DRAFT

Recovery Strategies for Industrial Development in Native Prairie

for the

Mixedgrass

Natural Subregion of Alberta

Mixedgrass Natural Subregion

Natural Recovery—Majorville Uplands

Pipeline through fescue grassland

Draft Framework # 2

April 2013

RECOVERY STRATEGIES FOR INDUSTRIAL DEVELOPMENT IN NATIVE PRAIRIE

FOR THE MIXEDGRASS NATURAL SUBREGION OF ALBERTA

APRIL 2013

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Prepared for:

RANGE RESOURCE MANAGEMENT BRANCH
PUBLIC LANDS DIVISION
ALBERTA ENVIRONMENT AND SUSTAINABLE RESOURCE DEVELOPMENT

Alberta Environment and Sustainable Resource Development

Petroleum Technology Alliance Canada

PTAC PETROLEUM TECHNOLOGY ALLIANCE CANADA

Prepared by:

GRAMINEAE SERVICES LTD., KESTREL RESEARCH INC. AND DESSERUD ENVIRONMENTAL LTD.

In Association with:

PARTICIPANTS OF THE RECOVERY STRATEGIES FOR INDUSTRIAL DEVELOPMENT IN NATIVE PRAIRIE ADVISORY GROUP

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Thanks team!

Marilyn Neville and *Jane Lancaster*

Preface

Reclamation practices following industrial disturbance in native prairie landscapes have been steadily evolving since the early 1980s. Industrial activity in native prairie has also been steadily increasing. The Mixedgrass Natural Subregion of Alberta is rich in petroleum resources with a large and diverse development infrastructure in native prairie. Recently, the development of renewable resources such as wind energy is also taking place, requiring a similar development infrastructure in native prairie as well. 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.

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.

This manual builds 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 recovery 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 development of the Natural Regions and Subregions of Alberta (Natural Regions Committee 2006) dichotomy as the first level of ecological classification in Alberta assists practitioners with the understanding of restoration opportunities and limitations within the Subregion context. 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 were developed to 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 predation. These tools are now being applied to assess and manage man-made disturbances. The tools are incorporated into pre-disturbance site assessment, development planning and reclamation certification for native grasslands, creating the need for a tool which provides guidance on appropriate recovery strategies for each Natural Subregion. These guidelines focus on recovery strategies for the Mixedgrass Natural Subregion.

The on-going 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. 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 and severely degraded sites are defined and discussed in the context of new restoration tools and recent publications.

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Abbreviations

ACIMS ... Alberta Conservation Information Management System
AENV ... Alberta Environment
AGRASID ... Agricultural Region of Alberta Soil Information Database
AI ... Alberta Innovates
AUPRF ... Alberta Upstream Petroleum Research Fund
cm ... centimetre
EAP ... Enhanced Approval Process
EBIPM ... Ecologically Based Invasive Plant Management
EPP ... Environmental Protection Plan
ERS ... Ecological Range Site
ERCB ... Energy Resources Conservation Board
ESRD ... Alberta Environment and Sustainable Resource Development
ESRRA ... Ecological Site Restoration Risk Analysis
Express ... Express Pipeline
FWMIS ... Fish and Wildlife Management Information System
g ... gram
GPS ... global positioning system
GVI ... Grassland Vegetation Inventory
ha ... hectare
IL ... Information Letter
kg ... kilogram
km ... kilometre
LAT ... Landscape Analysis Tool
m ... metre
MG ... Mixedgrass Natural Subregion
MGPCG ... Mixedgrass Plant Community Guide
NEB ... National Energy Board
NSR ... Natural Subregion
PCF ... Prairie Conservation Forum
PNC ... Potential Natural Community
PNT ... Protective Notation
PTAC ... Petroleum Technology Alliance Canada
RoW ... right-of-way
RPC ... Reference Plant Community
RRMP ... Range Resource Management Program
wt ... weight

1 A SHIFT TO FOCUS IN RESTORATION

Why is ecological restoration important for our native grassland ecosystems? We have lost much of our original native grasslands in the Mixedgrass Natural Subregion to cultivation and we continue to stress these important ecosystems with an increasingly large industrial footprint. If we are to conserve what remains of our native prairie for future generations, then we must continue to improve our reclamation practices and recovery strategies in native prairie landscapes. Our focus must shift from reclamation to restoration.

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). There is an increasing public awareness of the remaining native grassland ecosystems and the ecological goods and services they provide for Albertan's. The amount of industrial activity taking place in native grasslands has increased dramatically since the early 1990s. 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. It is 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 a greater 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.

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.

2 OVERVIEW OF 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 have provided 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* (Achuff1994). 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.

2.1 Physiography, Soils, Climate, 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 2). 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. 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 Hills 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 3 through 7). Topography, elevation, soils and climate have played a major role in the development of unique, sustainable native plant communities.

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).

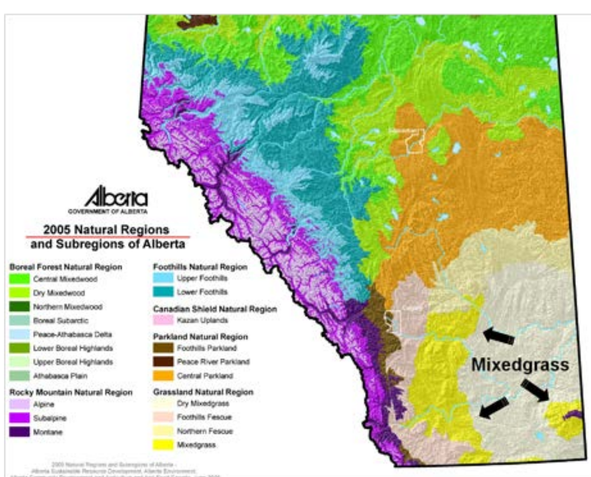
The Mixedgrass is dominated by Dark Brown Chernozemic soils. Parent materials are dominantly glacial till with lesser occurrences of glacio-lacustrine, glacial-fluvial and eolian parent materials. Topography in the plains ecodistricts is dominantly undulating to hummocky. Topography in the highland ecodistricts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

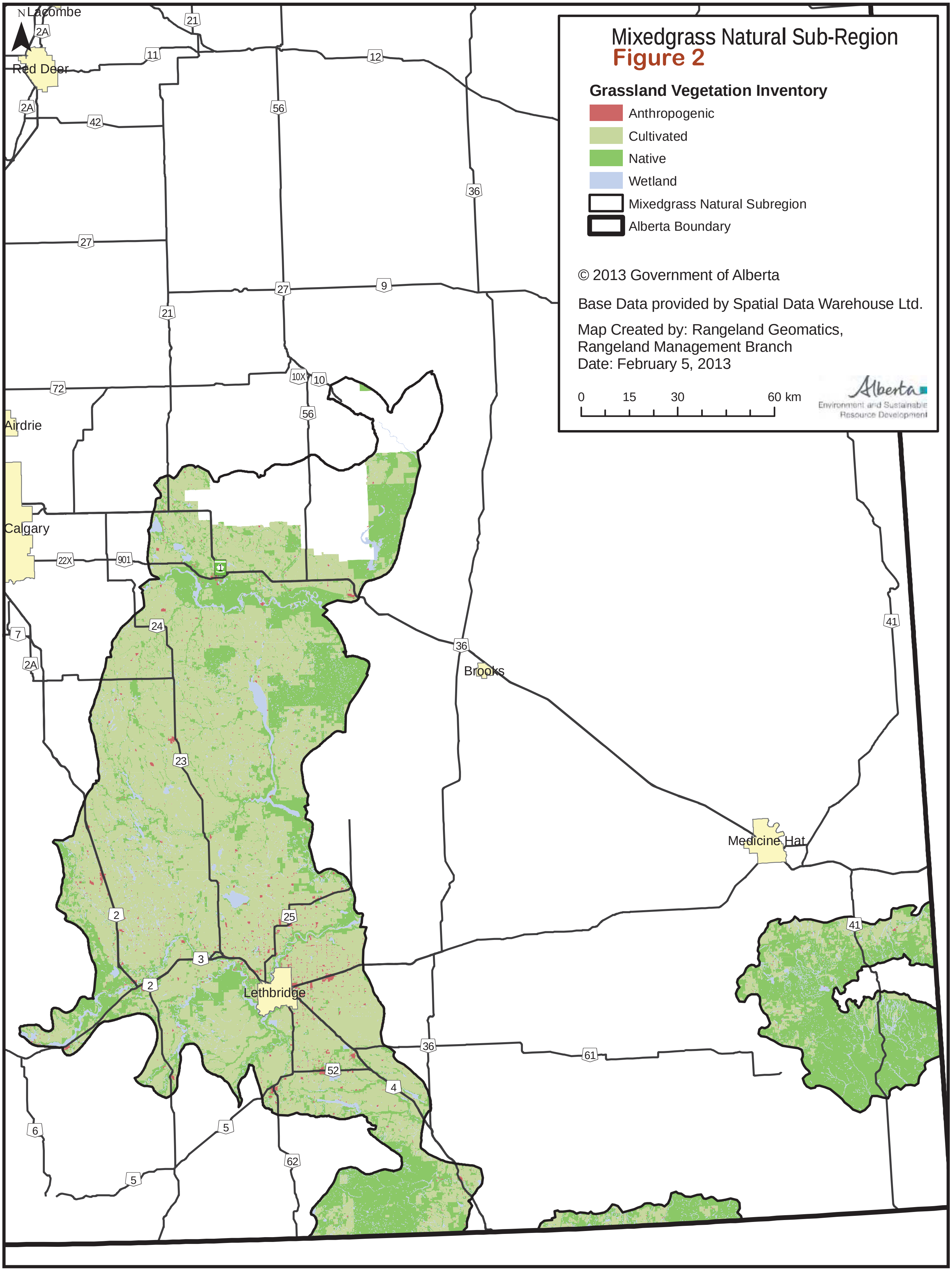
The climate of the Mixedgrass is characterized by short summers with warm days and cool nights. Mean summer temperatures are about 15°C and mean annual temperature is about 5°C (Adams et al. 2005). The Mixedgrass has slightly moister and somewhat cooler summers and milder winters than the Dry Mixedgrass Natural Subregion (Dry Mixedgrass) to the east. Even cooler and moister conditions prevail at higher elevations in the Mixedgrass highland ecodistricts. The milder winters are due to the influence of the 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 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, produces 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 needle-and-thread grass (*Stipa comate*), blue grama grass (*Bouteloua gracilis*), with northern wheatgrass (*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 support June grass (*Koeleria macrantha*), northern and western wheatgrass (*Agropyron smithii*), and needle-and-thread grass communities. Higher elevations support plains rough fescue (*Festuca hallii*), western porcupine grass, and sedge (*Carex species*) communities. The Milk River Upland and the slopes of the Sweetgrass Upland support northern wheatgrass, June grass, sedge communities and Idaho fescue (*Festuca idahoensis*), northern wheatgrass, 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. Rough fescue 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://www.srd.alberta.ca

