Recovery Strategies for Industrial Development In Native Grassland

for the

Foothills Fescue, Foothills Parkland and Montane

Natural Subregions of Alberta

Foothills Fescue Natural Subregion

Foothills Parkland Natural Subregion

Montane Natural Subregion

Revised
April 2018

First Approximation

Recovery Strategies for Industrial Development in Native Grassland

For The Foothills Fescue, Foothills Parkland, and Montane Natural Subregions of Alberta

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First Approximation

Prepared for the:

Foothills Restoration Forum

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In Association with:

Participants of the:

Foothills Restoration Forum Technical Advisory Committee

Recovery Strategies Stakeholder Workshops

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During the winter of 2017, three stakeholder workshops were held to critique the draft document and gather insight from a variety of grassland stakeholders, including the Technical Advisory Committee of the Foothills Restoration Forum. Workshops were held in Lethbridge, Cochrane and in the Municipal District of Ranchland building at Chain Lakes. We are grateful to all the participants for their time and thoughtful reviews ot the material, which have improved the document.

We hope the tools developed in the Recovery Strategies Guidance documents will enable land managers, planners, practitioners and community members to make informed choices to minimize loss of native grasslands and promote their restoration after disturbance.

A big thank-you to our sponsors!

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Preface

As the population and economy of Alberta expands, the extent and biodiversity of native grassland ecosystems is decreasing from the cumulative effects of agricultural conversion, energy development, transportation corridors, urban settlement and recreational activities. When compared to the balance of the Grassland Natural Region, the rough fescue grasslands of southwestern Alberta have experienced somewhat less impact from the development of petroleum resources with the exception of the region south of Hwy 3 to the US border. However, recently, development for renewable energy resources including wind energy is also taking place, resulting in extensive, long-term infrastructure in native grasslands. The cumulative effects of multiple industries and fragmentation by many linear projects are degrading the overall health of native grasslands and their resilience to disturbance. Disturbance promotes the establishment of invasive species which greatly reduces the ability of these ecosystems to recover the broad suite of ecological goods and services they provide to the benefit of all Albertans.

As the demand for development has increased, so has public pressure to reduce the impact of industrial disturbance and the cumulative effects of multiple activities on native grassland ecosystems. The South Saskatchewan Regional Plan (Alberta Environment and Parks 2017) identifies the retention of biodiversity and healthy ecosystems as a key goal, including to:

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

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

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.

In this, our final recovery strategy manual for the Grassland Natural Region, we will consider strategies for the native grasslands of southwestern Alberta in aggregate, pooling together knowledge and learnings for the Foothills rough fescue grasslands within the boundaries of the Foothills Fescue, Foothills Parkland and Montane Natural Subregions. 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 Foothills rough fescue grassland ecosystems. Construction, reclamation and restoration methods have evolved over time. Long-term monitoring data has been collected to assess the effectiveness of a number of practices. This document provides learnings from recent academic research, and from these field studies identifies strategies designed to provide the best chance at promoting successful retention and restoration of Foothills Fescue, Foothills Parkland and Montane ecosystems.

Reclamation practices following disturbance in native grasslands landscapes have been steadily evolving since the early 1980s. Over time the focus of reclamation practices in native grasslands 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 2013). The recovery strategies presented here have been developed to support the intent of the 2010 Criteria for Grasslands and to provide guidance for reclamation practitioners, contractors, landowners and Government of Alberta regulatory authorities. Results of workshops held with grassland stakeholders, including ranchers and industry, in the Natural Subregions associated with Foothills rough fescue grasslands are incorporated into the strategies and background. The strategies are not intended to be prescriptive, but rather strive to present options and pathways to enable selection of the most appropriate recovery strategy for the type of industrial disturbance on a site specific basis. Their purpose is to provide the expectations of what is required to reach the outcome of restoration over time. The concepts and strategies are also applicable to similar non-industry disturbances.

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 grasslands. Realizing the reclamation challenges faced for development in native grasslands and the benefits gained from minimizing the footprint of disturbance, other industries are modifying their construction practices.

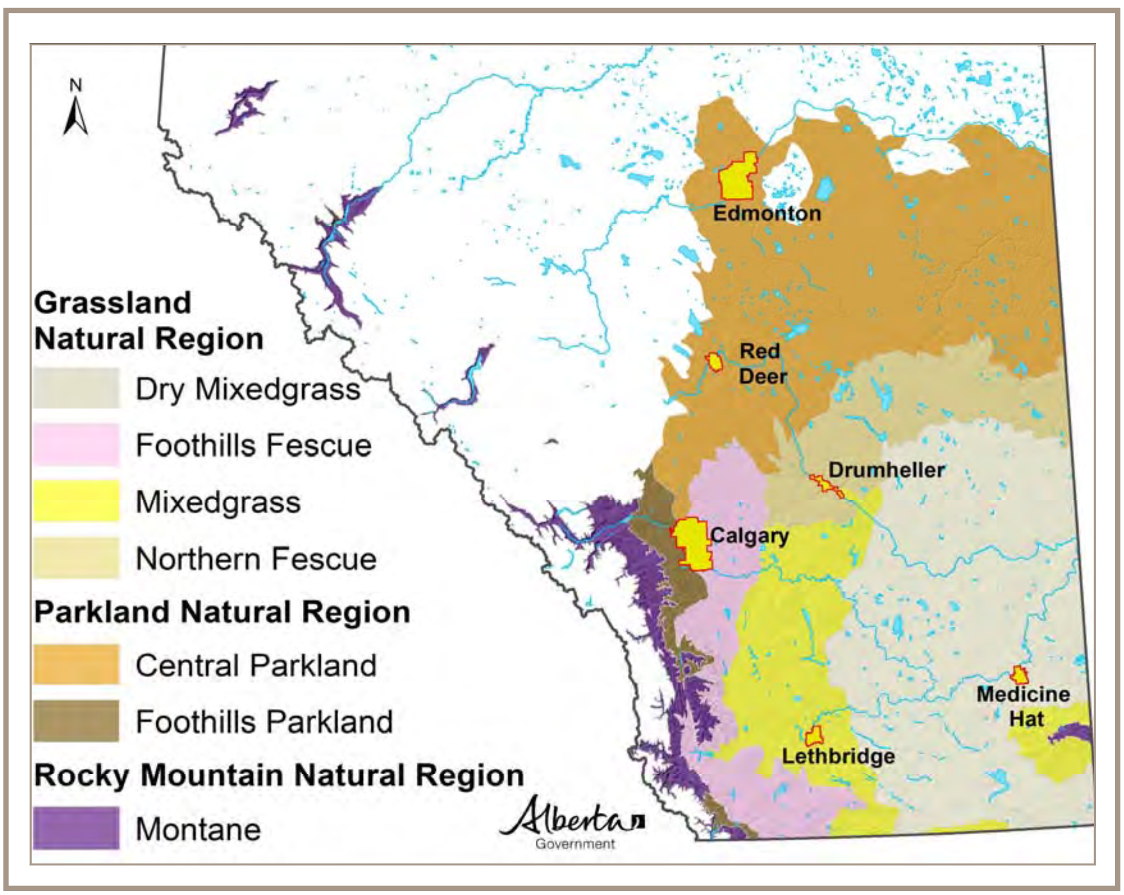
Each manual in the series is presented as a first approximation recognizing that revision will be required as our knowledge of native grasslands plant communities and their response to disturbance increases. Revision will also be required as reclamation practitioners use this approximation and industry 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 assist practitioners with understanding the Natural Subregion context of restoration opportunities and limitations (Figure 1). The 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) has greatly increased our understanding of native grassland ecosystems. These tools link native plant communities to soils and site characteristics and facilitate a more complete understanding of the ability of native plant communities to respond and adapt to natural disturbance regimes such as fire, grazing, drought, and insect predation. These tools are now being applied to assess and manage man-made disturbances. They are incorporated into pre-disturbance site assessment, development planning and reclamation certification for native grasslands, creating the need for an additional tool which provides guidance on appropriate recovery strategies for each Natural Subregion.

Again, this manual addresses the final portion of the Grassland Natural Region and draws linkages to rough fescue grasslands from adjoining natural regions. Projects have been underway through the partnership established between Alberta Environment and Parks (AEP), Petroleum Technology Alliance Canada (PTAC) and a variety of industries, including oil and gas field developments, pipelines, transmission lines and wind farms to capture the key experience and learnings that have accumulated over the past 10 to 20 year period since minimum disturbance practice was first established.

The Foothills Restoration Forum was originally formed in 2006 to address the particular challenges associated with disturbance and reclamation/restoration in the Foothills Fescue NSR grasslands. Much of the Foothills Fescue grasslands have been lost to cultivation, fragmented by industrial activity and roads and by invasion by agronomic grasses like Kentucky bluegrass (*Poa pratense*), Timothy (*Phleum pratense*) and smooth brome (*Bromus inermis*). The relatively mesic soils and climate of the southwest promote the spread of invasive non-native plants where soil disturbance has occurred. These Black Chernozemic soils, normally dominated by deep rooted and productive Foothills rough fescue (*Festuca campestris*), are extremely difficult to restore once disturbed, and should be avoided. The drier portions of the fescue grasslands may be more suited to a minimum disturbance development approach. A restoration risk analysis is a critical step in assessing restoration strategies prior to and after disturbance. Minimal disturbance construction procedures, and natural recovery or assisted natural recovery where appropriate, are the most effective strategies for restoring native plant communities in the Foothills rough fescue grasslands. Alternate strategies for large disturbances not suited to natural recovery as well as severely degraded sites are defined and discussed in the context of new restoration tools and recent publications 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 2016) .

