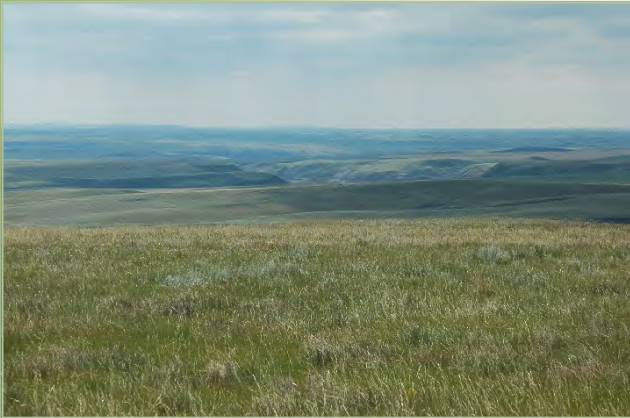


***Recovery
Strategies for
Industrial
Development
In Native
Grassland***

for the

**Northern
Fescue**

**Natural Subregion
of Alberta**



Plains Rough Fescue Grassland



Natural Recovery



Flowline Seeded to Native Species



First Approximation

March 2017

RECOVERY STRATEGIES FOR INDUSTRIAL DEVELOPMENT IN NATIVE GRASSLAND

**FOR THE NORTHERN FESCUE
NATURAL SUBREGION OF ALBERTA**

MARCH 2017

First Approximation

Prepared by:

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RECOVERY STRATEGIES FOR INDUSTRIAL DEVELOPMENT
IN NATIVE PRAIRIE ADVISORY GROUP

FOOTHILLS RESTORATION FORUM TECHNICAL ADVISORY COMMITTEE

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Thanks Everyone!

Jane Lancaster, Barry Adams, Peggy Desserud, Ross Adams and Marilyn Neville

Preface

Alberta's Grassland Natural Region, like much of the Canadian prairie, is considered to be amongst the most modified by human land use practices (PCF 2016). As the population and economy of Alberta expands, the extent and biodiversity of native prairie ecosystems is decreasing dramatically with the cumulative impacts of multiple overlapping land use activities including agricultural conversion, petroleum and non-renewable energy development, transportation corridors and urban settlement. The Northern Fescue Natural Subregion of Alberta is rich in petroleum resources with a large and diverse development infrastructure in native prairie. Recently, development for wind energy is also taking place, resulting in extensive, long-term infrastructure in native prairie. Cumulative effects of multiple industries and fragmentation by many linear projects are reducing the extent and degrading the overall health of native grasslands and their resilience to disturbance. Any disturbance promotes the establishment of both old and new invasive species in native grassland landscapes and reduces the ability of these ecosystems to recover (Bradley and Neville 2011). There is a growing awareness in the wider society that invasive species impose significant economic and environmental costs. Once native grasslands have become invaded, there are few options to restore them.

As the demand for development has increased, so has public pressure to reduce the impact of industrial disturbance and the cumulative effects (see page 12) of multiple activities on native prairie ecosystems. The South Saskatchewan Regional Plan (AEP 2014) identifies the retention of native grasslands along with their associated biodiversity and healthy ecosystems as a key goal. The SSRP sets out to:

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

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

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

This manual has been developed for planners, land managers, land owners, reclamation practitioners and regulatory authorities to identify suitable strategies to minimize further impacts to Northern Fescue ecosystems. Construction, reclamation and restoration methods have evolved over time. Long-term monitoring data has been collected to assess the effectiveness of a number of practices. This document provides learnings from recent academic research as well as long-term monitoring field studies and identifies strategies designed to retain and restore Northern Fescue native plant communities over time.

Northern Fescue Natural Subregion

The ongoing development of 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 partnerships established between Alberta Environment and Parks, industry and more recently the Prairie Conservation Forum (PCF) to capture the key experience and learnings that have accumulated over the past 10 to 20 years since minimum disturbance practice was first established (AEP 2016a).

Reclamation practices following industrial disturbance in native prairie landscapes have been steadily evolving since the early 1980s. 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* (AEP 2013a). 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 or focus on just oil and gas, but rather strive to present options and pathways to enable selection of the most appropriate recovery strategy for the type of industrial disturbance on a site specific basis. Their purpose is to provide the expectations of what is required to reach the outcome of restoration over time.

The strategies build on existing guidelines and information sources such as *Restoring Canada's Native Prairies, A Practical Manual* (Morgan et al. 1995), *A Guide to Using Native Plants on Disturbed Lands* (Sinton Gerling et al. 1996), *Native Plant Revegetation Guidelines for Alberta* (Native Plant Working Group 2000), *Prairie Oil and Gas, A Lighter Footprint* (Sinton 2001) and *Establishing Native Plant Communities* (Smreciu et al. 2003). While these guides continue to be excellent information sources, this manual incorporates new knowledge sources and technical innovations that have been developed since 2003. The upstream oil and gas industry has made major changes to the way wellsites and associated infrastructures are developed in native grasslands. 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 of a living document, recognizing that revision will be required as our knowledge of native prairie plant communities and their response to industrial disturbance increases. Revision will also be required as reclamation practitioners use this approximation and industry responds to the challenges of native plant community restoration with new technology designed to reduce the industrial footprint in native prairie landscapes.

The Natural Regions and Subregions of Alberta (Natural Regions Committee 2006) ecological classification and mapping assists practitioners with understanding the Natural Subregion context of restoration opportunities and limitations (Figure 1). Development of the *Grassland Vegetation Inventory (GVI)*, *Range Plant Community Guides* and *Range Health Assessment* protocol by the Alberta Environment and Parks (AEP) Range Resource Stewardship Section (RRSS) link native plant communities to soils and site characteristics and facilitate a more complete understanding of the ability of native plant communities to respond and adapt to natural disturbance regimes such as fire, grazing, drought, and insect predation. These tools are now being applied to assess and manage man-made disturbances. They are incorporated into pre-disturbance site assessment, development planning and reclamation certification for native grasslands, creating the opportunity for an additional tool which provides guidance on appropriate recovery strategies for each Natural Subregion.

The Northern Fescue NSR is unique in the challenges it presents to restoring disturbance from industrial development. Much of the Northern Fescue native prairie has been lost to cultivation and fragmented by industrial activity and roads. The fertile soils and climate of the Northern Fescue promote the spread of invasive non-native plants where soil disturbance has occurred.

A collaborative approach using science, available technology and practical knowledge of the disturbance related activities associated with the proposed development can avoid or reduce the impact to native grasslands. Restoration risk analysis (Gramineae and Landwise 2009) is a critical step in assessing restoration strategies prior to siting disturbances on the landscape. Avoidance followed by minimal disturbance construction procedures are the most effective strategies for conserving native plant communities in the Northern Fescue NSR. Alternate recovery strategies for large disturbances not suited to natural recovery as well as severely degraded sites are defined and discussed in the context of new restoration tools and recent publications. When disturbance is known to be an outcome of planned use, the implementation of recovery strategies will better prevent the establishment and spread of invasives species. Monitoring and ongoing adaptive management after disturbance are also critical procedures to restore healthy ecological range sites that can naturally infill without concern for invasives.

Figure 1 - Grassland Natural Subregions of Alberta

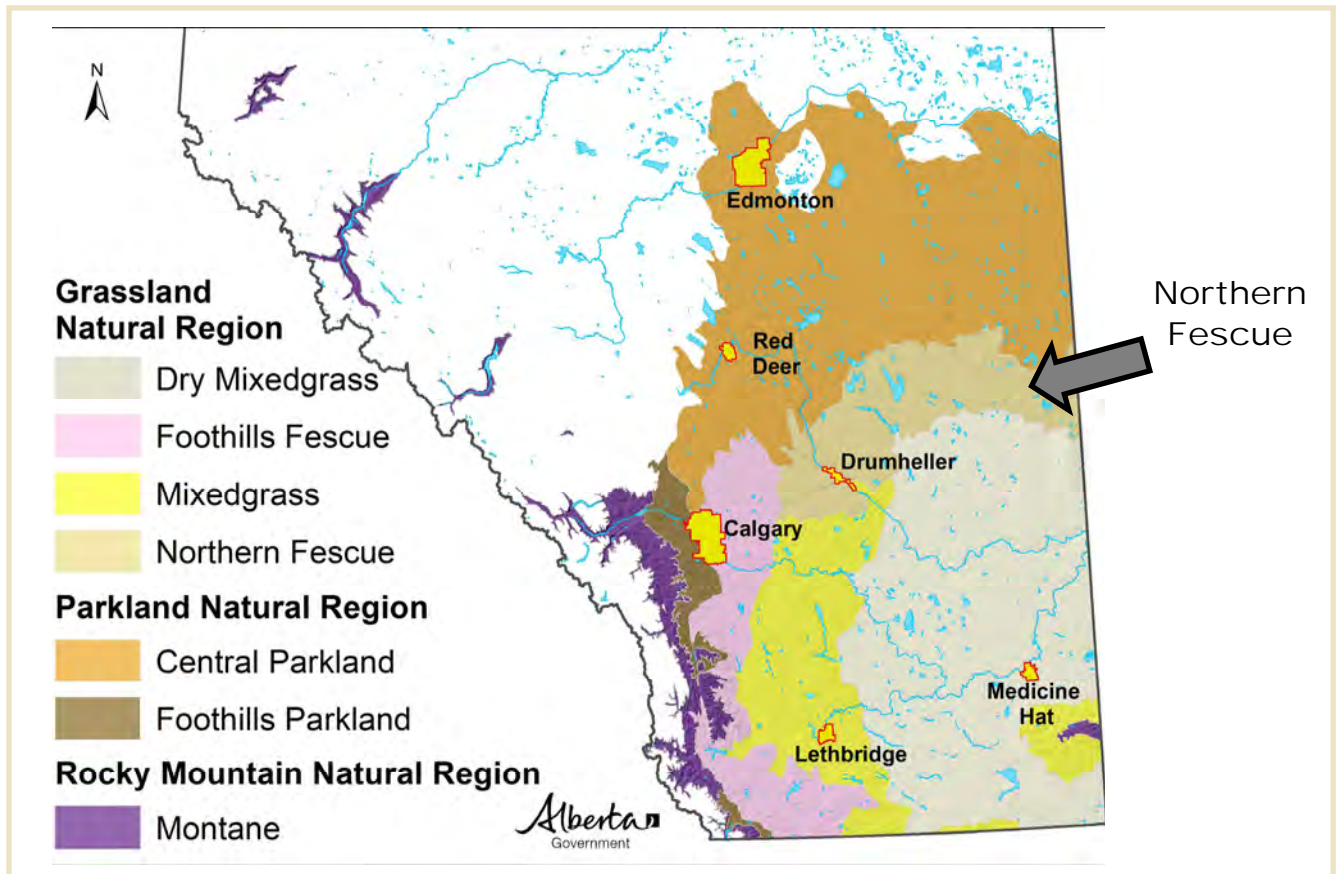


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Cover Photos

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Alberta/Northern Fescue, Image Courtesy of AEP

1-A Shift in Focus to Restoration

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

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

2-Overview of the Northern Fescue Natural Subregion

Northern Fescue NSR and Component Ecodistricts, Courtesy of AEP

4-Promoting Native Plant Community Succession

Breaking Sod with Case Tractor, Glenbow Archives NA-3738-5

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Smooth Brome Invasion, Jane Lancaster, Kestrel Research Inc.

Early Seral—Hand Hills Pipeline RoW, Jane Lancaster, Kestrel Research Inc.

Mid to Late Seral—Hand Hills, 7 Years After Reclamation, Peggy Desserud

5-Preparing the Pathway

Minimal Disturbance Wellsite, Jane Lancaster, Kestrel Research Inc.

Ranching Industry, Jane Lancaster, Kestrel Research Inc.

Land Man Image, Marilyn Neville, Gramineae Services Ltd.

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6-Selecting the Recovery Strategy

Minimal Disturbance Techniques, Marilyn Neville, Gramineae Services Ltd.

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7-Implementing the Strategy

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

8-Maintaining the Pathway

Thistle and Smooth Brome Invaded RoW; and Surveyors in Native Prairie, Jane Lancaster, Kestrel Research Inc.

9-The Importance of Long Term Monitoring

Reclamation and Monitoring Research Plot Layout, Image Courtesy of Peggy Desserud

10-Future Research Required

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

Abbreviations

ACIMS.....	Alberta Conservation Information Management System
ACIS.....	AgroClimatic Information Service
AEP.....	Alberta Environment and Parks
AER.....	Alberta Energy Regulator
AGRASID.....	Agricultural Region of Alberta Soil Information Database
AISC.....	Alberta Invasive Species Council
AITF.....	Alberta Innovates – Technology Futures
ANPC.....	Alberta Native Plant Council
ARC.....	Alberta Research Council
cm.....	centimetre
EAP.....	Enhanced Approval Process
EBIPM.....	Ecologically Based Invasive Plant Management
EPP.....	Environmental Protection Plan
ESRRA.....	Ecological Site Restoration Risk Analysis
FRF.....	Foothills Restoration Forum
FWMIS.....	Fish and Wildlife Management Information System
g.....	gram
GVI.....	Grassland Vegetation Inventory
ha.....	hectare
IL.....	Information Letter
kg.....	kilogram
km.....	kilometre
LAT.....	Landscape Analysis Tool
LSA.....	Local Study Area
m.....	metre
NF.....	Northern Fescue
NFPCG.....	Northern Fescue Plant Community Guide
NGO.....	Non-government Organization
NSR.....	Natural Subregion
PCF.....	Prairie Conservation Forum
PLS.....	pure live seed
PLVI.....	Primary Land and Vegetation Inventory
PNT.....	Protective Notation
RoW.....	Right-of-Way
RRSS.....	Range Resource Stewardship Section
SRM.....	Society for Range Management
wt.....	weight

1 A SHIFT IN FOCUS TO RESTORATION

Why is ecological restoration so important to preserving native grassland ecosystems? To date a large proportion, over 75% of the original native grasslands in the Northern Fescue Natural Subregion have been converted to cultivation. Consequently, these otherwise vibrant and adaptive landscapes are subject to ongoing risk from an increasingly large industrial footprint. The amount of industrial activity taking place in native grasslands has expanded dramatically since the early 1990s. If what remains of the native prairies is to be conserved for future generations, then it is critical to continue to improve reclamation practices and recovery strategies in native prairie landscapes. The focus must shift from reclamation to restoration.

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



Avoid Sensitive Landscape Features and Habitat

Cumulative Effects Management & Fragmentation

Cumulative effects are the combined effects of past, present and reasonably foreseeable future land use activities on the environment. Surface disturbance in grasslands can be grouped in a number of measurable categories that help in the understanding and management of cumulative impacts of land use practices to Alberta's native grasslands. These include:

- 1. Permanent conversion to non-native cover types:** Over the past century, extensive tracts of Northern Fescue grasslands have been permanently converted to non-native cover types primarily for agricultural cropping, transportation and energy infrastructure, and urban and country residential development. Incremental losses through these processes continue.
- 2. Reclamation success and plant community integrity:** Relative to each unique ecological site, intact native grasslands possess a rich diversity of native grasses, forbs and shrubs that produce a characteristic plant community structure, facilitating optimal use of moisture, nutrients and available sunlight. To the extent possible, reclamation practices aim to restore the native plant community so that ecological health and function, and the related ecological services are maintained. In the Alberta Grassland Natural Region, recovery of native plant communities can be more readily achieved in drier prairie environments while mesic northern fescue environments are much more challenging, primarily due to the greater competitiveness of agronomic grasses and weeds in the moister growing environment. Ecological health, function and associated ecological services are diminished when plant communities are modified by non-native species.
- 3. Anthropogenic edge density and fragmentation:** The progressive additions of linear developments like roads, pipelines and transmission rights-of-way in a unit of native grassland can be expressed as anthropogenic edge density and measured in km/km^2 of linear feature. Research shows that grassland intactness declines as anthropogenic edge increases. Left unmanaged it results in the progressive fragmentation of native grasslands, reducing their health and function.
- 4. Shadow effect and invasive species:** Anthropogenic edge results in disturbed grassland and also an interface into undisturbed grassland for invasive species. The seed stock of invasives may spread from the reclaimed linear feature or be transported by the associated traffic along the access feature. The rate at which invasives move off the linear feature can be measured and expressed as meters/year.
- 5. Reduced habitat effectiveness:** Habitat loss, alteration and fragmentation can result in reduced quality of wildlife habitat due to increased mortality, reduced reproductive success, displacement to other habitat and loss of habitat connectivity.
- 6. Reduced ecological services:** Reduced watershed protection, carbon storage and soil moisture retention.

Reclamation and Restoration Concepts

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

Reclamation can have various outcomes and includes *“revegetation, stabilization of the terrain, assurance of public safety, aesthetic improvement, and usually a return of the land to what, within the regional context, is considered to be a useful purpose”* (Society for Ecological Restoration 2004). Returning land to a useful purpose may or may not be a return to its original state. For example, revegetation of a native grassland disturbance to a forage crop may result in a useful purpose, but no resemblance to native grassland. For regulated industries, the end goal of reclamation is to get a reclamation certificate. However, standards vary between industries and some currently have none.

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

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

Linkage to the 2010 Reclamation Criteria

The recovery strategies documents are designed to dovetail with the *2010 Reclamation Criteria for Wellsites and Associated Facilities for Native Grasslands* (AEP 2013a) 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. These criteria and pathways for decision making are relevant to all industries operating on native grassland. In the 2010 Grassland Criteria, there is emphasis on native grassland plant communities as indicators of equivalent land capability. Equivalent Land Capability is defined in the 2010 Criteria *“as the condition in which ecosystem processes are functioning in a manner that will support the production of goods and services consistent in quality and quantity as present prior to disturbance”*. It is important that other industries strive to meet the same standards in order to retain functioning grassland ecosystems. The bar has been raised and now we must meet the challenge.

Trajectory and Timing

In practice, activities undertaken to promote the eventual restoration of a disturbance are reclamation activities. For reclamation to be considered successful and meet the 2010 Reclamation Criteria (AEP 2013a) there must be evidence of a positive trajectory within the plant community and soils towards restoration. The timing for actual restoration of a healthy, functioning plant community that supports species typical of the biodiversity of the area may take many years. Studies indicate it may take 10 to 20 years to re-develop healthy late seral plant communities. Groundcover components like moss, lichen and *Selaginella densa* (little club moss) may need 25+ years to re-establish equivalent cover (Kestrel Research Inc. and Gramineae Services Ltd. 2011).

Waiting 10-20 years to be assured that restoration is occurring is not practical. Therefore, confidence must be established that a recovering site is on a positive trajectory at the time of reclamation certification, with the expectation that recovery will continue unassisted towards restoration over time.

On non-challenging, well maintained sites, reclamation certification should be possible in about 5 years. At the other end of the spectrum, on extremely sensitive sites where there are protective notations (PNT) in place for rough fescue plant communities, reclamation certification could take much longer (e.g. 10+ years) and plant community restoration is very much an uncertain outcome. Use of the Landscape Analysis Tool (LAT) to avoid native prairie and site project disturbances in more resilient plant communities can significantly reduce restoration challenges and the time required to achieve reclamation certification.

Reducing Cumulative Effects

The most important principles in reducing the cumulative effects of industrial disturbance in native prairie landscapes include (AEP 2610a):

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

Minimum disturbance practices are an essential tool in the management of cumulative impacts of native grasslands.



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

2 OVERVIEW OF NORTHERN FESCUE NATURAL SUBREGION

The first step in restoration planning requires an understanding of Alberta's regional ecological land classification system. The Natural Regions and Subregions of Alberta provide the provincial ecological context within which resource management activities have been planned and implemented since the 1970s. The current revision entitled "*Natural Regions and Subregions of Alberta*" (Natural Regions Committee 2006) builds on two previous classifications: *Ecoregions of Alberta* (Strong and Leggat 1992) and *Natural Regions and Subregions and Natural History Themes of Alberta* (Achuff 1994).

It is important to understand the ecological diversity of the Grassland Natural Region and the unique restoration challenges offered in each Natural Subregion (NSR). The Natural Subregion distinction is the second 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 Northern Fescue Natural Subregion.

Physiography, Climate, Soils and Vegetation of the Northern Fescue Natural Subregion

The Northern Fescue Natural Subregion (Northern Fescue) occurs in a broad arc, extending from an area just east of Calgary, through the Drumheller Badlands to the Saskatchewan border, bounded by the Central Parkland to the north, the Dry Mixedgrass to the south, the Mixedgrass to the southwest and the Foothills Fescue to the west (Figure 2).

A detailed description of the Northern Fescue physiography, climate and soils has been provided by Kupsch et al. (2012) and is summarized as follows.

Bedrock formations in the Northern Fescue Natural Subregion are dominated by the Horseshoe Canyon Formation in the west, the Bearpaw Shale Formation in the central area, and the Belly River Group in the east. The Bearpaw Formation was deposited in a continental sea and is a marine shale deposit. The Horseshoe Canyon Formation is a sandstone, shale and coal deposit characteristic of the brackish tidal and deltaic zone at the edges of the Bearpaw Sea (Mussieux and Nelson 1998). The Belly River Group is a series of fresh (sandstone) and brackish (mudstone and shale) water deposits that reflects the changing margins of the continental sea as it frequently changed in size. The non-marine Paskapoo Formation, which consists mainly of alternating layers of medium- and coarse-grained sandstone, occurs in the extreme western portion of the Northern Fescue.

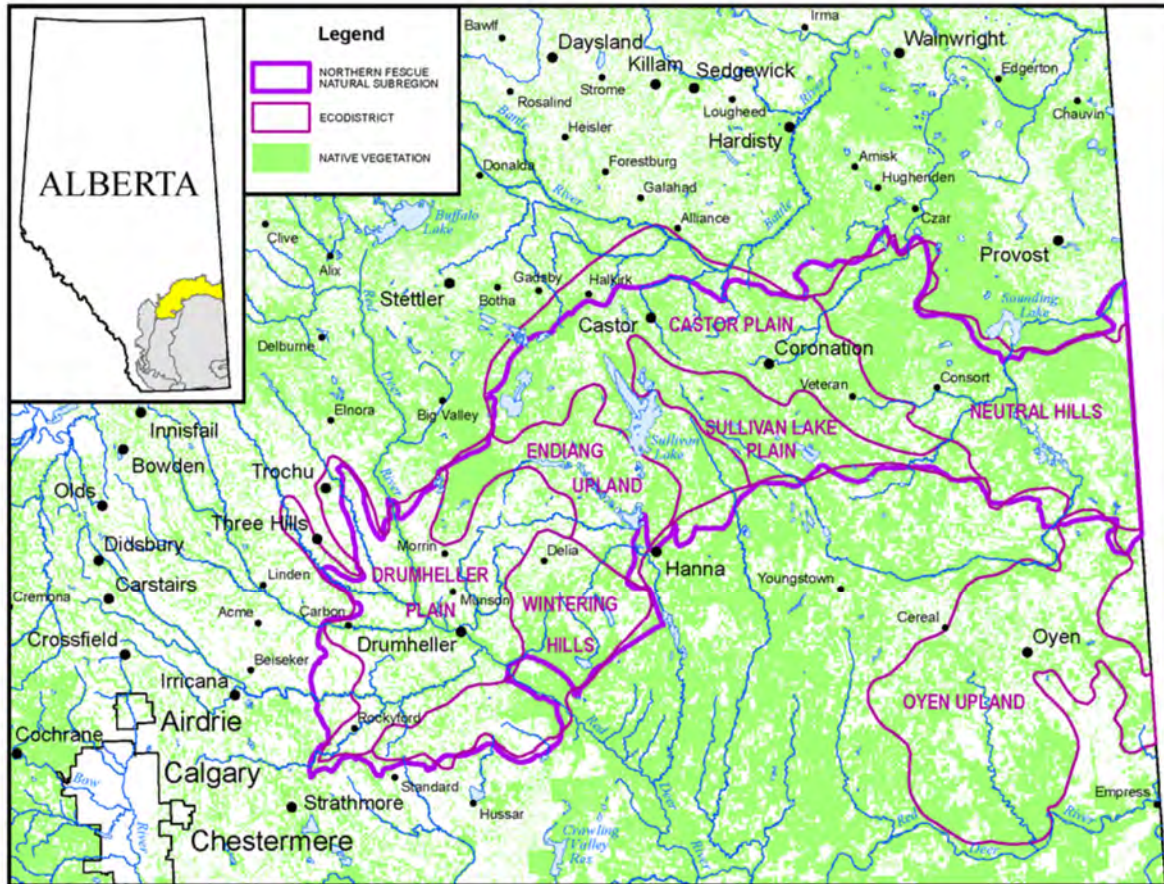
The Northern Fescue Natural Subregion is dominated by Dark Brown Chernozemic soils. Parent materials are dominantly glacial till, but also include glaciofluvial, eolian, and lacustrine materials. Topography on the plains ecodistricts is dominantly undulating, while upland ecodistricts, including the Endiang and Benton Uplands, are dominated by moderate-relief hummocky landscapes. Hill ecodistricts, including the Neutral Hills and the Wintering Hills, are dominated by rolling and inclined bedrock-controlled landscapes (Figure 2). The plains ecodistricts in the central region of the Northern Fescue (The Castor and Sullivan Lake Plains) are characterized by thin surficial deposits over bedrock. The Drumheller Plain is dominated by glaciolacustrine materials. Solonetzic soils are dominant mainly in the Castor and Sullivan lake Plains, secondary in the Neutral Hills and Endiang Uplands and of lesser extent in other ecodistricts.

The climate in the Northern Fescue Natural Subregion is characterized by a continental macroclimate with short summers, cold winters, and low precipitation. Mean daily temperatures and effective growing degree days are lowest in the eastern part of the Northern Fescue Natural Subregion and highest in the west, reflecting the greater moderating influence of chinooks in the west. The Brownfield station, which is close to the Central Parkland, has the highest annual precipitation. The central and eastern areas of the Northern Fescue, including Brownfield, Castor, Coronation, Sullivan Lake, and Macklin, have the lowest percentages of precipitation as rain. Precipitation during the growing season is highest in the west, at Drumheller, Scollard, Craigmyle, and Castor. The Northern Fescue experiences more days with moderate winds (< 52 km hr) than the chinook belt of the Mixedgrass and Foothills Fescue Natural Subregions. The most frequent wind direction recorded at Coronation is northwest.

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.

