain Ecodistricts (Adams et al. 2013).

Table B21 - Target Recovering Plant Community for Lethbridge, Vulcan Plain: Saline Lowland Range Sites

Species	Common Name	Average % Cover	Minimum % Cover	Maximum % Cover	% Constancy
Grasses and Sedges					
Distichlis stricta	Salt grass	34	10	72	100
Hordeumjubatum	Foxtail barley	11	0	21	90
Poa palustris	Fowl bluegrass	5	0	34	50
Agropyron smithii	Western wheat grass	5	0	18	70
Bromusinermis	Smooth brome	4	0	28	20
Carex praegracilis	Prairie sedge	3	0	16	30
Carex stenophylla	Low sedge	3	0	12	30
Juncus balticus	Wire rush	2	0	8	50
Poa arida	Plains bluegrass	2	0	14	40
Forbs					
Solidago Canadensis	Canada goldenrod	4	0	26	30
Lepidium densiflorum	Common pepper-grass	3	0	15	60
Achillea millefolium	Common yarrow	2	0	8	60
Average Total Vegetation Cover		**59**			
Average Forb Cover		**1**			
Average Moss and Lichen Cover		**<1**			
Average Soil Exposure		**20**			

This range site and plant community is strongly influenced by discharge of groundwater and accumulation of salts, hence the dominance of salt grass and western wheat grass. The site may show a cyclic response to variation in total annual precipitation, vegetation canopy cover will decline and bare soil increase during dry cycles, with a very strong cover of salt grass and western wheat grass during wet cycles. This community has a significant component of natural bare soil at about 20% (Adams et al. 2013). Foxtail barley can withstand soil disturbance and can dominate the site, limiting infill and species diversity and slowing the process of succession.

This information can then be used to design a native seed mix based on the common dominant species in the cluster and the performance of each species in the recovery process. Salt grass, Fowl bluegrass and western wheat grass are drivers in the process of succession and adapted to the cyclic moisture conditions.

Table B22 provides an example of the common dominant species recommended for inclusion in a native seed mix expressed as the portion required for each species in % Pure Live Seed by weight. An example for this range site could include:

Table B22 - Recommended Species for Lethbridge, Vulcan Plain: Saline Lowland Range Sites

Species	Proportion of Seed Mix % PLS by Weight	
Western wheat grass	*Agropyron smithii*	20%
Salt Grass	*Distichlis stricta*	40%
Fowl bluegrass	*Poa palustris*	20%
Slender wheat grass	*Agropyron trachycaulum*	20%

Western wheat grass, fowl bluegrass and salt grass are included as they are drought tolerant and can tolerate salt laden soils and fluctuations in soil moisture. Slender wheat grass is included as it is salt tolerant, will provide initial cover and competition to invasive plants and is expected to disappear from the stand in approximately 5 years, creating space for infill from the adjacent native plant community. If smooth brome is listed in the pre-disturbance site assessment, ecologically based invasive plant management will be required.

B.4 Target Recovering Plant Community for the Majorville Uplands Ecodistrict

The Majorville Upland Ecodistrict is characterized by increased elevation and rolling to hilly upland topography relative to the plains to the west and the east. The combination of elevation, topography and moist loamy soils has produced a unique reference plant community MGA36 Western Porcupine Grass – Northern Wheat Grass (Adams et al. 2013). The indicator species is western porcupine grass. Although portions of this ecodistrict have been fragmented by cultivation, there remain intact blocks of native grassland under the stewardship of large ranches.