Figure 1 - Grassland Natural Region and Surrounding Subregions that Support Native Grasslands in Southern Alberta



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Abbreviations

ACIMS……Alberta Conservation Information Management System
AEP……Alberta Environment and Parks
AER……Alberta Energy Regulator
AI……Alberta Innovates
AGRASID……Agricultural Region of Alberta Soil Information Database
AVI……Alberta Vegetation Inventory
cm……centimetre
EAP……Enhanced Approval Process
EBIPM……Ecologically Based Invasive Plant Management
EPP……Environmental Protection Plan
ESRRA……Ecological Site Restoration Risk Analysis
FF……Foothills Fescue Natural Subregion
FP……Foothills Parkland Natural Subregion
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
MO……Montane Natural Subregion
NGO……Non-government Organization
NSR……Natural Subregion
PLS……pure live seed
PLVI……Primary Land and Vegetation Inventory
PNC……Potential Natural Community
PNT……Protective Notation
PTAC……Petroleum Technology Alliance Canada
RoW……Right-of-Way
RPC……Reference Plant Community
RRSS……Range Resource Stewardship Section
SCA……Soil Correlation Area
wt……weight

1 A SHIFT IN FOCUS TO RESTORATION

Why is ecological restoration so important to preserving native grassland ecosystems? Foothills Fescue, Foothills Parkland and Montane Natural Subregions (NSRs) are important for the economic, social and biophysical health of southwestern Alberta. Well-managed fescue grasslands are a valuable resource for livestock production, which is a significant economic factor in southwestern Alberta. The fescue grasslands of southern Alberta foothills are considered the most productive of Alberta native grasslands (Smoliak et al. 1985). They play an important role in wildlife habitat, especially as critical winter habitat. Nevertheless, energy development, urban expansion and agriculture have resulted in the loss of native grasslands in southern Alberta. For example, of the 1.1 million hectares in the Foothills Fescue NSR, only 250,000 hectares or 16% of native grassland remain (Adams et al. 2005). If what remains of the native grasslands is to be conserved for future generations, then it is critical to continue to improve reclamation practices and recovery strategies in native grassland 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 disturbances in native grasslands. Developing effective recovery strategies is necessary to mitigate cumulative effects to native grasslands 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.

Expanding Urban Populations and Acreage Development are Putting Increasing Pressure on Remaining Foothills Fescue Grasslands.

Grassland Conservation and Cumulative Effects Management

Native grasslands are regarded as the native landscapes most altered by human land use practices and Alberta has only about one third of its original native grasslands remaining, mainly altered due to being very suitable for agriculture. Until the past decade, the prevailing assumption was that disturbed grasslands, once reclaimed, would gradually recover to a plant community with similar characteristics to the pre-disturbance plant community. Recent research and field studies show that with a minimum disturbance approach and appropriate development practices, considerable health and function may be recovered, while other plant communities may be more or less permanently altered to a non-native condition with enduring impacts on the ecological services provided.

Cumulative effects are the combined effects of past, present and reasonably foreseeable future landuse activities on the environment. Surface disturbance in grasslands can be categorized 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 Foothills rough 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 rough 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 units like km/square kilometer 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.

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

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 2013) 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 2013) 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 redevelop 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).

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 grasslands and site project disturbances in more resilient plant communities can significantly reduce restoration challenges and the time required to achieve reclamation certification.

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.

Reducing Cumulative Effects

The most important principles in reducing the cumulative effects of industrial disturbance in native prairie landscapes include (AER 2014, AEP 2016):

- 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.

Agriculture and energy development can create risk to native grasslands through footprint, fragmentation and the spread of invasive species.

Special Challenges in Restoration of Foothills Rough Fescue Grasslands

Of all native grassland communities in southern Alberta, rough fescue grasslands are the most difficult to restore. Rough fescue grasslands occur as the dominant cover type in the Foothills Fescue grassland, as co-dominant with forest and shrub communities in the Foothills Parkland and may occur as open valley bottom grasslands or on south facing slopes, ridges or interstitial patches in the Montane and Subalpine Subregions.

Foothills rough fescue (*Festuca campestris*) is a densely tufted bunchgrass, often forming large tussocks up to 30 cm in diameter, with stiff upright stems from 30 to 140 cm in height and roots up to 120 cm deep (Best et al. 1971). Under light disturbance pressure and in the absence of invasive species (as a native plant community) rough fescue may grow to the near exclusion of other plant species (Looman 1969). Its deep root structure makes it resistant to drought and fire. In addition, its growth begins early in the spring, completed by June, allowing it to use spring moisture for growth and not requiring much precipitation during the remainder of the growing season (Stout et al. 1981). Rough fescue plants cure on the stem due to a leaf cell structure that resists weathering and breakdown. Consequently, it provides valuable fall and winter forage for livestock and wildlife and is tolerant of winter grazing. The stiff, upright culms are accessible to foragers such as cattle and elk, even in deep snow (Dormaar and Willms 1990). Well-managed rough fescue grasslands are a valuable resource for critical wildlife habitat and livestock production, which is a significant economic factor in southwestern Alberta. They are low maintenance and highly productive.

There is a growing understanding that we lack the tools and knowledge to restore rough fescue grasslands after they are disturbed by land use activities like road construction, oil and gas development, mineral exploration developments and country residential developments. A number of invasive introduced grasses (termed agronomic invaders) including Kentucky bluegrass (*Poa pratensis*), smooth brome (*Bromus inermis*) and Timothy (*Phleum pratense*), will invade rough fescue grasslands with excessive disturbance, particularly where topsoil is exposed. The moister upland grassland soils, termed “thick black” Chernozems in the Foothills Parkland and moister portions of the Foothills Fescue are most vulnerable to invasion.

Invasion by agronomic invaders dramatically reduces the health and function of fescue grasslands. Forage yields are reduced, forage production is less stable, forage quality is diminished, plant species diversity is reduced along with potential for soil carbon sequestration. Once invaded by non-native species, the potential for recovery to a native community seems quite limited based on current knowledge.

2 OVERVIEW OF FOOTHILLS FESCUE, FOOTHILLS PARKLAND AND MONTANE NATURAL SUBREGIONS

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 native grasslands in the Foothills Fescue, Foothills Parkland and Montane Natural Subregions.

Physiography, Climate, Soils and Vegetation of the Foothills Fescue, Foothills Parkland and Montane Natural Subregions

Physiology, soils, climate and vegetation of the Foothills Fescue, Foothills Parkland and Montane Natural Subregions

Foothills Fescue Natural Subregion

The Foothills Fescue NSR occupies the area between the lower elevation, warmer, drier Mixedgrass NSR to the east, the lower elevation Northern Fescue NSR to the northeast and the higher elevation Foothills Parkland and Montane NSRs to the west. Elevations range from 800m in the north to over 1500m in the Porcupine Hills (Natural Regions Committee 2006). The boundaries correspond closely to Soil Correlation Area (SCA) 5 in the south (Del Bonita through Cardston to the Pekisko area), and with SCA 6 in the north (Stavely north to Crossfield and Trochu) (illustrated in Adams et al. 2005) (Brierley et. al 2001). The Foothills Fescue NSR is subdivided into four Ecodistricts (illustrated in Adams et al. 2005) based on elevation and latitude. The extent of remaining native grassland is illustrated in Figure 2 and is estimated to be less than 17% of the area of this NSR.

The climate in the Foothills Fescue NSR is characterized by short summers with warm days and cool nights, and long cold winters, moderated frequently by chinook winds, strong westerly winds that occur most frequently in late fall and winter. Precipitation in the form of snow is common in late winter and early spring (Adams et al. 2005). Yearly precipitation ranges 397 mm to 589 mm (Adams et al. 2005). Mean daily temperatures range from 4.3°C in the south at Del Bonita, 5.4°C in the Chinook wind affected west at Cardston and 3.5°C at Trochu in the north. Soils are predominantly Orthic Black Chernozems. Rego Black Chernozems occur on gravel and shallow to gravel deposits from glacio-fluvial outwash from mountain and foothills valleys. The fertile Black Chernozemic soils, combined with adequate average annual precipitation, provides the opportunity for non-native plants to invade and colonize disturbed soils, especially in areas fragmented by cultivation.

Native grassland plant communities in the Foothills Fescue NSR are influenced by ecological range sites including Wetland/Subirrigated, four Loamy types, Gravel/Shallow to Gravel and Thin Breaks. The moistest of upland Loamy sites, most common in the Willow Creek Upland, and to a lesser extent as remnants in the Delacour Plain support Foothills rough fescue, Parry oatgrass (*Danthonia parryi*) and Idaho fescue (*Festuca idahoensis*) plant communities. Foothills rough fescue with Idaho fescue plant communities tend to occur in more southerly portions of the Willow Creek Upland and south to the US border. This type seems to define a north-south moisture gradient, with Parry oatgrass dropping out of the stand in the southern Porcupine Hills and Oldman River drainage in the Cardston Plain. The presence of Western wheatgrass (*Agropyron smithii*) signals the transition to the drier Mixedgrass prairie that adjoins the Foothills Fescue to the east. Gravel/Shallow to Gravel range sites are common in the Pekisko and Oldman drainages. Limy range sites are commonly found in the Cardston Plain and the Del Bonita Upland. While plant communities closely resemble a number of Loamy site types, subtle difference in subdominant species are evident and productivity for these sites is considerably lower than on Loamy sites (Adams et al. 2005).