Fertile Dark Brown Chernozemic soils combined with adequate annual precipitation provide the opportunity for non-native plant invasion to occur, especially in areas fragmented by cultivation.

Figure 1 - Natural Subregions of Alberta




Mixedgrass Natural Sub-Region
Figure 2
Grassland Vegetation Inventory
Anthropogenic
Cultivated
Native
Wetland
Mixedgrass Natural Subregion
Alberta Boundary
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Medicine Hat
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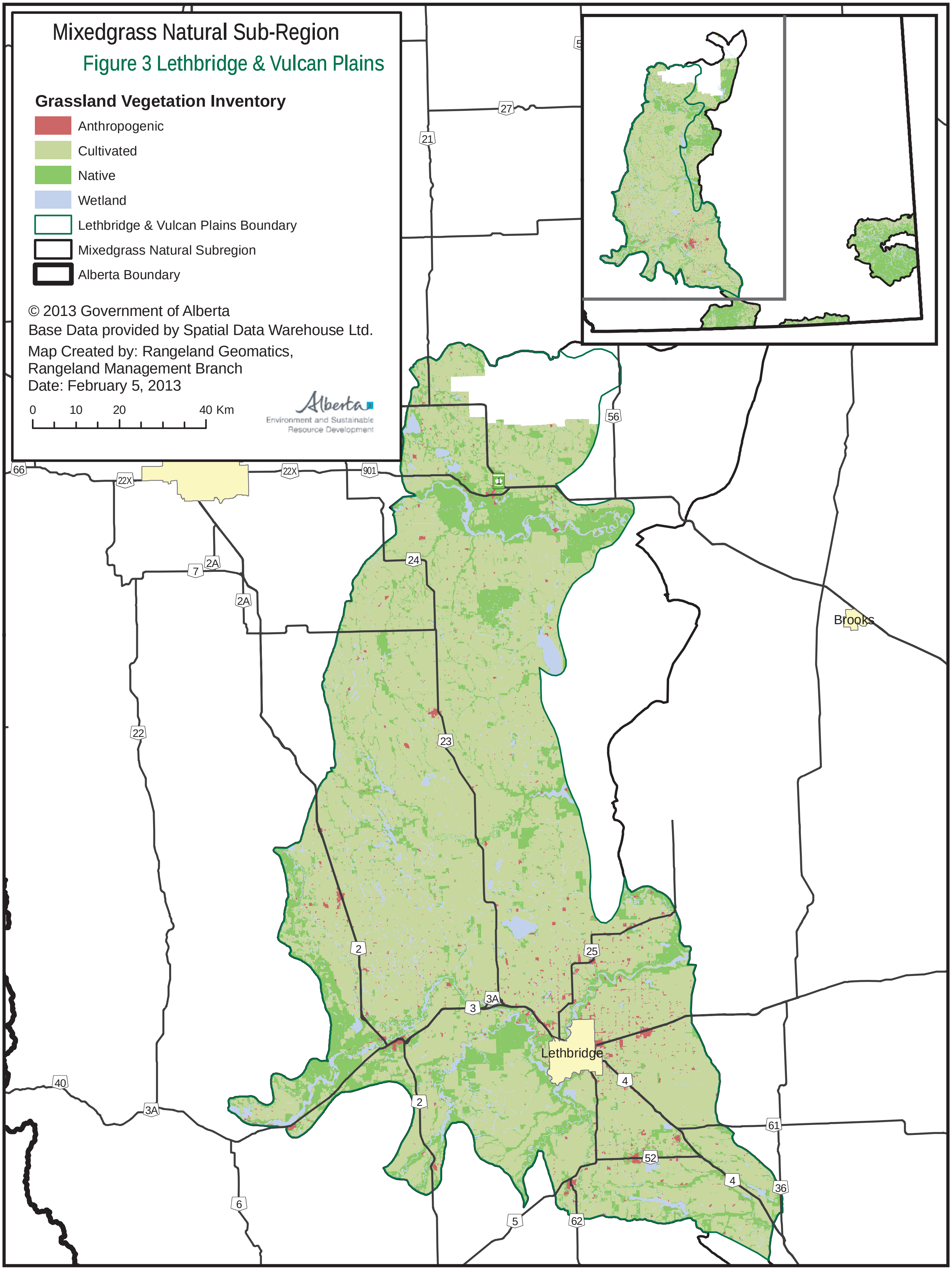
Mixedgrass Natural Sub-Region
Figure 3 Lethbridge & Vulcan Plains
Grassland Vegetation Inventory
Anthropogenic
Cultivated
Native
Wetland
Lethbridge & Vulcan Plains Boundary
Mixedgrass Natural Subregion
Alberta Boundary
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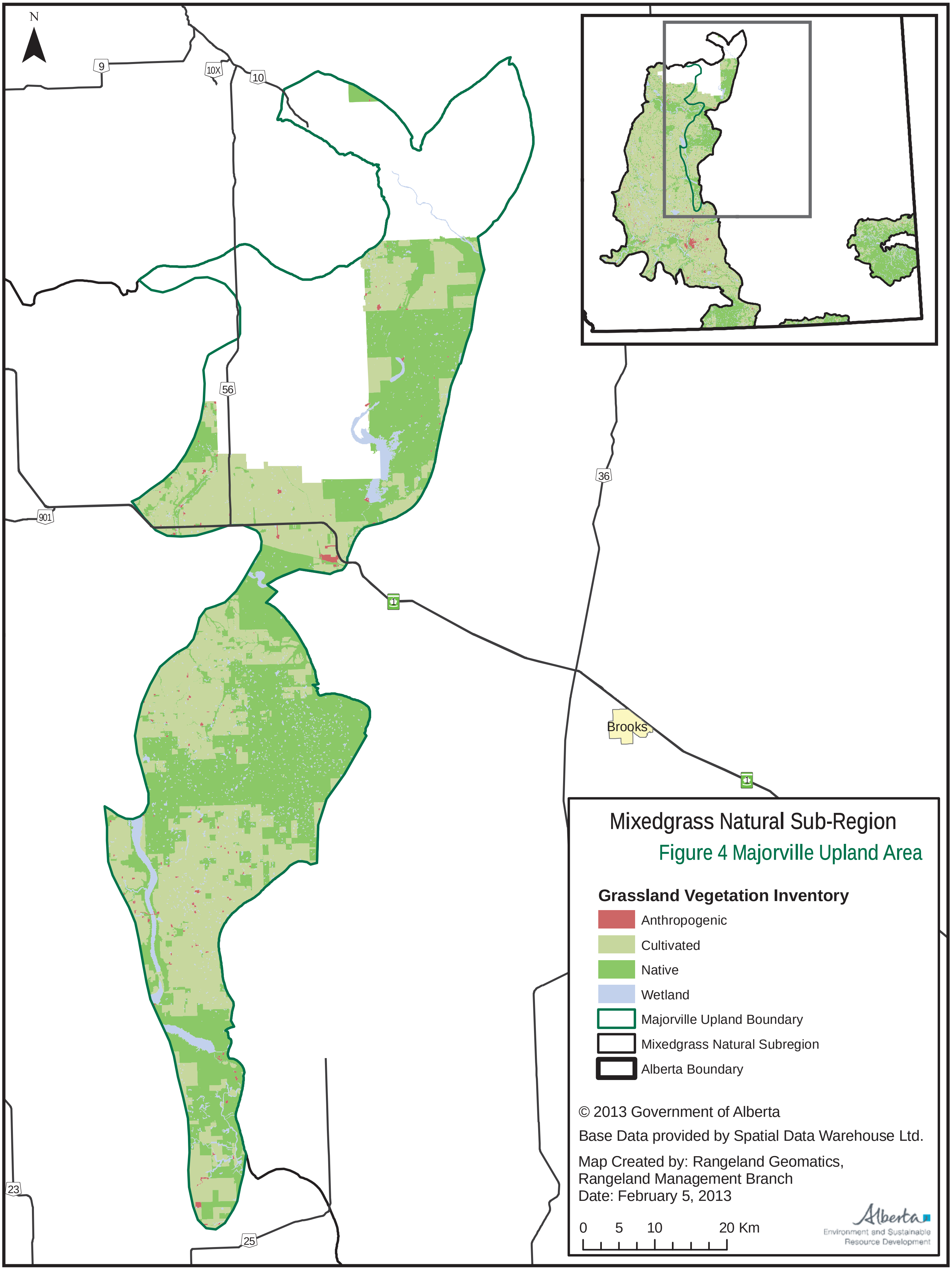
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Mixedgrass Natural Sub-Region
Figure 4 Majorville Upland Area
Grassland Vegetation Inventory
Anthropogenic
Cultivated
Native
Wetland
Majorville Upland Boundary
Mixedgrass Natural Subregion
Alberta Boundary
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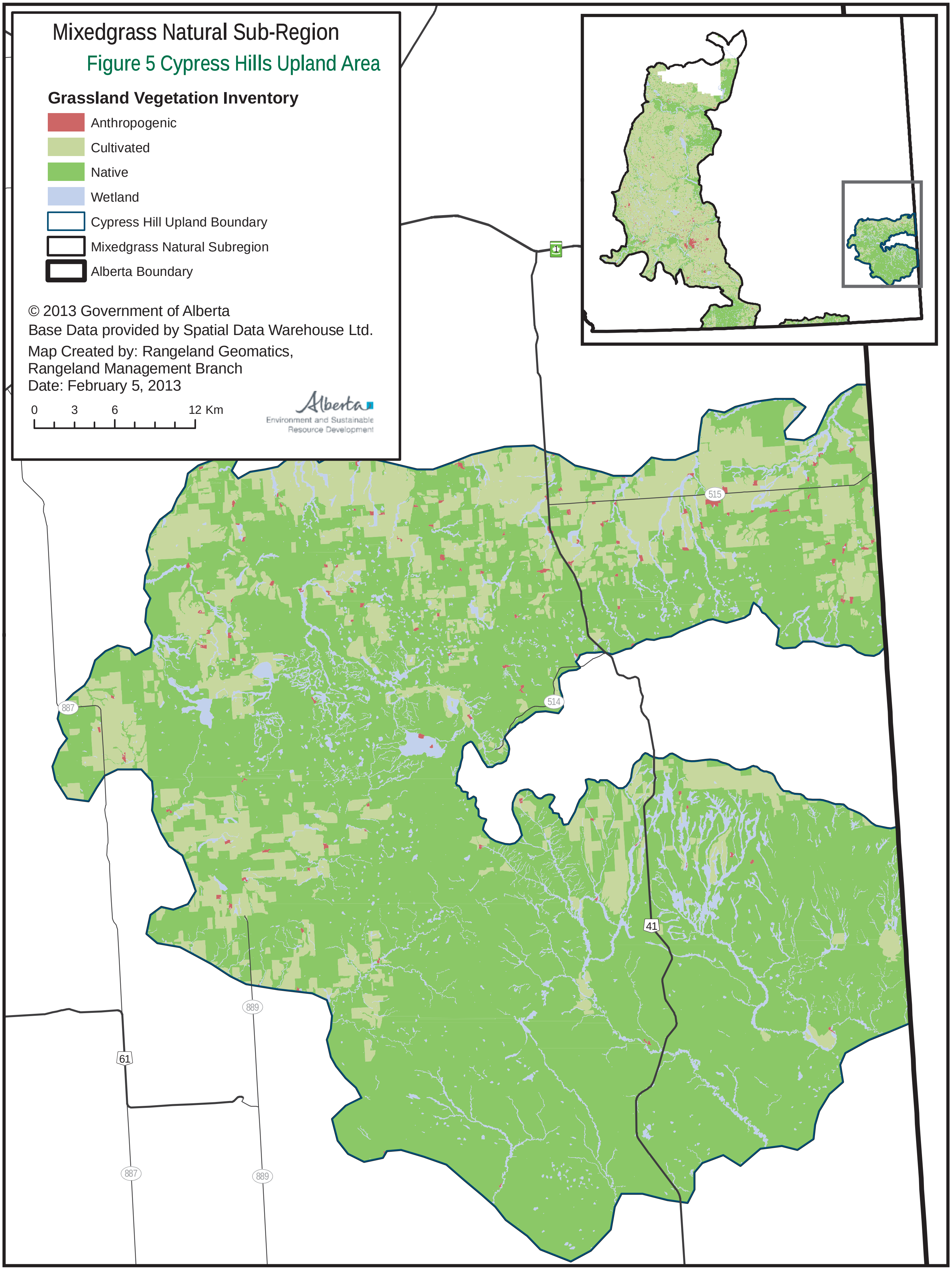
Mixedgrass Natural Sub-Region
Figure 5 Cypress Hills Upland Area
Grassland Vegetation Inventory