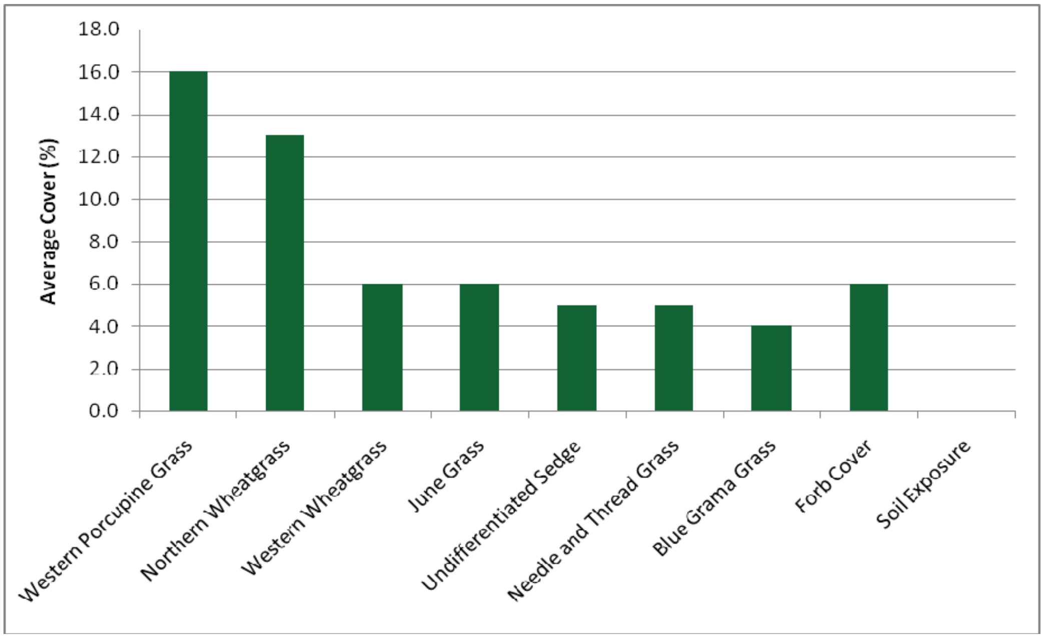
B.4.1 Majorville Upland Ecodistrict: Loamy Ecological Range Sites

Table B23 - Target Recovering Plant Community for Majorville Upland: Loamy Ecological Range Sites

Species	Common Name	Average % Cover	Minimum % Cover	Maximum % Cover	% Constancy
Stipa curtiseta	Western Porcupine Grass	16	10	26	100
Agropyron dasystachyum	Northern Wheat grass	13	4	20	100
Agropyron smithii	Western Wheat grass	6	1	14	100
Koeleria macrantha	June Grass	6	1	12	100
Carex species	Undifferentiated Sedge	5	1	6	100
Stipa comata	Needle-and-Thread Grass	5	1	9	100
Bouteloua gracilis	Blue Grama Grass	4	1	7	100
Average Total Vegetation Cover		**96**			
Average Forb Cover		**6**			
Average Moss and Lichen Cover		**11**			
Average Soil Exposure		**0**			

The dominant species for this cluster is western porcupine grass. Northern wheat grass is also prominent along with western wheat grass and June grass. Needle-and-thread grass and blue grama grass are present in early to mid- seral successional phases.

Figure B9 - Target Recovering Plant Community for Majorville Upland: Loamy Ecological Range Sites



This information can then be used to design a native seed mix based on the common dominant species in the cluster and the performance of each species in the recovery process. Table B24 provides an example of the common dominant species recommended for inclusion in a native seed mix expressed as the portion required for each species in % Pure Live Seed by weight. An example for this cluster could include:

Table B24 - Recommended Species for Majorville Upland: Loamy Ecological Range Sites

Species	Proportion of Seed Mix % PLS by Weight	
Western porcupine grass	*Stipa curtiseta*	45%
Northern wheat grass	*Agropyron dasystachyum*	10%
Western wheat grass	*Agropyron smithii*	05%
June grass	*Koeleria macrantha*	10%
Needle-and-thread grass	*Stipa comata*	20%
Slender wheat grass	*Agropyron trachycaulum*	10%

Slender, northern and western wheat grasses are available as native plant cultivars. They can be quite competitive and should be seeded at low application rates. Slender wheat grass is included to provide initial cover and competition to invasive plants and is expected to disappear from the stand in approximately 5 years. Western porcupine and needle-and-thread grass are seeded at high rates as they are available from wild harvested seed. If invasive non-native plants have been detected in the pre-disturbance site assessment, ecologically based invasive plant management will be required.