Northern Fescue Natural Subregion

Figure 2 - The Northern Fescue Natural Subregion and Component Ecodistricts



At this time, the line work for Ecodistricts has yet to be updated to the revised Natural Regions of Alberta (2006) hence the poor alignment of ecodistricts with Natural Subregion Boundaries.

Types of Industrial Activity

Numerous types of industrial activities are operating in the native grassland ecosystems of the Northern Fescue. Currently, oil and gas production and the associated infrastructure is an important industry, having contributed significant footprint within the subregion. 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 Northern Fescue native grassland. 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.

Recent development of renewable forms of energy has resulted in development of wind farms and upgrading of electrical transmission corridors in the Northern Fescue. Cumulative effects of industrial activity in the Northern Fescue are significant, and the long-term impact of surface soil disturbance on the ecological integrity of these grasslands is not well understood.

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 were developed by collaborative stakeholder working groups for Alberta Environment and Parks 2016 (<http://aep.alberta.ca>) and the Alberta Energy Regulator 2016 (<http://www.aer.ca>).

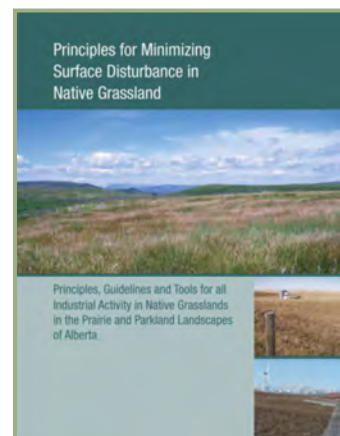
IL 92-12, IL 96-9, IL2002-1 and AER Manual 007, 2014

These information letters informed industry that agronomic grasses such as crested wheatgrass (*Agropyron cristatum*) could not be used in reclamation seed mixes in native prairie and moreover, informed industry of the importance of native prairie and parkland areas and the need to minimize surface disturbance through all phases of development activities when undertaking development in these areas.

Principles for Minimizing Surface Disturbance – Principles, Guidelines, and Tools for all Industrial Activity in Native Grasslands in the Prairie and Parkland Landscapes of Alberta (AER 2016a)

This document replaces Manual 007 (AER 2014). It 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:

- ⇒ Avoid native grasslands where possible, especially in critical ecological sites identified as extremely difficult to reclaim;
- ⇒ Reduce the area and impacts of industrial disturbance to the extent possible; and
- ⇒ Develop practical methods that will allow eventual restoration of disturbed areas.



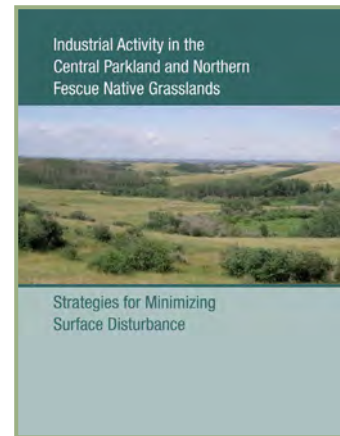
Northern Fescue Natural Subregion

Industrial Activity in the Central Parkland and Northern Fescue Native Grasslands - Strategies for Minimizing Surface Disturbance (AER 2016b)

This document, released as a companion document to *Principles for Minimizing Surface Disturbance – Principles, Guidelines, and Tools for all Industrial Activity in Native Grasslands in the Prairie and Parkland Landscapes of Alberta* (AER 2016a), was created to provide specific guidance on minimizing surface disturbances for Central Parkland and Northern Fescue NSRs. It describes the important grasslands in these NSRs and best practices for conservation and reclamation. The document emphasizes the importance of utilizing the proven threefold strategy below, while providing conservation and reclamation strategies specific to native grasslands in the Central Parkland and Northern Fescue NSRs.

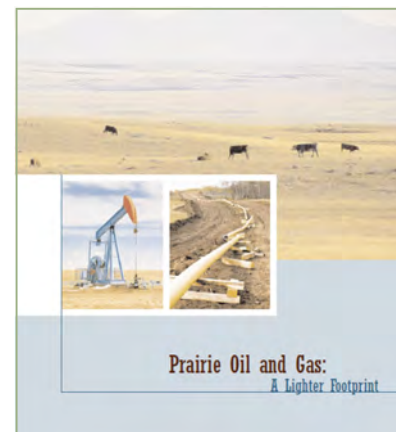
- ⇒ Avoiding native grasslands if possible, especially in critical ecological sites that are identified as extremely difficult to reclaim;
- ⇒ Reducing industrial disturbance to the extent possible; and
- ⇒ Developing practical methods that will allow eventual restoration of impacted areas.

This document is intended to be utilized when conducting any activity that may result in disturbance to native grasslands.



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

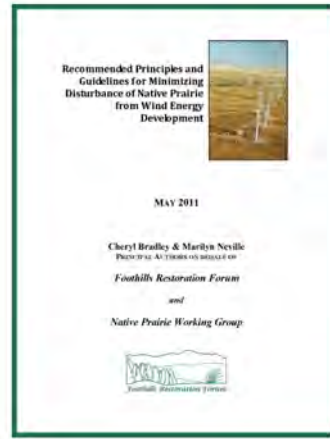
This booklet provides information, photos and illustrations about best development practices to reduce the impacts of oil and gas activities on prairie and parkland landscapes. It focuses on a “cradle to the grave” approach that ensures care taken during one phase of development is not undone at another stage (Sinton et al. 2001).



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 coordinated by the Foothills Restoration Forum (Foothills Restoration Forum Technical Advisory Committee 2011).



Alberta Prairie Conservation Forum Action Plan 2016 to 2020

The vision embedded in the Prairie Conservation Forum (PCF) 2016 to 2020 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 strategic or long-term environmental 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 2016-2020 Action Plan and valuable further information on the importance of prairie conservation is found on the Alberta Prairie Conservation Forum Website (PCF 2016).

3 TOOLS FOR THE RESTORATION TOOLBOX

Implementing improved recovery strategies involves not just practice change on the ground but also utilizing many new tools designed to understand site characteristics and plant communities linked to landforms and soils (Figure 3). These tools, described below, will improve project planning, reclamation best practices and restoration potential at all stages of development from pre-development planning through long-term monitoring to evaluating reclamation and restoration success. The timing of their use in developing a site-specific recovery strategy is described in Section 5: Preparing the Pathway.

Grassland Vegetation Inventory (GVI) Mapping

The Grassland Vegetation Inventory (GVI) is the Government of Alberta’s first comprehensive biophysical, vegetation and anthropogenic inventory of the Grassland Natural Region. Developed by AEP, the GVI provides mapped information of landscape scale soil/landform features and vegetation cover for use in planning and management of rangelands, fish and wildlife, wetlands, land use and reclamation. It also includes a coarse hydrological feature layer. GVI is comprised of ecological range sites based on landform, soils and vegetation information for areas of native vegetation and general land use for non-native areas (agricultural, industrial, and urban areas). Interpretation guides and examples are included for each Natural Subregion. Tables correlating soils and ecological range sites can be found in the Northern Fescue Range Plant Community Guide (Kupsch et al. 2012).

Figure 3—Standardized Grassland Assessment Tools



Image Courtesy of Alberta Environment and Parks

GVI Data

GVI data is available either by contacting the Resource Information Management Branch Data Distribution (within AEP) or obtaining website information (AEP 2013b).

GVI User Information and Technical Specifications:

User information for GVI including an example application of pre-site planning is also supplied by the Prairie Conservation Forum at <http://www.albertapcf.org>. A special page describes GVI with supporting links at: <http://www.albertapcf.org/native-prairie-inventories/gvi>.

This web page includes a user manual entitled “*Specifications for the Use and Capture of Grassland Vegetation Inventory (GVI) Data 5th Edition*” (ASRD and LandWise Inc. 2011).

Primary Land and Vegetation Inventory (PLVI) Mapping

The Primary Land and Vegetation Inventory (PLVI) is a photo-based digital inventory developed to identify the type, extent and conditions of vegetation in the forested and parkland areas of the province of Alberta. PLVI captures grassland site attributes only within the Central Parkland Natural Subregion. It may have some utility on the northern boundary of the Northern Fescue NSR beyond the extent of GVI mapping. The ecosite phase concept, more typical of forested ecosystems, is the main level of classification used in PLVI.

Agriculture Region of Alberta Soil Information Database (AGRASID) Mapping

Additional site-specific resources for soils mapping information are the Agriculture Region of Alberta Soil Information Database Version 3.0 (AGRASID) online database (ASIC: AAF 2016a) and regional soils maps (AAF 2015).

Figure 4 provides a comparison of the relative level of map detail provided by GVI and AGRASID mapping. GVI inventory polygons provide an improved resolution of landscape interpretation compared to the relatively coarse AGRASID soil landscape polygons.

Northern Fescue Natural Subregion

Figure 4 – Northern Fescue Landscape Comparing the Scale of GVI Site Polygons (green) Versus AGRASID Soil Polygons (yellow)

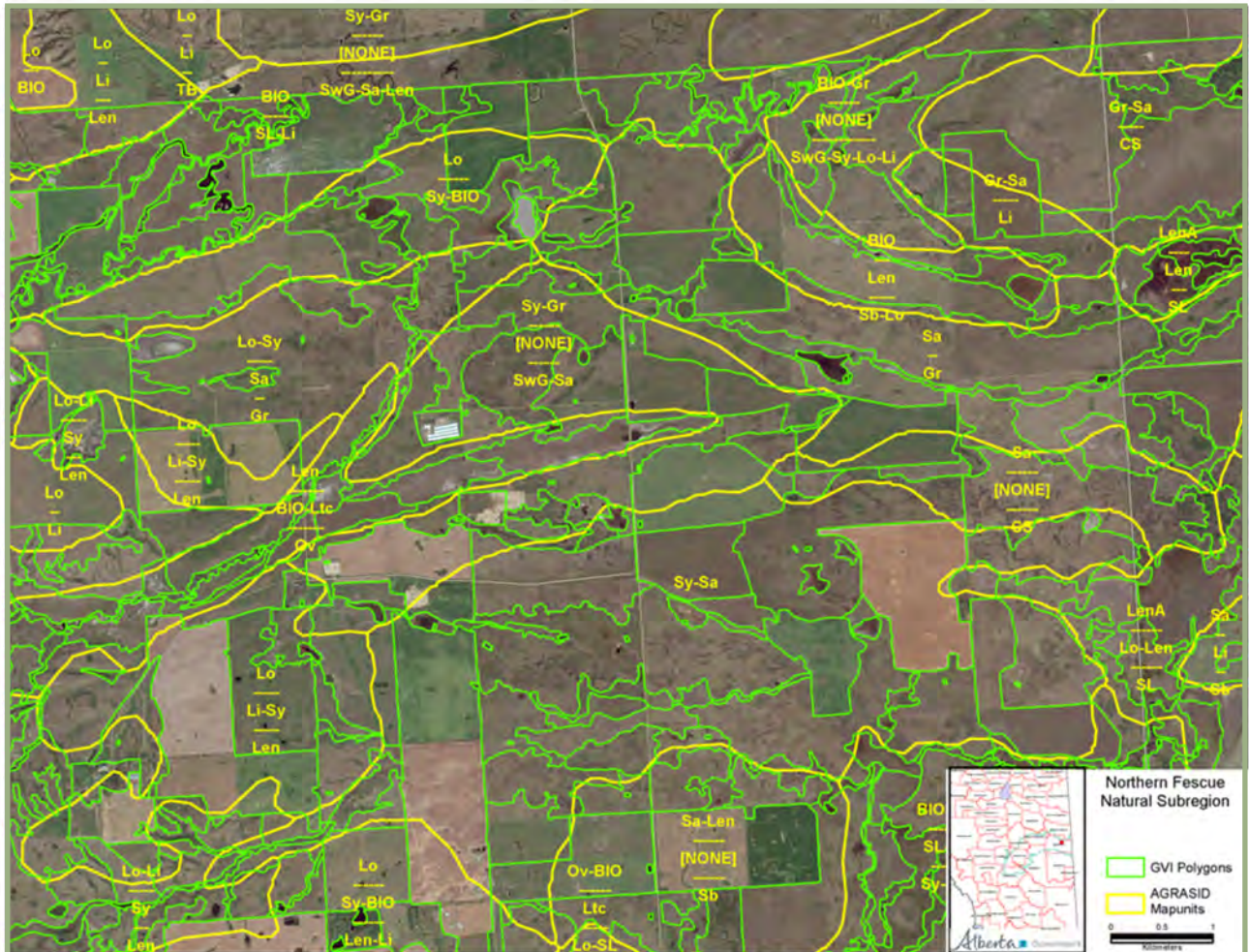


Image Courtesy of Alberta Environment and Parks

Range Plant Community Guides

The Northern Fescue Range Plant Community Guide is an essential reference for identifying common plant communities and conducting range health assessments in the Northern Fescue Natural Subregion of Alberta (Kupsch et al. 2012). The guide provides descriptions of common plant communities linked to ecological range site and ecodistrict

The Northern Fescue Range Plant Community Guide (Kupsch et al. 2012) is organized somewhat differently than the other Grassland Natural Subregion Plant Community Guides, where range sites are determined through key attributes of the landscape, soil features and textural groupings within larger mapped ecodistricts. The Northern Fescue Plant Community classification is a blend of the ecological site concepts developed for forests and rangelands in the province (Kupsch et al. 2012). The classification is hierarchical (Figure 5). Landscapes with similar climate, moisture and nutrient regimes are grouped into Ecological Sites. Native grassland Ecological Sites are associated with subxeric to submesic moisture regimes and a variety of nutrient regimes, from poor to rich. Within the Ecological Site classification, similar vegetation types are grouped into Ecosite Phases based on the dominant layer of vegetation being expressed.

Figure 5 - Rangeland Ecological Classification in Alberta

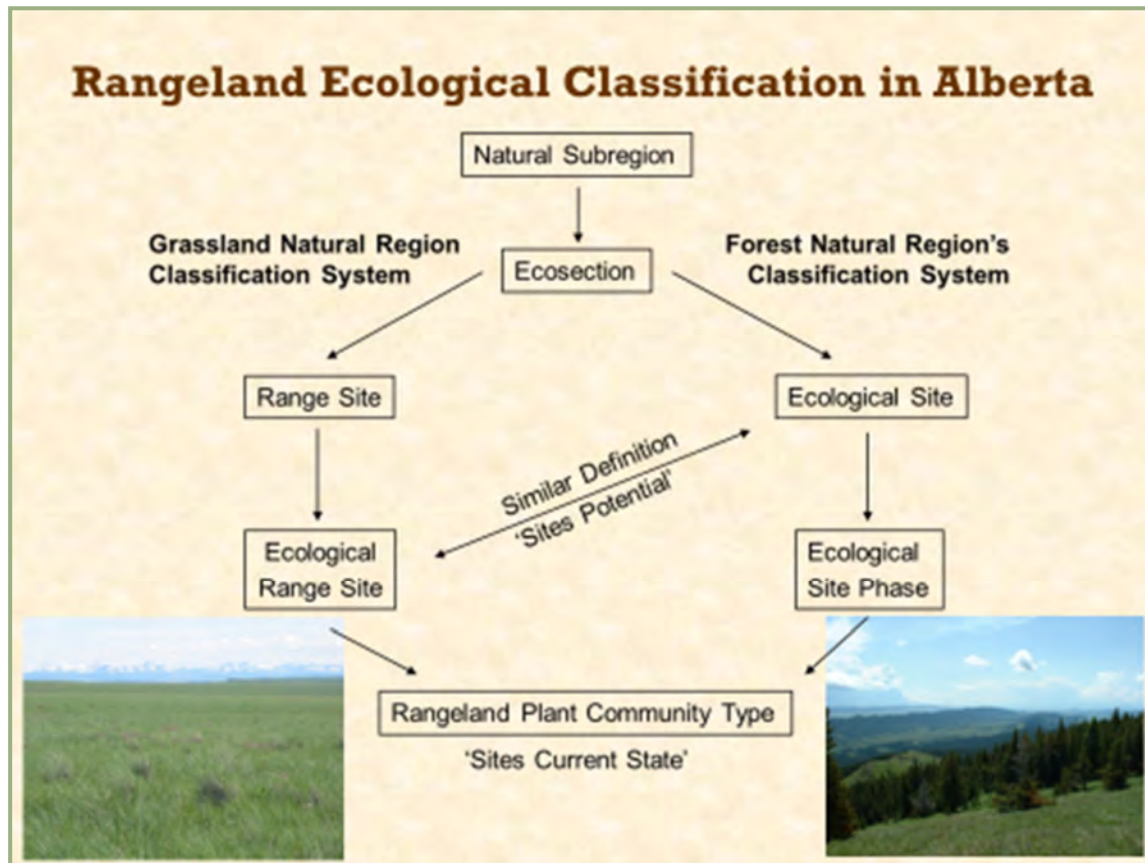


Image Courtesy of Alberta Environment and Parks

Northern Fescue Natural Subregion

Soils are predominantly Dark Brown Chernozemic (loamy), Solonetzic (saline) and Regosolic (sandy), with corresponding different plant communities. Plant communities fall into two general ecological sites: grassland and shrubland, influenced by moisture regimes. Mesic grasslands on loamy soils are dominated by plains rough fescue, western wheatgrass, western porcupine and sedges. In drier, sandier soils, species shift towards sandgrass and needle and thread grass. Grazing pressure results in an increase in Kentucky bluegrass. Shrublands in mesic, loamy areas are dominated by silverberry, snowberry, red osier dogwood, chokecherry, silver sagebrush or willows. Sandhills are characterized by the presence of juniper. Subirrigated shrubland communities are dominated by willows, water birch and red osier dogwood.

Range plant communities are characterized in three categories including reference, successional and modified communities depending on the level of grazing disturbance. The plant community that is an expression of site potential is referred to as the reference plant community (RPC) since it represents the natural community that develops without disturbance or stress. Sustainable stocking rates are attributed to the potential community. The plant community guides have been compiled from data collected by detailed vegetation inventories and the extensive system of reference areas established across the province by the AEP Range Resource Management Program. The guides are available on the AEP website and are updated on a regular basis as new data is gathered which can be linked to the GVI mapping (AEP 2013b).

Navigating the Northern Fescue Range Plant Community Guide

The Northern Fescue Range Plant Community Guide (NFPCG) 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. Using AGRASID or a published soil survey, identify the major soil series and associated range sites using the crosswalk table in Appendix A at the back of the NFPCG. Soil series codes appear in the far right column and then can be related to the appropriate range site type in the crosswalk table on the left side column of the table .
2. Alternately, using GVI, directly identify the dominant and subdominant range site types the project area is located in and then review the NFPCG Table: Range Plant Communities in the Northern Fescue Natural Subregion.
3. The soils based range site will be mapped at a landscape scale in the GVI data layer and 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.
4. Check the NFPCG Range Plant Community Table, which identifies the successional and modified communities associated with the reference plant communities. This will show the suite of range plant communities potentially present in the project area under different grazing pressure.
5. Once you are standing on the site, read through the descriptions of the range plant communities identified in NFPCG Tables.

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

Range Health Assessment

The Range Health Assessment protocol and the Range Health Assessment Field Workbook developed by the AEP – RRSS have been used to assess, monitor and manage Alberta’s rangeland since 2003 (Adams et al. 2009).

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 an early warning when management changes are needed. Understanding range health is an important component of a restoration risk assessment. In the context of reclamation after disturbance, it is a measure of ecosystem recovery.

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

Table 1 – Functions of Healthy Rangelands

<i>Rangeland Functions</i>	<i>Why Is the Function Important?</i>
Productivity	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Conservation and recycling of nutrients available for plant growth • Rangelands are thrifty systems not requiring the input of fertilizer
Plant Species Diversity	<ul style="list-style-type: none"> • 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

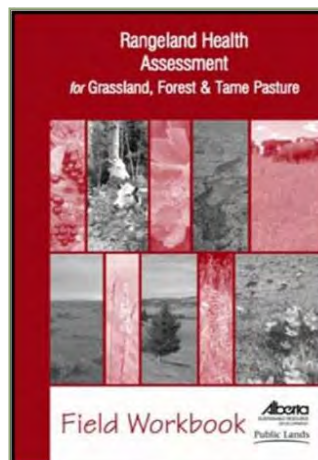
Northern Fescue Natural Subregion

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

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

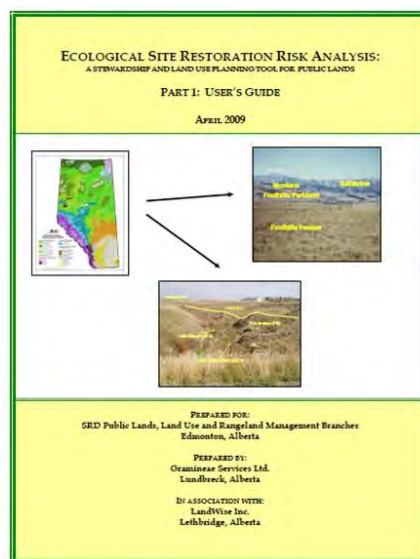
An evaluation of each indicator using the methods and scoring system detailed in the field workbook indicates whether these important ecological functions are being performed. A range health score is calculated as a percentage value, classified into one of three categories; unhealthy (0% to 49%), healthy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

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



Ecological Site Restoration Risk Analysis

The Ecological Site Restoration Risk Analysis (ESRRA) is a pathway for determining the ability of the components of an ecological range site to recover from the direct impact of industrial activity (Gramineae and Landwise 2009). This involves an understanding of the characteristics of the site, soils, landscape type, moisture regime and associated plant community.



Restoration Risk will Affect the Potential Restoration Outcome

In the Northern Fescue Natural Subregion 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 Northern Fescue, latitude plays an important role in seasonal precipitation accumulation and mean temperature. Cooler and moister growing conditions prevail in the more northerly and westerly ecodistricts versus those that adjoin the Dry Mixedgrass Natural Subregion.

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 (Province of Alberta 2010) and aggressive agronomic species such as smooth brome (*Bromus inermis*), crested wheatgrass (*Agropyron cristatum*), Timothy (*Phleum pratense*), alfalfa (*Medicago sativa*) and sweet clover (*Melilotus spp.*). Aggressive non-native grass species such as hard fescue (*Festuca duriuscula*), sheep fescue (*Festuca ovina*), Canada bluegrass (*Poa compressa*), Kentucky bluegrass (*Poa pratensis*), quackgrass (*Elymus repens*) also invade disturbances. The potential for non-native plant invasion on disturbed upland soils decreases as soil fertility, topsoil depths and soil moisture decreases. Relatively moist Overflow or Subirrigated ecological range sites and wetlands 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 restoration potential.
4. **The physical characteristics of soils limit restoration potential.** Limiting factors by soil features (e.g. soil series) and soil texture and/or soil chemistry includes Limy, Blowouts, Sands, Gravel and Shallow to Gravel.
5. **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.
6. **Adaptation to exposed soils.** 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 species at risk. Natural recovery, e.g. leaving disturbances to recover with little or no assistance, facilitates the ecological recovery processes. Seeding can deter these processes and alter the plant community composition.

7. **Adjacent land use also affects restoration potential.** Remnant native prairie areas in highly fragmented landscapes are of particular concern. For example, unhealthy rangelands will increase the risk to reclamation success and may increase the risk of weed invasion to the area to be reclaimed. Close proximity to transportation corridors or tame pasture seeded to invasive non-native agronomic plants such as crested wheatgrass, Kentucky bluegrass, smooth brome, sheep fescue or sweet clover can limit restoration potential. Industrial disturbances that are invaded by weeds and non-native invasive plants can also limit restoration potential and require complex recovery strategies.

8. **Grazing intensity both long-term and present on pastures affected by industrial development** must be factored into the restoration potential. Range health of the disturbed site will affect restoration potential.

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

- **Whether restoration risks are such that irreversible loss of native plant communities will occur and avoidance is the only mitigation; or when avoidance is not possible**

 - **The most appropriate mitigation to reduce the impact of development through minimal disturbance and best management practices designed to reach the expected outcome of restoration over time.**
-

4 PROMOTING NATIVE PLANT COMMUNITY SUCCESSION

Reflecting on Past History

Prior to the European settlement of the Canadian prairies, a number of key ecosystem processes shaped the native prairie landscape (Bradley and Wallis 1996). Chief among these were recurring drought, grazing and fire. These naturally occurring ecosystem processes each provide 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 little club moss, moss and lichen appears to take much longer. Large areas of south eastern Alberta, especially in the Special Areas, have recovered to native grasslands, having been abandoned from cultivation during the dustbowl conditions of the 1920s and 1930s.



Breaking Sod with Case Tractor near Veteran, Alberta. 1912

Periods of Reclamation History

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

Pre- 1972

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



Laying of Gas Pipeline between Carbon and Calgary, Alberta. 1958

1972 to 1985

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

Northern Fescue Natural Subregion



Invasion of Smooth Brome (the bright green grass) along a Seeded Pipeline

1985 to 1993

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

1993 to the Present

During this period, the importance of the native grassland plant communities 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.

A **cultivar** is an assemblage of cultivated plants which is distinguished by characteristics (morphological, physiological, cytological, chemical or other) which retains its distinguishing characteristics when reproduced. An **ecovar** is a seed source of plants resulting from plant collections from populations and environments within an ecozone. Cultivars and ecovars for several native grasses are available in Canada and have been widely used in the reclamation industry. Examples include: Walsh western wheatgrass (*Agropyron trachycaulum*), Elbee northern wheatgrass (*Agropyron dasystachyum*), and Lodorm green needle grass (*Stipa viridula*).

However, there are issues associated with the use of native plant cultivars. Some cultivars are more robust in stature than wild forms of the same species, 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 on the site.

Understanding the Process of Succession

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

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

Northern Fescue Natural Subregion

Figure 6 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. **Green boxes** highlight the portion of grassland succession that we currently know the most about, namely secondary succession and the effects that light, moderate and heavy grazing have on native plant communities. **Orange boxes** illustrate the area of current and future research emphasis to better understand the pathway of primary succession of plant communities from bare soil. **Red boxes** illustrate dramatic changes that may occur when invasive species subvert the path of recovery. **Arrows** illustrate trajectories that may or may not be reversible. We know much less about the dimensions of plant succession from disturbed topsoil and so have reduced confidence in predicting outcomes. Nonetheless, this successional tool provides a foundation for capturing and sharing key learnings and for using this knowledge to improve our development practices.