A Foothills Rough Fescue Community on Fertile Black Chernozemic soils in the Foothills Fescue NSR

Foothills Parkland Natural Subregion

The Foothills Parkland NSR represents a transition zone between grassland environments to the east and boreal and montane forests to the west and north (Natural Regions Committee 2006). Forming the most southerly portion of the Parkland Natural Region, it is found on the western edge of the Foothills, running from just north of Calgary to the Porcupine Hills, with another pocket located near the Alberta-Montana border (Figure 2).

The Foothills Parkland Natural Subregion has the highest precipitation, warmest winters, and shortest, coolest growing season of any of the parkland Natural Subregions. Proximity to the mountains and a greater incidence of Chinooks is responsible for these characteristics (Natural Regions Committee 2006). Mean annual precipitation in the Foothills Parkland Natural Subregion ranges from 454 to 807 mm. Precipitation decreases significantly from the south to the north and means daily temperature decreases slightly to the north. Southern areas receive a higher percentage of precipitation as snow (LandWise 2003).

This is the highest parkland Natural Subregion, and elevations range from 1025 m north of Calgary to about 1400 m in the Porcupine Hills. Rolling to hilly landscapes are typical. Grasslands similar to those in the Foothills Fescue Natural Subregion occur on dry sites, and aspen stands like those in the Montane Natural Subregion occur on moister, cooler northerly aspects and in seepage areas.

Soil parent materials include non-marine sandstones, mudstones and shales which underlie moderately fine, weakly calcareous till that is often less than 2 m thick on steeper slopes. Ice-contact glaciolacustrine sediments occur across about 20 percent of the Natural Subregion, mainly in lower valley positions. The Foothills Parkland is characterized by deep Orthic Black Chernozems with surface humus horizons at least 15 cm thick, associated with Foothills rough fescue dominated plant communities and open deciduous or coniferous forest stands. Forested areas are supported by Orthic Dark Gray Chernozemic soils. Seepage areas on lower slope positions and depressions support willow shrublands. Orthic Gleysols occur in the wettest, most poorly drained areas which typically support willow cover (Natural Regions Committee 2006). The Foothills Parkland NSR is described in the Agricultural Regions of Alberta Soils Information Database (AGRASID) as located in Soil Correlation Area 8 (Brierley et al. 2001).

Vegetation ranges from dry south and west facing slopes vegetated by Foothills rough fescue-Idaho fescue communities on rapidly drained soils to Foothills rough fescue-Parry oat grass on somewhat moister southerly slopes. Characteristic sites on moist, moderately well drained northerly slopes, seepage zones or low areas support aspen forests. Balsam poplar (*Populus balsamifera*) also occurs on moister sites, and white spruce (*Picea glauca*) or Douglas fir (*Pseudotsuga menziesii*) are occasional (DeMaere et al. 2012). In the northern unit of the Foothills Parkland Natural Subregion, moist willow groves dominated by beaked willow (*Salix bebbiana*) and with a significant tall herb component are a distinguishing feature (Natural Regions Committee 2006).

Foothills Parkland Natural Subregion

Montane Natural Subregion

In terms of elevation, the Montane Natural Subregion occurs below the Subalpine NSR in the mountains and above the Foothills Fescue and Foothills Parkland NSRs in southern Alberta (Figure 2). It occurs along lower slopes and valley bottoms in the front ranges, along the Porcupine Hills and at higher elevations in the Cypress Hills. Chinooks are frequent along the Front Ranges, and winters are warm with much greater winter snowfall than the Foothills Fescue NSR and lower amounts than the adjoining Subalpine and Alpine Natural Subregions. The Montane has the warmest winter temperatures of any forested region in Alberta because of chinook activity and reduced influence of Arctic air (Strong and Leggat 1992). Yearly precipitation ranges 308 mm to 1279 mm with two precipitation peaks occurring in May-June and again in August-September (Strong and Leggat 1992). Summer monthly temperatures average about 12^{o} C and are 2^{o} C warmer than the Subalpine and 2^{o} C colder than the Foothills Fescue Natural Subregions.

Terrain is complex, soils are variable and vegetation cover also reflects this diversity of slopes, aspects, substrates and moisture regimes (Natural Regions Committee 2006). The Montane is distinguished from the other Subregions by the presence of Douglas fir, limber pine (*Pinus flexilis*) and lodgepole pine (*Pinus contorta*). Understory species include juniper (*Juniperus spp.*), bearberry (*Arctostaphylos uva-ursi*) and horsetail (*Equisetum spp.*). Grasslands are made up of Foothills rough fescue plant communities similar to those found in the Foothills Fescue NSR. Drier grasslands are dominated by bluebunch wheatgrass (*Agropyron spicatum*) with Idaho fescue.

Dominant upland soils associated with forest cover are well drained, medium to fine textured Luvisolic and Brunisolic types. Grasslands associated with the Montane NSR are similar to those found in the Foothills Fescue and Foothills Parklands NSRs. Particularly well-defined vegetation patterns such as the grassland/forest mosaics of the Whaleback Ridge and the Porcupine Hills reflect the often abrupt nature of topographically controlled moisture and temperature gradients. Grasslands are common on moderately dry south- and west- facing aspects and include Foothills rough fescue, Idaho fescue and Parry oat grass on well to moderately well drained Chernozemic soils.

Vegetation Patterns in the Montane Reflect Topographically Controlled Moisture and Temperature Gradients.

Fertile Black Chernozemic soils combined with adequate annual precipitation provide the opportunity for non-native plant invasion to occur, especially in areas fragmented by cultivation. The thicker Black Chernozemic profiles are the most prone to invasion.

Figure 2 - Natural Subregions of Southwestern Alberta including the Foothills Fescue, Foothills Parkland and Montane

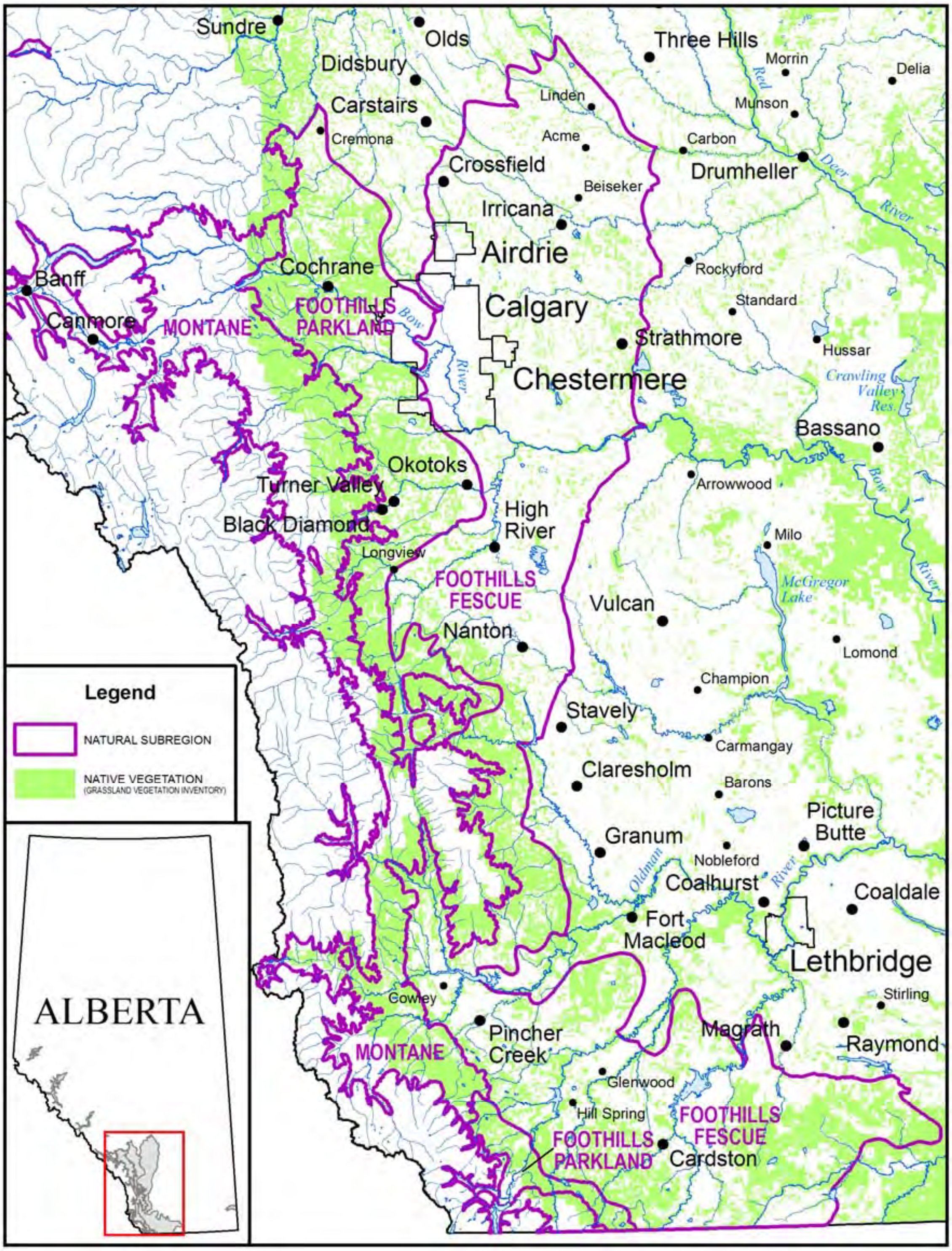


Image Courtesy of Alberta Environment and Parks

Types of Industrial Activity

Numerous types of industrial activities operate in the native grassland ecosystems of the Foothills Fescue, Foothills Parkland and Montane NSRs. Livestock production and associated crop agriculture is important in the Foothills Fescue and Foothills Parkland NSRs and these grasslands are particularly valued for providing winter forage for livestock and wildlife. Summer ranges for livestock are also found in Montane regions. Sand and gravel extraction occurs in the glaciofluvial sediments of river valleys and major hydro developments have flooded native grasslands in the Oldman and Chain Lakes area. Wood fibre production also occurs in the Montane. Oil and gas exploration and development has occurred on both private and public lands, though to a lesser extent than in more central regions. Several large diameter pipeline corridors cross extensive tracts of Foothill Fescue and Foothill Parkland native grassland. Recently the quest to develop renewable forms of energy has resulted in development of wind farms and upgrading of electrical transmission corridors in the southern Foothills Fescue NSR. Expansion of cities, towns and acreage developments are also resulting in permanent losses and fragmentation of native grasslands.