B.5 Final Step

Calculating Seeding Rates for Native Grassland Restoration Projects (Tannas Conservation Services 2014) provides detailed guidance for the final steps in seed mix design. The document is available via the Foothills Restoration Forum website at: http://www.foothillsrestorationforum.ca

Reports of Seed Analysis for each species and the seed lots available are required to make this final computation.

APPENDIX C SEEDING PATHWAYS

C.1 Example Reports of Seed Analysis...........Page 155

For more information on Sourcing Native Plant Material including source lists and availability, please visit:

The Alberta Native Plant Council

http://www.anpc.ab.ca/

The Native Plant Society of Saskatchewan

http://www.npss.sk.ca/

Canadian Grasslands Native Plant Materials Exchange

To obtain the link and login information please contact Ross Dahl at: rdahl@dahlbros.net

20/20 Seed Labs Inc.

Interpreting your Report of Seed Analysis:

Important notes:

- Your Report of Seed Analysis is based on the grade table that the crop type is found on.
- The “Date” found in the upper right hand corner of the report is the date that the germination is completed, not the date that the report is issued.
- A “Senior Member” is a proven skilled seed analyst who has undergone 2-4 years of training in an accredited Seed Laboratory and passed examination administered by CFIA. This seal represents a certification of skill and knowledge.

Purity tests

There are two tests that determine the quality of physical purity on a seed report:

1. % Pure Seed – this is component breakdown of classified contaminants (Pure Seed, Weeds, Other Crops, Inert, Ergot), as expressed as a percentage.
    - This test is performed on sample sizes that are based on 2500 seeds.
    - Pure seed for each species follows specific rules for accurate determination. This includes small, shriveled, or otherwise injured seeds, provided they are larger than one half the original size.

2. Purity test – this is an evaluation of any other species or disease body that is present in a seed lot, expressed as numbers or %, calculated to represent per 25 grams of seed.
    - This test is performed on sample sizes that are based on 25,000 seeds.
    - Note that some contaminants are listed in number quantities and others in percentages. For example, in the Northern Wheatgrass sample, the “Total Weed Seeds of All Kinds” equals 80. That means there were 80 species of weeds (all listed in the Noxious and Other Weed Categories and totaled here) present in 25 grams. However, the Other Crops are grouped together and reported as “Less Than” or “More Than” a percentage.
    - When contaminants are expressed as percentages, they must be reported as “Less than” the grade maximum. If the “Total Other Crop Seeds” reads “Less than 1% by weight”, it means that there were less than the maximum allowable % found in the sample. This doesn’t mean that there was actually 1% other crops found. The exact % of other crops (or other contaminants) is found in the % Pure Seed evaluation. These two tests must be interpreted together to have an accurate idea of which contaminants were found and at what rate in any given sample

Pure Living Seed

This is a calculation based on the % pure seed value multiplied by the germination value. This allows for a singular value when comparing seed lots that have high germination but varying % pure seed test results. For example, the two Northern wheatgrass samples provided both have relatively high pure seed % values, but differing germinations. This results in a very different Pure Living Seed calculation.

Germination Test

This test evaluates a seed lot's maximum germination potential. It is based on each individual seed's ability to produce healthy essential structures under optimal conditions.

- **Abnormals** are seedlings that have severe impairment to one or more of their essential structures. This means that the seedling does not have the genetic capability to carry itself to maturity. For example, seedlings with deep hypocotyl lesions that extend into the conducting tissue will not have the ability to become healthy and mature plants. They will be classified as "abnormal".
- **Dead** seeds are incapable of growth. Their embryo tissues are damaged and will not exhibit any growth
- **Fresh** seeds have imbibed water but have not begun the germination process. These seeds are viable but may have a physiological issue that is blocking the germination process, such as dormancy.
- **Hard** seeds are present and evaluated in clovers and other member of the *Fabaceae* family. Hard seed do not imbibe water but may be capable of growth in the future.