Figure 6 – Successional Pathways and Seral Stages

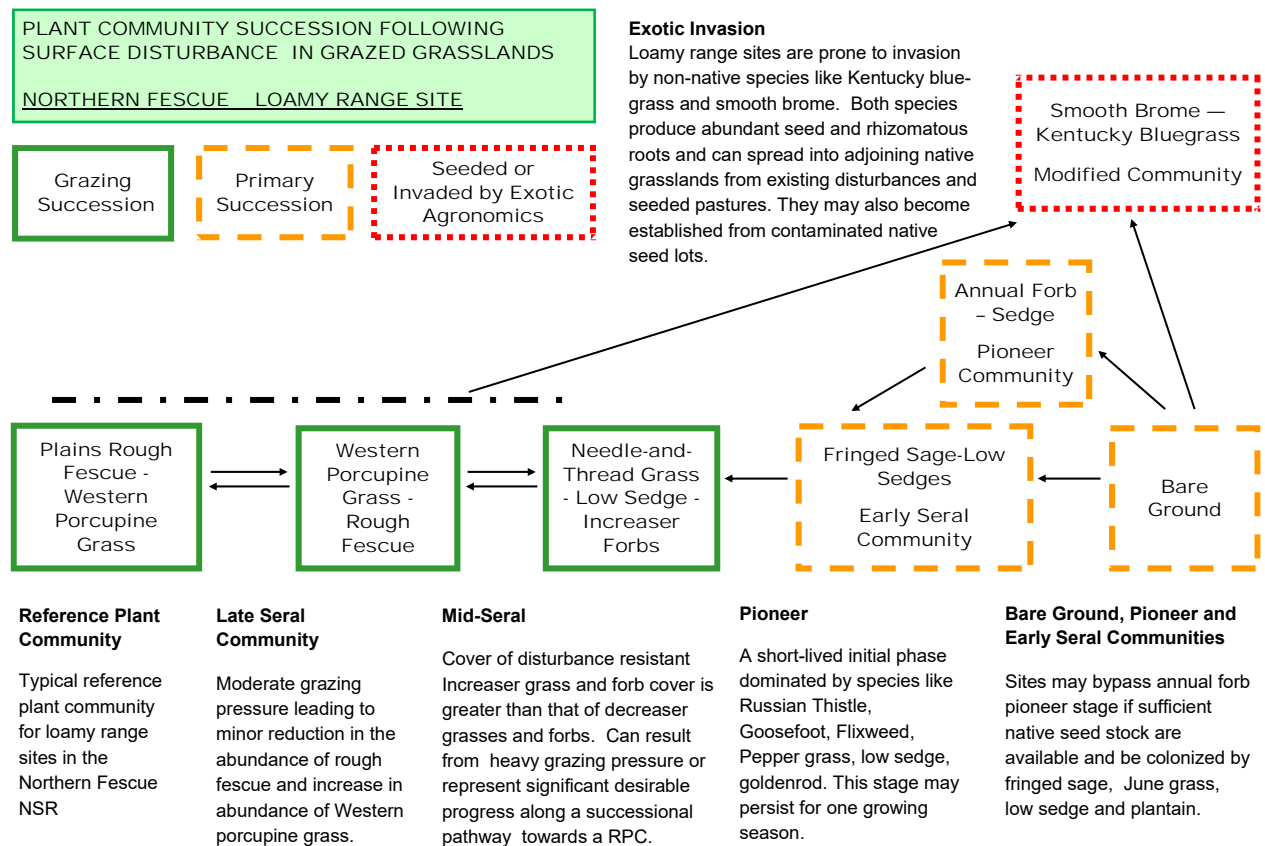


Image Courtesy of Alberta Environmental and Parks

Establishing a Positive Trajectory Following Disturbance

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

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

Expectations for the level of responsibility and the timeframe required to ensure sites are recovering is increasing. On non-challenging, well maintained sites in the Northern Fescue Natural Subregion, reclamation certification should be possible in about five to seven years. However, on sites on which there are invasive species issues, poor range health or particular sensitivity to invasion (e.g. such as more mesic rough fescue grasslands), reclamation certification could take much longer (e.g. 10+ years) and ongoing adaptive management during operations will be required.

In a multiple use landscape, reclamation assessment needs to assess the recovering grassland plant community under three years of "normal grazing management". Ensuring reclaiming grasslands are resilient to and benefiting from grazing can be a long term proposition. Heavy grazing may result in preferential grazing of an early seral community, resulting in degradation of the recovering site, not progression (M. Neville pers. comm.). Eliminating grazing for too long can also degrade a recovering site.

The timeframe required for the process of succession to take place may not be recognized by industry, land owners and reclamation practitioners. Industry needs to recognize their ongoing responsibility to grazers and the public to ensure restoration of their disturbances on native grassland in a timely manner and acquire a reclamation certificate.

Patience is required to reach the restoration outcome.

Industrial Disturbance and the Process of Plant Community Succession

Understanding successional stages for recovering plant communities is critical to having confidence that recovery is occurring on disturbed sites. Definitions of successional stages for a series of recovering plant communities on disturbed topsoil (Table 2) was developed from the Express Pipeline case study data (Kestrel Research Inc. and Gramineae Services Ltd. 2011). These descriptions assist practitioners with assessing the trajectory of reclamation progress and what constitutes a positive or negative successional trend over time.

During the pioneer stage (Figure 6 and Table 2), annual forb species, often referred to as nuisance weeds, play an important role in site stabilization and moisture retention. Examples are Russian pigweed (*Axyris amaranthoides*), flixed (*Descurainia sophia*), grey tansy mustard (*Descurainia richardsonii*), peppergrass (*Lepidium spp.*) and the goosefoots (*Chenopodium spp.*).

Northern Fescue Natural Subregion

It is also important to note that the pioneer, early and mid-seral plant communities (Figure 6 and Table 2) can contain non-targeted species that still function for erosion control and moisture retention such as the annual species listed above or pasture sagewort or fringed sage (*Artemisia frigida*). They stabilize the soils and help facilitate the process of succession over time. The role pioneer species play in the continuum of succession may not be recognized by landowners and reclamation practitioners and weed control of such annuals may be counter-productive.

Control of pioneer annual weeds may be counter-productive.

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

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

* Invasive non-native plants that are known to replace native species and establish permanent dominance in grassland communities include Kentucky bluegrass, smooth brome, quackgrass, crested wheatgrass, hard fescue and sheep fescue in the Northern Fescue NSR.

Recovery Strategies for Industrial Development in Native Grassland

Examples of successional plant communities following topsoil disturbance on Loamy ecological range sites in the Northern Fescue NSR and are illustrated in Appendix A. This data is part of the long-term monitoring data collected in the Northern Fescue NSR by a number of researchers and is summarized in the supporting document, “*Long-term Revegetation Success of Industry Reclamation Techniques for Native Grassland: Northern Fescue Natural Subregion*” (Lancaster et al. 2014).

Native plant communities are more likely to develop on disturbances if range health scores for the comparable control were “healthy” or “healthy with problems”. However, species composition and cover on the majority of disturbance sites are not similar to the undisturbed plant community in the Northern Fescue NSR as a result of past reclamation practice and the prevalence of aggressive agronomic grasses in the region (Lancaster et al. 2014).

Examples of Seral Stages



Early Seral—Hand Hills Pipeline RoW



Mid to Late Seral—Hand Hills, 7 Years After Reclamation

5 PREPARING THE PATHWAY

Planning to Reduce Disturbance

Planning to minimize impacts to native grasslands is a risk assessment process designed to optimize project placement and reduce the risk of costly and lengthy reclamation of disturbed native grasslands. Pre-disturbance planning is the first step in identifying the potential 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. The Alberta Environment and Parks publications *“Principles for Minimizing Surface Disturbance – Principles, Guidelines, and Tools for all Industrial Activity in Native Grasslands in the Prairie and Parkland Landscapes of Alberta”* (AEP 2016a) and *Strategies for Minimizing Disturbance in Native Grasslands within the Central Parkland and Northern Fescue Subregions* (AEP 2016b) alert and direct industry regarding the importance of avoiding disturbance in native prairie, and the need to minimize disturbance should avoidance not be possible. The principles and guidelines apply to all industrial activity in native grasslands.



Minimal Disturbance Wellsite—Hand Hills

Pre-Disturbance Site Assessment

Pre-disturbance site assessment is the decision-making process that enables productive and cost effective development planning (Figure 7). In the Northern Fescue, 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. Planning developments to minimize disturbance to native grasslands, wetlands and sensitive features is an iterative process which includes mapped and field based data collection and consultation with land owners / managers and regulators.

The intent of the desktop review is to capture as many planning variables as possible to limit re-siting at the field verification step. However, the field verification may prompt a return back to siting, adjusting the BMP and construction approach or any other previous step.

Guidelines for Pre-Disturbance Site Assessment Summarized in Figure 7 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 and operation.

Create a Local Study Area (LSA) around all areas of proposed development large enough to accommodate spatial adjustments to infrastructure if necessary and large enough to capture required setbacks for features such as wetlands and sensitive wildlife species in the area. Setback distances and timing are identified in the *AEP Integrated Standards and Guidelines* (AEP 2013d).

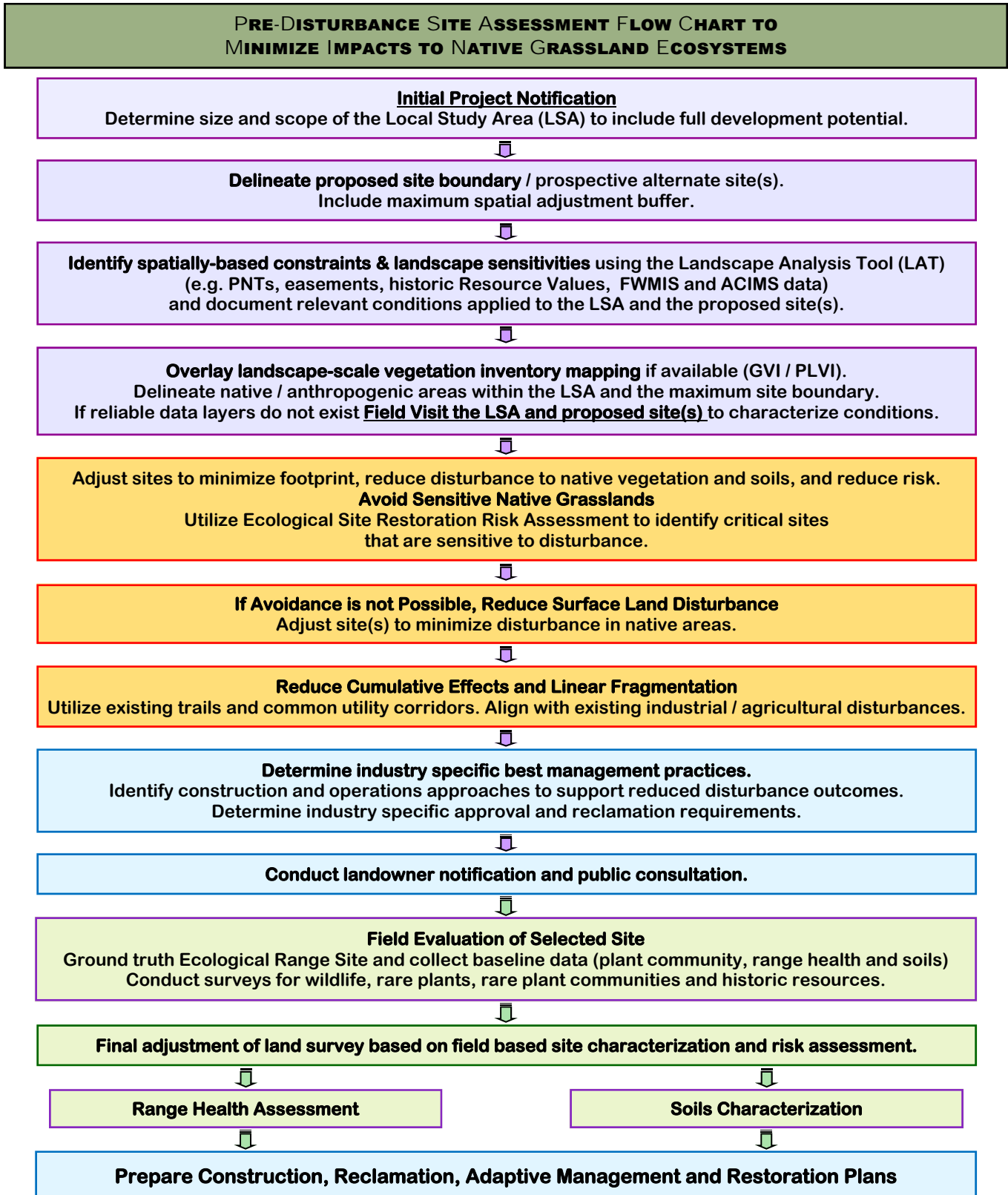
Delineate proposed site boundaries and prospective alternate sites on the most recent air photo or fine scale satellite imagery available. This is the area surrounding the proposed footprint(s) that will be directly affected by development activity. The area should be large enough to include the maximum allowable movement of the proposed footprint(s) on the landscape.

Identify spatially-based constraints and landscape sensitivities using the AEP Landscape Analysis Tool (LAT). The LAT is a web-enabled spatial tool that allows users to plan activities on Public Land (AEP 2013e). It uses approximately 80 data layers, including base features and sensitive features and identifies how they interact with a proposed land location and activity being considered for development. The LAT enables:

- Virtual siting of a proposed project activities;
- Linkage between landscape sensitivities including grasslands and wetlands;
- Identification of operational constraints that may apply to the activity such as Protective Notations (PNTs), easements, historic resource values, vegetation data (ACIMS) and wildlife data (FWMIS);
- Identification of areas requiring higher levels of risk mitigation planning;
- Virtual re-siting or changes to that proposed activity, at a landscape level, to mitigate concerns prior to application;
- Links to approval standards and operating conditions.

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Figure 7 - Pre-Disturbance Site Assessment Flowchart for Native Grassland Ecosystems



Although designed originally for oil and gas, this tool and the AEP Enhanced Approval Manual (AEP 2013c) are useful to other industries operating on Public Lands. If not operating on Public Land, Consult AER and AEP guidelines for appropriate directions. Conduct land titles searches and Surface Land Searches (available through Government of Alberta agencies) to determine if any instruments or conservation easements are in place on private lands.

On private as well as Public Lands, the following manuals apply and the concepts are the same: *Principles for Minimizing Surface Disturbance – Principles, Guidelines, and Tools for all Industrial Activity in Native Grasslands in the Prairie and Parkland Landscapes of Alberta* (AEP 2016a) and *AEP Strategies for Minimizing Disturbance in Native Grasslands within the Central Parkland and Northern Fescue Subregions* (AEP 2016b).

Consult the *Recommended Land Use Guidelines for Protection of Selected Wildlife Species and Habitat within Grassland and Parkland Natural Regions of Alberta* (AEP 2011) to determine any setback requirements for species at risk wildlife. Highlight areas with potential habitat for Species at Risk.

Overlay landscape scale vegetation inventory mapping (GVI or PLVI): This mapping will identify landscape scale range sites, and native and anthropogenic areas in the LSA. Delineate native and anthropogenic areas within the LSA and the maximum site boundary. If reliable data layers are not available, a field visit will be required to characterize the vegetation cover.

Referencing the above guidelines for minimizing surface disturbance in the Northern Fescue NSR, consider:

- If wetlands occur within the study area, consult the AEP Alberta Wetland policy (AEP 2015).
- If the site is located within aspen or shrubland cover greater than 30%, grassland standards do not apply.
- If the site is located in Loamy grassland, avoid the area and apply Loamy Standards (AEP 2016b). Search for anthropogenic features available within the target zones. If they are present, is shared use of the landscape feature possible? For example, is moving an industrial footprint to cultivated lands, or shared access agreements for roads and trails possible?
- If the site is located on Sandy grassland, apply Sandy grassland standards. Avoid the area if possible, and if not, apply minimum disturbance practices.

Adjust sites to minimize footprint, reduce disturbance to native vegetation and soils, and reduce risk. For proposed wells, wind towers or other structures with some latitude to fine tune placement, map a maximum spatial adjustment buffer around the target site(s). The buffer will provide the area on the landscape within which the site(s) can be moved and still remain effective. Map existing anthropogenic features too small to be included in the LAT data layer, including access roads and trails, wellsites, flow lines, buried utilities, etc. (Bradley and Neville 2011).

Identify potential construction issues and explore possible options. Contour or digital elevation mapping is very useful at this stage. Consult guidelines in *Principles for Minimizing Surface Disturbance in Native Grassland—Principles, Guidelines and Tools for all Industrial Activity in Native Grasslands in the Prairie and Parkland Landscapes of Alberta* (AEP2016a) and *AEP Strategies for Minimizing Disturbance in Native Grasslands within the Central Parkland and Northern Fescue Subregions* (AEP 2016b) for all proposed disturbances.

Northern Fescue Natural Subregion

Avoid Sensitive Native grasslands. Utilize Ecological Site Restoration Risk Assessment (Gramineae and Landwise 2009) to identify critical sites that are sensitive to disturbance.

If Avoidance is not Possible, Minimize Surface Land Disturbance. Adjust site(s) to minimize disturbance in areas of native vegetation.

Reduce Cumulative Effects and Linear Fragmentation. Utilize existing trails and common utility corridors. Use or align with existing industrial / agricultural disturbances and other anthropogenic features.

Determine Industry Specific Best Management Practices. Identify construction and operations approaches to support reduced disturbance outcomes. The Foothills Restoration Forum website references additional documents that can provide relevant information.

Determine Industry Specific Approval and Reclamation Requirements. Where reclamation requirements are lacking or do not meet the goal of restoring ecological health, function and operability to the disturbed site, determine a recovery strategy that will. Current standards for reclaiming native grasslands to Equivalent Land Capability are defined in the 2010 Wellsite Reclamation Criteria (AEP 2013a) *“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”*. These principles apply to restoration of all disturbances in native grassland.

Conduct Landowner Notification and Public Consultation. Local knowledge and experience can be very important at this point in the planning process. Consultation provides the opportunity for education and information exchange. Landowner/leaseholder concerns can be addressed and incorporated into the development plan at this stage.

Field Evaluation of Selected Site. Ground truth the Ecological Range Site(s) and collect baseline data (plant community, range health and soils). Conduct surveys for wildlife, rare plants, rare plant communities and historic resources. Scope the field survey 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 Northern Fescue, a general timeframe to conduct field verification is May 15 to September 15. Document plant communities and dominant species for each community in order to establish restoration targets.

Final Adjustment of Land Survey Based on Field Based Site Characterization and Risk Assessment. 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.

Range Health Assessments and Soils Assessments of the optimized site placement are then conducted to inform construction, reclamation, adaptive management and restoration plans. Conduct range health assessments and field characterization of soils within the project footprint. Establish off site controls for comparison. Document listed weeds, invasive plants and aggressive agronomic species concerns in the local area.

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

Develop Construction, Reclamation, Adaptive Management and Restoration Plans

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

Prepare clearly defined reduced impact construction plans that incorporate minimal disturbance soil handling procedures, wildlife habitat constraints and the appropriate native grassland recovery strategy. Include Historical Resource mitigation where required. Clearly define reclamation procedures designed to reduce the impact of disturbance for each phase of development. Prepare site-specific native plant community recovery strategy(s) designed to enable the successional process to progress over time. Identify adaptive management surveys and measures required for the first 2 to 3 years. Incorporate all plans into a detailed and site specific Environmental Protection Plan (EPP).

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

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

Monitor and inspect during and after construction to ensure contractual compliance.

Ensure the EPP, with construction, reclamation/restoration plans including adaptive management are incorporated into contract documents.

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.

Stakeholder workshops were held during the preparation of this manual. Participants included experienced representatives involved in industrial development and reclamation of native prairie, the Northern Fescue ranching community, the native seed industry, conservation organizations and Government of Alberta regulatory authorities. Results of the meetings are found in Appendix B - Rancher Workshop and Appendix C - Industry Workshop.

The importance of local knowledge should never be underestimated.

Notify and Consult with Landowners and/or Grazing Lease Holders

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

- Communication is extremely important. Ranchers have learned from experience what works and what does not work on their land.
- Specific guidelines for notification and consultation are required on grazing leases and grazing reserves on Public Land. They are included in the Integrated Standards and Guidelines of the Enhanced Approval Process.
- When consulting private landowners incorporate the specific requests of the landowner within the limits of existing legislation. Landowners would like to establish better consultation with development companies in terms of seeding agreements for grazing and land management practices (Appendix B: Rancher Workshop Summary).
- 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 a fenced management unit.
- When using minimal disturbance practices to construct buried utilities, allow for settlement of soils over the trench. Subsidence over trenchline can be a safety concern and an infrastructure integrity issue if sinkholes develop over time.
- Landowner cooperation is required when attempting natural recovery (Appendix C: Industry Workshop Summary).
- Recovery is returning the landscape to how it was before development (Appendix B: Rancher Workshop Summary). Depending on the type of industrial development and the extent of soil disturbance or compaction, 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 disturbed grassland needs to be sufficiently recovered to tolerate grazing as soon as possible. The developer needs to understand this and work with the rancher to reduce the impact. Recovery is considered successful if you can no longer see where the disturbance occurred. Once recovered, livestock should graze both the disturbed and surrounding area uniformly (Appendix B: Rancher Workshop Summary).

Recovery Strategies for Industrial Development in Native Grassland

- Climate and the timing of activity need to be considered to determine the timeframe for a positive plant community successional trend to be established on disturbed topsoil. Hope for a minimum of 5 years, but expect 7 years or more depending on moisture conditions. If reclamation is conducted properly, success should be apparent in 5-6 years (Appendix B: Rancher Workshop Summary).
- Confine disturbance to what is absolutely necessary.
- Access control is a key issue of concern which extends beyond the initial development phase, through the operations phase and to decommissioning and abandonment. Minor access during production can become a large problem during reclamation, for example access on frost and continuing light truck access during all seasons can result in long, linear disturbance which can be very challenging to reclaim.
- Poor development practices always lead to weed invasion. Using clean equipment is extremely important as leafy spurge and other invasive species are easily moved by equipment. Moving or bringing in soil from a remote area also increases the risk of invasive species (Appendix B: Rancher Workshop Summary).
- Weed management is another key issue of concern that extends beyond the initial development phase, through the operations phase to decommissioning and abandonment.



Ranching Industry, Northern Fescue Natural Subregion

Northern Fescue Natural Subregion

- Reclamation fencing is often left in place well beyond when it is needed for vegetation establishment. It is better to remove fences early and replace with a tech fence (a cattle barrier) around infrastructure requiring protection. Neglected fencing is often not maintained and becomes a liability for the rancher. Litter build up is a consideration as too much litter encourages invasive smooth brome and sweet clover to move into the stand (Appendix B: Rancher Workshop Summary). 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 to influence plant succession. Fencing, with access points for cattle, may be required during early stages to allow desired grazing impact to assist recovery.
- Concerns were expressed by workshop participants during the consultation process for this project that the Enhanced Approval Process (EAP) lacks sufficient checks and balances to ensure best management practices and minimal disturbance principles and guidelines are implemented during industrial development. There were concerns that the EAP eliminates vital communication with landowners and land managers .
- Maintain that vital communication link through the operations phase. Use respect!



Use Respect!

Ensure Compliance with Regional Land Use Policy

The Northern Fescue 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 Parks (AEP) provides policy and guidelines for reclamation and remediation throughout Alberta, issues approvals for development activity, and is responsible for remediation and reclamation certification at decommissioning and abandonment, (AEP 2016a, AEP 2016b).
- Much of the Northern Fescue Natural Subregion lies within the Special Areas. The Special Areas Board requires minimum disturbance on native range – Policy 06-05 (SAB 2016a) and no tolerance of introduced invasive plant species on reclamation sites – Policy 06-06 (SAB 2016b).
- The Public Lands Act and the AEP Enhanced Approval Process (EAP) for upstream oil and gas development on Public Lands, specifically the *Integrated Standards and Guidelines* (AEP 2013c) provide the framework for the Alberta Energy Regulator (AER) to implement and regulate approvals and compliance assurance for energy development on Public Lands. Both AEP and AER are working together towards sustainable land use and restoration.
- The Alberta Energy Regulator implements acts and regulations and issues directives governing energy development such as “*Principles for Minimizing Surface Disturbance – Principles, Guidelines, and Tools for all Industrial Activity in Native Grasslands in the Prairie and Parkland Landscapes of Alberta*” (AEP 2016a)
- The Reclamation Certification Criteria does not discriminate between land ownership types (Public or Private lands), therefore planning at the “front end is critical to conserving Northern Fescue Grasslands for future generations.



Aggregate Quarry Industry, Northern Fescue Natural Subregion

6 SELECTING THE RECOVERY STRATEGY

Industrial developments typically 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 resource exploitation 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.

2. Production 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. This phase can last for many years. The production phase reclamation focus should be to wherever possible to set the stage for the process of recovery at decommissioning and abandonment.

Interim reclamation should reduce the footprint of disturbance to soils and native plant communities by reclaiming infrastructure no longer required, stabilizing and maintaining the integrity of the soils, controlling invasive species 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.”

Native Grasslands Restoration Potential

Reclamation monitoring studies in the Northern Fescue NSR document that, with few exceptions, disturbed soils support different plant communities than undisturbed soils (Elsinger 2009, Lancaster et al. 2012, Lancaster et al. 2014). The productive soils of the Northern Fescue NSR have resulted in conversion and fragmentation from multiple land uses, principally agriculture. The health of the native grassland before disturbance affects the ability of a disturbed area to respond and can affect the outcome of restoration. However, even healthy rangelands are vulnerable to invasive species establishment in a fragmented landscape. Invasive species are ubiquitous and major barriers to restoration in the Northern Fescue NSR. These results support the need to avoid development on native grasslands in the Northern Fescue NSR if at all possible and to minimize disturbance when it is not possible. Re-introducing plant materials to soil disturbances will be needed in most cases to compete with invasive species and the risks of successful restoration are considerable.

The primary recovery strategies for native grasslands in the Northern Fescue NSR are assisted natural recovery and the use of native seed mixes.

Conducting a reclamation risk assessment considering the size and nature of the disturbance, the range health of the surrounding area and proximity of invasive species is key to selecting the most appropriate recovery strategy to promote restoration success in the Northern Fescue NSR.