Anthropogenic
Cultivated
Native
Wetland
Cypress Hill Upland Boundary
Mixedgrass Natural Subregion
Alberta Boundary
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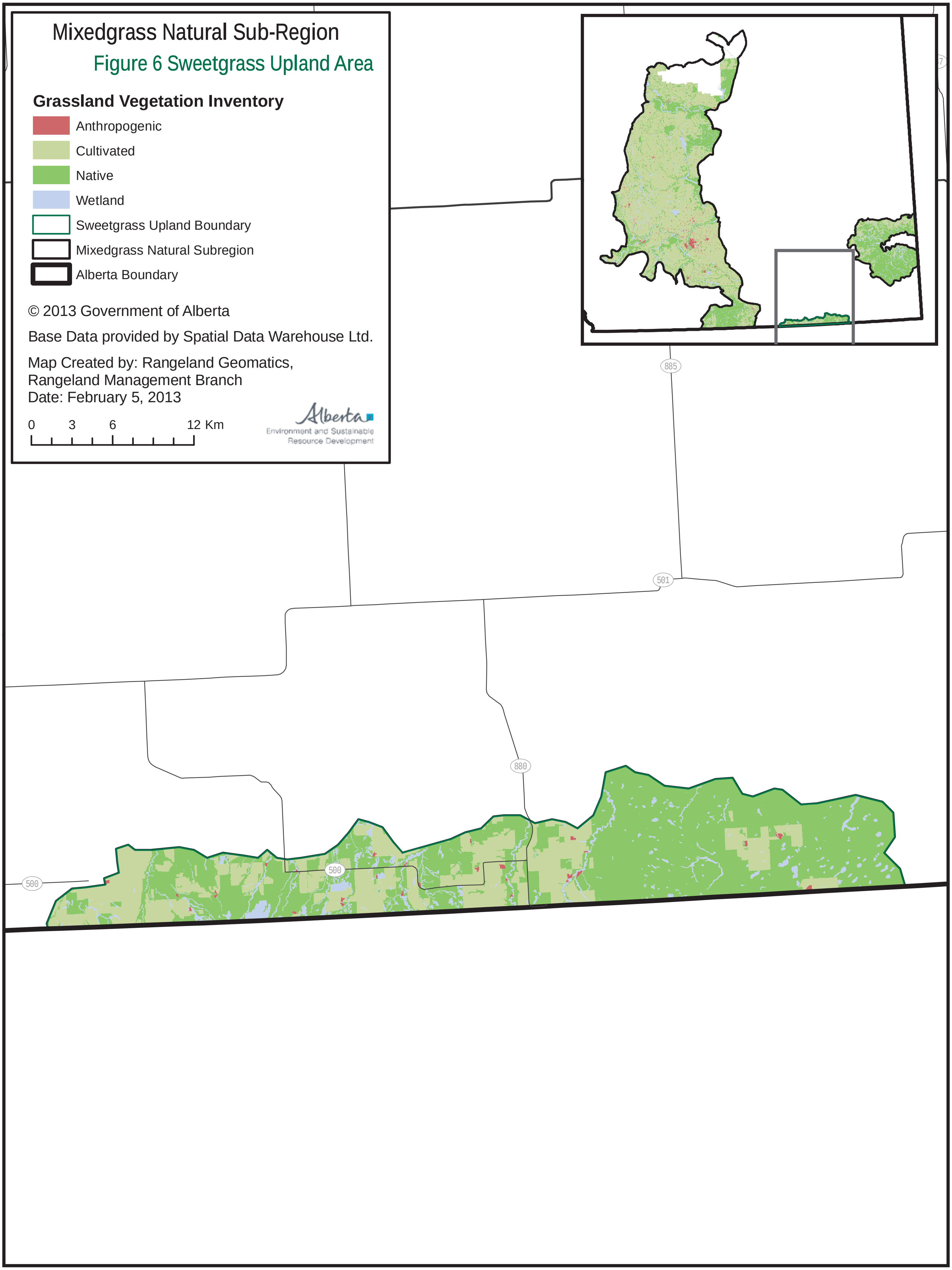
Mixedgrass Natural Sub-Region
Figure 6 Sweetgrass Upland Area
Grassland Vegetation Inventory
Anthropogenic
Cultivated
Native
Wetland
Sweetgrass Upland Boundary
Mixedgrass Natural Subregion
Alberta Boundary
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Map Created by: Rangeland Geomatics,
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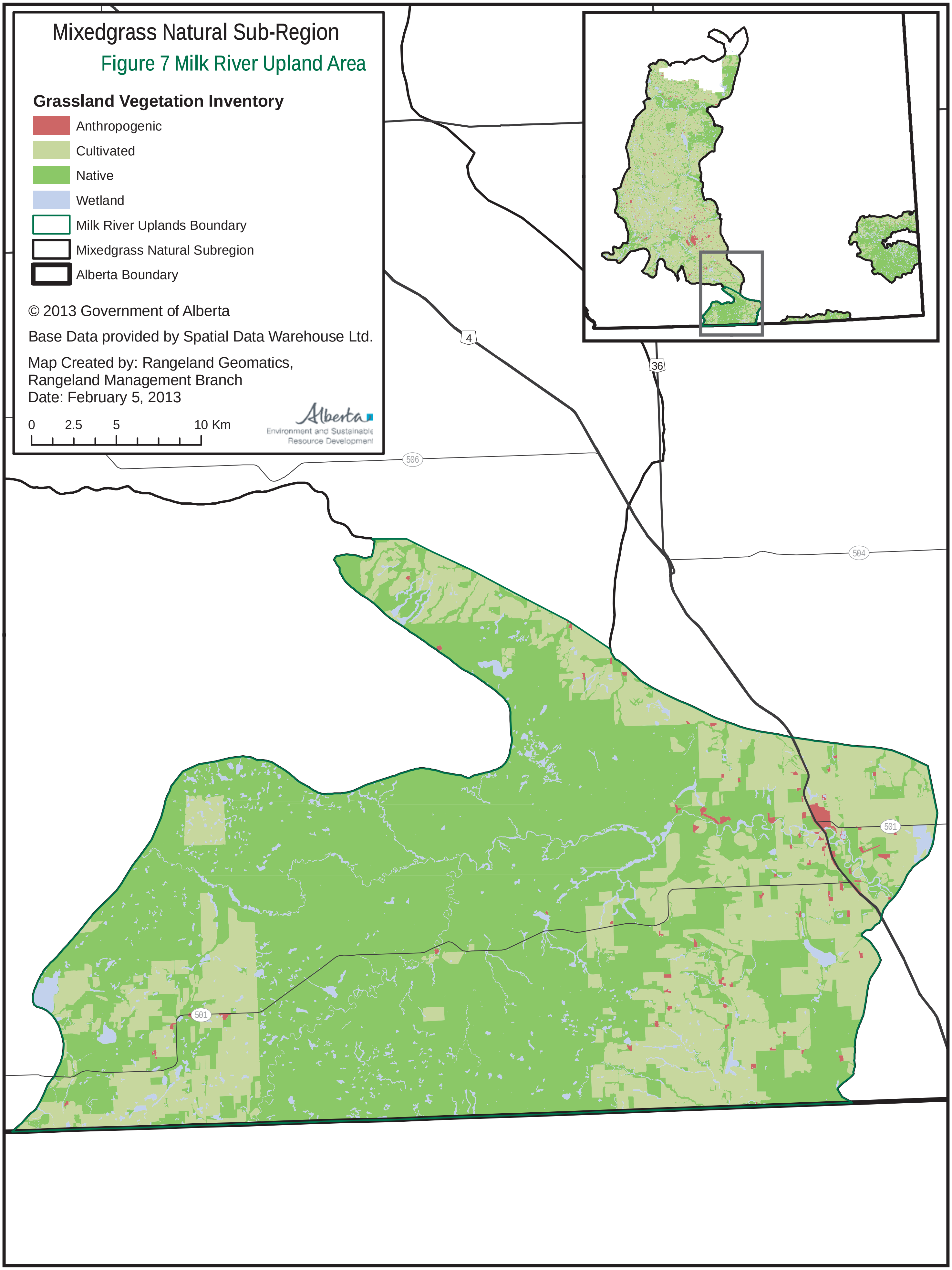
Mixedgrass Natural Sub-Region
Figure 7 Milk River Upland Area
Grassland Vegetation Inventory
Anthropogenic
Cultivated
Native
Wetland
Milk River Uplands Boundary
Mixedgrass Natural Subregion
Alberta Boundary
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Date: February 5, 2013
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Environment and Sustainable Resource Development
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2.2 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 create 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 seen the development of wind farms and the upgrading of electrical transmission corridors. 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.