Tetrazolium chloride (TZ) Test:

This test is a quick representation of seed viability. It is usually available within 24 hours of the lab receiving the sample and should reflect the seed's germination capability. However, it is particularly useful in species where deep dormancy is often observed, such as in native species. When used in conjuction with the germination test, it can establish a level of dormancy and also the maximum germination potential.

In the example of the Needle and Thread grass, the germination is only 62%. However, there are 33% fresh seeds reported. The TZ is reporting 95% viability. This means that the fresh seeds are dormant, and when added to the "normal" evaluation, the maximum potential of the seed lot is 95%. Not all seed testing companies will give their customers a profile of the dead or fresh seeds. If this was the case in this sample, and a TZ was not performed, the customer would think that the maximum potential of the seed lot was on 62%. However, through a more comprehensive germination profile and the utilization of a TZ test, we have a much more accurate picture of what this seed is capable of.

The Report of Seed Analysis is very complicated and represents many aspects of the Canadian Grading System. The correct interpretation, proper combination of seed tests, along with the knowledge and experience of a certified seed analyst can ensure that confident and informed decisions are made for each individual seed lot.

Carey Matthiessen, 20/20 Seed Labs Inc.
Senior Analyst
Lab Manager

20/20 Seed Labs Inc.

Report Of Seed Analysis

CFIA Accreditation No.1068

This designates

that a sample of Wheatgrass, northern

Lot# 123-4567

Date: Apr 18, 2012

Lab No. AB1120401008

was received from:
Scarecrow Enterprises
#201, 509 11 Avenue

Nisku, AB, CA
T9E 7N5

and was tested at:
20/20 Seed Labs Inc.
Suite #201, 509 - 11 Avenue
Nisku, AB, CA T9E 7N5
p 780-955-3435 f 780-955-3428
w http://clients.2020seedlabs.ca/
e reports@2020seedlabs.ca

signed by:
SENIOR MEMBER OF
Commercial Seed Analysts Association of Canada Inc.
139
Carey Matthiessen

This sample was analyzed according to Canadian Methods and Procedures (CFIA)* for:

% PURE SEED *

Pure Seed	99.9	Other Crop Seeds	0.0	Weed Seeds	0.0	Inert Matter	0.1
Ergot	0.0	Multiple Seed Units	N/A			Pure Living Seed	90

PURITY *

WEED SEEDS: No. PER 25 GRAMS **TOTAL GRAMS ANALYZED FOR PURITY: 50**

NOXIOUS WEED SEEDS		OTHER WEED SEEDS		OTHER CROP SEEDS	
Prohibited Noxious					
Total Prohibited	0.0				
Primary Noxious					
Total Primary	0.0				
Secondary Noxious					
Total Secondary	0.0				
Primary Plus Secondary	0.0	**Total Weed Seeds of All Kinds**	0.0	**Total Other Crop Seeds**	0%
Brassica spp.	0.0			**Sclerotia Bodies**	n/a
				Sweet Clover	0.0
				Ergot Bodies	0%

Germination *

Germination (%)	90	Hard Seeds (%)	0	Germ. Incl. Hard Seeds (%)	N/A
Abnormals (%)	2	Deads (%)	8	Fresh (%)	0

ACCREDITED REMARKS

Total extended pre-chill days that were used to break dormancy: 3

The responsibility for any seed sold under this Report with respect to Grade or any other specification rests entirely with the seller.
Accredited by CFIA to conduct tests in accordance with the laboratory's scope of accreditation and the Canadian Methods and Procedures for Testing Seed.

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20/20 Seed Labs Inc.

Detailed Testing Result Summary

CFIA Accreditation No.1068

Date: Apr 18, 2012

This designates

that a sample of Wheatgrass, northern

Lot# 123-4567

Lab No.
AB1120401008

was received from: Scarecrow Enterprises **and was tested at:** 20/20 Seed Labs Inc.