Types of Recreation Activities

Numerous types of recreation activities occur in parts of the Foothills Fescue, Foothills Parkland and Montane NSRs. Camping, hiking and fishing are common in the Chain Lakes area, Porcupine Hills, Livingston and Castle areas, Beaver Lake and other southern lakes. Camping and hiking occur in Waterton National Park. Off-highway vehicular (OHV) activities occur in the Porcupine Hills, Livingston and Castle areas. Horseback riding is found throughout the region. Motorized activities in particular cause linear disturbance, soil exposure and compaction, stream-bank and hillside erosion and invasive species introduction.

Managing Surface Disturbance

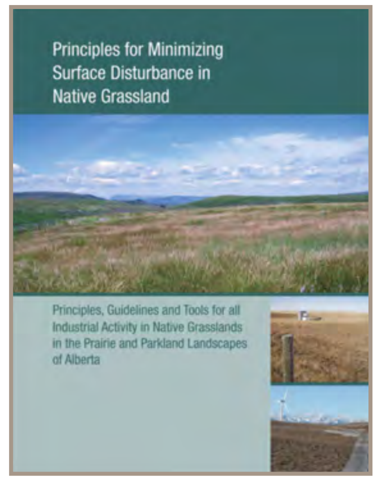
The importance of managing surface disturbance and maintaining the integrity of native plant communities during industrial development in native grasslands has been formally recognized since 1992. The following information letters, principles and guidelines were developed by collaborative stakeholder working groups for Alberta Government regulators and conservation organizations.

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 grassland 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 2016)

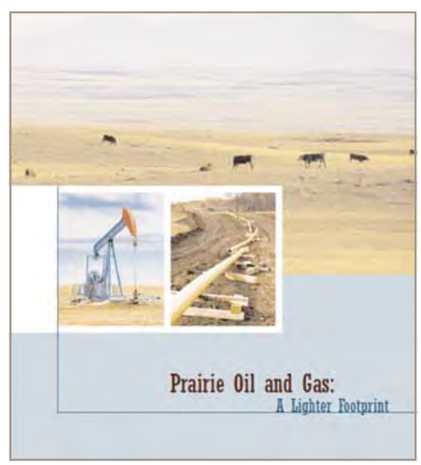
This document replaces Manual 007 (AER 2014). It was prepared by a working group comprised of representatives from government agencies having jurisdiction over petroleum industry activities in native grassland and parkland areas. It provides specific direction for all phases of petroleum development 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.

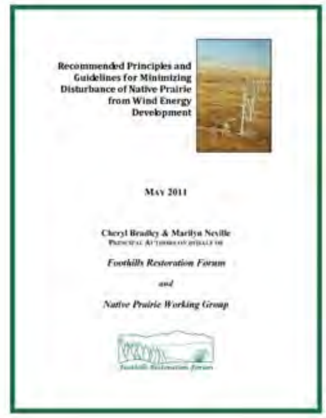
Prairie Oil and Gas: A Lighter Footprint (Sinton 2001)

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).



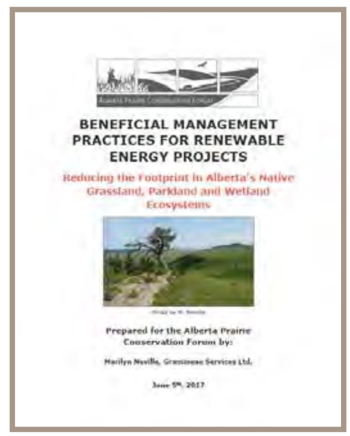
A lighter footprint requires a “cradle to the grave” approach.

Recommended Principles and Guidelines for Wind Energy Development in Native Prairie



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 (Bradley and Neville 2011).

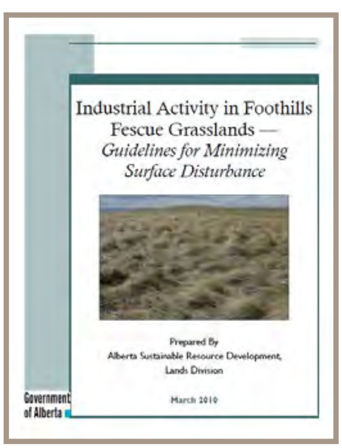
Beneficial Management Practices for Renewable Energy Projects; Reducing the Footprint in Alberta's Native Grassland, Parkland and Wetland Ecosystems



This document addresses industry-specific beneficial management practices for renewable energy developments. Through development of this document, the intent of the Prairie Conservation Forum is to foster a positive working relationship with the renewable energy industry to assist in drafting practical beneficial management practices that sustain prairie biodiversity at the species, community and ecosystem levels (Gramineae Services Ltd. 2017).

Industrial Activity in Foothills Fescue Grasslands – Guidelines for Minimizing Surface Disturbance (AEP 2012)

IL 2010-02 Foothills Fescue Grassland Principles for Minimizing Surface Disturbance (AEP 2010)



These documents were prepared by working groups comprised of representatives from government agencies having jurisdiction over petroleum industry activities in the Foothills Fescue NSR. They provide specific direction for all phases of petroleum development activity including seismic and geophysical programs. Key general guidelines include:

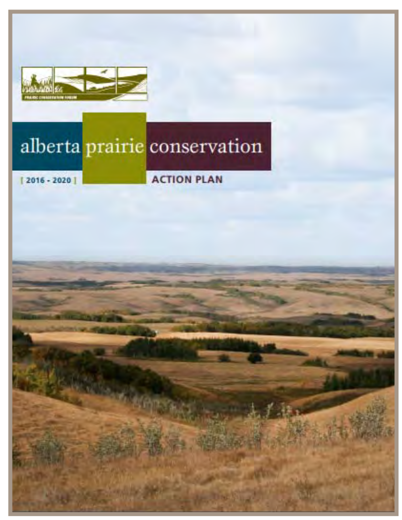
- avoidance of rough fescue grasslands if at all possible;
- the use of previously disturbed areas such as existing access roads and trails;
- the requirement for special planning measures, field based environmental assessments, minimal disturbance construction techniques and the use of native plant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

A caution to industry that it may not be possible to achieve required reclamation outcomes as surface disturbance to rough fescue grasslands will result in a permanent alteration of the plant community to a non-native character.

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.

Figure 3—Standardized Grassland Assessment Tools

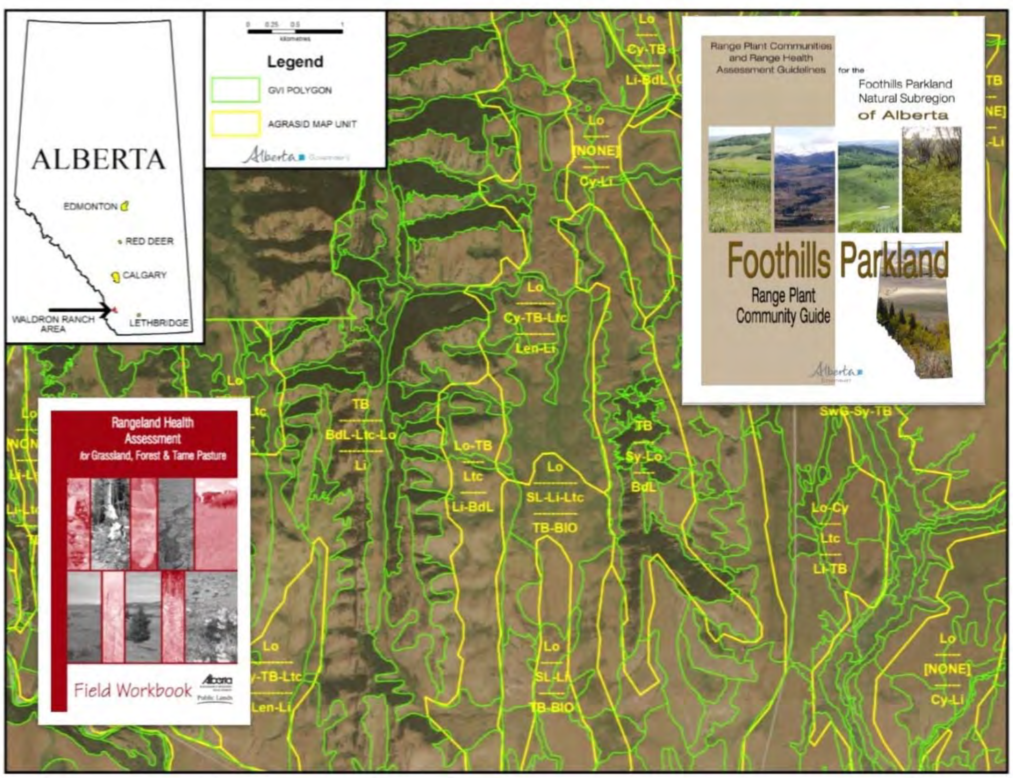


Image Courtesy of Alberta Environment and Parks

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 generalized 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 Foothills Fescue Range Plant Community Guide (Adams et al. 2005).