2.3 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 Energy Resources Conservation Board (ERCB) http://www.ercb.ca/

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

This information letter informed industry that agronomic grasses 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 activities in these area. IL 2002-1 recognizes the importance of the Parkland Natural Region.

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; and
- 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.
- The importance of weed control is emphasized and environmental monitoring is recommended.

Prairie Oil and Gas: A Lighter Footprint (Sinton et al 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.

A lighter footprint requires a "cradle to the grave" approach.

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

This document recommends 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.

Alberta Prairie Conservation Forum Action Plan 2011 to 2015

The vision embedded in the Prairie Conservation Forum (PCF) 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 Forum 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. These tools will improve 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.

3.1 Grassland Vegetation Inventory

The Grassland Vegetation Inventory (GVI) represents the Government of Alberta's first comprehensive biophysical vegetation and anthropogenic inventory of the Grassland Natural Region. 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. Developed by ESRD, the Grassland Vegetation Inventory is comprised of ecological range sites based on soils and vegetation information for areas of native vegetation and general land use for non-native areas (agricultural, industrial, and urban areas). It also includes a coarse hydrological feature layer. A user manual entitled "*Specifications for the Use and Capture of Grassland Vegetation Inventory (GVI) Data 5th Edition" (*Alberta Sustainable Resource Development and LandWise Inc. 2011) is available on the web.

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/

3.2 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 plant community descriptions by ecological range site, which can be linked to the GVI site types. The plant community that is an expression of site potential is referred to as the reference plant community (RPC) since it represents the potential natural community 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 (RRMP). The guides are available on the ESRD website and are updated on a regular basis as new data is gathered.

http://srd.alberta.ca/LandsForests/GrazingRangeManagement/documents/MixedgrassSubregionAssessmentGuidelines.pdf

3.2.1 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 2: Ecodistricts in the Mixedgrass NSR);
2. Identify the major soil series and associated ecological range sites found in the ecodistrict (MGPCG Table 4: 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 10: 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 11 to 13 to identify successional and modified communities associated with the reference plant communities. This table 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, work through the Key to Range Plant Communities or read through the descriptions of the communities identified in MGPCG Tables 11 to 13.
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.

3.3 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, they provide 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
2. Community Structure
3. Hydrologic Function and Nutrient Cycling
4. Site Stability
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.

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.

Figure 8 - Standardized Grassland Assessment Tools

3.4 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://www.foothillsrestorationforum.ca

Restoration risk will affect your potential restoration outcome

In the Mixedgrass the following factors affect restoration potential:

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 crested wheatgrass (*Agropyron cristatum, A. sibiricum*), Kentucky bluegrass (*Poa pratensis*) and sweet clover (*Melilotus spp.*). Aggressive non-native grass species such as downy brome (*Bromus tectorum*) and Japanese brome (*Bromus japonicas*) are of particular concern in the Mixedgrass due to their adaptation to semi-arid conditions and disturbed soils. These species are particularly of concern in the Sweetgrass and Milk River Uplands. It has been observed that 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 at the ecological range site level. For example within the Mixedgrass, Overflow range sites are more prone to non-native plant invasion than Sands or Blowout range sites.
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 the 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 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 wheatgrass, Kentucky bluegrass, awnless brome (*Bromus inermis*) or sweet clover can limit restoration potential. Industrial disturbances surrounded by localized areas invaded by weeds and non-native invasive plants, can also limit restoration potential.
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.