REQUESTED TEST	RESULTS	
Pure Living Seed (1)		
	Pure Living Seed (%)	90

The responsibility for any seed sold under this Report with respect to Grade or any other specification rests entirely with the seller.
Accredited by CFIA to conduct tests in accordance with the laboratory's scope of accreditation and the Canadian Methods and Procedures for Testing Seed.

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20/20 Seed Labs Inc.

Report Of Seed Analysis

CFIA Accreditation No.1068

This designates

that a sample of Wheatgrass, northern

Lot# 123-4567

Date: Apr 18, 2012

Lab No. AB1120401009

was received from:
Scarecrow Enterprises
#201, 509 11 Avenue

Nisku, AB, CA
T9E 7N5

and was tested at:
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Nisku, AB, CA T9E 7N5
p 780-955-3435 f 780-955-3428
w http://clients.2020seedlabs.ca/
e reports@2020seedlabs.ca

signed by:
SENIOR MEMBER OF
COMMERCIAL SEED ANALYSTS ASSOCIATION CANADA INC
139
Carey Matthiessen

This sample was analyzed according to Canadian Methods and Procedures (CFIA)* for:

% PURE SEED *

Pure Seed	88.94	Other Crop Seeds	4.10	Weed Seeds	2.18	Inert Matter	4.79
Ergot	0.10	Multiple Seed Units	N/A			Pure Living Seed	60

PURITY *

WEED SEEDS: No. PER 25 GRAMS | **TOTAL GRAMS ANALYZED FOR PURITY: 50**

NOXIOUS WEED SEEDS		OTHER WEED SEEDS		OTHER CROP SEEDS	
Prohibited Noxious		Green needlegrass	21.5	Slender wheatgrass	
Total Prohibited	0.0	Narrow-leaved hawk's beard	11.0	Alfalfa	
Primary Noxious		Downy brome	37.5	Smooth bromegrass	
Cleavers bedstraw	0.5	Japanese brome	6.5		
Canada thistle	0.5				
Total Primary	1.0				
Secondary Noxious					
Night-flowering catchfly	2.5				
Total Secondary	2.5				
Primary Plus Secondary	3.5	**Total Weed Seeds of All Kinds**	80.0	**Total Other Crop Seeds**	More than 3% by weight
Brassica spp.	0.0			**Sclerotia Bodies**	n/a
				Sweet Clover	0.0
				Ergot Bodies	Less than 1% by weight

Germination *

Germination (%)	67	Hard Seeds (%)	0	Germ. Incl. Hard Seeds (%)	N/A
Abnormals (%)	15	Deads (%)	18	Fresh (%)	0

ACCREDITED REMARKS

Total extended pre-chill days that were used to break dormancy: 3

The responsibility for any seed sold under this Report with respect to Grade or any other specification rests entirely with the seller. Accredited by CFIA to conduct tests in accordance with the laboratory's scope of accreditation and the Canadian Methods and Procedures for Testing Seed.

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20/20 Seed Labs Inc.

Detailed Testing Result Summary

CFIA Accreditation No.1068

Date: Apr 18, 2012

Lab No. AB1120401009

This designates that a sample of Wheatgrass, northern

Lot# 123-4567

was received from: Scarecrow Enterprises **and was tested at:** 20/20 Seed Labs Inc.

REQUESTED TEST	RESULTS	
Pure Living Seed (1)		
	Pure Living Seed (%)	60

The responsibility for any seed sold under this Report with respect to Grade or any other specification rests entirely with the seller. Accredited by CFIA to conduct tests in accordance with the laboratory's scope of accreditation and the Canadian Methods and Procedures for Testing Seed.

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20/20 Seed Labs Inc.