GVI Data

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

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. 2010).

Agriculture Region of Alberta Soil Information Database (AGRASID) Mapping

Additional site-specific resources for soils mapping information include the:

- Agricultural Region of Alberta Soil Information Database Version 4.1 (AGRASID) digital soil landscape data (ASIC 2015);
- Alberta Soil Names File (Generation 4) User's Handbook (ASIC 2016);
- and regional soil survey maps for Alberta (AAF 2017).

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.

Additional site-specific resources for soils mapping information are the Alberta Soil Information Viewer http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sag10372 and regional soils maps.

Figure 4 - A Foothills Parkland Landscape Comparing the Scale of GVI Site Polygons (green) Versus AGRASID Soil Polygons (yellow)

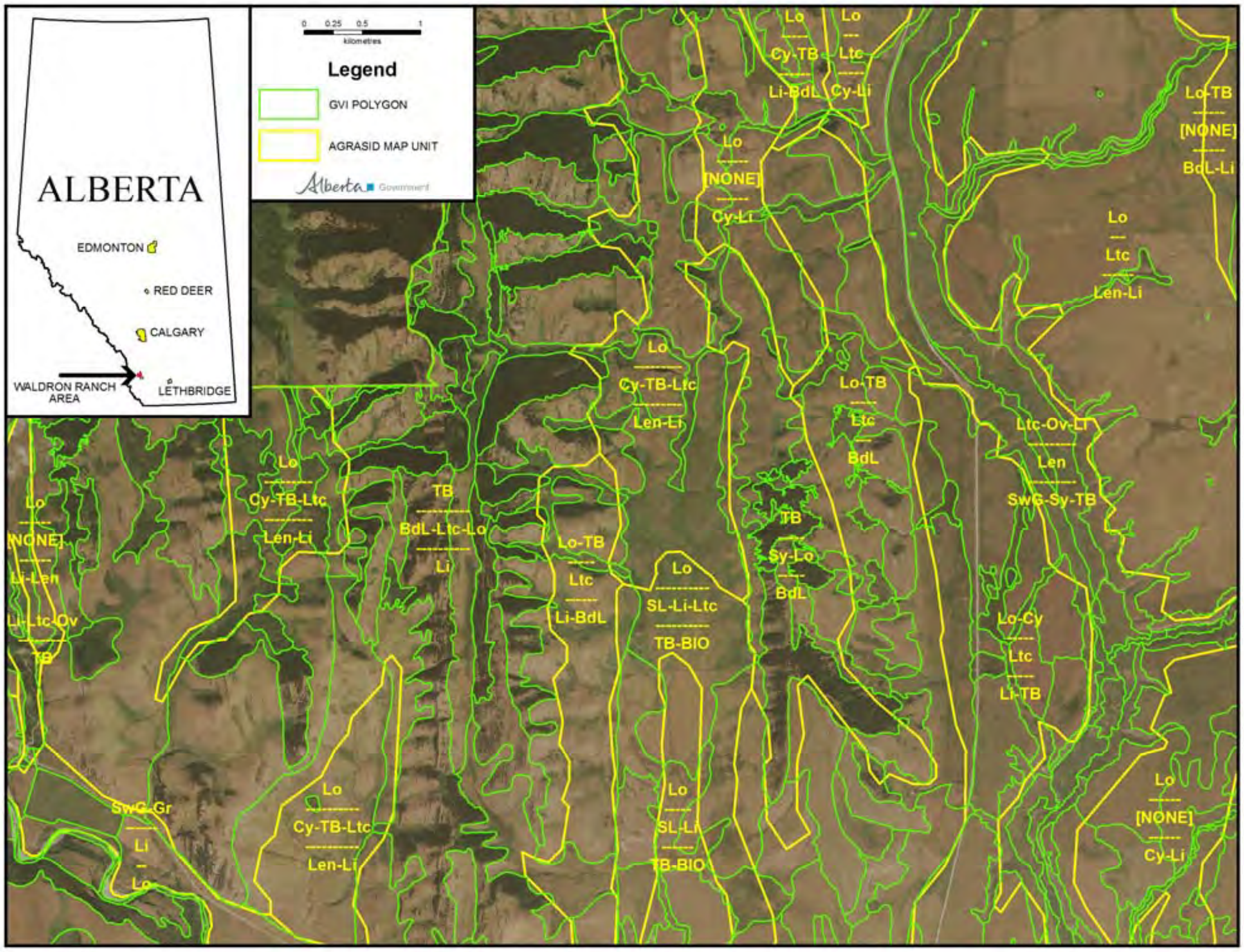


Image Courtesy of Alberta Environment and Parks , Lethbridge, Alberta

Alberta Vegetation Inventory (AVI) Mapping

The Alberta Vegetation Inventory (AVI) is a photo-based digital inventory developed to identify the type, extent and conditions of vegetation in the forested areas of the province of Alberta. AVI captures grassland site attributes only within the Montane Natural Subregion (AEP 2017b). The ecosite phase concept, more typical of forested ecosystems, is the main level of classification used in AVI.

Range Plant Community Guides

The Foothills Fescue Range Plant Community Guide (Adams et al. 2005), Foothills Parkland Range Plant Community Guide (DeMaere et al. 2012) and Range Plant Community Types and Carrying Capacity for the Montane Subregion, Seventh Approximation (Willoughby et al. 2008) are essential field guides for identifying common plant communities and conducting range health assessments in the Foothills Fescue, Foothills Parkland and Montane NSRs of Alberta. They are available at: http://aep.alberta.ca/lands-forests/grazing-angemanagement/range-plant-community-guides-stocking-rates.aspx.

The plant community guides have been compiled from data collected from detailed vegetation inventories and an extensive system of reference areas established across the province by the AEP Range Resource Stewardship Section. Assessing the composition and health of native grassland plant communities requires taxonomic expertise in identification of grasses in vegetative and fruiting stages, in lightly and heavily grazed conditions and training in range health assessment protocols. The guides provide descriptions of common plant communities linked to range site type and Ecodistrict.

Two hierarchal classification systems are used in Alberta to classify ecological sites and plant communities (Figure 5). Ecological sites are defined as "*a distinctive kind of land with specific physical characteristics that differ from other kinds of land in its ability to produce a distinctive kind and amount of vegetation*" (Task Group on Unity in Concept and Terminology 1995).

1. In Parkland and Rocky Mountain Natural Regions, landscapes with similar climate, moisture and nutrient regimes are grouped into ecological sites (ecosites). Grassland ecosites are typically associated with subxeric to submesic moisture regimes and a variety of nutrient regimes, from poor to rich. Within the ecosite classification, similar vegetation types are grouped into ecosite phases based on the dominant layer of vegetation.
2. Plant communities in Grassland Natural Regions are classified based on their association with range sites, determined through key attributes of the landscape, soil features and textural groupings within larger mapped ecodistricts (Adams et al. 2005). Ecological range sites are subdivisions of range site based on plant community composition.

Range plant communities are reported in three categories including reference, successional and modified communities depending on the level of grazing disturbance. The plant community that is an expression of site potential is referred to as the reference plant community (RPC) since it represents the natural community that develops under light or moderate grazing disturbance. This potential community is described as healthy for comparison in range health assessment. The plant community guides have been compiled from data collected from detailed vegetation inventories and the extensive system of reference areas established across the province by the AEP Range Resource Stewardship Section.

Assessing the composition and health of native grassland plant communities requires taxonomic expertise in identification of grasses in vegetative and flowering or reproductive stages, in lightly and heavily grazed conditions and training in range

Figure 5 - Rangeland Ecological Classification in Alberta

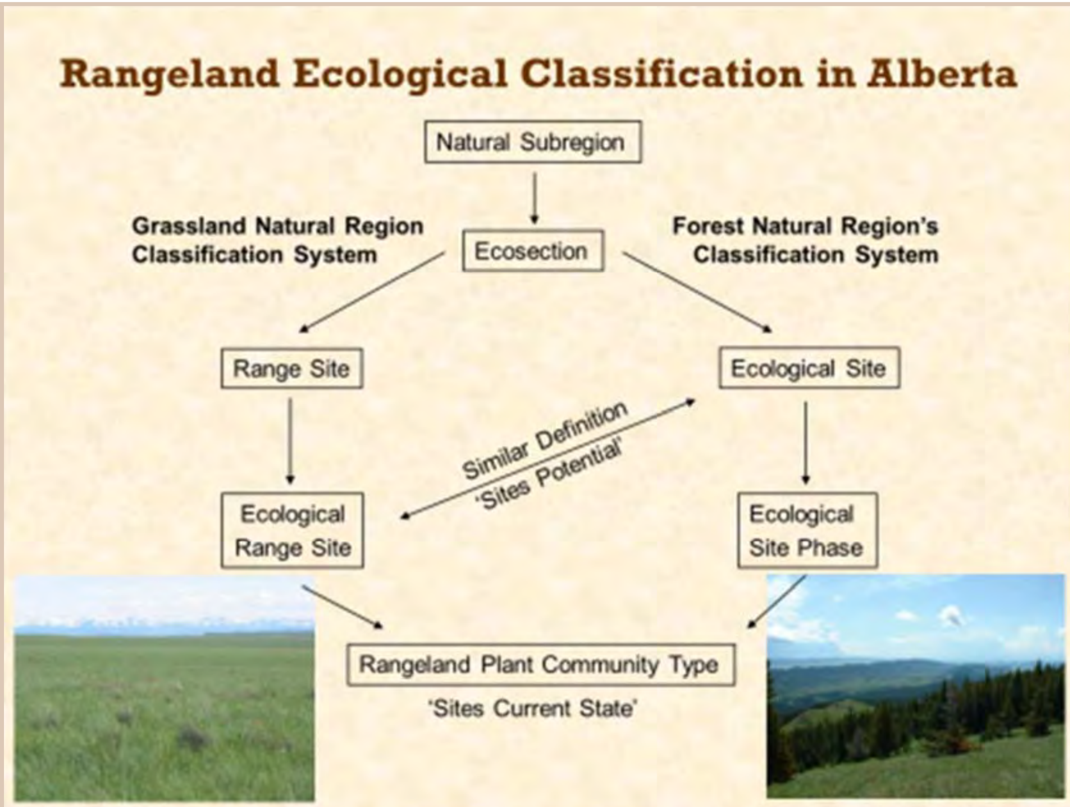


Image Courtesy of Alberta Environment and Parks - Rangeland Resource Stewardship Section