Recovery Strategies for the Northern Fescue NSR

The accompanying flow charts (Figures 8 and 9) for disturbances to grasslands in the Northern Fescue NSR provide a pathway for decision making when considering natural recovery, assisted natural recovery and native seed mixes.

Figure 8 provides pathways for selecting the appropriate strategy for minimal vegetation and soil disturbances, including sites where:

- Development activity takes place on unstripped vegetation;
- Development activity takes place on on barrier materials such as construction matting placed over vegetation for short periods or during dormant conditions;
- Topsoils exposures are less than 4 square metres;
- Linear exposures of topsoil due to trenching are less than 0.5 metres wide.

This guideline generally applies to activities such as shallow gas wells and associated infrastructure or matted workspaces associated with transmission line construction where much of the development activity takes place on the vegetation surface or the surface protected by construction matting (Appendix C: Industry Workshop Summary). It applies to areas where use of matting for extended periods through the growing season has not resulted in large areas of dead vegetation.

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 Northern Fescue natural recovery and assisted natural recovery will be more successful on soil disturbances that are located in close proximity to and/or surrounded by undisturbed native grassland. Reclamation options also differ depending whether the disturbance is short or long term (Appendix C: Industry Workshop Summary).

Northern Fescue Natural Subregion

Figure 9 provides guidance for selecting the appropriate strategy for sites where soil exposures are more than 4 square metres or linear soil exposures are more than 0.5m wide. Examples are larger buried utilities where soils have been stripped and replaced, strip mines, graded access roads and infrastructure pads and matted areas where the vegetation has died due to prolonged burial.

Site Potential

A first step for selecting any recovery strategy is to understand the characteristics of the site.

Consult landscape scale vegetation inventory mapping (GVI or PLVI). This mapping will identify dominant vegetation cover, native, and anthropogenic areas in the area.

Determine dominant range site(s). Two systems of ecosystem classification converge in the Northern Fescue, reflecting systems developed for forests and grasslands (Figure 7). GVI will identify ecological range sites and PLVI will identify ecological sites, which are compatible to Ecological Range Sites.

Ground truth to confirm ecological range site(s). A field evaluation of sites to be reclaimed is necessary to confirm Ecological Range Site(s) and assess the soils.

Determine reference and successional plant communities to document the plant communities present on the site and adjacent to the site in a compatible plant community to set the reclamation objective.

Conduct a range health assessment pre-disturbance or on compatible adjacent plant community. This will identify whether the plant community has the resources to recover naturally and whether there are weed and invasive plant concerns in the area.

Ecological Risk Assessment

When considering natural recovery or assisted natural recovery, it is important to conduct an ecological risk assessment (refer to Section 3) to determine the site-specific risk factors that will affect the successional process (Figures 8 and 9).

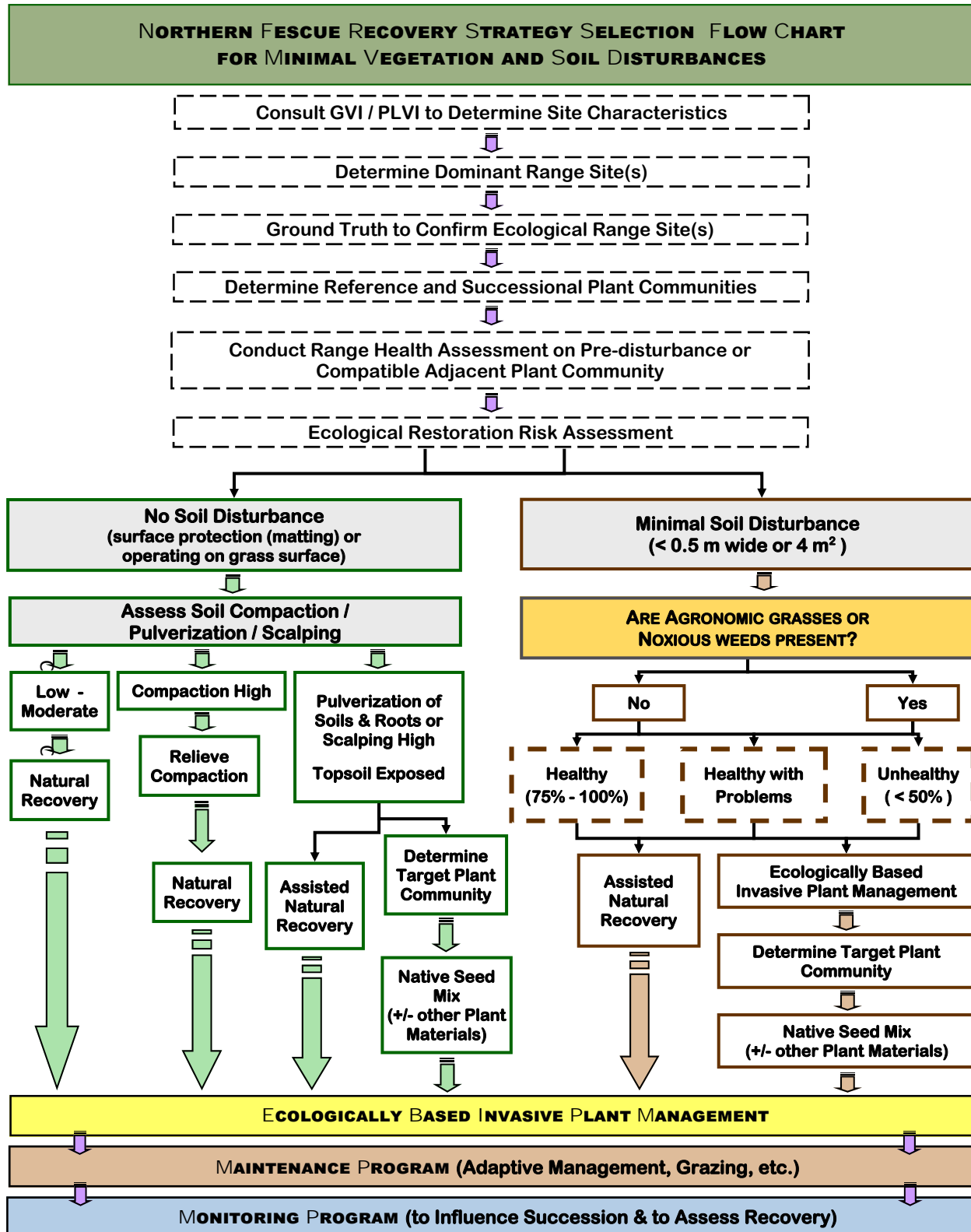
Does the native plant community have the resources to re-establish on the disturbed vegetation? Disturbance plant communities are more likely to re-develop into native plant communities if range health scores for the comparable control are “healthy” or “healthy with problems” (Lancaster et al. 2014). Lower range health can affect the diversity and supply of propagules available to naturally revegetate a site.

Are there sources of invasive species in the onsite community or in the surrounding area that may also colonize the disturbance? Has soil, sand or gravel contaminated with weeds been introduced to the site?

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

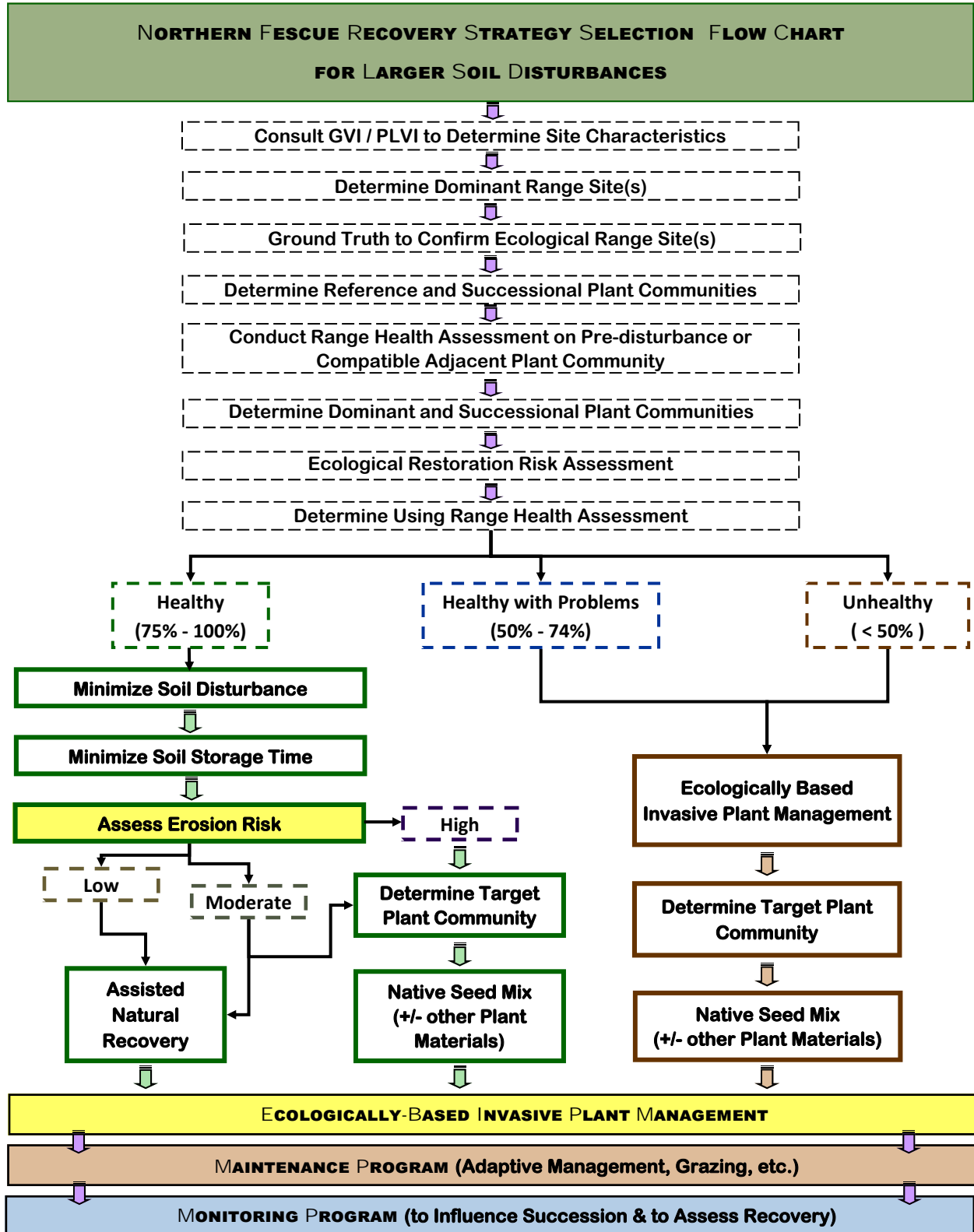
The fragmented native prairie landscape in the Northern Fescue presents additional challenges for invasive non-native plant management. Reclamation monitoring found that trending-to-modified plant communities and modified plant communities can establish after disturbance whether range sites are healthy or not (Lancaster et al. 2014).

Figure 8 - Northern Fescue Recovery Flow Chart for Minimal Vegetation and Soil Disturbances



Northern Fescue Natural Subregion

Figure 9 - Northern Fescue Recovery Flow Chart for Larger Soil Disturbances



Minimal Disturbance

The importance of minimal disturbance in native grasslands has been recognized by provincial regulators and is the focus of new guidelines: *Principles for Minimizing Surface Disturbance – Principles, Guidelines, and Tools for all Industrial Activity in Native Grasslands in the Prairie and Parkland Landscapes of Alberta* (AEP 2016a) and *Strategies for Minimizing Disturbance in Native Grasslands within the Central Parkland and Northern Fescue Subregions* (AEP 2016b). Plains rough fescue native plant communities are particularly sensitive to soil handling and minimal disturbance practices are clearly advantageous to promote restoration. In an assessment of pipelines left to natural recovery, Desserud and Naeth (2013a) concluded that in rough fescue dominated areas in the Northern Fescue NSR, it is important to retain sod as deep-rooted plains rough fescue will not tolerate soil stripping.

Examples of minimal disturbance include conserving vegetation and topsoil through use of construction matting or other buffers for temporary access and work pads. Another example is the short-term operation of equipment directly on native sod during dry or frozen ground conditions such as during shallow gas well drilling and small diameter pipeline construction. When burial of utilities is necessary, excavations and soil exposures are limited to a small area (<4m²), and linear disturbances from buried utilities are narrower than 0.5m wide over the trenchline (these sizes are linked to the high risk of invasive species establishment in the Northern Fescue NSR).

Monitoring soil moisture conditions and traffic control are essential factors for success when implementing minimal disturbance procedures with the expectation of natural recovery. Use of heavy equipment and vehicle traffic over unstripped sod can cause persistent compaction in the soil profile that adversely affect growing conditions and recovery of native vegetation. Repeated traffic on vegetation can pulverize the above ground plant material and damage the crowns and roots from which new growth will develop. Scalping may also occur when soil is retrieved after storage on the grass surface. In wet conditions heavy traffic can also cause ruts and soil profile admixing. After construction, sites need to be assessed for these potential impacts before natural recovery is prescribed as a recovery strategy (Figure 8).

Construction activity timing is also an important factor in the successful use of minimal disturbance construction mitigation. It is important to avoid the growing season April to August (with April to July 15 being the most critical time period), when traffic or prolonged shading by matting can kill vegetation, leaving the site available for invasion by weeds and undesirable agronomic species.

The pre-disturbance native vegetation may recover from minimal disturbance procedures providing the rangeland is healthy and relatively free of invasive and agronomic species, the impact is short-term, soil exposure is minimal 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.

Plains rough fescue native plant communities are particularly sensitive to soil handling and minimal disturbance practices are clearly advantageous to promote restoration.

Minimal Disturbance Techniques



Reduced Disturbance Wellsite Construction During Dry Ground Conditions.



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



Temporary Access Using Matting to Protect Underlying Grassland.

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 (AEP 2013a). No seed or other plant materials from beyond the disturbance are planted on the site during reclamation. Natural recovery is a benefit of minimal disturbance industrial development procedures which minimize the disturbance to the soils and native vegetation.

However, the natural recovery strategy for topsoil disturbances represents a significant risk in the Northern Fescue NSR. Of the 36 observations of natural recovery sites documented in the monitoring report, *Long-term Revegetation Success of Industry Reclamation Techniques for Native Grassland: Northern Fescue Natural Subregion* (Lancaster et al. 2014), sixteen sites (44%) were trending-to-modified or modified plant communities. Twenty-five sites (9%) were early or early to mid-seral plant communities and only eleven sites (31%) had developed into mid-seral or late seral native plant communities. An assessment of the resiliency of sites where natural recovery is proposed, in terms of range health and the potential for invasive species incursion from surrounding areas, is necessary to assess the risk of failure.

Natural recovery should only be considered for disturbances on which vehicles are operating on the vegetation surface or where timely use of construction matting has conserved living vegetation capable of recovering. It may not be a suitable strategy for areas matted throughout the growing season or for areas where soil and roots have been pulverized, scalped or compacted.

Natural recovery on disturbed soils relies on the native seedbank present in the uppermost layer of the topsoil, seed rain from the surrounding undisturbed native plant community, and native plant propagules (rhizomes and crowns) present in the disturbed soil to revegetate exposed soils. The prevalence of invasive species propagules and the degree of native landscape fragmentation in the Northern Fescue NSR creates a significant risk of invasive species establishment and reclamation failure using a natural recovery strategy. Attempts to reduce or eradicate non-native grasses once established in native grasslands have met with little success since some non-native species are too aggressive to be completely eliminated once established (Dessserud and Naeth 2013b). Invasive plant management and an adaptive management strategy (Figure 8) will be necessary for several years after the initiation of a recovery strategy to keep it on a positive successional trajectory towards restoration of pre-disturbance plant communities.

The natural recovery strategy for topsoil disturbances represents a significant risk of reclamation and restoration failure in the Northern Fescue NSR.

Assisted Natural Recovery

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

Timing of Topsoil Stripping and Replacement

Topsoil contains a wealth of plant propagules including roots and seeds of native species adapted to the site. Where soil disturbance is necessary, the timing of topsoil stripping and replacement can have a dramatic effect on the success of the assisted natural recovery revegetation strategy in the Northern Fescue NSR. 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. Ideally topsoil stripping and replacement should occur when the native vegetation is dormant (mid-summer to early winter in the Northern Fescue), within the same year and before the next growing season (Kestrel Research Inc. and Gramineae Services Ltd. 2011).

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. Seeding annuals like oats or barley will help utilize soil nitrogen and make the site less prone to invasion by perennial weeds (Appendix C: Industry Workshop Summary). A combination of fall rye (*Secale cereal*) and flax (*Linum sp.*) at a light seeding rate (1/2 bushel per acre of each species) has been used on industrial disturbances since the late 1990s. However, cover cropping with fall rye is not recommended in situations where there is competition for moisture and nutrients in the spring (Appendix C: Industry Workshop Summary). Winter wheat (eg. *Triticum aestivum*) in place of fall rye has also been used. 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 to limit competition with desirable species (3 to 5 kg per hectare depending on type of application) and a carrier (e.g. polished short grain rice or chick starter) will be required to adequately disperse the seed.

It is important to obtain Certificates of Seed Analysis before purchasing the seed to ensure there are no Prohibited Noxious weeds, Noxious weeds, undesirable invasive agronomic species or ergot in the seed (Appendix C: Industry Workshop Summary). Retain the Certificates of Seed Analysis on file as they may be required during an environmental audit and are valuable for documenting project history during adaptive management and monitoring.

Grazing management must be considered when using a cover crop. The combination of fall rye and flax is relatively unpalatable to livestock in pastures with healthy range health condition. Local knowledge and communication with the landowner/grazing leaseholder is very important when considering the implementation of this strategy.

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. The addition of cover crops does delay the process of natural recovery. However, where erosion or invasion by undesirable species is a concern it does provide an option to native seed mixes if suitable native seed is not available.

Assisted natural recovery may be appropriate where topsoil exposure has occurred on healthy rangeland when there is potential for additional soil erosion.

Wild Harvested Hay Mulch

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

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

The areas to be harvested must be free of invasive plants. For example, species such as smooth brome 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 can be a viable source of locally adapted seed including species that are not available commercially.



Native hay harvester mowing plains rough fescue grassland in the Northern Fescue NSR, developed by Ron Johnson (Medicine Hat, AB) & Marshal Gillespie (Finnegan, AB)

Native Seed Mixes

Long-term monitoring case studies conducted to prepare this manual (Lancaster et al. 2014) 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 Northern Fescue, 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 Northern Fescue plant communities including western porcupine grass and plains rough fescue is essential. This will be achieved by changing the way native seed mixes are designed and by developing a reliable supply of the required key native species.

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 Northern Fescue NSR. These disturbances include:

- decommissioned wellsites with significant soil disturbance, reclaimed access roads, large diameter stripped and graded pipelines, borrow 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 Northern Fescue Range Plant Community Guide (Kupsch et al. 2012) and newer work commissioned by the Special Areas Board to plant communities on drier sites in the southern part of the NSR. 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.

There are problems with the specifications that are currently being applied to native seed lot analysis. Native seed lots may be contaminated with invasive non-native plants, which may not appear on the Certificate of Seed Analysis. Native seed is unique in the seed industry and the specifications need to be revised to ensure high quality seed (Appendix C: Industry Workshop Summary).

Appropriate native seed can be difficult to source, and is expensive. Controlling invasive non-native plants is also expensive and time consuming (Appendix C: Industry Workshop Summary).

Care and diligence in sourcing suitable seed is worth the effort to avoid problems later on.

Target Recovering Plant Communities

The goal of using native seed mixes is to establish the pathway(s) to restore the pre-disturbance plant communities associated with each ecological range site that has been disturbed. On larger projects, particularly linear projects, this creates a major challenge, 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. For instance, the current Range Plant Community Guide for the Northern Fescue NSR (Kupsch et al. 2012) describes 18 native grassland plant communities and four native shrubland plant communities. Newer work commissioned by the Special Areas Board describes an additional 22 grassland communities in drier southern areas of the Northern fescue NSR (Adams et. al 2015).

However, a number of ecological range sites support plant communities with common dominant native grass species. To assist with cost effective and practical seed mix design, it is necessary to establish which ecological range sites have similar growing conditions (based on AGRASID soil and landscape correlation) and species in common. These groupings of ecological range sites with common dominant native grass species are referred to as target recovering plant communities (Appendix D).

Succession is a process defined as the gradual replacement of one plant community by another over time. Seral stages are measures of succession used to describe the state and health of a plant community. More mature seral stages have greater range health and greater ability to perform ecological functions including; net primary production, maintenance of soil/site stability, capture and beneficial release of water, energy and nutrient cycling and plant species functional diversity (Kupsch et al. 2012). Target recovering plant communities are composed of the native grass species that are dominant drivers in the successional process and not just species prominent in mature reference native plant communities.

The target recovering plant community tool is designed to provide easy reference to the suite of potential species that could be used to seed disturbances in any particular ecological range site in the Northern Fescue NSR. Example native seed mixes are provided for each target recovering plant community (Appendix D). When seeded at appropriate seeding rates, (refer to Section 7: Implementing the Strategy), these component grass species will provide the vegetative cover to stabilize disturbed soils and facilitate the recovery of the plant community over time.

The target recovering plant community tool is designed to provide easy reference to the suite of species that could be used to seed disturbances in each ecological range site in the Northern Fescue NSR.

Designing Native Seed Mixes

Native plant communities are complex assemblages of species that provide diversity in; above and below ground structure (fibrous and rhizomatous grasses), timing of growth (early and late season), strategies for reproduction and responses to climate events. Planning seed mixes considers the concepts of range health (refer to Section 3) to build a plant community that stabilizes disturbances, excludes noxious weeds and agronomic invaders and builds resilience and diversity similar to pre-disturbance plant communities over time. Healthy native rangeland communities include tall, mid, low and ground cover structural layers (Figure 10). Diversity in the canopy structure provides resilience to herbivory and climate events. Seed mixes can be used to develop vascular plant structure. Typically, development of the groundcover layer, (e.g. little club moss, mosses and lichen), relies on natural recovery and takes many years (Kestrel Research Inc. and Gramineae Services Ltd. 2011).

Figure 10 - Structural Layers in a Healthy Native Grassland Community

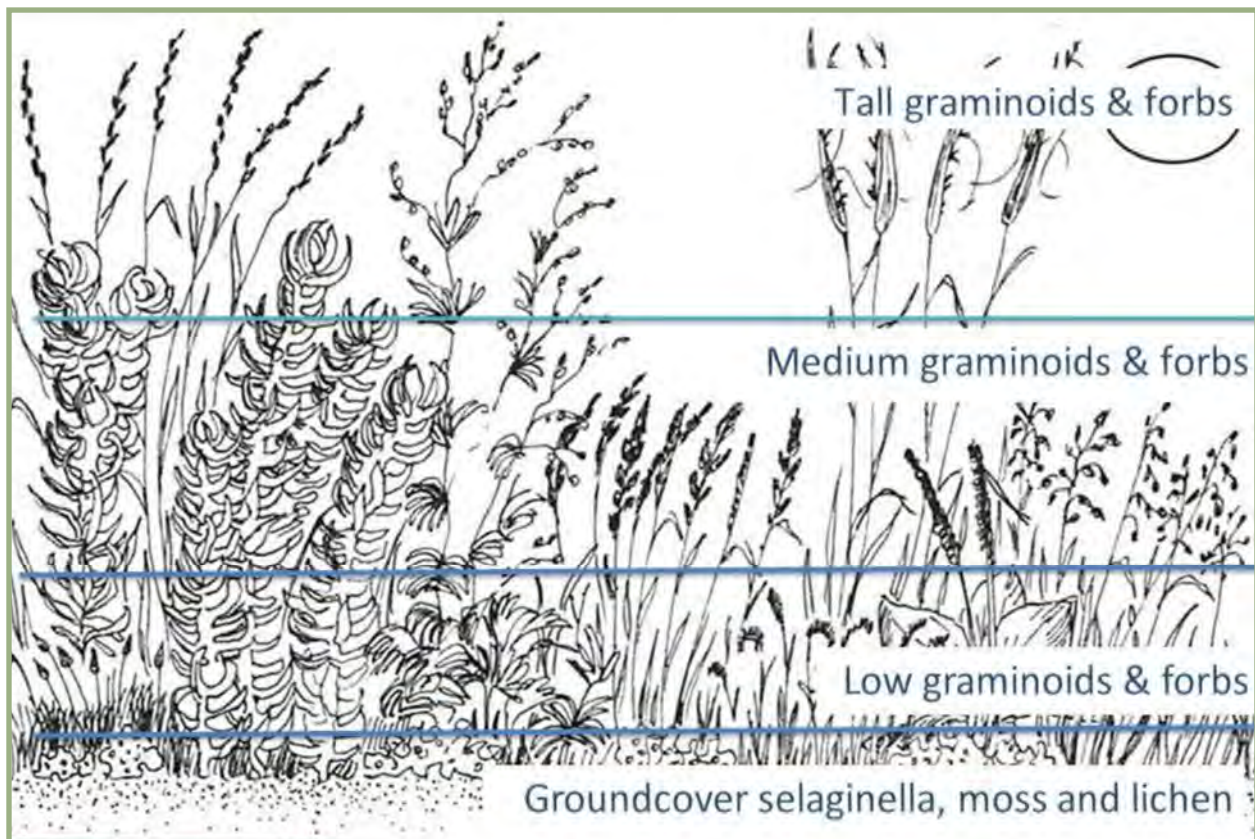


Image courtesy of Alberta Environment and Parks

Recommendations for seed mixes from key findings of the supporting document, *Long-term Revegetation Success of Industry Reclamation Techniques for Native Grassland: Northern Fescue Natural Subregion* (Lancaster et al. 2014) include:

- Use proportionally less rhizomatous wheatgrasses, e.g. western or northern wheatgrass;
- Use a more diverse seed mix and incorporate native species, and
- Use broadcast seeding, which allows the incorporation of small native seeds.

Slender wheatgrass, although dying out within five years, may impede the establishment of slow-growing species such as plains rough fescue (Desserud and Naeth 2013b).