Report Of Seed Analysis

CFIA Accreditation No.1068

This designates

that a sample of Needle And Thread

Lot# 345-6789

Date: Apr 18, 2012

Lab No. AB1120401050

was received from:

Scarecrow Enterprises
#201, 509 11 Avenue

Nisku, AB, CA
T9E 7N5

and was tested at:

20/20 Seed Labs Inc.
Suite #201, 509 - 11 Avenue
Nisku, AB, CA T9E 7N5
p 780-955-3435 f 780-955-3428
w http://clients.2020seedlabs.ca/
e reports@2020seedlabs.ca

signed by:

SENIOR MEMBER OF

COMMERCIAL SEED ANALYSTS ASSOCIATION CANADA INC

139
Carey Matthiessen

This sample was analyzed according to Canadian Methods and Procedures (CFIA)* for:

% PURE SEED *

Pure Seed	94.3	Other Crop Seeds	Trace	Weed Seeds	0.2	Inert Matter	5.5
Ergot	0.0	Multiple Seed Units	N/A			Pure Living Seed	

PURITY *

WEED SEEDS: No. PER 25 GRAMS — **TOTAL GRAMS ANALYZED FOR PURITY: 150**

NOXIOUS WEED SEEDS		OTHER WEED SEEDS		OTHER CROP SEEDS	
Prohibited Noxious		Green foxtail	0.8	Creeping red fescue	
Total Prohibited	0.0	Wild barley	0.3	Slender wheatgrass	
Primary Noxious		Downy brome	1.8		
Total Primary	0.0				
Secondary Noxious					
Total Secondary	0.0				
Primary Plus Secondary	0.0	**Total Weed Seeds of All Kinds**	2.9	**Total Other Crop Seeds**	Less than 2% by weight
Brassica spp.	0.0			**Sclerotia Bodies**	n/a
				Sweet Clover	0.0
				Ergot Bodies	0%

Germination *

Germination (%)	62	Hard Seeds (%)	0	Germ. Incl. Hard Seeds (%)	N/A
Abnormals (%)	3	Deads (%)	2	Fresh (%)	33

Method: AOSA Germination Method: P 15-25°C, 14 day prechill 5°C

ACCREDITED REMARKS

Total extended pre-chill days that were used to break dormancy: 7

The responsibility for any seed sold under this Report with respect to Grade or any other specification rests entirely with the seller.
Accredited by CFIA to conduct tests in accordance with the laboratory's scope of accreditation and the Canadian Methods and Procedures for Testing Seed.

40.01-B Page 1 / 2 Revision: 111129

20/20 Seed Labs Inc.

Detailed Testing Result Summary

CFIA Accreditation No.1068

Date: Apr 18, 2012

Lab No. AB1120401050

This designates
that a sample of Needle And Thread
Lot# 345-6789

was received from: Scarecrow Enterprises **and was tested at:** 20/20 Seed Labs Inc.

REQUESTED TEST	RESULTS	
Tetrazolium chloride (1)		
	Viable Seeds (%)	95.0

The responsibility for any seed sold under this Report with respect to Grade or any other specification rests entirely with the seller.
Accredited by CFIA to conduct tests in accordance with the laboratory's scope of accreditation and the Canadian Methods and Procedures for

Appendix D Species Names – Common and Scientific

D.1 Species Names Ordered by Common Name

Common Name	Scientific Name	*Synonym (Flora of North America (2013)*
absinthe wormwood	*Artemisia absinthium*	
alkali cord grass	*Spartina gracilis*	
alsike clover	*Trifolium hybridum*	
annual flax	*Linum usitatissimum*	
blue grama	*Bouteloua gracilis*	
Idaho fescue; bluebunch fescue	*Festuca idahoensis*	
Bluegrass species	*Poa sp.*	
blue-joint reed grass; marsh reed grass	*Calamagrostis canadensis*	
broad-leaved toad-flax	*Linaria dalmatica*	
broomweed	*Gutierrezia sarothrae*	
Canada bluegrass	*Poa compressa*	
Canada goldenrod	*Solidago canadensis*	
Canada thistle; creeping thistle	*Cirsium arvense*	
common dandelion	*Taraxacum officinale*	
common goatsbeard	*Tragopogon dubius*	
common knotweed	*Polygonum arenastrum*	
common pepper-grass	*Lepidium densiflorum*	
common wild rose	*Rosa woodsii*	
common yarrow	*Achillea millefolium*	
crested wheat grass	*Agropyron pectiniforme*	*Agropyron cristatum ssp. pectinatum*
downy chess	*Bromus tectorum*	
everlasting species	*Antennaria sp.*	
fall rye	*Secale cereale*	
field mouse-ear chickweed	*Cerastium arvense*	