These 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.

Figure 9 - Drier is Better

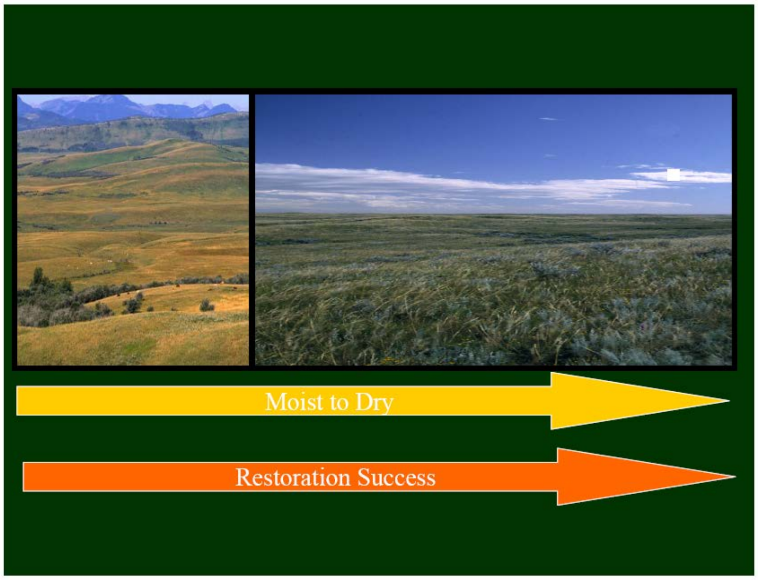


Image Courtesy of Barry Adams, ESRD Rangeland Management Branch

4 PROMOTING NATIVE PLANT COMMUNITY SUCCESSION

4.1 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.

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.

Photo courtesy of Dennis Milner, Medicine Hat

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.

1972 to 1985

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

1985 to 1993

During this period reclamation practices focused on 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 fragmentation of native plant communities and increased the risk of aggressive non-native plant invasion.

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.[1] 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.

4.2 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" found on page 14. These concepts include:

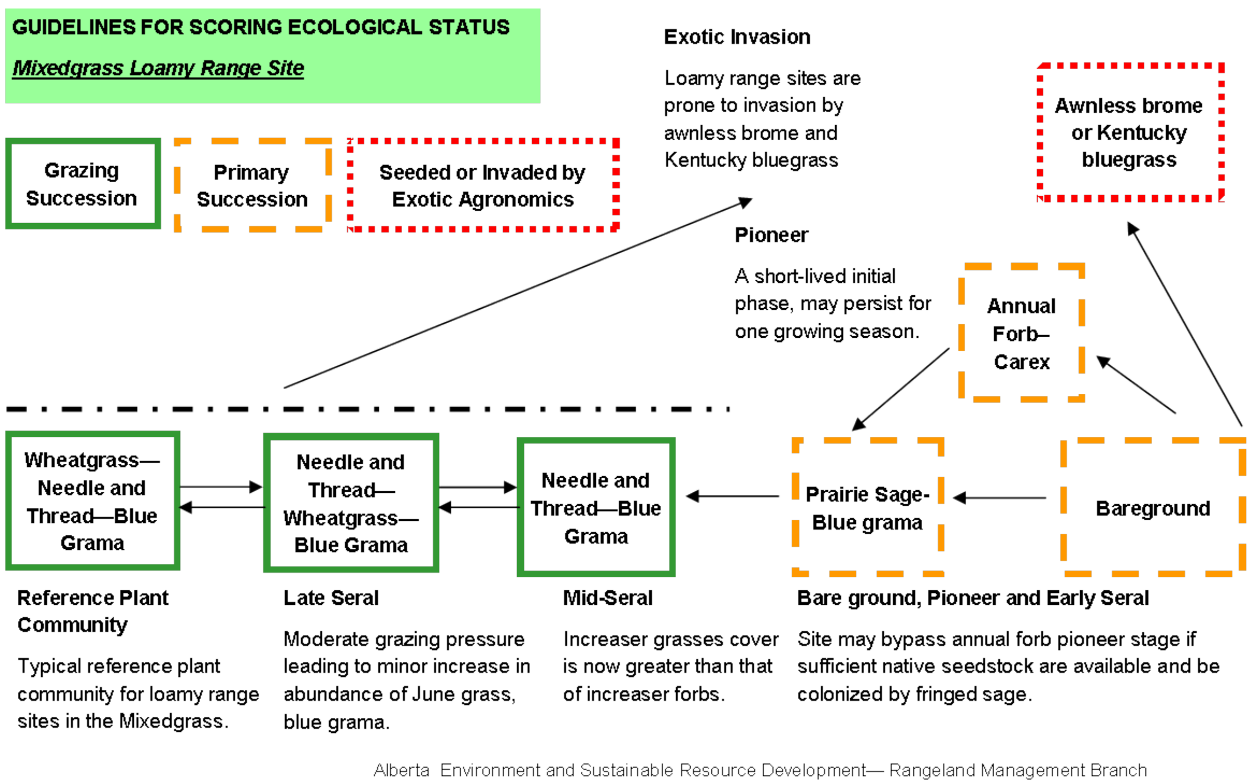
- **Plant communities** are mixtures of plant species that interact with one another.
- **Succession** is the gradual replacement of one plant community by another over time.
- **Successional pathways** describe the predictable pathway of change in the plant community as it is subjected to different 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.
- **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)** since we use it as the "reference" for comparison.
- **Reference plant community (RPC)** is the term we use for the potential natural plant community since we use it as the "reference" for comparison.
- 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.

[1] . 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 wheatgrass, Elbee northern wheatgrass, and Leodorm green needle grass.

- **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 awnless brome, timothy (*Phleum pretense*) or Kentucky bluegrass) with a 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 none native state.

Figure 10 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 the impact that light, moderate and heavy grazing have on the plant communities. The brown boxes illustrate the area of current and future emphasis to better understand the pathway of plant community succession from bare soil and the red boxes illustrate dramatic changes that may occur when invasive species subvert the path of recovery. We know much less about these dimensions of plant succession with reduced confidence in predicting outcomes. None the less, this successional tool provides a foundation for capturing and sharing key learnings and for using this knowledge to improve our development practices.

Figure 10 – Guidelines for Scoring Ecological Status



It is important to note that the pioneer, early and mid-seral stages in Figure 10 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.

4.3 Industrial Disturbance and the Process of Plant Community Succession

Appendix B includes case studies summarized from long term monitoring projects undertaken by this project team to gather native plant community recovery data and subsequent learnings relevant to the preparation of this manual. The reports are entitled "*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) and *Natural Recovery on Minimal Disturbance Well Sites in the Mixedgrass NSR – 2012 Monitoring (* Appendix B Case Studies*).* The purpose of these case studies is to provide industry and the Government of Alberta with much needed data on the long term revegetation success of reclamation techniques used in native prairie. The case studies present data, discussion and recommendations relevant to the Mixedgrass (Appendix B Case Studies). A species list has been included as Appendix F. The complete reports are posted in the Information Portal on the Foothills Restoration Forum website at http://www.foothillsrestorationforum.ca.

A key learning from the interpretation of the Express case study data was the definition of successional phases of the recovering plant communities following pipeline construction. Table 2 provides these definitions from bare ground resulting from soil profile disturbance associated with construction practices such as topsoil stripping, grading and trenching. **Annual forb species often referred to as nuisance weeds such as kochia (*Kochia scoparia*), Russian thistle (*Salsola kali*) and the goosefoots (*Chenopodium spp*.) play an important role in site stabilization and moisture retention in the pioneer stage. The role these pioneer species play in the continuum of succession may not be recognized by landowners and reclamation practitioners. Nor is the time frame required for the process of succession to take place. Patience is required to reach the restoration outcome.**

Patience is required to reach the restoration outcome

Table 2 – Definitions of Successional Phases of Recovering Plant Communities

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 wheatgrass, Kentucky bluegrass, awnless brome and sheep fescue (*Festuca ovina*) in the Mixedgrass NSR.

5 PREPARING THE PATHWAY

5.1 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 vegetation 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 Working Group 2002) and have been implemented widely and successfully by the industry. Other industries are encouraged to develop industry specific guidelines.

5.1.1 Pre-Disturbance Site Assessment

Pre-disturbance site assessment is the decision-making process that enables productive and cost effective development planning. 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.

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[2]. 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 (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.

[2] 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.

Map the 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.