Navigating the Foothills Fescue Range Plant Community Guide

The Foothills Fescue Plant Community Guide (Adams et al. 2005) organizes plant communities based on ecological range sites, a refinement of a range site by placement within a Natural Subregion and landform. Range sites are determined through key attributes of the landscape, soil features and textural groupings (Adams et al. 2005). Knowing the soil series of the location being examined provides a key clue to range site, as crossover tables have been developed that links soil series to range sites. Steps to attaining plant community information for a location in the Foothills Fescue Natural Subregion are:

1. Identify the soil series that are associated with the location. The Agricultural Regions of Alberta Soil Inventory Database (AGRASID) is a useful tool to attain this information and is available online. Cross-over tables between soil series and range site occur in Table 3, 4, and 5 in the Foothills Fescue plant community guide. Another method is through the Grassland Vegetation Inventory (GVI), which uses AGRASID, landscape, and colour infrared imagery to remotely sense a site type. Upland site types are analogous to range sites in GVI.
2. Once on the ground, the soil series and range site should be confirmed and then these attributes used to help derive the ecological range site. This is performed by placing that range site in the context of its specific location within the Natural Subregion and other attributes attained on the site (such as slope position).

3. Utilize table 9 within the guide: Plant Communities Listed by Ecological Range Site within the Foothills Fescue Grassland, which links ecological range site with reference plant communities.
4. Check the table to identify 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. These communities should be within the derived range site and have similar species compositions for the location. Once standing on the site, read through the descriptions of the range plant communities identified in the tables.
5. Understanding the ecological range site and range plant communities within a proposed project site is vital to conducting an ecological risk assessment for project planning.

Navigating the Foothills Parkland and Montane Range Plant Community Guides

The Foothills Parkland Plant Community Guide (DeMaere et al. 2012) is organized somewhat differently than the Foothills Fescue Plant Community Guide, where range site types are determined through key attributes of the landscape, soil features and textural groupings within larger mapped Ecodistricts (Adams et al. 2005). The classification is a blend of the ecological site concepts developed for forests and rangelands in the province (Figure 5) (DeMaere et al. 2012). The Foothills Parkland classification is hierarchical. 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.

Key steps to finding information for a project area are:

1. Check the appropriate edatopic grid to understand where physical conditions allow grasslands to naturally occur. For example, in these guides, this typically occurs in xeric to submesic ecological sites.
2. Identifying soil series may help to understand soil properties. Although these natural subregions border the boundary of AGRASID and GVI, some of the area is covered.
3. Identify the project locations physical properties such as its slope steepness, slope position and aspect. Utilizing these values will allow for proper placement of the location on the edatopic grid and derive the ecological site.
4. Ecosite Phase is confirmed by viewing the dominant canopy; i.e. whether it is dominated by grassland, deciduous, mixedwood, or coniferous forest. Refer to the range plant community tables within the guides to identify potential Ecosite Phases for each ecological site.
5. Once at the location, utilizing the range community guide, identify the plant species present to first confirm the dominant vegetation stratum to identify ecosite phase, then read through the descriptions of the reference, successional and modified range plant communities identified to identify the most appropriate plant community for that phase.
6. Understanding the Ecosite Phase and range plant communities within a proposed project site is vital to conducting an ecological risk assessment for project planning .

Range Health Assessment

The Range Health Assessment protocol and the Range Health Assessment Field Workbook developed by the AEP – RRSS is used to assess, monitor and manage Alberta's rangeland (Adams et al. 2016).

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 provides 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 1-1 (reproduced below as Table 1) from the Range Health Field Workbook describes the functions of healthy rangelands and why they are important.

Table 1 – Functions of Healthy Rangelands

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

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. Range health assessment is an important component of the 2010 Reclamation Criteria for Wellsites and Associated Facilities for Native Grasslands (AEP 2013). Annual range health assessment training programs are 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. The ESRRA report, prepared by AEP – RRSS in consultation with AEP Rangeland Agrologists and Land Use Specialists can be found in the information portal on the Foothills Restoration Forum website at http://www.foothillsrestorationforum.ca.

Restoration risk will affect the potential restoration outcome. The submesic rough fescue grasslands on rich Loamy soils are the most difficult to restore of all Alberta native grasslands.

In the native grasslands of the Foothills Fescue, Foothills Parkland and Montane Natural Subregions the following factors affect restoration potential:

1. **Climatic processes such as fall and winter chinooks.** These strong, warm, westerly winds are a significant factor influencing restoration potential once the native grassland vegetation has been removed. Winter thawing of frozen soils presents challenges for operating heavy equipment on native grassland vegetation. The potential for soil loss due to wind erosion is a significant factor that must be considered in development planning.

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 plants such as smooth brome (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), sheep fescue (*Festuca ovina*), sweet clovers (*Melilotus officinalis and M. alba*), orchard grass (*Dactylis glomerata*), Canada bluegrass (*Poa compressa*) and Timothy (*Phleum pratense*).

   The potential for non-native plant invasion on disturbed upland soils decreases as soil fertility, topsoil depths and soil moisture decreases. The Black Loamy soils of the Foothills Fescue Natural Subregion are much more prone to non-native plant invasion than drier ecological range site types in the NSR. In general, restoration is more difficult in the moist ecosystems of Foothills Fescue, Foothills Parkland and Montane Natural Subregions than in drier ecosystems, e.g. Mixedgrass or Dry Mixedgrass NSRs.

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 range sites are more adapted to soil disturbance than others. On Thin Breaks range sites in the Foothills Fescue NSR or subxeric grasslands in the Montane, significant amounts of bare soil and plants uniquely adapted to colonizing the bare soil are factors which maintain the habitat for species of concern or at risk. Natural recovery facilitates the ecological recovery processes. Seeding can deter these processes and alter the plant community composition. However, some mitigation for wind erosion will be necessary.

7. **Adjacent land use also affects restoration potential.** Remnant native grassland areas in highly fragmented landscapes are of particular concern. For example, unhealthy rangelands will increase the risk to successful reclamation 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 alfalfa (*Medicago sativa*), orchard grass, Kentucky bluegrass, smooth brome, sheep fescue or sweet clover can limit restoration potential. 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. Poor range health will lead to low restoration success as the community has lost resiliency.

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.**

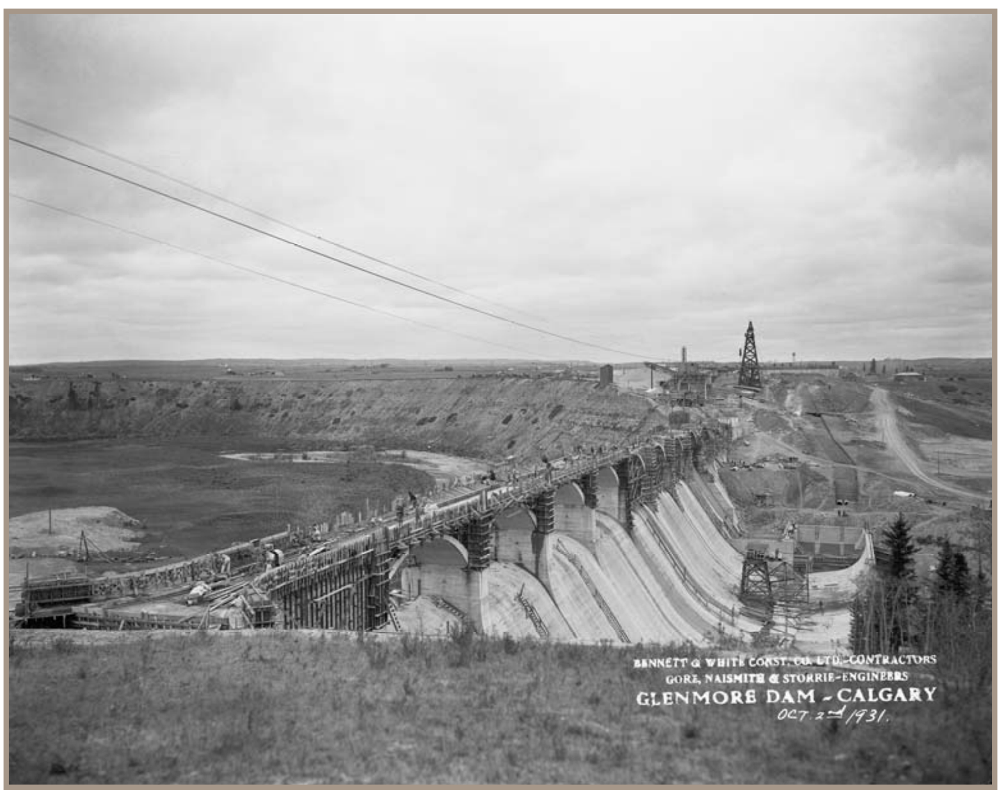
4 Promoting Native Plant Community Succession

Reflecting on Past History

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

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

Following the extensive cultivation and abandonment of prairie landscapes, Canadian plant ecologist Robert Coupland observed recovery of grassland 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). Many studies have been conducted on the effects of livestock grazing on foothills rough fescue communities to the west, all concluding that recovery of plant communities dominated by this species appears to take much longer (Willms et al. 1985; Willms 1988; Willms et al. 1988).