Common Name	Scientific Name	Synonym (Flora of North America (2013))
foxtail barley	*Hordeum jubatum*	
fringed sage; pasture sagewort	*Artemisia frigida*	
goatsbeard	*Tragopogon dubius*	
Goosefoot species	*Chenopodium sp.*	
graceful sedge	*Carex praegracilis*	
green needle grass	*Stipa viridula*	*Nassella viridula*
gumweed	*Grindelia squarrosa*	
Indian rice grass	*Oryzopsis hymenoides*	*Achnatherum hymenoides*
intermediate oat grass	*Danthonia intermedia*	
Japanese chess	*Bromus japonicus*	
June grass	*Koeleria macrantha*	
Kentucky bluegrass	*Poa pratensis*	
kochia; summer-cypress	*Kochia scoparia*	*Bassia scoparia*
lamb's-quarters	*Chenopodium album*	
leafy spurge	*Euphorbia esula*	
prairie selaginella; little club moss	*Selaginella densa*	
low sedge	*Carex stenophylla*	*Carex duriuscula*
mountain rough fescue	*Festuca campestris*	
needle-and-thread	*Stipa comata*	*Hesperostipa comata*
northern wheat grass	*Agropyron dasystachyum*	*Elymus lanceolatus*
Nuttall's salt-meadow grass	*Puccinellia nuttalliana*	
pineappleweed	*Matricaria matricarioides*	*Matricaria discoidea*
plains bluegrass	*Poa arida*	
plains muhly	*Muhlenbergia cuspidata*	
plains rough fescue	*Festuca hallii*	
prairie rose	*Rosa arkansana*	
prairie sagewort	*Artemisia ludoviciana*	
quack grass	*Agropyron repens*	*Elytrigea repens var. repens*
Russian wild rye	*Elymus junceus*	*Psathyrostachys juncea*
Russian-thistle	*Salsola kali*	
salt grass	*Distichlis stricta*	
sand grass	*Calamovilfa longifolia*	

Common Name	Scientific Name	*Synonym (Flora of North America (2013)*
sedge species	*Carex sp.*	
sheep fescue	*Festuca ovina*	
silver sagebrush	*Artemisia cana*	
slender wheat grass	*Agropyron trachycaulum*	*Elymus trachycaulus*
smooth brome; smooth brome	*Bromus inermis*	
snowberry; buckbrush	*Symphoricarpos occidentalis*	
spiny iron plant lance-leaved ironplant	*Haplopappus lanceolatus*	*Pyrrocoma lanceolata*
streambank wheat grass	*Agropyron riparium*	*Elymus lanceolatus ssp. riparius*
sun-loving sedge	*Carex pensylvanica*	
thread-leaved sedge	*Carex filifolia*	
timothy	*Phleum pratense*	
toadflax	*Linaria vulgaris*	
tufted hair grass	*Deschampsia cespitosa*	
western wheat grass	*Agropyron smithii*	*Pascopyrum smithii*
white sagebrush	*Artemesia ludoviciana var. gnaphalodes*	*Artemesia ludoviciana ssp. ludoviciana*
white sweet-clover	*Melilotus albus*	
wild vetch	*Vicia americana*	
winter-fat	*Eurotia lanata*	*Krascheninnikovia lanata*
wire rush	*Juncus balticus*	
yellow sweet-clover	*Melilotus officinalis*	