Seeding rate recommendations for native species have traditionally been around 10 – 15 kg/ha depending on seeding methods. Seeding rate should reflect the health of the surrounding community and the opportunity for infill or expression of a viable seedbank in the exposed soils to be seeded. More guidance for seed mix design and links to relevant publications such as *“Plant Material Selection and Seed Mix Design for Native Grassland Restoration Projects”* (Tannas and Webb 2016) can be found on the Foothills Restoration Forum website.

Suitable species for revegetating the variety of ecological range sites found in the Northern Fescue NSR are presented in Appendix D: Target Recovering Plant Communities.

Cultivars

Cultivars for several native grasses are available in Canada and are widely used in the reclamation industry. However, they can be problematic. Many were developed much further south in the U.S.A and are structurally different than local plant materials. While cultivars may improve the reliability of seed germination, it often results in a loss of species diversity as a result of genetic shift (Woosaree 2007). In Alberta successful native plant cultivars suitable for use in the Northern Fescue NSR have been developed by the Alberta Research Council (now Alberta Innovates - Technology Futures) (Table 3).

Findings from the supporting document, *Long-term Revegetation Success of Industry Reclamation Techniques for Native Grassland: Northern Fescue Natural Subregion* (Lancaster et al. 2014) are that dominant seeded cultivars on older sites are green needle grass (*Stipa viridula*), northern wheatgrass (*Agropyron dasystachyum*) and western wheatgrass (*Agropyron smithii*). They often persist at higher than natural cover levels due to expansion or high seeding rates. Western wheatgrass is also able to persist with aggressive agronomic grasses on older trending-to-modified sites.

Northern Fescue Natural Subregion

Table 3 - Ecological Variety Releases Suitable for the Northern Fescue NSR by AITF

Varietal Release	Scientific Name	Soils Adaptation	Origin
'ARC Metisko' awned wheatgrass	<i>Elymus trachycaulus ssp. subsecundus</i> (<i>Agropyron subsecundum</i>)	Sandy, Brown, Dark brown	Metiskow
'AITF Badlands' blue grama grass	<i>Bouteloua gracilis</i>	Brown soil	Hand Hills, Hanna
'ARC Hillbilly' nodding brome grass	<i>Bromus anomalus</i>	Sandy/Parkland	Wainwright area
'ARC Centennial' Canada wild rye	<i>Elymus canadensis</i>	Sandy	Wainwright area
'AITF Bison' plains rough fescue	<i>Festuca hallii</i>	Dark Brown/Brown Chernozem	Northern fescue NSR
'ARC Porter' Indian rice grass	<i>Oryzopsis hymenoides</i> (<i>Achnatherum hymenoides</i>)	Sandy, Dark brown	Wainwright – Ribstone Creek
'ARC Grouse' green needle grass	<i>Stipa viridula</i> (<i>Nassela viridula</i>)	Black Chernozem, Brown	Wainwright area
'ARC Aspen' Canada milk vetch (legume)	<i>Astragalus canadensis</i>	Sandy/Parkland	Vegreville

Seeding Forbs

Recovery of perennial forbs other than the disturbance colonizing sageworts is lacking on sites where grass seed mixes are used (Lancaster et al. 2014). Inclusion of forbs propagules in reclamation mixes can increase diversity on recovering disturbances and create habitat for pollinators and other wildlife. Forbs seeds can be included in the original seed mix, or introduced later by broadcast seeding or as seedlings. This is a useful strategy if reclamation sites are likely to use herbicides initially to control weeds (Appendix C: Industry Workshop Summary). Forb seed can be difficult to source in quantity but there are suppliers for a number of species common to the Northern Fescue NSR. The Alberta Native Plant Council maintains a Native Plant Source List (ANPC 2016). Suitable species will be those found in the surrounding undisturbed plant community.

Wild Harvested Seed

Wild harvest of key species that are not grown commercially in large quantities such as needle-and-thread grass, western porcupine grass or plains rough fescue can be a valuable source of locally adapted species for restoration. “Bicatch” of other native species can also be useful to add diversity to a site.

Examples of successful use of wild harvested grasses are documented in wellsite reclamation by Desserud and Naeth (2013b). Rough fescue mast flowered in the Northern Fescue NSR in 2006 and seed was harvested with a small nursery combine. Seed was cleaned and rough fescue and western porcupine grass were isolated. The seed was used in a straw amendment experiment. Rough fescue was seeded with a drill seeder and western porcupine grass was hand-seeded, due to its hard long awns. In a monoculture seeding, rough fescue became well established in three years. Western porcupine grass did not appear until after three years, possibly requiring at least two freeze-thaw cycles to scarify the hard seed coat (Desserud and Naeth 2013b). Seven years later both grasses were well established, along with other seeded and infill species, e.g. June grass, blue grama, other needle grasses and wheatgrasses (P. Desserud pers. comm.).

Pre-planning is important for wild harvesting. Locate seed harvesting locations on healthy range sites compatible with the disturbed site. Seed production varies from year to year. Collection methods must be considered. During a flowering event for plains rough fescue, seed density may be sufficient for mechanical harvesting (Desserud and Naeth 2013b).

Further guidance on wild harvesting is provided later in this document in “Guidelines for Wild Harvested Native Plant Material”.

Native hay can also be a viable technique for ensuring a reliable seed source that is adapted to local site conditions. Its success depends on the variability of native seed production from year to year, the timing, which will result in the dominance of whichever species have set seed at that time; and methods, such as crimping, to keep the hay in place (Desserud and Naeth 2011).

Plains Rough Fescue

Locally developed plains rough fescue cultivars and wild harvested seed can produce a rough fescue plant community over time. However, seeded wheatgrasses can inhibit establishment of seeded rough fescue. Desserud and Naeth (2013b) observed that seed mixes with no or little wheatgrass components may allow rough fescue time to become established by the third year, with reduced competition from fast-growing wheatgrasses. Common cover crops, e.g. Dahurian rye, may also reduce the establishment of some species, such as plains rough fescue (Sherritt 2012). Use of plugs or seedlings can provide a competitive advantage for slow growing species like rough fescue.

Infill

Infill is the natural re-establishment of plants on disturbances from propagules in the soil or from the surrounding area. An important early seral infill species is western porcupine grass, which is found in the majority of the late seral to reference plant communities of the Northern Fescue NSR. It is present in newer seed mixes but has also re-established successfully through infill on large diameter pipelines where topsoil was replaced in the same season after construction. It may require two to three seasons to become established from seed; however, once established, it will persist on the site, providing diversity and structure and resilience to grazing (Lancaster et al. 2014).

Recovery of perennial forbs other than the disturbance colonizing sageworts is lacking on sites where grass seed mixes are used (Lancaster et al. 2014). Inclusion of forb propagules in reclamation mixes or as nursery propagated seedlings can increase diversity on recovering disturbances. Industry experience is that there are challenges with establishing enough decreasers (typically late seral grasses preferred by grazers) and diversity on sites (Appendix C: Industry Workshop Summary).

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 Northern Fescue NSR, the same ecodistrict and an equivalent ecological range site as the disturbed area to be restored. The plant material must be removed from the nursery and allowed to adapt to the site specific condition where they will be planted to prevent transplant shock and die-back. A monitoring and adaptive management program is required to maximize the success rate of this recovery strategy. Prairie conditions are harsh for young tender plants.

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

Considerations for Complex Sites

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

Approaches to consider prior to further disturbance and during restoration when dealing with complex fragmented sites include the following:

- Pre-construction spraying of undesirable invasive species on site.
- Raking accumulated litter thatch that may be reducing range health, harbouring undesirable seed or reducing opportunities for infill by native species.
- Mowing the site while the natives are not actively growing.
- Wiping out the old invaded sward of native and non-native communities completely and starting from scratch.
- Seeding tough nurse crops lightly with a native cultivar mix that is not long lived but competes with invasives while native plants establish (e.g. slender wheatgrass). Reduce wheatgrasses if plains rough fescue is in the mix.
- Regular monitoring and timely management of re-establishing vegetation.

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



Timeframe for Recovery

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 should be noted that full recovery or restoration is not a requirement for the issuance of a reclamation certificate under the 2010 Reclamation Criteria for Wellsites and Associated Facilities for Native grasslands (AEP 2013a). The criteria must show evidence of restoring ecological function and that the target plant community is on the trajectory to resemble the plant community in the control or adjoining undisturbed native grassland. It is important to recognize the role annual weeds and forbs play in stabilizing the site during the early years of recovery. The timeframe for when indicator species will infill the site is dictated by ongoing environmental site conditions. For example, extended periods of drought, salt laden soil, range condition or above average moisture can affect the timeframe for recovery in a negative or positive way.

Considerations for Wetland Sites

In most cases, government policy and regulations will strictly limit industrial activities which disturb lotic (flowing water) or lentic (still water) wetlands. When disturbance does occur, maintaining the health and function of all classes of water bodies is extremely important. Alberta's Wetland Policy provides specific direction regarding development activity near all classes of wetlands (AEP 2013f).

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 (AEP 2013c).

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

When decommissioning existing industrial infrastructure located in or near lentic or lotic sites, it is important to ensure remediation of all contamination issues (both soil and water) according to the current reclamation criteria (AEP 2013a).

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

Recovery Strategies for Industrial Development in Native Grassland

During reclamation, replacing stripped subsoils and topsoil so that the original wetland contours are re-created 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 prairie wetlands. Zonation patterns of wetland vegetation communities occur in response to dynamic seasonal moisture conditions. Prairie wetlands contain large sources of buried viable seed capable of responding to changing environmental conditions including disturbance (summarized in Keddy 2000). Seed is redistributed within wetlands during high water events.

Barriers to restoration of prairie lentic wetlands include:

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

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

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



Hand Hills Wetland

7 IMPLEMENTING THE STRATEGY

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

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

Salvaging Native Plant Material Resources

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

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

Site Preparation and Micro-Contouring

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

Recommended Timing of Reclamation Activities

The Express project (Kestrel Research Inc. and Gramineae Services Ltd. 2011) 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 wheatgrasses, needle-and-thread, western porcupine grass, and plains rough fescue. Ideally, warm season grasses, eg. blue grama (*Bouteloua gracilis*) should be seeded mid to late June. They need the soil to remain consistently warm for germination and emergence. Seeding is not recommended during the heat of the summer months when moisture is at a deficit. If seeding is required during mid-summer, use a cover crop (refer to section 5).

Soil Amendments

Native plant species are generally adapted to nutrient poor conditions. Many native species have the ability to outcompete introduced species in nutrient-poor soils. While addition of fertilizers and moisture can affect species productivity, it can favour the establishment of weeds and non-native invasive species over native species on reclamation sites.

Impeding nitrogen uptake with a carbon addition to the soil such as clean straw may reduce or eliminate weedy species. Plains rough fescue, June grass, western wheatgrass and blue grama responded well to soil straw amendment and lowered nitrogen (Desserud 2011; Desserud and Naeth 201c). Further discussion can be found in the supporting literature review document (Lancaster et al. 2014).

Use of fertilizers on topsoils are not recommended on native grasslands as they can favour the establishment of weeds and non-native invasive species over native species.

Selecting Equipment to Suit the Strategy

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

Some seed, such as wild harvested western porcupine grass, 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 (Prairie Habitats 2015).

Guidelines for the Procurement of Native Seed

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

- For large disturbances such as large diameter pipelines, wind energy projects, mines, borrow 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 Northern Fescue or the Central Parkland if possible, or no farther away than central Alberta to the northern US plains.
- 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 western porcupine grass, plains rough fescue or needle-and-thread grass to ensure an adequate supply for the project. Reputable and experienced companies are listed on both the Foothills Restoration Forum and Alberta Native Plant Council websites. Specify the ecological range sites from which the material should be harvested (i.e. 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 Northern Fescue by reputable research institutions such as Alberta Innovates (listed in Table 3). Consider forward contracting to ensure an adequate supply of appropriate species.
- Specify source identified seed grown within the Northern Fescue or Central Parkland or the Northern Fescue 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 and invasive agronomic species such smooth brome, or Kentucky bluegrass in the Northern Fescue. Seed lots containing quackgrass (*Elymus 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.
- For more information on native seed selection, analysis, certification and seed mix design, see *Plant Material Selection and Seed Mix Design for Native Grassland Restoration Projects* (Tannas and Webb 2016). The document is available on the Foothills Restoration Forum website.

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 Northern Fescue, 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, smooth brome, Kentucky bluegrass and sweet clover. Wild harvesting includes the following.

1. **Use of specially designed equipment that harvests only the seed from the stems of select species** such as plains rough fescue, western porcupine grass, needle-and-thread, June grass (*Koeleria macrantha*), or blue grama grass. 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 plains rough fescue similar to the Ducks Unlimited (2016) Ecovar program or the Alberta Innovates Technology Futures (2016) 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 to determine if other guidelines are in place and/or if permits are required.

1. The proponent will be required to obtain written consent from the grazing leaseholder 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, smooth brome and sweet clover.
3. The proponent must notify the AEP 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 wild harvesting seed for site access permissions and site selection. Additional guidelines pertain to native hay cutting.

1. Native harvesters vary from small mowers that cut and collect native hay to larger modified combines, all equipped with specialized blades to handle hard native grasses. If a mower/collector is used, timing is essential as dominant grasses must have produced seed. 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 critical.
2. Native grassland should be cut in strips, leaving uncut strips to act as a seed rain source for the cut areas.
3. The amount of native grassland required for harvesting varies with Natural Subregions. In drier Northern Fescue 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.

Recovery Strategies for Industrial Development in Native Grassland

4. If the area is grazed, it is recommended grazing be suspended until after harvesting. Ideally, grazing should continue the following year, after the cut areas have had a chance to recover.
5. Native hay mulch harvesting will not occur on the same site for a period of 7-10 years following the harvest (depending on climate and range health conditions).
6. Wild harvested hay may be cut with a variety of equipment.

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

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



***Wild Hay
Harvester;
mows and
collects
Native
Hay***



***Wild
Harvested
Hay
Spread on
Pipeline
RoW***



***Minimal
Disturbance
to Ground
Cover***

8 MAINTAINING THE PATHWAY

Restoration projects will require a monitoring and adaptive management program for the first five growing seasons. Funds will need to be secured for this program early in the restoration 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.

The principles of adaptive management combine research and monitoring with flexible management practices. By formulating clear restoration goals and then monitoring achievement of those goals as the project develops, a “feedback loop” of continuous learning is created. The restoration activity can then be modified and enhanced by that learning (Gayton 2001).

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

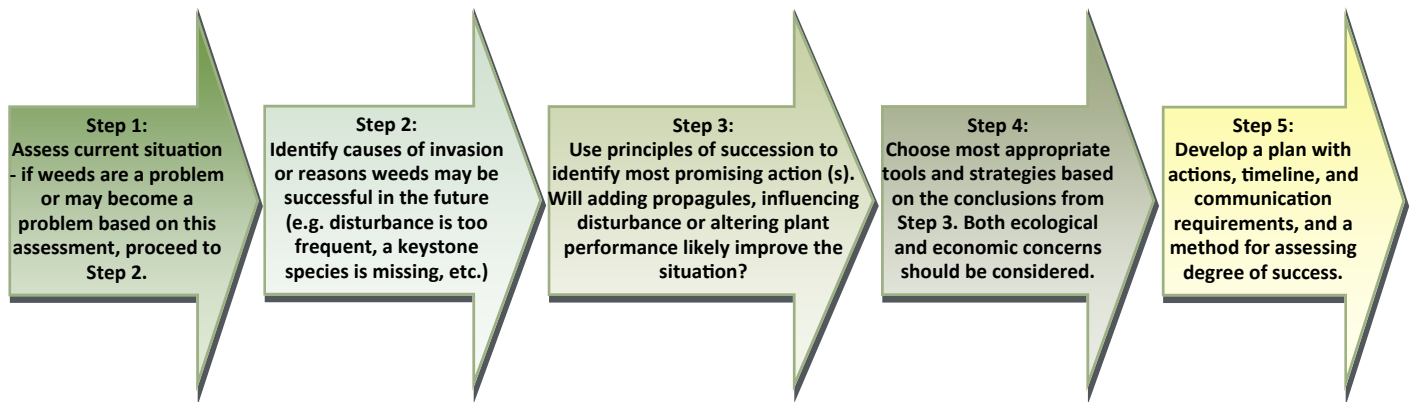
On private lands discuss invasive plant management with the landowner. Be aware that certified organic producers will have specific requirements and specifications for weed control.

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 “initial cover crop” that promotes the healing process by stabilizing the soil and retaining moisture. Where necessary, mowing annual weeds prior to seed set can reduce the competition for available soil moisture, reduce weed seed set and enhance seedling survival of desired species. However, where a lot of weed biomass is present (often the situation when mowing is desirable), care should be taken to either limit mowing height and just remove seed heads, or rake or swath/bale weeds to remove biomass. Maintaining a database of areas where vegetation management is required and evaluating the success of the control methods implemented are important steps in a successful vegetation management program.

Ecologically Based Invasive Plant Management (EBIPM)

Ecologically Based Invasive Plant Management (EBIPM) is an approach to rangeland invasive plant management which applies scientific principles and management experiences in a step-by-step plan (Figure 11) (Rangelands 2012).

Figure 11 - The Step-by-Step Process of EBIPM from Rangelands



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

Prior to applying EBIPM, it is important to understand the history of the area, especially locating and evaluating historical cultivation. Cultivation has been practiced in southern Alberta since the 1880's. 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 Species Council (AISC) is an important source of information regarding new weeds of concern and methods of control. Their website is located at: <http://www.abinvasives.ca/>. The Alberta Native Plant Council (ANPC) also maintains a list of non-native plants, "Alberta Exotic Plants Wiki". Their website is located at <http://www.anpc.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 the United States. The USDA Agricultural Research Service has conducted considerable research in the field of vegetation management. A publication entitled *Revegetation Guidelines for the Great Basin: Considering Invasive Weeds* (Sheley et al. 2008) is a valuable source of information relevant to the Northern Fescue NSR of Alberta.

The Noxious Weeds section of the *Rangeland Health Assessment Field Workbook* (Adams et al. 2009) is a useful tool for assessing noxious weeds and invasive plants. The Density Distribution Guide for Rating Noxious Weed infestations found in the field workbook will assist in describing the extent and scoring the severity of invasion as a start to planning the management process.

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

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

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

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

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

- Disturbances surrounded by native grassland will be less likely to be invaded than those adjacent to areas dominated by invasive plants, e.g. crested 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, smooth brome will thrive close to riparian areas.
- Special attention must be paid to areas that might promote the growth of invasive plants while waiting for ideal germination conditions i.e. soil disturbance exposes buried seeds.

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

When invasive plant performance is controlled through herbicides, biological control, mowing, or other methods, niches are opened in the plant community allowing for native plant infill or for further weed invasion. Refer to section 4.2 - Understanding the Process of Succession for more information on succession processes. Use Figure 6 and Table 2 to determine the current stage of the invasive plant community.



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

Invasive plants found in the Northern Fescue are identified in Table 3. The use of a particular management tool for control of invasive plants often depends on the life cycle of the target invasive plant or plants, as well as the life cycle of the desirable plants within the community. Some of the more successful treatments for invasive species invasion based on industry experience are presented in Appendix C: Industry Workshop Summary. Treatments are site specific and typically involve more than one management approach. Potential management approaches include the following.

- Livestock grazing can be one of the most useful approaches to keep rangelands in good condition and maintain optimum production. Livestock can remove excessive litter, recycle nutrients, stimulate tillering of perennial grasses, and reduce seedbanks of competitive annual plants. Targeted grazing is an effective approach for invasive plant control, especially if managers exploit differences in plant growth stages. For example, invasive plants may be more susceptible to grazing when green and when perennial grasses are brown and dormant. Table 4 indicates if cattle grazing is an option for control. Browsers, including sheep and goats, will eat many weeds. Goats and sheep can digest toxins in weed plants that cows cannot. Goats are being used to manage toadflax in Alberta. Sheep are being used to control leafy spurge in southern Alberta. This practice will increase in use in the future to control weeds and in some cases to control shrub growth (e.g. on ski hill runs). A good reference for toxicity of some plants for all livestock species is *"Stock-poisoning Plants of Western Canada"* (Majak et al. 2008).
- Applying herbicides is a common strategy to control invasive species, especially for perennial weeds, and may require repeated application over a long-term control time. Biennial weed species are best controlled before flowering of mature plants and also again in the fall to control rosettes of new growth (summer and fall spraying in 1 year). Repeated application over a season and over several years may be required. Alberta Agriculture provides information on all registered herbicides (AAF 2016b).
- Mowing is effective for annual species, if done prior to seed setting. If infestations are low, hand pulling of taprooted species or spot herbicide applications may be effective.

Northern Fescue Natural Subregion

Table 4 – Non-native Invasive Plants Found in the Northern Fescue NSR with Grazing Responses

Noxious weeds are indicated by *

Common Name	Scientific Name	Growth Habit	Grazing Option
Forbs			
alfalfa	<i>Medicago sativa</i>	perennial, taproot	Good
cleavers	<i>Galium aparine</i>	perennial, creeping rhizomes	Poor
common chickweed	<i>Stellaria media</i>	perennial	Fair
Canada thistle*	<i>Cirsium arvense</i>	perennial, deep rhizomes	Poor – cattle avoidance
dandelion	<i>Taraxacum officinale</i>	perennial, taproot	Fair
field bindweed*	<i>Convolvulus arvensis</i>	perennial, vine	Poor
flixweed	<i>Descurania sophia</i>	annual	Poor - unpalatable
hemp nettle	<i>Galeopsis tetrahit</i>	annual	Poor
leafy spurge*	<i>Euphorbia esula</i>	perennial, rhizomes	Poor – unpalatable, except by sheep
night-flowering catchfly	<i>Silene noctiflora</i>	annual/biennial, taproot	Poor
oxeye daisy*	<i>Chrysanthemum leucathemum</i>	perennial, rhizomes	Poor – unpalatable
redroot pigweed	<i>Amaranthus retroflexus</i>	annual	Poor – unpalatable
round-leaved mallow	<i>Malva rotundifolia</i>	annual	Poor
Russian thistle	<i>Salsola pestifer</i>	annual	Poor - palatable when young
scentless chamomile*	<i>Tripleurospermum inodorum</i>	annual	Poor - unpalatable
sow-thistle, perennial*	<i>Sonchus arvense</i>	perennial, rhizomes	Fair – when young
sow-thistle, annual	<i>Sonchus oleraceus</i>	perennial, rhizomes	Fair – when young
stinkweed	<i>Thlapsi arvense</i>	annual	Poor
toadflax, dalmation*	<i>Linaria dalmatica</i>	perennial, rhizomes	Poor
Grasses			
brome, smooth	<i>Bromus inermis</i>	perennial, rhizomes	Good – very palatable
Canada bluegrass	<i>Poa compressa</i>	perennial, rhizomes	Good – spring grazing
Kentucky bluegrass	<i>Poa pratensis</i>	perennial, rhizomes	Good – spring grazing
crested wheatgrass	<i>Agropyron cristatum</i>	perennial, tufted	Good – spring grazing
hard fescue	<i>Fescuca duriuscula</i>	perennial, tufted	Good
sheep fescue	<i>Festuca ovina</i>	perennial, tufted	Good
quackgrass	<i>Elymus repens</i>	perennial, rhizomes	Good
Timothy	<i>Phleum pratense</i>	perennial, tufted	Good – spring grazing

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

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

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

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

Grazing Management

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

- Early consultation with the landowner or leaseholder is important. Grazing management plans implemented to enhance recovery of industrial disturbances should incorporate local knowledge, be designed in consensus with the rancher and be well documented regarding the responsibilities of both parties, including who is responsible for removing fencing.
- Use the Range Health Assessment protocol and consultation with land manager to determine when temporary fencing might be appropriate (Adams et al. 2009). Restoration sites located in fields with unhealthy range health scores will require temporary fencing.
- Interim reclamation sites where topsoil resources have been stripped and stored may require fencing until vegetation is re-established. Once established the fencing should be removed.
- Industrial soil disturbances located in pastures rated as “healthy with problems” may require temporary fencing depending on which factors are affecting the range health scores. Also the timing and duration of grazing will need to be factored into the decision.
- The size and type of disturbance also determines the requirement for fencing. For example, reclaimed wellsites with more than 25% disturbance may require fencing. This will allow seeded areas at least one growing season for seed to germinate and establish a root system before grazing is allowed. If possible, allow the newly established plants a second year to set seed (usually by mid-summer) prior to removing the fence. This recommendation will result in livestock trampling a portion of the seed into the upper soil surface to further enhance infilling.
- Fencing can also restrict the movement and distribution of livestock and wildlife within the pasture surrounding the industrial development. Ensuring access to water is a primary concern. Livestock will need some time to become familiar with new fences, particularly when used on large diameter pipeline rights-of-way. Additional disturbance to the soils adjacent to the fencing has been observed as grazing animals negotiate a new barrier to movement. 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. The AEP Range Health Assessment Field Workbook (Adams et al. 2009) (figure 7, page 36) does not provide data specific for Northern Fescue soil types. The Northern Fescue is a transition zone between the Aspen Parkland and the Mixedgrass, therefore optimum litter rates can be calculated as an average of those two natural subregions. 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, may provide opportunities for weed or agronomic invasion and reduces seed infiltration, which can negatively influence the process of plant community succession. Make certain there are adequate funds allocated for fence removal.

Ensure fencing is removed once the plant community has reached target litter levels.



Monitoring Recovery

The purpose of monitoring is two-fold. In the first few years after disturbance, monitoring is a component of an adaptive management approach to maintaining a site to ensure that erosion, invasive species or grazing concerns do not inhibit revegetation by desirable species. In the long-term, monitoring is required to demonstrate a positive trajectory towards plant communities present prior to disturbance or towards a target native plant community.

Reclaimed sites that are not monitored or managed can quickly deteriorate resulting in costly measures required to mitigate problems. Establishing a standardized method of monitoring industrial restoration projects and evaluating restoration success is required to allow us to communicate progress to stakeholders with increased confidence. Standardized methods will also assist in defining areas where improvement in the methods and strategies used are required. Monitoring should be approached with an adaptive management plan, incorporating goals for expected recovery with recurring monitoring (Sheley et al. 2009).

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



Example of a Thistle and Smooth Brome Invaded RoW

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 and through several successional stages as ecosystem processes re-develop, and species composition and structure matures (Kestrel Research Inc. and Gramineae Services Ltd. 2011). The following sources provide information on site conditions, such as climate, soils, and the potential plant community to help establish restoration targets, methods and potential timeframes.