Glenmore Dam Under Construction, Calgary, Alberta 1931

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.

Digging Pipeline, Turner Valley, Alberta, 1929

Earthmover working on CP Railway Spur Line 11 Miles South of Pincher Creek, Alberta, 1961

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.

Old Pipeline Rights-of-Way in Native Grassland Seeded to Smooth Brome (dark rust colour)

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. During this period a prohibition on use of agronomic species came into effect 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. 2016) 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 plant communities that develop in ecological succession relative to their reference community.
- 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, timothy or Kentucky bluegrass) with a relative composition of greater than 70% non-native species.
  Note: The relatively high threshold composition of 70% non-native to define a modified community was selected as our general scientific knowledge of plant community recovery is still quite limited and further study is necessary to better establish a hard tipping point towards a permanent shift of the plant community to a non-native state.

Figure 6 is an example of a successional pathway diagram that serves to capture our understanding of how plant communities respond to disturbance on Loamy soils in Foothills rough fescue grasslands, 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. The **arrows** illustrate trajectories that may or may not be reversible.

We know much less about the dimensions of plant succession from disturbed topsoil compared to grazing impacts and so have reduced confidence in predicting outcomes. A key learning from field based studies is that most often, surface disturbance of rough fescue grasslands will result in more or less permanent alteration of the plant community to a modified, non-native plant community. 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

PLANT COMMUNITY SUCCESSION FOLLOWING SURFACE DISTURBANCE IN

FOOTHILLS ROUGH FESCUE GRASSLANDS — _LOAMY RANGE SITE_

Reference Plant Community

Typical reference plant community for loamy range sites in the Foothills Fescue Natural Subregion

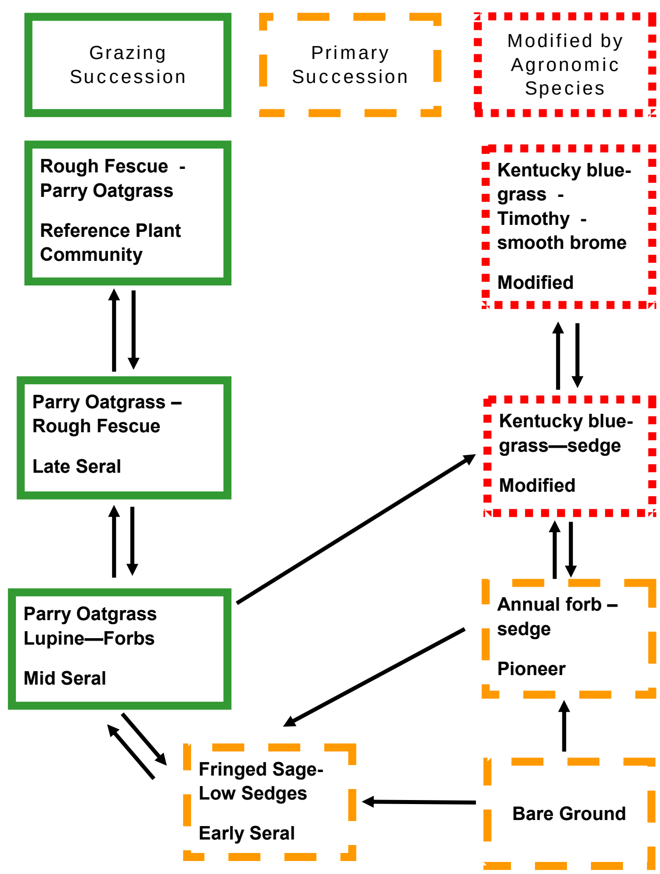
Late Seral

Moderate grazing pressure leading to minor reduction in the abundance of rough fescue and increase in abundance of Parry oatgrass.

Mid-Seral

Cover of disturbance resistant increaser grasses and forb species is greater than that of decreaser grasses and forbs. Can result from heavy grazing pressure or alternately

represent significant desirable progress along a successional pathway towards late seral reference plant community.



Exotic Invasion

Loamy range sites are prone to invasion by non native species like Kentucky bluegrass, smooth brome and Timothy. Bluegrass and brome spread by seed and vegetative roots and Timothy through abundant seed production. These species will spread off of disturbed areas into adjoining native grassland. Once invaded, these modified communities are stable with very limited potential for recovery to native status.

Pioneer

A short-lived initial phase dominated by species like stink weed, Goosefoot, flixweed, pepper grass, and low sedge. This stage may persist for one growing season.

Bare ground, Pioneer and Early Seral

Site may bypass annual forb pioneer stage if sufficient native seed stock is available and be colonized by fringed sage, June grass, low sedge and other native forbs.

Image Courtesy of Alberta Environmental and Parks - Land Policy Branch, and Policy and Planning Division

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 reference plant communities as found in adjacent, non-disturbed areas will not be immediately evident in the two year period historically 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 Foothills Fescue, Foothills Parkland or Montane NSRs, 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 sensitivities to invasion (e.g. such as more mesic foothills rough fescue grasslands), reclamation certification could take much longer (e.g. 10+ years) and ongoing adaptive management during operations will be required.

The Influence of Grazing on Succession

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.). On the other hand, eliminating grazing for too long by fencing can result in thatch build-up, moisture regime alteration and invasion by unwanted species, thus degrading 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 acquisition of a reclamation certificate.**

Patience is required to reach the restoration outcome.

Cattle Round-Up Approaching the Corrals in the Alberta Foothills, 1893

Surface 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), which monitored 63 sites over a 14 year timeframe. 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*), flixeed (*Descurainia sophia*), stinkweed (*Thlaspi arvense*), grey tansy mustard (*Descurainia richardsonii*), peppergrass (*Lepidium spp.*) and the goosefoots (*Chenopodium spp.*).

It is also important to note that the pioneer, early and mid-seral plant communities (Figure 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 (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.

Late seral native plant communities are more likely to develop on disturbances if range health scores for the comparable surrounding area are "healthy" or "healthy with problems". However, long-term monitoring data collected from several reclamation monitoring projects in the Foothills rough fescue grasslands (Desserud et al. 2010; Tannas 2011; Sherritt 2012; Lancaster et al. 2015) illustrate that species composition and cover on the majority of topsoil disturbance sites monitored in the Foothills Fescue, Foothills Parkland and Montane NSRs are not similar to the undisturbed plant community as a result of past reclamation practice and the prevalence of aggressive agronomic grasses in the region.

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.

Monitoring data indicates that aggressive non-native species may persist over time and result in an alteration of the successional pathway to a modified state. Invasive non-native plants that are known to replace native species and establish permanent dominance in grassland communities include Timothy, smooth brome and sheep fescue in the Foothills Fescue, Foothills Parkland and Montane NSRs. In combination with heavy grazing, Kentucky bluegrass, Canada bluegrass and orchardgrass can also permanently alter native plant communities.

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 publication "*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 2016) alerts and directs industry regarding the importance of avoiding disturbance in native grassland, and the need to minimize disturbance should avoidance not be possible. The principles and guidelines apply to all industrial activity in native grasslands.

Range Health Assessment - Foothills Fescue Natural Subregion

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 Foothills Fescue, Foothills Parkland and Montane, 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 to siting, adjusting the proposed beneficial management practices (BMPs) and construction approach or any other previous step.

An example of how pre-disturbance planning based on landscape scale vegetation mapping (GVI) can optimize placement of development to minimize disturbance is illustrated in Figure 8.

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 Enhanced Approval Process (EAP) Integrated Standards and Guidelines (Gov't of Alberta 2013).

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 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 (Gov't of Alberta 2013). 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.

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

PRE-DISTURBANCE SITE ASSESSMENT FLOW CHART TO MINIMIZE IMPACTS TO NATIVE GRASSLAND ECOSYSTEMS

Initial Project Notification
Determine size and scope of the Local Study Area (LSA) to include full development potential.

↓

Delineate proposed site boundary / prospective alternate site(s).
Include maximum spatial adjustment buffer.

↓

Identify spatially-based constraints & landscape sensitivities using the Landscape Analysis Tool (LAT) (e.g. PNTs, easements, historic Resource Values, FWMIS and ACIMS data) and document relevant conditions applied to the LSA and the proposed site(s).

↓

Overlay landscape-scale vegetation inventory mapping if available (GVI / PLVI).
Delineate native / anthropogenic areas within the LSA and the maximum site boundary.
If reliable data layers do not exist **Field Visit the LSA and proposed site(s)** to characterize conditions.