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, and Historic Resource Values. 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 (Fish and Wildlife Division, Sustainable Resource Development, 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. Landowner/lease holder 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 for field work 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 and reclamation practices, with expected restoration strategies and outcomes. Prepare a detailed and site specific environmental protection plan (EPP).

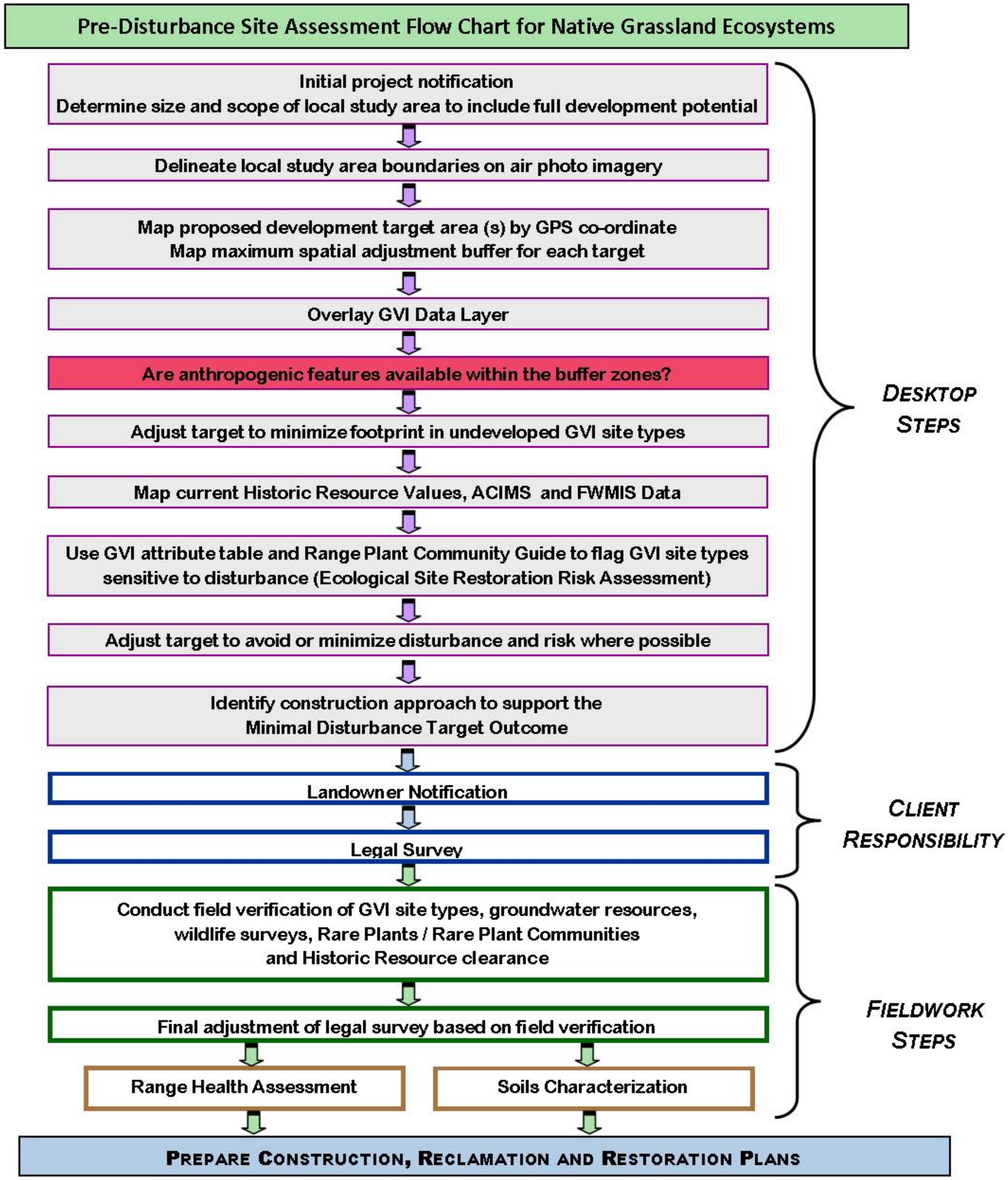
Ensure the EPP, with construction, reclamation and restoration plans are incorporated into contract documents. Where appropriate to the development type and construction plan include interim restoration planning to reduce the disturbance and bridge the gap between the operations phase and decommissioning.

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

Monitor to ensure contractual compliance.

Sidebar: Communicates a progressive message to analyze, adapt and improve practices.

Figure 11 - Pre-Disturbance Site Assessment Flowchart for Native Grassland Ecosystems



5.1.2 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 and Use Respect!

5.1.2.1 Notify and Consult with Landowners and/or 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 and 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.
- Allow for settlement of soils over the trench when constructing minimal disturbance pipelines and flowlines. Subsidence over trench line 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 time frame 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, through 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) lacked 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!

5.1.2.2 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:

- 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"[3]) is reclaimed[4]. 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 and compliance is required; and
- 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.

5.2 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:

1. ***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.

[3] See Glossary

[4] 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.

2. ***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.
3. ***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 for a single production site). 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 $36m^2$ 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 include: natural recovery, assisted natural recovery and the use of native seed mixes.

5.2.1 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). Natural recovery is linked to minimal disturbance industrial development procedures which minimize the disturbance to the soils and native vegetation. Examples include: minimal disturbance shallow gas wells that are drilled and operated with the native sod and soils intact except for a small area at well centre, and pipeline construction where the only soil disturbance is over the trenchline**.** 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 (Desserud 2013).

The pre-disturbance native vegetation recovers from the procedure 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.

The pre-disturbance native vegetation recovers from the procedure providing the rangeland is healthy, the impact is short term, and development is conducted under dry or frozen ground conditions.

Natural recovery relies on the native seed bank present in the uppermost layer of the topsoil, seed rain from the surrounding undisturbed native plant community, and native plant propogules (rhizomes and crowns) present in the disturbed soil to revegetate areas where soil disturbance has occurred. 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.

When considering natural recovery, it is important to conduct an ecological risk assessment to determine the ecological status and range health of the native grassland surrounding the disturbance.

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 (see Appendix B, Section B.1.3).

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

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

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

The fragmented native prairie landscape in the Mixedgrass presents additional challenges for invasive non-native plant management. It is important to know whether non-native invasive plants are present in the on-site community, or in the surrounding area near the site. In the Mixedgrass, invasive plants such as downy brome (*Bromus tectorum*), Japanese brome (*Bromus japonicus*), awnless brome (*Bromus inermis*), crested wheat grass (*Agropyron cristatum, A. sibiricum*), Kentucky bluegrass (*Poa pratensis*), sweet clover (*Melilotus officinalis*), alsike clover (*Trifolium hybridum*), Canada thistle (*Cirsium arvense*), common dandelion (*Taraxacum officinale*), toad flax (*Linaria spp.*), wormwood absinthe (*Artemesia absinthium*) and leafy spurge (*Euphorbia esula*) are known to invade bare ground and are very difficult to eradicate.

The following key learnings, regarding the use of natural recovery in the Mixedgrass have been summarized from the case studies conducted for this project (included as Appendix B).

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

Use of natural recovery as the strategy for narrow linear disturbances on Loamy and Limey ecological range sites in the Majorville Upland resulted in a positive successional trend towards the recovery of the disturbance over the trenchline (Appendix B Case Studies). Range health scores have increased on all trenchline monitoring sites from 2008 to 2011 indicating that the process of infill is occurring. Exposure of bare ground over the trenchline has decreased from 2008 to 2011 and total vegetation has increased within the sample sites.

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

Over the long term (eleven years post-construction), western and northern wheatgrasses 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 continue to provide 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 (Appendix B Case Studies). 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. 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 topsoils.

Performance of Natural Recovery on Minimal Disturbance Well Sites

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” (see Appendix B3). 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 number on undisturbed grassland;
- Litter values on undisturbed areas are double those found on the disturbance;
- Introduced weeds are goat's beard and common dandelion;
- Disturbances may be targeted by grazers, which can affect recovery.

For loamy range sites in the Majorville, Lethbridge and Vulcan Plains ecodistricts, the Wheatgrass - Needle-&-Thread (MGA21) range plant community is a reference plant community. 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 goat's beard, common dandelion, flixweed and lamb's quarters;
- Invasive species present despite healthy range condition on undisturbed areas include crested wheatgrass, and both crested wheatgrass and Canada thistle on disturbances;
- Dominant natural recovery species are western wheatgrass, needle-and-thread and blue grama (see Appendix 3B).

Factors to consider in the risk assessment for minimal disturbance well sites are the availability of native seed on site 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. A well site on thin Loamy soils on an upper west-facing slope has experienced topsoil deflation in the five years since construction. The site is moderately grazed and is dominated by exposed crusted soil and annual weeds. This site is downwind of an intensive livestock operation which may also contribute weed seed through wind transport.

A well site in thin Loamy soils on an upper east-facing slope recovered well. This site is on a slight lee slope and surrounded by native prairie in good range health.