D.2 Species Names Ordered by Scientific Name

Scientific Name	*Synonym*	Common Name
Achillea millefolium		common yarrow
Agropyron dasystachyum	*Elymus lanceolatus*	northern wheat grass
Agropyron pectiniforme	*Agropyron cristatum ssp. pectinatum*	crested wheat grass
Agropyron repens	*Elytrigea repens var. repens*	quack grass
Agropyron riparium	*Elymus lanceolatus ssp. riparius*	streambank wheat grass
Agropyron smithii	*Pascopyrum smithii*	western wheat grass
Agropyron trachycaulum		slender wheat grass
Antennaria sp.		everlasting species
Artemisia absinthium		absinthe wormwood
Artemisia cana		silver sagebrush
Artemisia frigida		Fringed sage; pasture sagewort
Artemisia ludoviciana		prairie sagewort
Artemesia ludoviciana var. gnaphalodes	*Artemesia ludoviciana ssp. ludoviciana*	white sagebrush; prairie sagewort
Bouteloua gracilis		blue grama
Bromus inermis		smooth brome; smooth brome
Bromus japonicus		Japanese chess
Bromus tectorum		downy brome; downy chess
Calamagrostis canadensis		blue-joint reed grass; marsh reed grass
Calamovilfa longifolia		sand grass
Carex filifolia		thread-leaved sedge
Carex pensylvanica		sun-loving sedge
Carex praegracilis		graceful sedge
Carex sp.		sedge species
Carex stenophylla	*Carex duriuscula*	low sedge
Cerastium arvense		field mouse-ear chickweed
Chenopodium album		lamb's-quarters

Scientific Name	*Synonym*	Common Name
Chenopodium sp.		Goosefoot species
Cirsium arvense		Canada thistle; creeping thistle
Danthonia intermedia		intermediate oat grass
Deschampsia cespitosa		tufted hair grass
Distichlis stricta		salt grass
Elymus junceus	*Psathyrostachys juncea*	Russian wild rye
Euphorbia esula		leafy spurge
Eurotia lanata	*Krascheninnikovia lanata*	winter-fat
Festuca campestris		mountain rough fescue
Festuca hallii		plains rough fescue
Festuca idahoensis		Idaho fescue; bluebunch fescue
Festuca ovina		sheep fescue
Grindelia squarrosa		gumweed
Gutierrezia sarothrae		broomweed
Haplopappus lanceolatus	*Pyrrocoma lanceolata*	spiny iron plant; lance-leaved ironplant
Hordeum jubatum		foxtail barley
Juncus balticus		wire rush
Kochia scoparia	*Bassia scoparia*	kochia; summer-cypress
Koeleria macrantha		June grass
Lepidium densiflorum		common pepper-grass
Linaria dalmatica		broad-leaved toad-flax
Linaria vulgaris		toadflax
Linum usitatissimum		annual flax
Matricaria matricarioides	*Matricaria discoidea*	pineappleweed
Melilotus albus		white sweet-clover
Melilotus officinalis		yellow sweet-clover
Muhlenbergia cuspidata		plains muhly
Oryzopsis hymenoides	*Achnatherum hymenoides*	Indian rice grass
Phleum pratense		timothy
Poa arida		plains bluegrass

Scientific Name	*Synonym*	Common Name
Poa compressa		Canada bluegrass
Poa palustris		fowl bluegrass
Poa pratensis		Kentucky bluegrass
Poa sandbergii		Sandberg bluegrass
Poa sp.		Bluegrass species
Polygonum arenastrum		common knotweed
Puccinellia nuttalliana		Nuttall's salt-meadow grass
Rosa arkansana		prairie rose
Rosa woodsii		common wild rose
Salsola kali		Russian-thistle
Secale cereale		fall rye
Selaginella densa		prairie selaginella; little club moss
Solidago canadensis		Canada goldenrod
Spartina gracilis		alkali cord grass
Stipa comata	*Hesperostipa comata*	needle-and-thread
Stipa viridula	*Nassella viridula*	green needle grass
Symphoricarpos occidentalis		snowberry; buckbrush
Taraxacum officinale		common dandelion
Tragopogon dubius		common goatsbeard
Trifolium hybridum		alsike clover
Vicia americana		wild vetch