- The 2010 Reclamation Criteria for Wellsites and Associated Facilities for Native Grassland (AEP 2013a) provide established methods that can be used as a baseline for monitoring and targets for defining successful recovery.
- Refer to the Northern Fescue Natural Subregion Range Plant Community Guide (Kupsch et al. 2012) to determine what the potential plant communities might be.
- Alberta climate information is available at AgroClimatic Information Service (ACIS), providing historical Alberta Climate Maps and Alberta Weather Station Data and Graphs (AAF 2016a). ACIS models climate information by extrapolating from multiple weather stations. Weather stations in the project site vicinity are easily found. Tracking precipitation and temperature for the duration of monitoring will provide important information about potential and actual recovery success.
- of invasive species, grazing pressure and range health). For example, if the surrounding area has a low range health score, the proposed site has a sensitive species such as rough fescue, or it is located in a moist/loamy range site, recovery may be slow (e.g. 15-20 years for rough fescue communities). Patience is required to allow natural successional processes to take place.

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

Establish a Monitoring and Adaptive Management Plan

Develop a Monitoring Plan

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. Planning steps include the following.

- 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.
- 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

Incorporating the experience and concerns of stakeholders is important to establishing a viable, cost effective and useful adaptive management and monitoring plan.

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

Time Frames for 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 Northern Fescue, dominated by western porcupine grass and wheatgrasses, may recover similarly to the Mixedgrass NSR. Moister areas, such as those dominated by plains rough fescue, may recover more slowly. Recovery to a mid-seral plant community can be expected in 5 to 7 years (Desserud and Naeth 2013b).

General Monitoring Guidelines

General monitoring guidelines are described in Alberta Environmental Protection's *"Principles for Minimizing Surface Disturbance in Native Grasslands - Principles, Guidelines and Tools for all Industrial Activity in Native Grasslands in Prairie and Parkland Landscapes of Alberta"* (AEP 20016a) and *AEP Strategies for Minimizing Disturbance in Native Grasslands within the Central Parkland and Northern Fescue Subregions* (AEP 2016b) for all proposed disturbances.

- For wellsites, the 2010 *Reclamation Criteria for Wellsites and Associated Facilities for Native Grassland 2013* (AEP 2013a) 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 AEP, can determine if the disturbed site is on a positive successional pathway.

Monitoring and Adaptive Management Years 1-3

In the first few years after disturbance, monitoring is a component of an adaptive management approach to maintaining a site to ensure that erosion, invasive species, grazing concerns or other issues do not inhibit revegetation by desirable species.

Monitoring in Years 1-3

Monitoring vegetation establishment on disturbed topsoil when seedlings are tiny assesses species composition and numbers of seedlings, rather than determining percent foliar cover of each species.

- Delineate a $\frac{1}{4}$ m² and count the young plants. Do this 10 times over the assessment area and average the count. Compare the species composition on site 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.
- Conduct Range Health Assessments using the current manual (Adams et al. 2009 or more recent) 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

Early and regular monitoring provides the information to assess and if necessary change management practices to nip any potential problems in the bud at the earliest opportunity. Particularly for invasive species, the best time to remove them is when they are few in number. The following are some beneficial adaptive management considerations early in the restoration process.

- Fencing to prevent grazing may be used in the first 1 to 3 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 spot spraying herbicide application (see EBIPM Section).
- The longer the problems are allowed to go unattended the more difficult and costly it will be to achieve successful restoration.

Monitoring and Adaptive Management Years 3-5+

Regular monitoring as plant communities develop from early to more mature seral stages (see Appendix A: Table A2) provides the information to assess whether a positive trajectory towards restoration is occurring. More mature seral stages have greater range health and greater ability to perform ecological functions including; net primary production, maintenance of soil/site stability, capture and beneficial release of water, energy and nutrient cycling and plant species functional diversity (Adams et al. 2009). Monitoring will provide the information to assess whether changes in management practices or invasive species control is required.

Monitoring after Year 3

As vegetation becomes established (years three and later on disturbed topsoil) 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.

- Document the recovering plant community using the methods described in the Range Survey Manual for Alberta Rangelands (Version One (ASRD 2007) or more recent).
- Conduct Range Health Assessments using the current manual (Adams et al. 2009 or more recent) to document redevelopment of ecological functions and 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 After Year 3

Common adaptive management considerations after year three to promote recovery:

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

Noxious weeds must be removed, by hand-picking or spot spraying herbicide application (see EBIPM Section).

Draw Conclusions and Update the Plan

These steps should be repeated with each cycle, ultimately improving management, until a positive trajectory towards restoration is demonstrated.

- If vegetation passes the 2010 Reclamation Criteria (AEP 2013a) apply for a Reclamation Certificate. If not, update the plan. The principles and standards in the 2010 Reclamation Criteria are applicable to other industries operating on native grasslands.
- 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 (AEP 2013a) shifts the focus from reclamation to restoration. As wellsites and associated facilities are assessed with the criteria our knowledge of the most successful recovery strategies on a site specific basis will increase.

9 THE IMPORTANCE OF LONG-TERM MONITORING

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

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

Valuable components of extended timeframe monitoring are as follows.

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

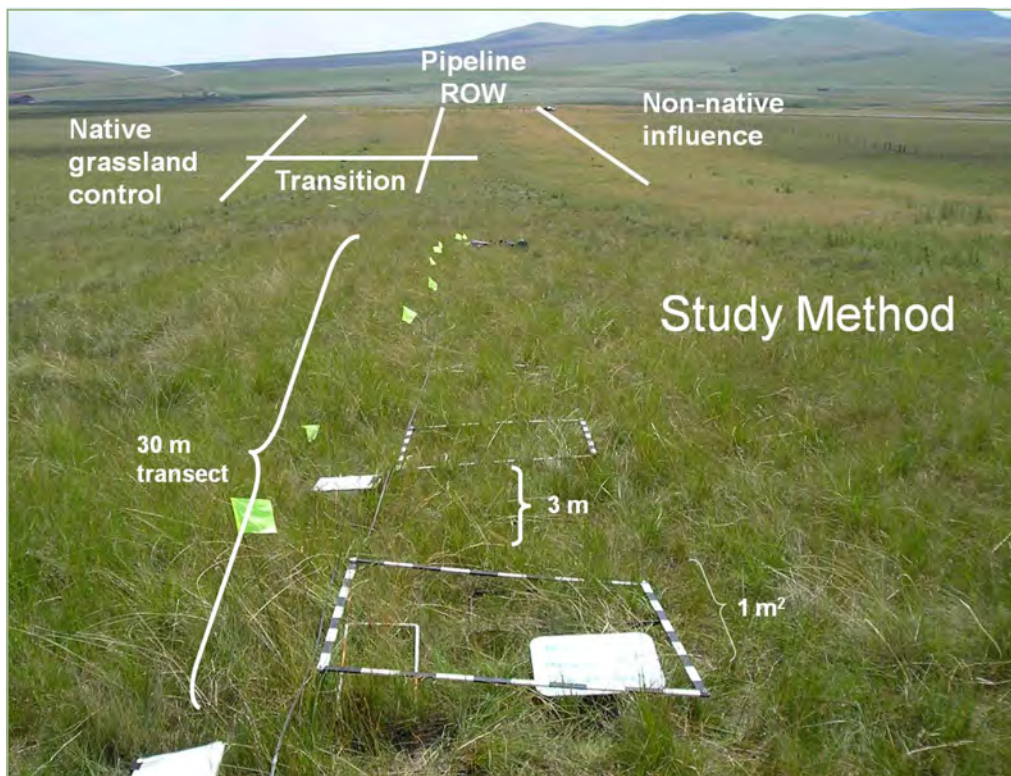
Monitoring provides the opportunity to reflect on construction and reclamation procedures used in the past and make informed choices that will improve future restoration potential.

Recovery Strategies for Industrial Development in Native Grassland

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

- The results of the Express monitoring project (Kestrel Research Inc. and Gramineae Services Ltd. 2011) 14 years after construction indicated that significant changes in the composition of recovering plant communities may occur after the first five years of reclamation both in positive and negative directions. Components of seed mixes performed differently over time, with some cultivars resulting in negative trajectories that will not achieve restoration. Ordinations of monitoring data collected over a series of year (1,2,3,5, and 14 years post-construction) were used to develop definitions of successional stages of recovering plant communities on disturbed topsoil.
- Establishment of plains rough fescue was slow; however after 14 years average cover exceeded 50% of the cover of controls (Kestrel Research Inc. and Gramineae Services Ltd. 2011).
- Seeding experiments in the Northern Fescue NSR indicate that seeding plains rough fescue as a monoculture resulted in better diversity on the site over time than seeding plains rough fescue with aggressive species, such as wheatgrasses, in the seed mix (Desserud and Naeth 2013b).

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



Example of a Reclamation and Monitoring Research Plot Layout

10 FUTURE RESEARCH REQUIRED

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

- * Natural recovery may be considered the best solution for long-term recovery; however, it is not suitable in all situations. More analysis is required to determine the consequences of allowing a site to recover naturally rather than with assistance.
- * 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. More applied research in documenting native plant community succession over time is warranted.
- * What are the best methods to manage smooth brome, leafy spurge, sheep fescue, hard fescue and crested wheatgrass including: herbicidal products, alternatives to chemical treatment and the timing of chemical application or alternative treatments?
- * Is it possible that some aggressive invasive species may alter soil properties to the detriment of native grasses? Further research on the effects of soil properties on native species establishment?
- * 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 are the methods to stimulate seed production in healthy areas surrounding disturbance?
- * Further study on the successful use of wild harvested hay to revegetate topsoil disturbances is required, including an assessment of infill.
- * Development of guidelines is needed to ensure recovery of harvested for native hay or wild seed harvesting.
- * The potential for centrally located designated areas to supply native hay should be investigated.
- * Further research on seed mixes, including forbs, rates, competition. What seeding rates are most effective and how do they differ by subregion?
- * What role do forbs play in plant community succession?

- * What is the success rate of planting of wild harvested native grasses without processing them first? An example would be western porcupine grass, which has very hard seed and long awns and is very difficult to clean.
- * How effective is planting nursery propagated native plant material (rooted seedlings) to introduce hard to establish species (e.g., shrubs, forbs) or, to establish native species on difficult sites (steep terrain, exposed areas, xeric sites)?
- * Development of cultivars appropriate to the Northern Fescue and Central Parkland NSRs.
- * How can damage to the seed be reduced during processing to remove the awn for species such as western porcupine grass and needle-and-thread grass, which can damage up to 50% of the seed, increasing the cost.
- * What methods can be used to effectively a seed mulch for fluffy seed or awned seed?

Recovery Strategies Feedback

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

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



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APPENDIX A SUMMARY OF RECLAMATION MONITORING STUDIES IN THE NORTHERN FESCUE NSR

Long-term Revegetation Success of Industry Reclamation Techniques for Native Grassland: Northern Fescue Natural Subregion

The following information is summarized from the 2014 supporting document to the Northern Fescue Recovery Strategies:

Lancaster J., M. Neville, P. Desserud, V. Craig, R. Adams, B. Adams, and J. Woosaree. 2014. *Long-term Revegetation Success of Industry Reclamation Techniques for Native Grassland: Northern Fescue Natural Subregion*. Prepared for: Range Resource Management Branch, Public Lands Division, Alberta Environment and Sustainable Resource Development.

A.1 Data Collection Methods

Vegetation inventory data from recovering industrial disturbances and associated controls in the Northern Fescue NSR was acquired from several sources in addition to the field data collected in 2013 by the project team. A cluster analysis was conducted to compare disturbed sites and controls.

A.2 Data Analysis and Interpretation

Cluster Analysis and Plant Community Ordination Methods

Several Grassland Vegetation Inventory (GVI) range site types were included in the cluster analysis including; Loamy, Overflow, Sandy and Blowout range sites with better soil development. These range sites were judged to be of similar productivity for comparison. An ordination illustrated fairly tight grouping of undisturbed control sites across these range site types, confirming the validity of combining them in the analysis. Cluster analysis of the control data resulted in eight species groupings, which were correlated with range plant communities described in the *Northern Fescue Range Plant Community Guide* (Kupsch et al. 2012). Control range plant communities and associated seral stage are presented in Table A1.

Table A1 - Control Plant Communities Correlated to the Northern Fescue NSR Range Plant Community Guide

Community Code	Range Plant Community	Seral Stage
NFA1 high	Plains Rough Fescue – Western Porcupine Grass	Reference (Lo 1)
NFA1 low	Plains Rough Fescue – Western Porcupine Grass - grazed	Reference (Lo 1)
NFA2	Plains Rough Fescue - Kentucky Bluegrass	Late seral
NFC2	Snowberry/Plains Rough Fescue - Kentucky Bluegrass	Mid-seral
NFA7	Western Porcupine Grass - Plains Rough Fescue	Reference (Lo 2)
NFA10	Plains Rough Fescue - Sedge	Reference (BIO)
NFA8	Sedge - Plains Rough Fescue - Western Porcupine	Mid-seral
NFA9 Festhal	Blue Grama – Sedge – (Plains Rough Fescue)	Early to mid seral
NFA9 Stipcur	Blue Grama – Sedge – (Western Porcupine Grass)	Early to mid seral

A total of 179 sites compatible with the Loamy range site were included in the analyses. Disturbance data was collected primarily from areas where topsoil was disturbed and replaced during construction. Several data sets are also from minimal disturbance areas such as access roads and unstripped portions of wellsites. The data set includes data from undisturbed controls, large diameter pipelines, flow lines and wellsites, and encompasses a variety of ages, construction methods and reclamation treatments.

An initial cluster analysis of the entire data set, including undisturbed and disturbed site observations indicated that none of the disturbed sites clustered with the controls; whereas, undisturbed control sites across these range site types were fairly tight clustering, with no obvious outliers on a range site basis.

Assessment of Successional Stage

Succession is a process defined as the gradual replacement of one plant community by another over time. Seral stages are measures of succession used to describe the state and health of a plant community. More mature seral stages have greater range health and greater ability to perform ecological functions including; net primary production, maintenance of soil/site stability, capture and beneficial release of water, energy and nutrient cycling and plant species functional diversity (Adams et al. 2013).

Assessing the seral stage on disturbance plant community clusters was based on species cover and composition, and an understanding of species persistence (for example annual weeds versus persistent long-lived species versus invasive species). Definitions for plant community seral stages on disturbed topsoil (refer to Table 2 in the main body of the document) have been developed based on long-term reclamation monitoring on the Express Pipeline project (Kestrel Research Inc. and Gramineae Services Ltd. 2011). Invasive non-native species are known to replace native species and establish permanent dominance in grassland communities. Reclaiming grassland sites where invasive non-native species occupy greater than 5% of the total live cover are at risk of succession to non-native modified plant communities.

Influence of Ecodistrict on Range Plant Community

The location of control plant communities was not correlated to Ecodistrict. Similar undisturbed plant communities were found on Loamy, well developed Blowouts, Overflow and Sandy ecological range sites across each of the Ecodistricts sampled, including the Drumheller Plain, Endiang Upland, Neutral Hills, Oyen Upland and Wintering Hills.

A.3 Successional Plant Communities following Disturbance on Loamy Range Sites

Cluster diagrams, using PCORD© were produced for undisturbed monitoring sites and recovering disturbances associated with each control plant community (Table A1). The diagrams illustrate relationships between species cover and composition on disturbances and undisturbed sites. Across the range of control plant communities, most of the revegetation treatments (including seeded and natural recovery sites) are not clustering closely with the controls, indicating that species composition and cover on the reclaiming disturbance sites are not similar to the undisturbed plant community. However, many of the treatments appear similar to one another.

Time Frame for Recovery

None of the disturbance plant communities are equivalent in composition, structure or range health to undisturbed control areas or to native plant communities described in the Northern Fescue Range Plant Community Guide (Kupsch et al. 2012), although some may be trending in this direction (Table A2). Only one of the sixteen groupings of disturbance plant communities from the cluster analysis (Plains Rough Fescue - Green Needle Grass - Slender Wheatgrass) is categorized as a mid- to late seral plant community (Table A2). Succession to later seral stages appears to be slower on Loamy range sites in the Northern Fescue NSR as compared to Mixedgrass seeded sites, where forty percent of all sites where disturbed topsoil was seeded developed into a late seral plant community after 14 years (Kestrel Research Inc. and Gramineae Services Ltd. 2011). However, half of the undisturbed control Northern Fescue range plant community types assessed are also in early to mid-seral or mid-seral successional stages (Table A1). Plant communities at an earlier successional stage often have lower range health scores. Lower range health can affect the diversity and supply of propagules available to naturally revegetate a site. Longer time frames required for native grassland plant communities to recover following industrial disturbance mean that exposed soils are vulnerable for longer periods of time to colonization by invasive species. For example, early seral disturbance Cluster 8 (Table A3), a Snowberry - Kentucky bluegrass shrubland community, is composed of eight older sites (33-55 years) which appear to have stabilized as an early seral native/non-native community.

Influence of Site Health on Recovery

Disturbance plant communities were more likely to develop native plant communities if range health scores for the comparable control were “healthy” or “healthy with problems”. However, trending-to-modified plant communities and modified plant communities can result whether range sites are healthy or not.

Influence of Invasive Species

About 29% of the observations in the full data set of 179 disturbance monitoring sites are plant communities that have greater than 70% relative cover of non-native vegetation (modified) or greater than 5% cover of persistent or invasive non-native species (Table A2). Dominant cover species of primary concern are the seeded non-native bunchgrass sheep fescue and aggressive rhizomatous grasses including smooth brome, Kentucky bluegrass and quackgrass.

Natural Recovery

Of the 36 observations of natural recovery sites in the combined data set, sixteen sites (44%) were trending-to-modified or modified plant communities. This recovery strategy represents a significant risk in the Northern Fescue NSR. Twenty-five sites (9%) were early or early to mid-seral plant communities and eleven sites (31%) had developed into mid-seral or late seral native plant communities. An assessment of the resiliency of sites where natural recovery is proposed, in terms of range health and the potential for invasive species incursion from surrounding areas, is necessary to assess the risk of failure.

Native Seed Mixes

Dominant seeded species on older sites are green needle grass, northern wheatgrass and western wheatgrass, which when persisting may express as much taller and more dominant cover than local native seed stock. They are species and cultivars that typically have been most available over the past 20 years. Green needle grass is prominent on both younger and older sites and is represented above natural cover levels (Table A3). Similar long-term persistence and cover were observed on the Express Pipeline after 14 years in a variety of range sites (Kestrel Research Inc. and Gramineae Services Ltd. 2011). Northern wheatgrass and awned wheatgrass are in the top three cover species on several early to mid-seral disturbance plant communities. Western wheatgrass is also able to persist with aggressive agronomic grasses on older trending-to-modified sites.

Infill

An important early seral infill (spreading from undisturbed cover to the disturbance or from the seed bank) species in the Northern Fescue NSR is western porcupine grass. It is present in newer seed mixes but has also re-established successfully through infill on large diameter pipelines where topsoil was replaced in the same season after construction. It may take two or three seasons to become established if seeded; however, once established, it will persist on the site, providing diversity and structure and resilience to grazing.

Northern Fescue Natural Subregion

Table A2 Successional Plant Communities following Disturbance on Loamy Northern Fescue NSR Sites

Seral Stage	Reclaiming Plant Community	# of Observations
pioneer	Pasture Sagewort - Slender Wheatgrass	11
early to mid-seral	Pasture Sagewort - Slender Wheatgrass - Foxtail Barley	16
early to mid-seral	Pasture Sagewort - Green Needle Grass - Awned Wheatgrass	11
early to mid-seral	Slender Wheatgrass - Green Needle Grass	17
early seral	Snowberry - Kentucky Bluegrass	4
mid-seral	Slender Wheatgrass - Green Needle Grass - Plains Rough Fescue	13
mid-seral	Green Needle Grass - Western Wheatgrass - Awned Wheatgrass	12
mid-seral	Western Wheatgrass - Northern Wheatgrass - Western Porcupine Grass	9
mid-seral	Northern Wheatgrass - Western Porcupine Grass - Low Sedge	17
mid to late mid-seral	Plains Rough Fescue - Green Needle Grass - Slender Wheatgrass	17
mid-seral to trending-to-modified	Pasture Sagewort - Slender Wheatgrass	11
trending-to-modified	Smooth Brome - Slender Wheatgrass - Kentucky Bluegrass	16
trending-to-modified	Kentucky Bluegrass - Western Wheatgrass	11
Trending-to-modified	Sheep Fescue - Western Wheatgrass	5
modified	Quackgrass - Kentucky Bluegrass	4
modified	Smooth Brome - Kentucky Bluegrass	5

Table A3 Descriptions of Reclamation Treatments associated with Successional Plant Communities Following Disturbance on Loamy Northern Fescue NSR Sites

Seral Stage	Reclaiming Plant Community	Description	Comment (treatment & age)	# of Observations
Pioneer	Pasture Sagewort - Slender Wheatgrass	Plant communities with relatively low total vegetation cover (10%); including low cover of native and seeded grasses, annual weeds and infill forbs.	1 to 2 years since reclamation (Cluster 13 Subset A; 11 of 22 obs.)	11
early to mid-seral	Pasture Sagewort - Slender Wheatgrass - Foxtail Barley	Native plant community dominated pasture sagewort at 15.0% cover, slender wheatgrass at 5.6% cover and foxtail barley at 5.8% cover.	Native grass seed mixes, two diverse mixes of native grasses and forbs (ARC and collected,) and natural recovery. 9 of 16 sites are 1 or 2 years since reclamation and 7 of 16 sites are 3-5 years since reclamation	16
early to mid-seral	Pasture Sagewort - Green Needle Grass - Awned Wheatgrass	Pasture sagewort established from infill. Seeded green needle grass and awned wheatgrass are the dominant grasses. Plains rough fescue cover at 4.5% and constancy of 90.9% is associated with seeded treatments.	Native grass seed mixes, two diverse mixes of native grasses and forbs (ARC and collected,) and natural recovery. Observations primarily 2-5 (13) years after reclamation.	11
early to mid-seral	Slender Wheatgrass - Green Needle Grass	Dominated by seeded species and minor cover of pasture and prairie sagewort; 13 of 17 observations appear to be on a positive trajectory to native dominated plant communities while 4 sites are trending-to-modified	2-5 years since reclamation	17
early seral	Snowberry - Kentucky Bluegrass	Shrubland community dominated by buckbrush, common wild rose and Kentucky bluegrass or quackgrass.	Older sites (33-55 years); appears to have stabilized as an early seral native/non-native community	4
mid-seral	Slender Wheatgrass - Green Needle Grass - Plains Rough Fescue	Dominated by seeded species including seeded plains rough fescue		13
mid-seral	Green Needle Grass - Western Wheatgrass - Awned Wheatgrass	Dominated by seeded green needle grass, western wheatgrass and awned wheatgrass	Observations reclaimed with native grass seed mixes and agronomic seed mixes (may include native grasses) Observations 3 - 55 years after reclamation.	12
mid-seral	Western Wheatgrass - Northern Wheatgrass - Western Porcupine Grass	Dominated by western wheatgrass from infill and seed mixes with lesser cover of Northern wheatgrass and June grass. Western porcupine grass present as infill.	2 of 7 sites trending to a modified plant community. Kentucky bluegrass and sheep fescue are the dominant non-native species associated the trending-to-modified communities.	9

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Seral Stage	Reclaiming Plant Community	Description	Comment (treatment & age)	# of Observations
mid-seral	Northern Wheatgrass - Western Porcupine Grass - Low Sedge	Native plant community. Northern wheatgrass and western porcupine grass established from infill and, or seed mixes, low sedge from infill. Plains rough fescue averaged 4.5% cover with a constancy of 58.8% and highly variable regarding site treatment and year since reclamation.	Native grass seed mixes, agronomic seed mixes (may include native grasses) and as natural recovery. Observations 6 - 55 years following reclamation.	17
mid to late mid-seral	Plains Rough Fescue - Green Needle Grass - Slender Wheatgrass	Native plant community dominated by plains rough fescue and seeded green needle grass and slender wheatgrass, western porcupine grass was present but at low cover and constancy.	Dominance of plains rough fescue in this cluster may be due to minimal disturbance construction and, or superior reclamation practices.	17
mid-seral to trending-to-modified	Pasture Sagewort - Slender Wheatgrass	Includes observations with relatively low total vegetation cover (48%) 3 to 10 years since reclamation. Sites have low cover values for native and seeded grass species and high relative cover of non-natives species (18%).	Other disturbances such as moderate grazing pressure may be a factor in reducing cover and desirable species.	11
trending-to-modified	Smooth Brome - Slender Wheatgrass - Kentucky Bluegrass	Dominated by invasive species smooth brome, Kentucky bluegrass and to a lesser extent quackgrass, alfalfa and crested wheatgrass.	Observations on primarily older sites. 3 sites 5 years old or less. 9-55 years old.	16
trending-to-modified	Kentucky Bluegrass - Western Wheatgrass	24% relative cover of non-natives species, including Kentucky bluegrass (19%), smooth brome (3%) and sheep fescue (1%)	Kentucky bluegrass present in 7 controls, absent in 4 controls but present in the adjoining disturbances.	11
Trending-to-modified	Sheep Fescue - Western Wheatgrass	56% relative cover of non-native species, including sheep fescue (32%), meadow brome (7%), intermediate wheatgrass (2%) and Kentucky bluegrass (1%)	Older sites (19-51 yrs) reclaimed with a mix of agronomic and native grass species	5
modified	Quackgrass - Kentucky Bluegrass	Dominated by quackgrass, Kentucky bluegrass, sweet clover, dandelion, and to a lesser extent, smooth brome.	Observations 8-38 years after reclamation, with native and compatible agronomic species mixes, an agronomic mix and a native mix.	4
modified	Smooth Brome - Kentucky Bluegrass	Dominated by invasive species, seeded or infilled; smooth brome, Kentucky bluegrass, sheep fescue quackgrass, intermediate wheatgrass, crested wheatgrass and sweet clover.	Older sites, surveyed 12 and 18 years since reclamation	5

A.4 Beneficial Reclamation Practices - Positive Recovery of Plant Communities on Loamy Range Sites

Diverse Seed Mixes

Recovering plant communities with promising recovering plant community composition are highlighted in the sites and treatments associated with the mid- to late seral recovering plant community cluster, Plains Rough Fescue - Green Needle Grass - Slender Wheatgrass (Table A3).