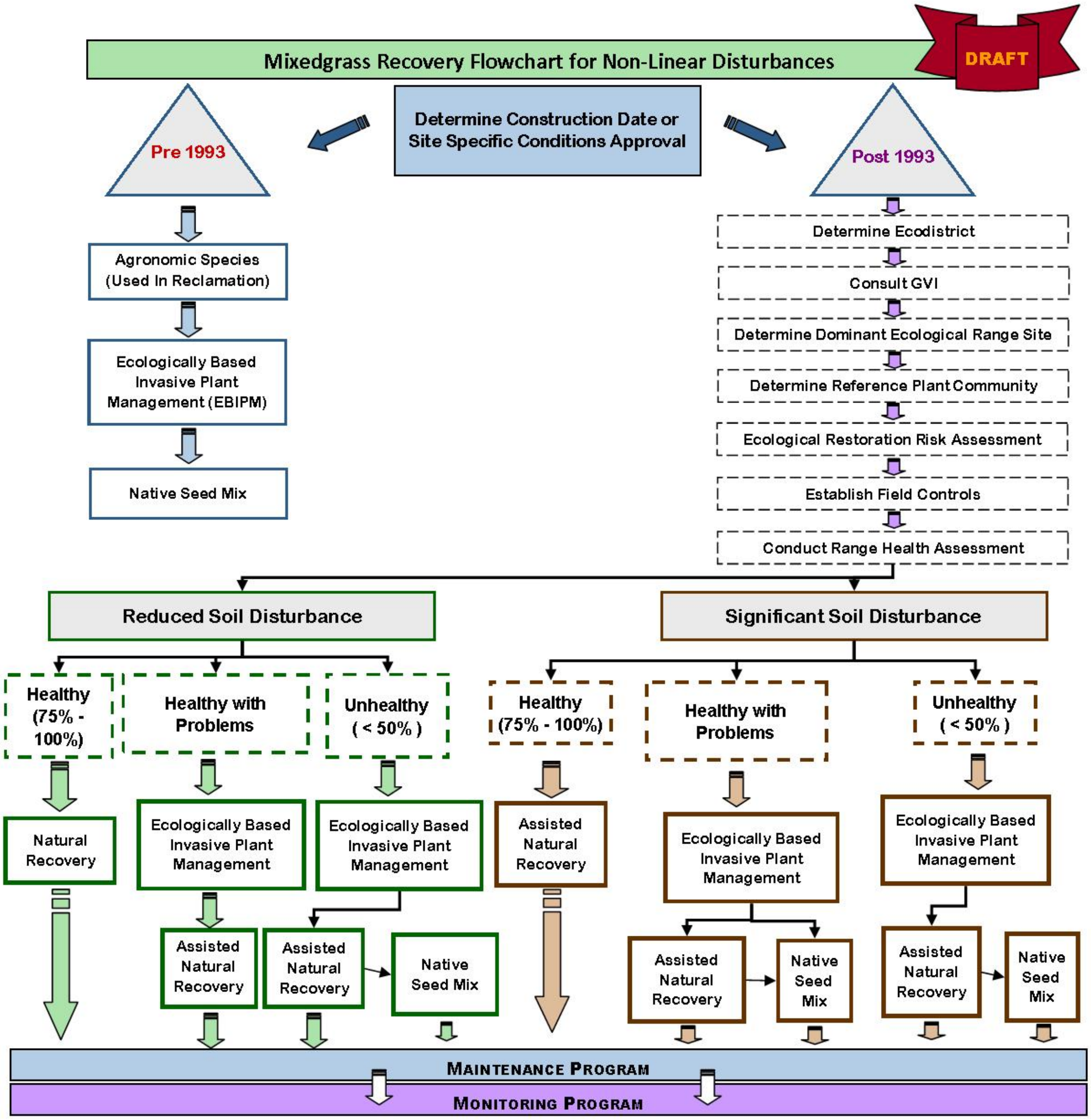
The Timing of Topsoil Stripping and Replacement affects the Success of Natural Recovery

Where soil disturbance is necessary, the timing of topsoil stripping and replacement can have a dramatic effect on the success of this 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) and within the same year (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. It is important to recognize the role annual weeds and forbs play in stabilizing the site during the early years of recovery. The timeframe for when indicator species will 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.

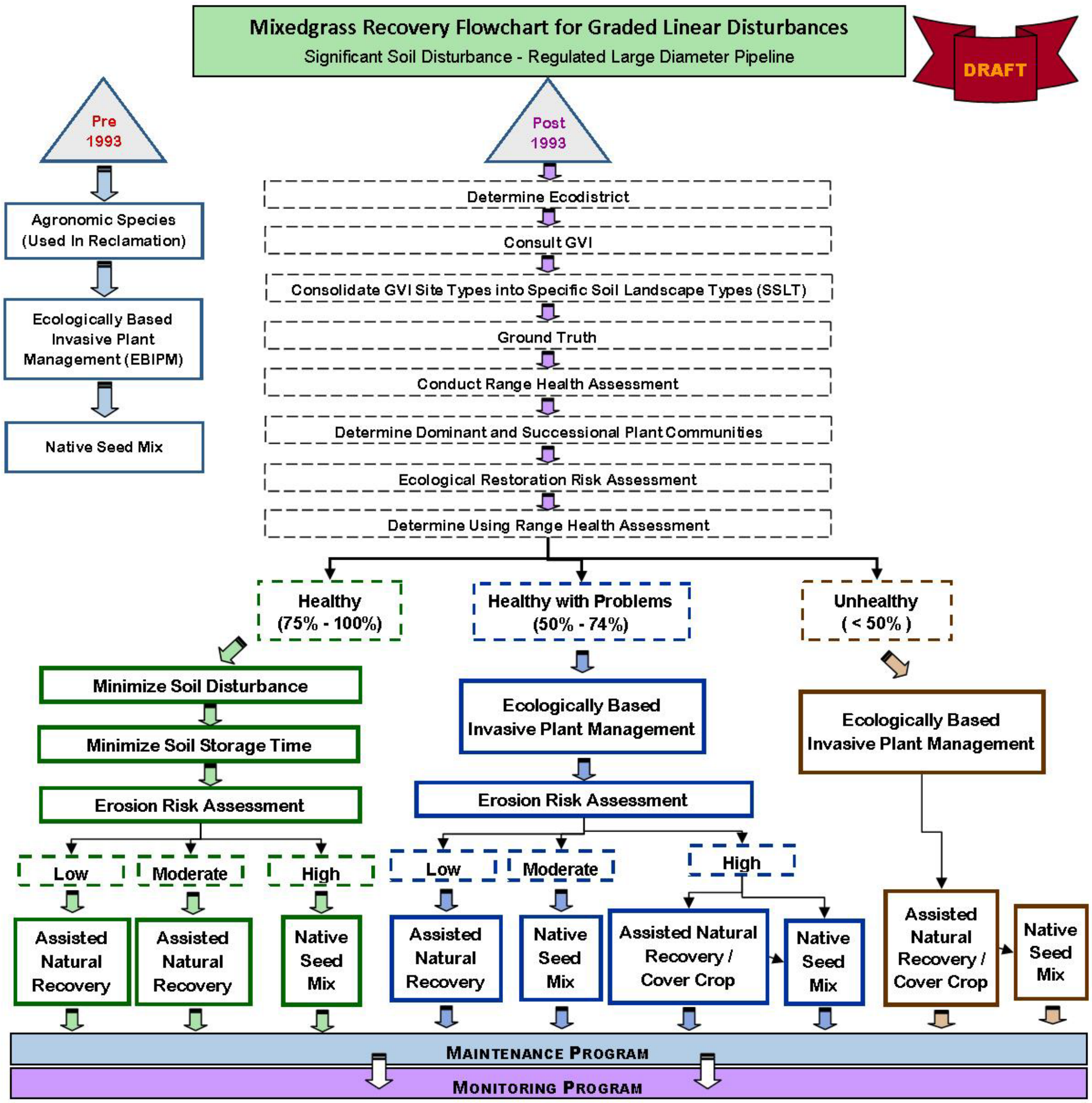
The accompanying flow charts (Figures 12 and 13) for linear and non-linear disturbances provide a pathway for decision making when considering natural recovery, assisted natural recovery and native seed mixes.

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



Note: Reduced refers to small soil disturbances with a large edge to disturbance ratio. Significant refers to soil disturbances with small edge to disturbance ratio.

Figure 13 - Mixedgrass Recovery Flow Chart for Linear Disturbances



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 Act and/or by the National Energy Board. They are generally greater than 20 inches in outside diameter.

5.2.2 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 (Appendix B Case Studies) and on other industrial disturbances since the late 1990s. Other short lived perennial native cultivars such as Canada wild rye (*Elymus Canadensis*) and slender wheatgrass (*Agropyron trachycaulum*) have been used as well. Applying the seed at low seeding rates is essential (3 to 5 kgs per hectare depending of 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 is 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 lease holder is very important when considering the implementation of this strategy.