This cluster of 17 observations is composed of sites reclaimed with a variety of native grass seed mixes and a diverse mix composed of native grasses and ten forbs (Table A4). All the Alberta Research Council (ARC), now known as Alberta Innovates - Technology Futures (AI) sites had 67% plains rough fescue in the seed mixes.

Vegetation monitoring transects were completed between 4 and 30 years following reclamation with the majority sampled 12 and 13 years after seeding, when slow growing late seral species like plains rough fescue have become established.

The cluster represents a native plant community dominated by plains rough fescue at 22% cover and seeded grasses green needle grass and slender wheatgrass at 11% and 6 % cover, respectively. Western porcupine grass is present at low cover, averaging 3% with a constancy of 47%. The seeded native wheatgrasses and green needle grass are present at lower cover than earlier seral clusters.

Dominance of plains rough fescue in this cluster could be due to minimal disturbance construction, high proportions of plains rough fescue in the seed mixes or superior reclamation practices. Desserud and Naeth (2013) observed that seed mixes with no or little wheatgrass components may allow rough fescue time to become established by the third year, with reduced competition from fast-growing wheatgrasses (Appendix E). The ARC / AI seed mixes that show good establishment of plains rough fescue also had low composition of wheatgrasses in mixes M01 and M02.

Desserud's (2013) rough fescue seeding study demonstrated that the success of plains rough fescue establishment with little competition underscores the importance of reducing the amount and number of aggressive species in rough fescue grassland reclamation seeding. While monoculture seeding of plains rough fescue is not practical due to low seed availability and high cost, seed mix performance may improve by reducing or eliminating wheatgrasses, and instead use other native grasses common in the area.

Prairie and pasture sageworts are the dominant native infill forbs, followed by wild vetch and common yarrow which could have come from native infill or the diverse seed mix treatment, or both. Inclusion of forbs in seed mixes may be beneficial to increase diversity. Long-term monitoring of infill on a BIO range site on the Express pipeline illustrated that infill of perennial forbs other than the disturbance sageworts is lacking after 14 years (1% cover) compared to the undisturbed grassland (14.5% cover). Forb cover was compared on four revegetation trials established by ARC on three wellsites in mesic plains rough fescue grassland settings. The trials included a natural recovery site, and three seed mixes including a simple grass mix, a diverse mix including 10 forbs, and a reclamation mix with only two species, plains rough fescue and slender wheatgrass.

Forb cover was greatest and most consistent on the reference site, averaging between 30% and 40% cover. The cover of disturbance forbs may contribute to high forb cover levels on the seeded and natural recovery sites. Forb cover appears to decline on the natural recovery site and the simple mix site. Forb cover increases over time on the reclamation mix site, where only plains rough fescue and slender wheatgrass were seeded. The forb cover is more stable with less fluctuation on the diverse mix site. The diverse seed mix included 10 forb species.

In the mid- to late seral recovering plant community cluster, Plains Rough Fescue - Green Needle Grass - Slender Wheatgrass (Table 5-3), 12 of the observations appear to be on a positive trajectory to native dominated plant communities. Kentucky bluegrass and smooth brome as individual or combined were present in 5 out of 12 sites at 3% to 5% cover. The remaining 4 observations are trending-to-modified with Kentucky bluegrass and smooth brome as individual or combined at 7% to 23% cover. This illustrates that despite best practices, managing invasive species is critical in the Northern Fescue and surface disturbance poses significant restoration challenges.

The risks associated with restoring surface disturbances are mitigated by minimal disturbance construction techniques. Desserud and Naeth (2011) followed recovery of three newly-constructed pipelines in the Rumsey Natural Area which were left to natural recovery. Third year results were combined with Elsinger's (2009) data of natural recovery pipelines constructed between 1983 and 2000. Each of the pipelines was installed in a narrow trench, about 80 cm wide. Five of the pipelines were installed using a plough-in technique. A plough creates a narrow trench the width of the bucket, pipe is fed into the trench, and soil and sod are allowed to fall back into place. Six pipelines were topsoil-stripped, where topsoil was stripped from the trench and replaced following pipe installation. Two pipelines used ditch-witch construction, with a trencher that chops sod, mixing it with trench soil, and the broken sod/soil mix is used to cover the pipe.

Despite differences in specific species, all natural recovery pipelines had something in common with undisturbed grassland. They all have significantly more native species and few non-native species, such as Canada thistle, Canada bluegrass (*Poa compressa*) and smooth brome.

Use of Plains Rough Fescue Seedlings (Plugs)

Use of plugs or seedlings can provide a competitive advantage for slow growing species like rough fescue and can be used to increase diversity on a site, for instance with forb plugs. The data set for the three year old large diameter pipeline includes observations of 28 sites three years after plains rough fescue seedlings (plugs) were planted along with a native seed mix containing plains rough fescue seed. Sixty-four percent of the resulting plant communities are on a positive successional pathway and vary from early to mid-seral, and mid-seral successional stages. Plains rough fescue is not dominant on any sites but this is to be expected given the age of the sites and slow growth rates of rough fescue. Several direct observations of plug material during the third year monitoring document their persistence on the seeded RoW. Two sites have stalled at an early seral stage as a community where Kentucky bluegrass is dominant. Twenty-nine percent of the sites are mid-seral to trending-to-modified, or trending-to-modified, indicating a negative trajectory with greater than 5 percent invasive species present on site. These results illustrate that use of seedlings will not outcompete invasive species and emphasize the need for control of invasive species establishment before reclamation and thorough adaptive management after initial reclamation.

Table A4 Treatments and Site Conditions Associated with a Recovering Mid to Late Seral Disturbance Community (Disturbance Cluster 5)

Monitoring Site ID	Disturbance	Treatment	Years Since Reclamation	Control Plant Community	Control Community Seral Stage
AIHH04M01	Wellsite	ARC Simple Seed mix	9	NFA9 Feha	Early to mid seral
AIHH07M01	Wellsite	ARC Simple Seed mix	12	NFA1 high	Reference (Lo 1)
AIHH08M01	Wellsite	ARC Simple Seed mix	13	NFA1 low	Reference (Lo 1)
AINH04M01	Wellsite	ARC Simple Seed mix	9	NFA9 Feha	Early to mid seral
AINH07M01	Wellsite	ARC Simple Seed mix	12	NFA9 Feha	Early to mid seral
AINH08M01	Wellsite	ARC Simple Seed mix	13	NFA9 Feha	Early to mid seral
AIHH07M02	Wellsite	ARC Diverse Seed mix	12	NFA1 high	Reference (Lo 1)
AIHH08M02	Wellsite	ARC Diverse Seed mix	13	NFA1 low	Reference (Lo 1)
AINH04M02	Wellsite	ARC Diverse Seed mix	9	NFA9 Feha	Early to mid seral
AINH07M02	Wellsite	ARC Diverse Seed mix	12	NFA9 Feha	Early to mid seral
AIHH07M03	Wellsite	ARC Reclamation mix	12	NFA1 high	Reference (Lo 1)
AINH08M03	Wellsite	ARC Reclamation mix	13	NFA9 Feha	Early to mid seral
APAC02R	Wellsite	Full width strip; seeded	20	NFA7	Reference (Lo 2)
ELPL09D	Pipeline	Topsoil stripping, likely natural recovery	30	NFA1 high	Reference (Lo 1)
ELWS05D	Wellsite	Minimal disturbance, Natural recovery	4	NFA1 low	Reference (Lo 1)
ELWS21D	Wellsite	??		NFA1 low	Reference (Lo 1)
HUSK732R	Wellsite	Seed Mix	7	NFA7	Reference (Lo 2)

APPENDIX B SUMMARY OF THE RANCHER'S WORKSHOP APRIL 24TH, 2013

Recovery Strategies for Industrial Development in Native Prairie for the Northern Fescue Natural Subregion

Rancher's Workshop April 24th, 2013 Summary

Expectations of Recovery

Recovery is returning the landscape to how it was before development. Recovery is considered successful if you can no longer see where the disturbance occurred. Cattle should graze both the disturbed and surrounding area uniformly.

Natural Recovery, Assisted Natural Recovery and some Seed Mixes have produced good results in the area. There is a general understanding among landowners that the system may not be perfect, but is on a pathway to continual improvement with better management practices, enforcement and the new Reclamation Criteria.

Common standards such as Range Health Assessments are important tools to evaluate outcomes and management plans, i.e. if you can't measure it, you can't manage it.

If reclamation is conducted properly, success should be apparent in 5-6 years.

Non-Native Species Invasion

Common species of concern are gumweed (a native disturbance species), flixweed, mustards, leafy spurge, smooth brome and crested wheatgrass.

Experience with non-native species invasion suggests that:

- Poor development practices always lead to weed invasion.
- Wipe application is not effective on brome or crested wheatgrass.
- Reseeding with a no till drill will require multiple years of clean up of crested wheat using spray / annual cropping.
- Using clean equipment is extremely important as leafy spurge is easily moved by equipment.
- Moving or bringing in soil from a remote area increases the risk of invasive species.
- Litter build up is a consideration as too much litter encourages smooth brome and sweet clover to move into the stand.

Grazing Management

There is a general agreement of landowners present that oil and gas development in their area has had minimal impact on grazing management.

It is better to remove fences early and replace with a tech fence around the well bore.

Landowners would like to establish better consultation with development companies in terms of seeding agreements for grazing and land management practices.

Additional Recommendations

There is a need to diversify seed mixes, for example to move away from the use of the four Special Areas Seed Mixes developed by soil types and towards site specific seed mix design to encourage compatibility and succession. The Special Areas seed mixes use some cultivars that are not compatible.

Discussion regarding the use of seeded non-native fescues:

- They appear to be very persistent in the Special Areas and remain the dominant species on some sites.
- May be the only component providing stabilization on very sandy soils.
- When fence is removed cattle may over graze the new shoots and inhibit plant community succession.

APPENDIX C SUMMARY OF THE INDUSTRY WORKSHOP APRIL 24TH, 2013

Recovery Strategies for Industrial Development in Native Prairie for the Northern Fescue Natural Subregion

Industry Workshop April 25th, 2014 Summary

The workshop included presentations on the “*Recovery Strategies for Industrial Development in Native Prairie*” project and overviews of long term revegetation success, reclamation techniques, issues and challenges within the Northern Fescue Natural Subregion. Breakout sessions focused on questions designed to capture the knowledge participants have gained from their experience working in native prairie restoration. The following is a compilation of the participant’s responses to the roundtable discussion questions.

Best Practices for Recovery in Northern Fescue Prairie

Pre-disturbance site assessment to determine factors in the surrounding area that could affect recovery strategies and post-construction site management (e.g. presence of invasive non-native plants) is important to reclamation success. Development should be timed to take place during the dormant growing season on suitably dry or frozen ground conditions. Reclamation options differ depending whether the disturbance is short or long term.

Natural Recovery

Works well on narrow pipeline disturbances, blade width or <12 inches. Appropriate equipment such as the use of Prairie Protector Blades and the Rangeland Sweeper minimize disturbance and protect the soils. Landowner cooperation is required when attempting natural recovery. Natural recovery is not recommended for full strip well sites and large disturbances in the Northern Fescue due to the reduced edge effect and infill potential. Some companies refuse to utilize natural recovery because they believe it will take too long to get reclamation certification.

Assisted Natural Recovery

Assisted natural recovery is appropriate where there is a need for soil conservation and stabilization. Cover crops can attract livestock to the reclaimed disturbance. Landowners have expressed concerns regarding rocks being brought to surface during the seeding of cover crops.

Seeding annuals will help utilize soil nitrogen and make the site less prone to invasion by perennial weeds. Oats and barley have been successfully used as a cover crop. The large seeds are easy to clean and less likely to be contaminated than grass seed. Cover cropping with fall rye is not recommended in situations where there is competition for moisture and nutrients in the spring.

Sheerness mine has used an annual cover crop on legacy sites to get control of crested wheat and brome. Apply Glyphosate in spring, plant oats @ 75 lb/acre, mow in July and leave on site, glyphosate again in fall, repeat for 3 years. Care is needed when sourcing seed for cover crops to avoid introducing more invasive non-native plants.

The use of native hay could promote more species diversity, however the seed content can be highly variable. Wild hay does provide clean organic matter, where required on lands with organic certification. A "Zamboni harvester" was mentioned that captures seed from the seed bank for transfer to the reclamation area.

Seeding with Native Seed Mixes

Native seed mixes should be based on the pre-disturbance site assessment. Appropriate native seed can be difficult to source, and is expensive. Native seed lots may be contaminated with invasive non-native plants, which may not appear on the Certificate of Seed Analysis. There are problems with the specifications that apply to native seed lot analysis. Native seed is unique in the seed industry and the specifications need to be revised to ensure high quality seed. Controlling invasive non-native plants is expensive and time consuming.

Many well sites in the Northern Fescue NSR have been seeded with wheatgrass cultivar seed mixes and/or agronomic seed mixes depending on the age of the site. Often there are no records of the reclamation practices or seed mixes. The species on site are not compatible with the native plant community surrounding the site. Pat Porter has recommended native seed mixes for the public lands, based on cultivars developed through Alberta Innovates. The Special Areas does have four specified native seed mixes based on soil types.

It is particularly difficult to find forb seed. Seeding with forbs needs to be delayed until weed control and invasive non-native plant management has been completed.

No till drill and barely burying the seed (in two batches based on seed size for better distribution if feasible) is preferable to broadcast seeding. Broadcast seeding can attract birds and usually requires harrowing or chains to create microsites for water and seed catch after seeding. Some participants indicated success with spring seeding, particularly in moister years, but fall seeding is recommended for better success by most.

Blowouts are difficult to revegetate. Erosion control matting has been successfully used. Soil tackifier (hydromulch) was not successful.

Clients concerned with fast results can create problems by requesting overseeding to get greenery established quickly instead of being patient. Overseeding to improve diversity is also problematic as clients don't want to take the time to manage a reclamation project that way.

Two to three growing seasons are needed to adequately assess the recovery of reclaimed disturbances in native grasslands.

Plug Planting

Species diversity and the creation of structure in the stand are becoming an important best management practice and can be achieved with the use of nursery propagated native grass and forb plugs, and container grown shrubs. Rough fescue plugs planted with comparable species from offsite has been used with success in the area on a large diameter pipeline. Plug planting is a new procedure on well sites and is being conducted on a trial basis. Planting plugs of shrubs or forbs interferes with weed control and so are best installed after the first year or two of invasive plant management. Mice can be a problem with fall plug planting as they eat the plugs.

Invasive and Non-native Species Management

What are the species of concern from your experience in the Northern Fescue Natural Subregion?

Leafy spurge, perennial sow thistle, and Canada thistle are the dominant weed concerns. Smooth brome, crested wheatgrass, quackgrass, Kentucky bluegrass, sweet clover, and the non-native hard fescues from previous reclamation practices are species of particular concern in the Northern Fescue.

Hard fescue is often mistakenly identified as rough fescue by inexperienced pre-site assessment personnel. Hard fescue is invasive in choppy sandhill range sites in the Central Parkland. It has been observed 15 to 20 meters off site. Kentucky bluegrass is often overlooked as a species of concern.

What management measures have you used and what has been the success?

Periodic range health assessments are an excellent monitoring tool. If there are issues (declining score in the rating of the assessment questions) then specific management strategies can be implemented to deal with the issue. Some of the more successful treatments for invasive species invasion involve using a site specific combination of the following:

- A combination of chemical or rotopick fallow for 2 or 3 years with seeding to provide competition, hand picking and spot spraying for any further weed occurrences.
- Mowing, herbicide by spot (Leafy spurge requires spot spraying), boom spraying and wicking as required.

- Use of species appropriate herbicides; many stopped using Roundup in favor of Simplicity (which may stress native species but won't kill them).
- Lontrel is recommended for control of Canada thistle as it has low residual effects and landowners are familiar with it. Spray the 3rd week in September for best results.
- Control of weeds or invasive non-native plants may not be realistic if present in the surrounding undisturbed terrain.
- Downy brome control can be successful if you continue to control the seed set. Early spring grazing and promoting competition and infill has been successful.
- Early spring spraying and/or fire have been used to control crested wheatgrass. Fire appears to reduce the seed bank. Mow and use the Zamboni to remove litter and seed bank.

What are the stumbling blocks preventing improved restoration potential?

Expectations of the timeframe for recovery

Unrealistic expectations of the time frame for recovery often result in failures. Unless the reclamation project is minimal disturbance, getting a reclamation certificate is not possible in 5-6 years. There are also problems with establishing enough decreasers and diversity on sites. The "aesthetics" of colonizing annual weeds may cause concern for landowners and it may be difficult to convince them of their role in the successional process.

In some cases tame species are used on private lands if the landowners are not concerned with native prairie restoration.

Lack of suitable species for seed mixes

Suitable cultivars and wild harvested seed is often difficult to obtain, expensive and may be unsuitable due to contaminants. Industry has had problems with larger seed houses substituting seeds based on availability, and not necessarily notifying the buyer. The needle grasses (needle and thread and western porcupine grass from local wild harvest) are particularly difficult to obtain. This may be due to a lack of seed set in good quality large stands. Quality control could be an issue. Suitable forb seed is difficult to obtain and often in short supply.

Regarding seed certificates, it is important to check each individual lot prior to blending rather than purchasing pre-mixed seed. In addition, there is a problem with the 'other' category on certificates, it needs to be identified.

There is a need within the Northern Fescue Natural Subregion to increase the supply of suitable locally sourced native seed and plant material.

Grazing Management

Fencing should be assessed on a site by site basis and in cooperation with landowners to determine the best vegetation establishment and weed control practices. Fencing reclaimed well sites allows management to be controlled. Fencing RoWs can allow the introduction of grazing for weed management in a controlled environment.

Cattle can cause erosion problems around gates. Opening a well site fence at the four corners gives more access and causes less erosion.

Livestock management on sites seeded with non-native hard fescues is very difficult.

Lack of follow-up after initial reclamation treatment

Follow up is becoming a more integral part of the approval process as post construction monitoring forces companies to monitor and implement adaptive management. The National Energy board is setting a good example by requiring a five year monitoring period and advocating that seral stage recognition is an important indicator of the process of native plant community succession.

Concerns about monitoring are:

- Pipeline companies tend to monitor soils for pipe integrity but not vegetation issues.
- There is a high turnover in property ownership and a lack of documentation of past reclamation practices. There is a lack of continuity in site management due to high turnover of staff and consultants.
- Detailed site assessment tends to fall to junior people or others with a lack of expertise, which can be problematic.

Knowledge Gaps and Potential Research Questions

- * The new Alberta Energy Regulator and system are currently a knowledge gap.
- * Suggestion that the AER examine the current conditions for development approvals as there may be conflicts with current best management practices developed for native prairie.
- * Requirements for small diameter pipeline regulation and monitoring need to be upgraded.

- * There is a general lack of expertise in many areas:
 - Newer practitioners are not receiving field experience above a junior level.
 - Initial site reclamation techniques – consultants lack knowledge of the specialized equipment used in native prairie reclamation.
 - Lack of good vegetation ID skills or knowledge on how to maintain or promote vegetation.
 - People coming out of college and university are unskilled to do vegetation and soils work.
- * Lack of a fee to submit applications for reclamation certificates for well sites to the AER results in a strategy to flood the regulator with applications that likely won't be reviewed. There is also a lack of regulatory personnel to inspect or hold industry to account.
- * Research directed toward crested wheatgrass, smooth brome and other invasive species eradication on older well sites (pre-1993) to determine which methods work.
- * Are there any annual native species that could be used for cover crops? Flixweed?
- * What is the seral stage that needs to be reached to ensure that recovery back to the pre-disturbance plant community will continue after reclamation certification is obtained?
- * Will preferential grazing of a well site affect restoration?
- * Is there a way to capture tacit knowledge and document anecdotal restoration trials?
- * There is a gap in the way pipeline companies are dealing with contractual seeding agreements. Seeding requirements need to be determined by pre-disturbance site assessment and adaptive management plans (i.e. not just specify a specific number of times to seed).

APPENDIX D TARGET RECOVERING PLANT COMMUNITIES FOR NORTHERN FESCUE NSR

D.1 Introduction

Designing native seed mixes for industrial disturbances not suited to assisted natural recovery in the Northern Fescue Natural Subregion (NSR) is as much an art as it is a science. The purpose of a native seed mix is to revegetate the disturbance with native species that will allow the process of succession to take place and establish a stable and resilient mid- to late-seral plant community over time. Refer to Table 2 in the main body of the report for descriptions of successional stages of recovering plant communities following topsoil disturbance.

The *Northern Fescue Range Plant Community Guide* (Kupsch et al. 2012) provides a detailed discussion of plant community classification methods and the resulting plant community descriptions reported as one page summaries. Each plant community description provides the mean percent cover for each species, the range of cover values expressed by each common species and the percent constancy of occurrence for each species within the dataset. Plant community composition is linked to environmental variables including: ecological range site, soils, moisture and nutrient regimes, elevation, soil drainage, slope and aspect.

The Target Recovering Plant Communities are to be used as a companion to the Northern Fescue Range Plant Community Guide

The following document, Target Recovering Plant Communities, has been developed from the *Northern Fescue Range Plant Community Guide* (Kupsch et al. 2012) and more recently described communities in the more southerly and drier areas of the Northern Fescue NSR in the Special Areas region (Adams et al. 2015). This document is intended to be used as a companion document to the Range Plant Community Guide for designing native seed mixes.

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, and the impracticality of designing specific mixes for variable plant communities on large projects, it is useful to establish which ecological range sites have species in common within the Natural Subregion. These “clusters” of ecological range sites with common dominant native grass species are referred to as **target recovering plant communities**.

To develop descriptions of target recovering plant communities, ecological range sites with common dominant native grass species in the reference plant communities are grouped. Within these groups, successional plant communities are then included and the range of cover values for component native grass species are combined. The combined plant community data includes data from both reference and earlier successional native plant communities expressed as mean percent cover of the dominant native grass species.

Including both successional and reference plant communities ensures that species that are drivers in the successional process are represented. The average combined percent cover of the native forb species and native shrub species are also provided to illustrate the components of the target recovering plant community at a mid- to late- successional stage. AEP Range Resource Management Branch provided the data set used to develop the target recovering plant communities.

The resulting target recovering plant communities for each grouping of ecological range sites are presented in this appendix, accompanied by recommendations for seed mix design. The recommended native species will provide the initial vegetative cover to stabilize disturbed soils and facilitate the recovery of the plant community over time.

Reference materials used to compile the recommendations include:

- Findings from the background document for this guide, “*Long-term Revegetation Success of Industry Reclamation Techniques for Native Grassland: Northern Fescue Natural Subregion*” (Lancaster et al. 2014),
- *Common Plants of the Western Rangelands Volume 1: Grasses and Grass-like Species* (Tannas 2003),
- *Manual of Plant Species Suitability for Reclamation in Alberta 2nd Edition* (Hardy 1989),
- *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), and
- *Forage and Reclamation Grasses of the Northern Great Basin and Rocky Mountains* (Majerus 2009).

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To provide structural diversity and resilience to climate, grazing disease and disturbance, seed mix design needs to consider and include; species that will provide cover quickly to reduce erosion potential, the desired component species in the late seral target plant community and species of different heights and rooting characteristics.

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

A significant challenge in the Northern fescue is the lack of seed for many of the component graminoids species, particularly the upland sedges, blunt sedge (*Carex obtusata*), sun-loving sedge (*C. pensylvanica*), low sedge (*C. stenophylla*) and hay sedge (*C. siccata*). Sedges are a prominent component of most native plant communities in the Northern Fescue. Sedges will have a much better chance of recovery after short term soil disturbances, when seed and root banks in the soil are still viable.

Common grasses in the Northern Fescue NSR that can be difficult to source include Hooker's oat grass (*Helictotrichon hookeri*) and intermediate oat grass (*Danthonia intermedia*).

It is important to note that this is only the first step in seed mix design. It is recommended that professionals with experience in native prairie restoration be consulted for native seed mix design. Further information can be found in the document, "Plant Material Selection and Seed Mix Design for Native Grassland Restoration Projects" (Tannas and Webb 2016), posted on the Foothills Restoration Forum website.

D.2 Plains Rough Fescue—Sedge

The Plains Rough Fescue - Sedge target recovering plant community is associated with moist **Overflow, Loamy 1** and **Blowout** ecological range sites. Plant communities in the grouping include reference communities NFC4, NFA1, NFA4, NFC1 and NFA10, and successional plant communities NFA2, NFA3, NFA5, NFA6, NFC2, NFC3, NFA11 and NFA12. On these **moister** sites, plains rough fescue is clearly dominant (Figure D1). Table D1 lists the dominant graminoids species in this target recovering plant community and combined species cover for other groups. They are also illustrated in Figure D1. Average soil exposure in these moist, undisturbed communities is 1.2% and moss and lichen cover 13.8%. Moss and lichen cover is not expected to regenerate for many years after disturbance.

This information can be used to design a native seed mix based on the common grasses in Northern Fescue NSR: **Overflow, Loamy 1** and **Blowout** Ecological Sites. Table D2 provides an example of the common dominant species recommended for inclusion in a native seed mix expressed as the portion required for each species in percent (%) Pure Live Seed (PLS) by weight.

Table D1 Plains Rough Fescue – Sedge Target Recovering Plant Community Composition

Species	Common Name	Average % Cover	Minimum % Cover	Maximum % Cover	% Constancy
<i>Carex</i> species combined	combined sedge species	14.7	7	25	100
<i>Festuca hallii</i>	plains rough fescue	32.2	0	60	92.3
<i>Koeleria macrantha</i>	June grass	2.8	0	10	84.6
<i>Stipa curtisetata</i>	western porcupine grass	5.1	0	10	61.5
<i>Agropyron</i> species	wheatgrass species	1.3	0	5	38.5
<i>Elymus trachycaulus</i> var. <i>trachycaulus</i>	Slender wheatgrass	0.7	0	3	38.5
<i>Stipa</i> species	needle grass species	1.7	0	8	30.8
<i>Helictotrichon hookeri</i>	Hooker's oat grass	0.6	0	4	30.8
<i>Danthonia intermedia</i>	intermediate oat grass	0.4	0	2	30.8
<i>Agropyron smithii</i>	western wheatgrass	2.7	0	32	23.1
<i>Bouteloua gracilis</i>	blue grama	0.3	0	3	15.4
<i>Elymus lanceolatus</i> ssp. <i>lanceolatus</i>	Northern wheatgrass	0.2	0	1	15.4
<i>Salix petiolaris</i>	basket willow	0.1	0	1	7.7
<i>Stipa spartea</i>	porcupine grass	0.1	0	1	7.7
<i>Stipa viridula</i>	green needle grass	0.1	0	1	7.7
<i>Symphoricarpos occidentalis</i>	buckbrush	6.2	0	16	76.9
<i>Rosa arkansana</i>	prairie rose	1.1	0	3	61.5
<i>Populus tremuloides</i>	aspen	0.3	0	2	15.4
<i>Artemisia cana</i>	silver sagebrush	0.1	0	1	7.7
Average Forb Cover		11.4	6	17	100
Average Total Vegetation Cover *		81			
Average Moss and Lichen Cover *		13.8			
Average Exposed Soil *		1.2			

* For clustered reference plant communities

Northern Fescue Natural Subregion

Figure D1 Native Graminoids and other Groups in the Plains Rough Fescue - Sedge Target Recovering Plant Community

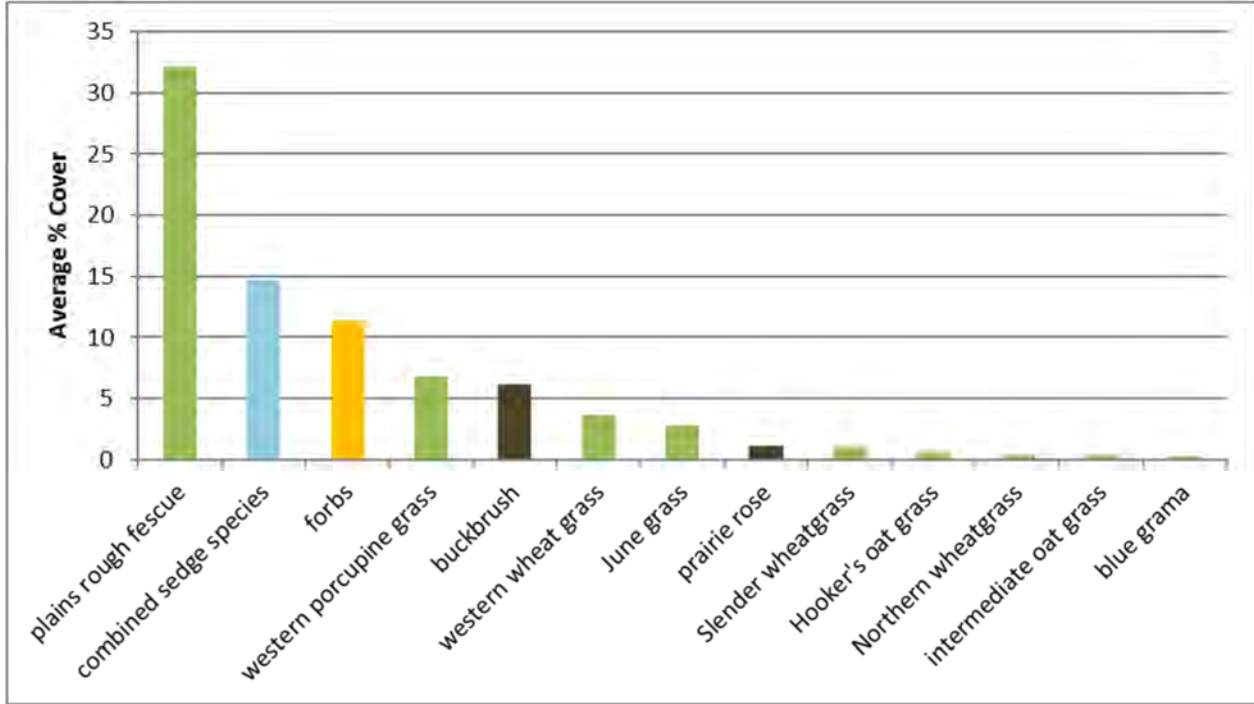


Table D2 Recommended Reclamation Grasses for Seed Mixes in the Northern Fescue NSR: Plains Rough Fescue – Sedge Plant Communities

Species	Proportion of Seed Mix % PLS by Weight	
Plains rough fescue	<i>Festuca hallii</i>	50%
Western porcupine grass	<i>Stipa curtisetata</i>	35%
Western wheatgrass	<i>Agropyron smithii</i>	5%
June Grass	<i>Koeleria macrantha</i>	5%
Awneid wheatgrass	<i>Agropyron trachycaulum ssp. subsecundum</i>	5%

Plains rough fescue plant communities are difficult to restore. A slow growing, deeply rooted perennial, rough fescue is slow to establish. It does not compete well with other species. Observations indicate restoration potential is greater on drier sites than moist Loamy range sites that are more prone to invasion by non-native plants such as Kentucky bluegrass and smooth brome.

Awneid wheatgrass has been added to provide initial cover and is expected to disappear from the stand in approximately five years, providing additional space for infill of the seeded species and encroachment from off site. Western wheatgrass has been selected to stabilize the soils and provide structure in the stand. The proportion of plains rough fescue has been increased based on results of the long-term monitoring projects conducted for this project and the proportion of the western porcupine grass has been increased to compensate for the variability in viable wild harvested seed. June grass will provide structure in the stand. Slender wheatgrass may impede the establishment of slow-growing species such as plains rough fescue (Desserud and Naeth 2013b) so was not included.

D.3 Plains Rough Fescue – Western Porcupine Grass

The Plains Rough Fescue – Western Porcupine Grass target recovering plant community includes communities found on drier **Loamy 2** or **Sandy** ecological range sites. Plant communities in the grouping include reference communities NFA7 and NFC6, and successional plant communities NFA8 and NFA9. On these **drier** sites, Western porcupine grass is dominant or co-dominant with rough fescue in later successional stages (Figure D2). Average soil exposure in undisturbed plant communities on these drier range sites is 4.0% and moss and lichen cover 4.5%. Moss and lichen cover is not expected to regenerate for many years after disturbance.

Table D3 lists the dominant graminoids species in this target recovering plant community and combined species cover for other groups. They are also illustrated in Figure D2.

This information can be used to design a native seed mix based on the common grasses in Northern Fescue NSR: **Loamy 2** or **Sandy**. Table D4 provides an example of the common dominant species recommended for inclusion in a native seed mix expressed as the portion required for each species in percent (%) Pure Live Seed (PLS) by weight.

Table D3 Plains Rough Fescue – Western Porcupine Grass Target Recovering Plant Community Composition

Species	Common Name	Average % Cover	Minimum % Cover	Maximum % Cover	% Constancy
<i>Festuca hallii</i>	plains rough fescue	17	11.0	27.0	100.0
<i>Stipa curtisetata</i>	western porcupine grass	13	11.0	16.0	100.0
<i>Koeleria macrantha</i>	June grass	5	1.0	7.0	100.0
<i>Agropyron smithii</i>	western wheatgrass	2	1.0	3.0	100.0
<i>Bouteloua gracilis</i>	blue grama	4	0.0	18.0	80.0
<i>Carex pensylvanica</i>	sun-loving sedge	3	0.0	7.0	80.0
<i>Carex obtusata</i>	blunt sedge	1	0.0	2.0	80.0
<i>Elymus lanceolatus ssp. lanceolatus</i>	northern wheatgrass	1	0.0	2.0	80.0
<i>Carex species</i>	sedge species	3	0.0	5.0	60.0
<i>Helictotrichon hookeri</i>	Hooker's oat grass	1	0.0	4.0	60.0
<i>Stipa species</i>	needlegrass species	2	0.0	4.0	40.0
<i>Carex stenophylla</i>	low sedge	1	0.0	2.0	40.0
<i>Symphoricarpos occidentalis</i>	buckbrush	6	0.0	15.0	80.0
<i>Rosa arkansana</i>	prairie rose	1	0.0	2.0	60.0
<hr/>					
Average Forb Cover		15	7.7	24.0	100.0
Average Total Vegetation Cover *		80			
Average Moss and Lichen Cover *		4.5			
Average Exposed Soil *		4			

* For clustered reference plant communities

Northern Fescue Natural Subregion

Figure D2 Native Graminoids and other Groups in the Plains Rough Fescue – Western Porcupine Grass Target Recovering Plant Community

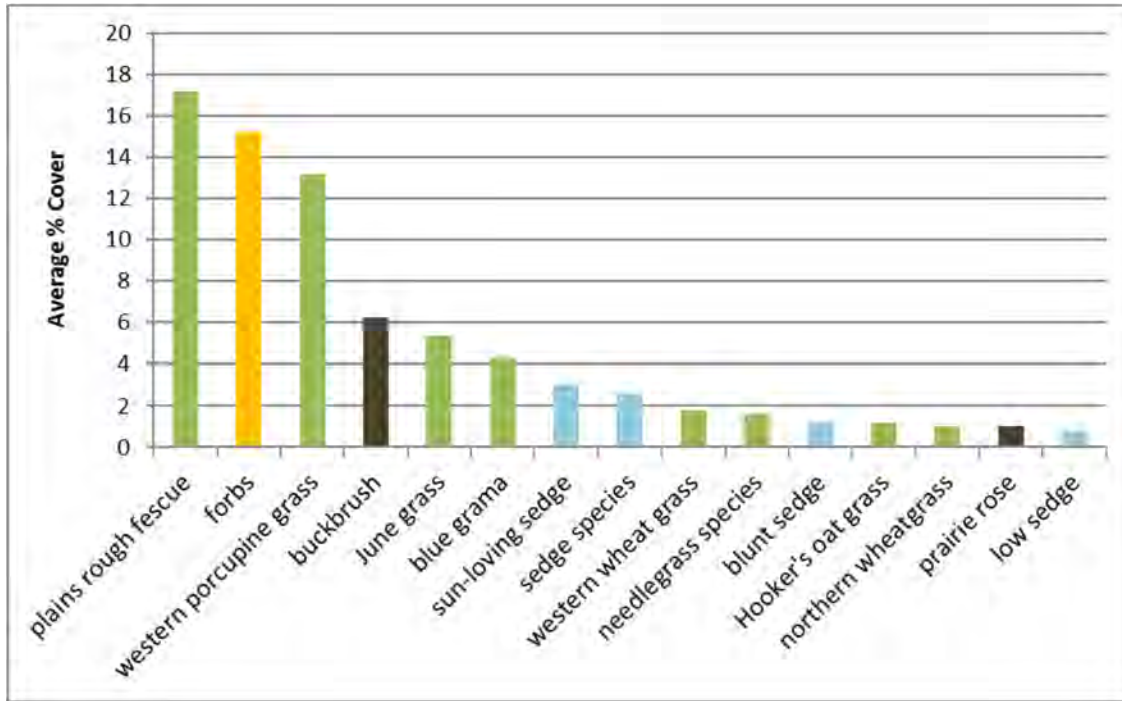


Table D4 Recommended Reclamation Grasses for Seed Mixes in the Northern Fescue NSR: Plains Rough Fescue – Western Porcupine Grass Target Recovering Plant Community

Species	Proportion of Seed Mix % PLS by Weight	
Plains rough fescue	<i>Festuca hallii</i>	38%
Western porcupine grass	<i>Stipa curtiseta</i>	30%
June Grass	<i>Koeleria macrantha</i>	10%
Western wheatgrass	<i>Agropyron smithii</i>	5%
Blue Grama	<i>Bouteloua gracilis</i>	10%
Canada wild rye	<i>Elymus canadensis</i>	5%
Awne d wheatgrass	<i>Agropyron trachycaulum ssp. subsecundum</i>	2%

Restoration potential for plains rough fescue plant communities is greater on drier sites. Canada wild rye is a tall cool season bunchgrass adapted to sandy soils. It provides short term cover and will disappear from the stand after three to four years. Slender wheatgrass performs a similar function but may impede the establishment of slow-growing plains rough fescue (Desserud and Naeth 2013b) so was not included. Western porcupine grass is a valuable early seral species for stabilizing sites as well as a desired component species in the late seral target plant community. Drier sites support blue grama, a short, warm season grass that grows primarily during the summer rather than in early spring when the cool season grasses put on most of their growth. Seed mixes with no or little wheatgrasses may allow rough fescue time to establish by the third year, with reduced competition from fast-growing wheatgrasses. Another locally developed seed variety suitable for Sandy ecological range sites is 'ARC Porter' Indian rice grass, sourced from the Wainwright – Ribstone Creek area.

D.4 Blunt Sedge – Western Porcupine Grass

The Blunt Sedge – Western Porcupine Grass target recovering plant community includes communities found on a variety of the **driest** ecological range sites found in southern portions of the Northern Fescue NSR in the **Special Areas** region. They include **Loamy 2, Blowouts, Sand** and **Gravel** ecological range sites. Plant communities in the grouping include reference communities SANFA1, SANFA10, SANFA5, SANFA7 and SANFA8, and successional plant communities SANFA2, SANFA3, SANFA4, SANFA11 and SANFA12. On these relatively dry sites, the needle grasses, western porcupine grass and needle-and-thread grass are dominant with upland sedges playing a major role in successional plant community composition. Plains rough fescue is expressed in later successional stages (Figure D3). Average soil exposure in undisturbed plant communities on these drier range sites is 1.1% and moss and lichen cover 10.8%. Moss and lichen cover is not expected to regenerate for many years after disturbance.

Table D5 lists the dominant graminoids species in this target recovering plant community and combined species cover for other groups. They are also illustrated in Figure D3. Table D6 provides an example of the common dominant grasses recommended for inclusion in a native seed mix expressed as the portion required for each species in percent (%) Pure Live Seed (PLS) by weight.

Table D5 Blunt Sedge – Western Porcupine Grass Target Recovering Plant Community Composition

Species	Common Name	Average % Cover	Minimum % Cover	Maximum % Cover	% Constancy
<i>Carex obtusata</i>	blunt sedge	9.3	1.7	33.2	100.0
<i>Stipa curtisetata</i>	western porcupine grass	8.7	0.5	19.0	100.0
<i>Stipa comata</i>	needle-and-thread	3.9	0.0	13.6	81.8
<i>Carex pensylvanica</i>	sun-loving sedge	3.5	0.3	8.0	81.8
<i>Elymus lanceolatus</i> ssp. <i>lanceolatus</i>	northern wheatgrass	3.1	0.0	12.5	81.8
<i>Agropyron smithii</i>	western wheatgrass	2.0	1.0	4.9	81.8
<i>Koeleria macrantha</i>	June grass	1.9	0.0	5.0	81.8
<i>Festuca hallii</i>	plains rough fescue	2.4	0.0	8.0	72.7
<i>Carex stenophylla</i>	low sedge	1.1	0.0	5.2	63.6
<i>Bouteloua gracilis</i>	blue grama	0.5	0.0	2.5	45.5
<i>Muhlenbergia richardsonis</i>	mat muhly	0.9	0.0	3.5	27.3
<i>Poa pratensis</i>	Kentucky bluegrass	0.7	0.0	2.0	27.3
<i>Helictotrichon hookeri</i>	Hooker's oat grass	0.5	0.0	1.3	27.3
<i>Danthonia intermedia</i>	intermediate oat grass	0.2	0.0	1.8	27.3
<i>Rosa arkansana</i>	prairie rose	0.6	0.0	2.3	9.1
<i>Symphoricarpos occidentalis</i>	buckbrush	0.4	0.0	1.6	27.3
<i>Rosa woodsii</i>	common wild rose	1.5	0.0	1.5	36.4
Average Forb Cover					
		6.5	2.6	21.5	100.0
Average Total Vegetation Cover *					
		48			
Average Moss and Lichen Cover *					
		10.8			
Average Exposed Soil *					
		0			

* For clustered reference plant communities

Northern Fescue Natural Subregion

Figure D3 Native Graminoids and other Groups in the Blunt Sedge – Western Porcupine Grass Target Recovering Plant Community

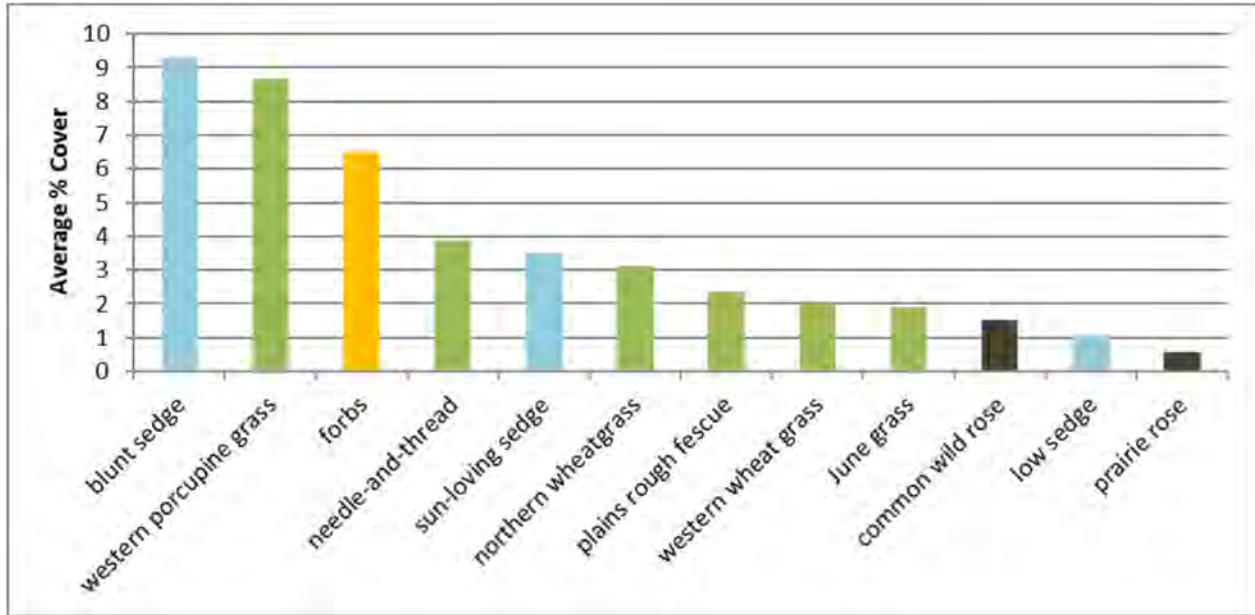


Table D6 Recommended Reclamation Grasses for Seed Mixes in the Northern Fescue NSR: Blunt Sedge – Western Porcupine Grass Target Recovering Plant Community

Species	Proportion of Seed Mix % PLS by Weight	
Plains rough fescue	<i>Festuca hallii</i>	20%
Western porcupine grass	<i>Stipa curtiseta</i>	35%
Needle-and-thread grass	<i>Stipa comata</i>	25%
June Grass	<i>Koeleria macrantha</i>	5%
Northern wheatgrass	<i>Elymus lanceolatus ssp. lanceolatus</i>	5%
Blue Grama	<i>Bouteloua gracilis</i>	5%
Awne d wheatgrass	<i>Agropyron trachycaulum ssp. subsecundum</i>	5%

Awne d wheatgrass will provide initial cover and is expected to disappear from the stand in approximately 5 years, providing additional space for infill of the seeded species and encroachment from off site. Western porcupine grass and needle-and-thread grass are valuable early seral species for stabilizing sites as well as a desired component species in the late seral target plant community. Northern wheatgrass has been selected to stabilize the soils and provide structure in the stand. Drier sites support blue grama, a short, warm season grass that grows primarily during the summer rather than in early spring when the cool season grasses put on most of their growth. Seed mixes with no or little wheatgrasses may allow rough fescue time to establish by the third year, with reduced competition from fast-growing wheatgrasses.

On Sandy or Sand ecological range sites, suitable locally developed seed varieties include ‘ARC Porter’ Indian rice grass, sourced from the Wainwright – Ribstone Creek area and ‘ARC Centennial’ Canada wild rye, sourced from the Wainwright area.

D.5 Sedge – Western Wheatgrass

The Sedge – Western Wheatgrass target recovering plant community is associated with **Clay** ecological range sites found primarily in eastern portions of the Northern Fescue NSR. Plant communities in the grouping include reference and successional plant communities NFA13 and NFA14 respectively. Clays are challenging environments for plant growth due to their capacity for shrinking and expanding in response to moisture, high matric potential and low permeability. Plains rough fescue is expressed in later successional stages (Figure D4). Average soil exposure in undisturbed plant communities on these drier range sites is 1.0% and moss and lichen cover 15.0%. Moss and lichen cover is not expected to regenerate for many years after disturbance.

Table D7 lists the dominant graminoids species in this target recovering plant community and combined species cover for other groups. They are also illustrated in Figure D4. Table D8 provides an example of the common dominant grasses recommended for inclusion in a native seed mix expressed as the portion required for each species in percent (%) Pure Live Seed (PLS) by weight.

Table D7 Sedge - Plains Rough Fescue Target Recovering Plant Community Composition

Species	Common Name	NFA13	NFA14	Average % Cover	% Constancy
<i>Carex species</i>	combined sedge species	12.0	25.0	18.5	100
<i>Agropyron smithii</i>	western wheatgrass	14.0	10.0	12.0	100
<i>Festuca hallii</i>	plains rough fescue	20.0	1.0	10.5	100
<i>Koeleria macrantha</i>	June grass	7.0	9.0	8.0	100
<i>Stipa curtisetata</i>	western porcupine grass	6.0	1.0	3.5	100
<i>Stipa comata</i>	needle-and-thread	3.0	3.0	3.0	100
<i>Poa cusickii</i>	early bluegrass	0.0	5.0	2.5	50
<i>Helictotrichon hookeri</i>	Hooker's oat grass	3.0	0.0	1.5	50
<i>Bouteloua gracilis</i>	blue grama	2.0	0.0	1.0	50
<i>Poa sandbergii</i>	Sandberg bluegrass	0.0	1.0	0.5	50
<i>Agrostis scabra</i>	rough hair grass	0.0	1.0	0.5	50
<i>Poa species</i>	bluegrass species	0.0	1.0	0.5	50
<i>Elymus lanceolatus ssp. lanceolatus</i>	northern wheatgrass	0.0	1.0	0.5	50
<i>Symphoricarpos occidentalis</i>	buckbrush	4.0	0.0	2.0	50
Average forb Cover					
		16.0	9.0	12.5	
Average Total Vegetation Cover					
		89.0	68.0	78.5	
Average Moss and Lichen Cover *					
		15.0	50.0	32.5	
Average Exposed Soil					
		1.0	10.0	5.5	

* For clustered reference plant communities

Northern Fescue Natural Subregion

Figure D4 Native Graminoids and other Groups in the Sedge – Western Wheatgrass Target Recovering Plant Community

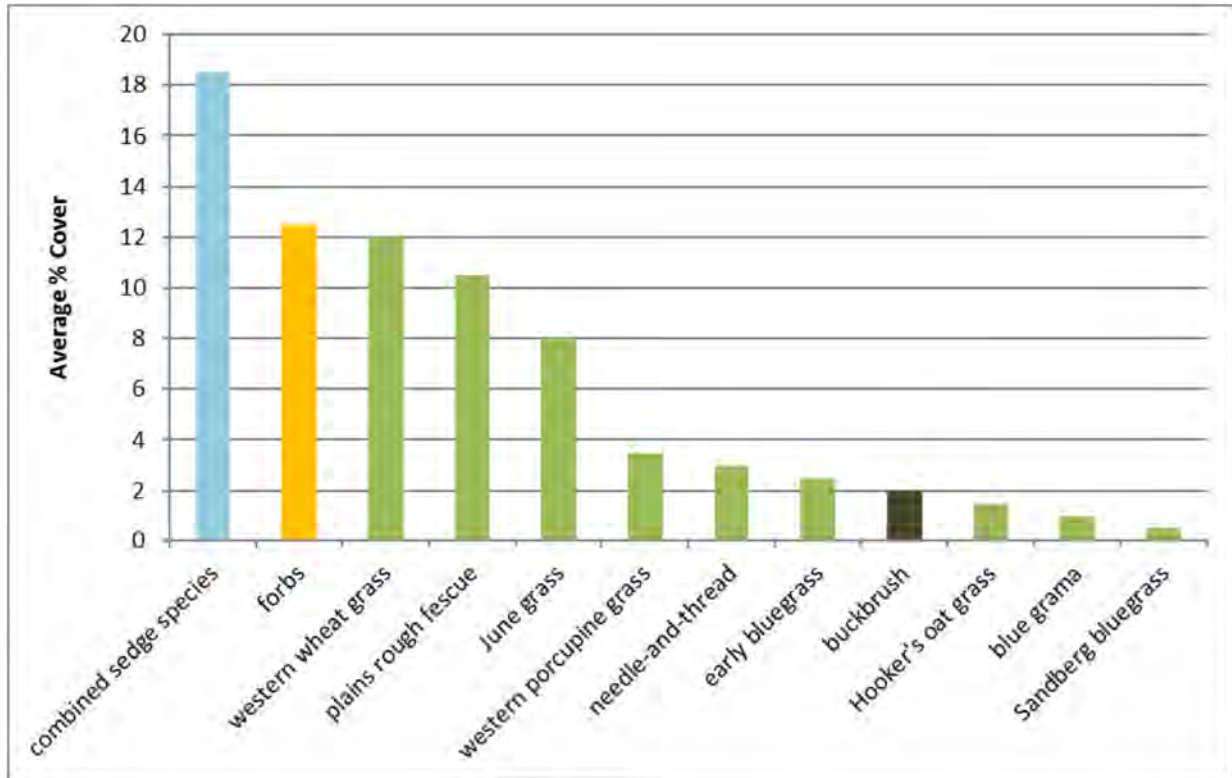


Table D8 Recommended Reclamation Grasses for Seed Mixes in the Northern Fescue NSR: Sedge - Western Wheatgrass – Plant Communities

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

Awned wheatgrass will provide initial cover and is expected to disappear from the stand in approximately 5 years, providing additional space for infill of the seeded species and encroachment from off site. Western porcupine grass and needle-and-thread grass are valuable early seral species for stabilizing sites as well as a desired component species in the late seral target plant community. Western wheatgrass is a prominent component of the target plant community and adapted to heavy Clay soils. Blue grama, a short, warm season grass grows primarily during the summer rather than in early spring when the cool season grasses put on most of their growth. Sandberg’s bluegrass could be a short bunch grass substitute for June grass.