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 with no additional added 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 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.

Native hay harvester developed by Ron Johnson (Medicine Hat, AB) and Marshal Gillespie (Finnegan, AB)

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 the seeded species 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.

5.2.3 Use of Native Seed Mixes

Long term monitoring case studies conducted to prepare this manual (Kestrel Research Inc. and Gramineae Services Ltd. 2011; Lancaster, Neville and Hickman 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.

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 well sites, 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 C). 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 C includes the specifics of the target recovering plant communities and examples of the expected outcome.

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 hardened off prior to installation 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.

5.3 Special Consideration for Lentic and Lotic 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 Lentic and Lotic sites.

When decommissioning existing industrial infrastructure located in or near lentic or lotic 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 is likely to provide the most effective mitigation for wetland communities. Exposed moist wetland soils are vulnerable to colonization by invasive plants.

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;
- 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 occurs through spread of neighbouring rhizomatous species.

For riparian (lotic) wetlands, more intensive reclamation strategies such as the use of erosion control fabric and geotextiles, hydomulching, nursery raised shrub and forb transplants and seedlings and soil bioengineering procedures such as live fachines or live staking may be required to control water erosion and promote restoration.

6 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

6.1 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 seed bank, 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:

- 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;
- minimize the timeframe between topsoil stripping and replacement; and
- avoid pulverizing and mixing the soils.

6.2 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. Do not harrow to break down the sod and pulverize the soil. Clumps of sod contain live plant material and the native seed bank 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.

6.3 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.

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. Warm season grasses should be seeded ideally 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.

6.4 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.

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. http://www.prairiehabitats.com/

6.4.1 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 wheatgrasses, 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 the Foothills Restoration Forum and the 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 (*Bromus tectorum*), Japanese brome (*Bromus japonicus*), and invasive agronomic species such as crested wheatgrass (*Agropyron cristatum*), awnless brome (*Bromus inermus*), 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 is found in Appendix D.3

6.4.2 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 wheatgrass, awnless brome, Kentucky bluegrass and sweet clover.

Methods of obtaining the necessary material include:

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 DU 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. You will be required to obtain written consent from the grazing lease holder for the area that you are planning to carry out your seed harvest.
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 wheatgrass, awnless brome and sweet clover.
3. You must notify the ESRD - Range Agrologist responsible for the selected area 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).

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. 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 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).

Wild harvested hay may be cut with a variety of equipment (photos in the Wild Harvested Hay Mulch section).

Finally, wild harvested native plant material is a precious resource. Before you harvest 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.

7 MAINTAINING THE PATHWAY

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.

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

Control of Restricted Noxious and Noxious weeds is required under the Alberta Weed Control Act (Province of Alberta 2010A). Weed and invasive plant management is a specialized area of expertise and requires a Commercial Applicator's licence. Contractors hired should be familiar with the 2010 Reclamation Criteria-Native Grasslands, and the desired long term outcome of native grassland restoration. Control of specific weed species at identified locations 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.

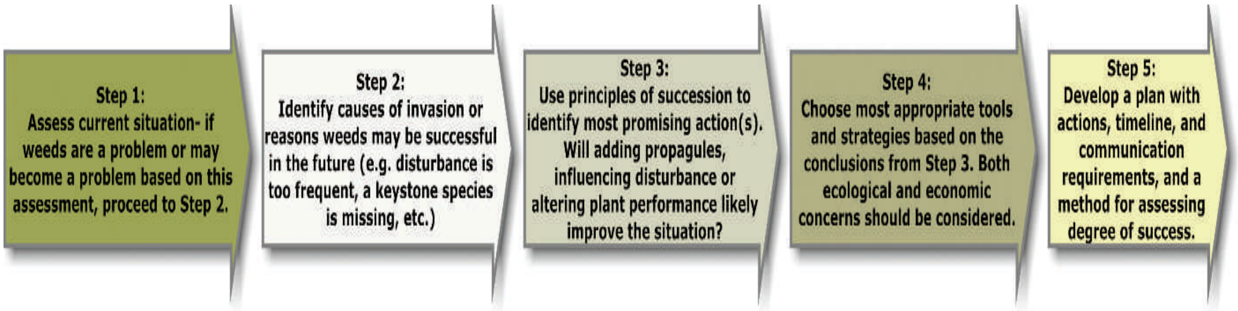
A coordinated, multi-faceted approach to vegetation management is often the most successful and cost effective. Maintaining a database of areas where vegetation management is required and evaluating the success of the control methods implemented are important steps in a successful vegetation management program.

7.1 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 is an approach to rangeland invasive plant management which applies scientific principles and management experiences in a step by step plan (Figure 14).

Figure 14 - The step by step process of EPBIM from Rangelands

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



Prior to applying EBPIM, 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 and Mangold et al. March 2011) 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 plans, e.g. crested wheatgrass.
- 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, awnless brome will thrive close to riparian areas.
- Special attention must be paid to areas that might promote the growth of invasive plants.

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 succession. Refer to section 4.2 for more information on succession processes. Use Figure 10 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*

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.
- Applying herbicides is a common strategy to control invasive species, especially for annual weeds, and may require repeated application over a long-term control time.

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

The following invasive plants are found in the Mixedgrass (Table 3). Alberta Agriculture provides information on all registered herbicides for these species http://www.agric.gov.ab.ca/app23/herbsel. The table indicates if grazing is an option.

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

Common Name	Scientific Name	Growth Habit	Grazing Option
Forbs			
absinth	*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
goats-beard	*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 and update the plan.

These steps should be repeated with each cycle, ultimately improving management.

7.2 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 lease holder 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. 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 which can negatively influence the process of plant community succession. Make certain there are adequate funds allocated for fence removal.

7.3 Monitoring Recovery

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.

7.3.1 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 both 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. Patience is required to allow natural successional processes to take place.

7.3.2 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 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 one to three years to allow plant germination and establishment (see section 7.2 Grazing Management).
- 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 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 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, which should be done at each monitoring site, both on the disturbance and the reference area.

Adaptive Management after Year 3

- Litter may start to build up, especially if the area has been fenced. If necessary, mow or rake the 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 herbicide application (see EBIPM Section).

Draw Conclusions and Update the Plan

- The above monitoring and adaptive management steps should be repeated with each monitoring cycle, ultimately improving management.
- 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 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.

8 THE IMPORTANCE OF LONG-TERM MONITORING

If we are to conserve what remains of our native prairie for future generations, then we must continue to improve our recovery practices in native prairie landscapes. In the past, equivalent land capability focused on salvaging soil. Today, equivalent land capability includes restoration of native plant communities in native rangeland. Our focus must shift from reclamation to restoration.

Time is an important factor in the process of recovery from industrial disturbance in native grasslands. Extended timeframe monitoring using standardized methods of evaluation provides the opportunity to reflect on construction and reclamation procedures used in the past and make informed choices that will improve future restoration potential. Time is required to meet our restoration goals.

The results of the Express monitoring project 14 years after construction indicate 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. 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. Additional data is required to fully understand native plant community successional pathways following industrial disturbance in the long term. 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. 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.

9 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. Summaries of the workshops are included as Appendix E. 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. Research priorities proposed by the stakeholders include:

- 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. Research should be funded and given priority. 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 invasive impacts of invasive agronomic species.
- More monitoring and research is required to define appropriate seeding rates for sites that require seeding.
- The best methods to manage downy brome including: herbicidal products, alternatives to chemical treatment and the timing of chemical application or alternative treatments are required.
- The effects of soil disturbance on mycorrhizal populations and whether inoculating disturbance will improve restoration potential should be researched.
- Does uneven distribution of replaced topsoils 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?
- Regarding wild harvested hay, guidelines to ensure recovery of harvested areas, percentage filling in, and potential for centrally located designated areas to supply native hay. Further study on the success of the technique is required.
- What is the role of early colonizers in perennial establishment?
- Research is required regarding the role of forbs in plant community succession. Suggestion to include more information on the use of forbs in plantings, perhaps as a follow up to seeding?
- Further research and monitoring regarding the importance of the two-lift stripping procedure to native plant community restoration is required.
- The planting of wild harvested native grasses without processing first. An example would be marsh reed grass (*Calamagrostis Canadensis)*. It is a very light seed and is very difficult to clean.
- Effectiveness of using nursery propagated native plant material, (rooted seedlings) to start hard to establish species (e.g., shrubs, forbs) or, to establish native species on difficult sites (steep terrain, exposed areas, xeric sites).
- Awns play an important role in establishing seed naturally. Processing to remove the awn can damage up to 50% of the seed, increasing the cost. We need to understand the function of the awn. Consider methods of applying seed mulch? Example, needle-and-thread grass (*Stipa Comata)*, problem with awn, seeds fluffy, how to apply rather than clean it, seed mulch?

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