↓

Adjust sites to minimize footprint, reduce disturbance to native vegetation and soils, and reduce risk.
Avoid Sensitive Native Grasslands
Utilize Ecological Site Restoration Risk Assessment to identify critical sites that are sensitive to disturbance.

↓

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

↓

Reduce Cumulative Effects and Linear Fragmentation
Utilize existing trails and common utility corridors. Align with existing industrial / agricultural disturbances.

↓

Determine industry specific best management practices.
Identify construction and operations approaches to support reduced disturbance outcomes.
Determine industry specific approval and reclamation requirements.

↓

Conduct landowner notification and public consultation.

↓

Field Evaluation of Selected Site
Ground truth Ecological Range Site and collect baseline data (plant community, range health and soils)
Conduct surveys for wildlife, rare plants, rare plant communities and historic resources.

↓

Final adjustment of land survey based on field based site characterization and risk assessment.

↓ ↓

Range Health Assessment | **Soils Characterization**

↓ ↓

Prepare Construction, Reclamation, Adaptive Management and Restoration Plans

Although designed originally for oil and gas, this tool and the Enhanced Approval Manual (Gov't of Alberta 2013) 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 2016).

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): 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.

GVI mapping of ecological range sites in a development target area facilitates placement of infrastructure pads and access to minimize new disturbance to Loamy soils supporting rough fescue plant communities.

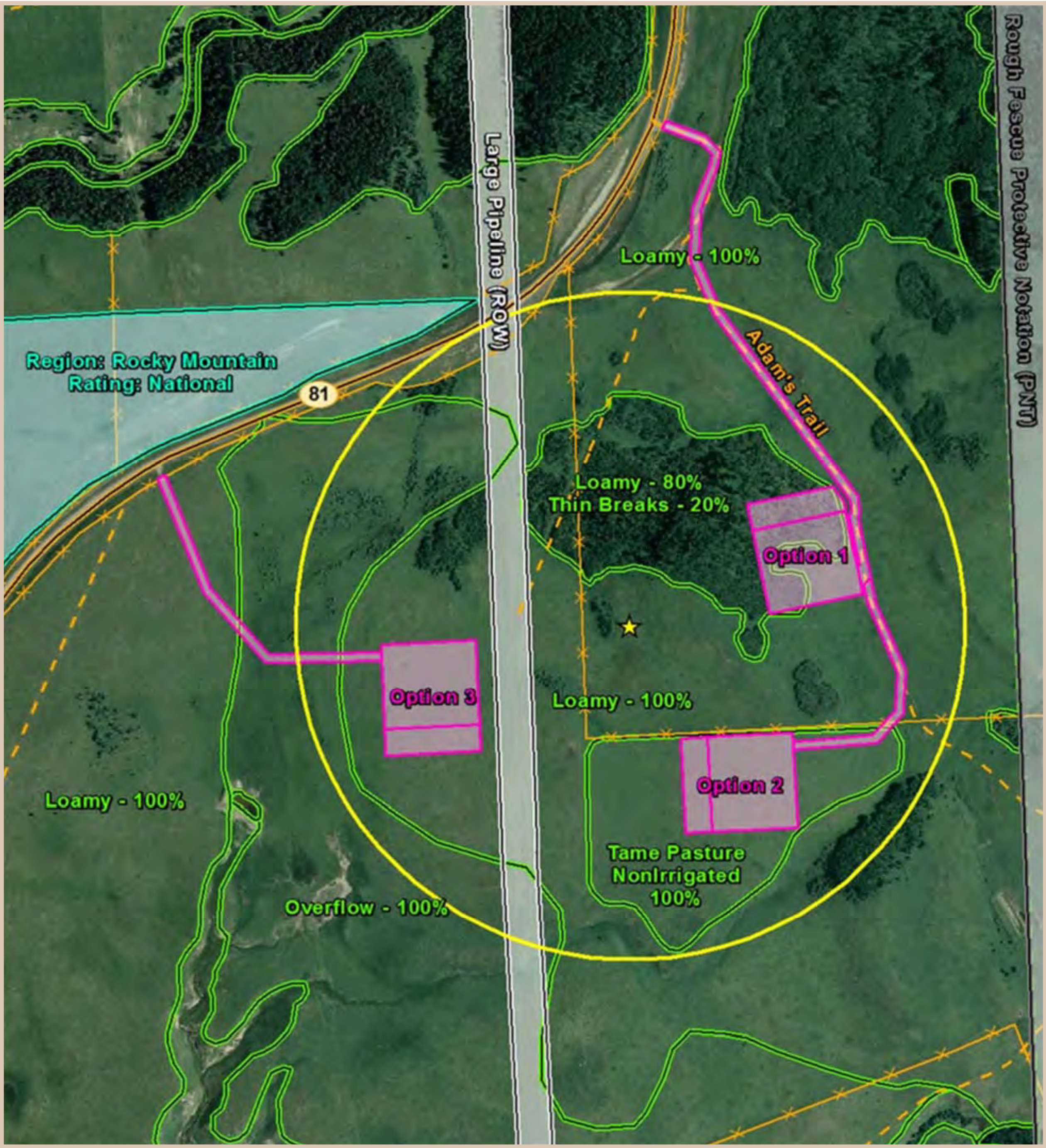
Referencing the above guidelines for minimizing surface disturbance in the Foothills Fescue, Foothills Parkland and Montane NSRs, consider:

- If wetlands occur within the study area, consult the AEP Alberta Wetland policy (AEP 2013b) and policy implementation documents.
- Avoid all native grasslands and particularly sensitive foothills rough fescue grasslands if possible (AEP 2016). 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? See Figure 8 for an example.
- If native grasslands cannot be avoided, 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 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 *"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 2016).

Figure 8 - Reduce Disturbance Through Site Selection



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

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, www.foothillsrestorationforum.ca, 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 (Updated 2013) (AEP 2013) "*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. A general timeframe to conduct field verification is June 1 to September 30. Document species composition and cover for each community in order to establish restoration targets. The target plant communities developed for each range site in Appendix A will assist with planning an appropriate seed mix if necessary. Appendix B summarizes seed sources for suitable grass species.

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. Use of buffer materials like construction matting can greatly reduce soil stripping requirements if used appropriately.

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 grassland restoration.

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

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

Incorporating Local Knowledge

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

The importance of local knowledge should never be underestimated.

Notify and Consult with Landowners and/or Grazing Disposition Holders

The following comments are summarized from stakeholder workshops and are presented here for consideration and discussion.

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

- Communication is extremely important. Ranchers have learned from experience what works and what does not work on their land.
- Specific guidelines for notification and consultation are required on Public Land grazing dispositions and grazing reserves on Public Land. They are included in the Integrated Standards and Guidelines of the Enhanced Approval Process (Gov't of Alberta 2013).
- When planning access and linear features, make an effort to use existing trails and old roads to minimize further fragmenting the landscape.
- 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 forming agreements for grazing and land management practices.
- Transparency and the opportunity for dialogue and collaboration on baseline vegetation information collected by developers and proposed seed mixes is important.
- 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 trenchlines can be a safety concern and an infrastructure integrity issue if sinkholes develop over time.
- Landowner cooperation is required when attempting natural recovery.
- Recovery is returning the landscape to how it was before development. Depending on the type of industrial development and the extent of soil disturbance or compaction, the type of forage can change and the amount of available forage on the ranch may be reduced for many years. The rancher will have to adjust their management plan to compensate for the impact of the development. The recovering disturbance needs to be able to tolerate grazing as soon as possible. The developer needs to understand this and work with the rancher to reduce the impact. Recovery is considered successful when the area where the disturbance occurred is no longer visible. Once recovered, livestock should graze both the disturbed and surrounding areas uniformly.

- 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. Expect a minimum of seven years or more depending on moisture conditions.
- Avoid soil disturbances during and soon after winter chinooks due to potential soil thawing.
- 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 and agronomic species are easily moved by equipment. Moving or bringing in soil from a remote area increases the risk of introducing invasive species.
- Weed management is another key issue of concern that extends beyond the initial development phase, through the operations phase to decommissioning and abandonment.
- Fencing, with access points for cattle, may be required during early stages to allow desired grazing impact to assist recovery.
- 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.
- Ungrazed areas can result in too much litter build up, which encourages invasive agronomic grasses and Canada thistle (Cirsium arvense) to move into the stand. 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 and improve restoration outcomes.
    - Electric fencing can be used to control grazing in specific areas for specific objectives.
    - Early and late season skim grazing can be used to suppress Timothy and brome.
    - Short term mob grazing can reduce the height of tall grasses, allowing shorter species to flourish.
- Maintain that vital communication link through the operations phase. Timely notification of access is important.. Use respect!

Use Respect!

Ensure Compliance with Regional Land Use Policy

The Foothills Fescue, Foothills Parkland and Montane Natural Subregions encompass a number of federal, provincial and regional policy directives regarding land use. Specific geographic areas where development in native grasslands 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 2016).
- The Public Lands Act (Gov't of Alberta 2014) and the AEP Enhanced Approval Process for upstream oil and gas development on Public Lands, specifically the *Integrated Standards and Guidelines* (Gov't of Alberta 2013) 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.
- Alberta Environment and Parks *South Saskatchewan Regional Plan* supports long-term management of land and natural resources including recreation on Public Land. It includes plans, mapping, signage, and other tools to be used to manage recreation and provide clarity about access to Public Land (AEP 2017).
- Indian Oil and Gas Canada is the responsible authority for oil and gas exploration and development on specified First Nations Reserves. Exploration and development planning and activities are federally regulated and must be compliant with the Canadian Environmental Assessment Act.
- 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 2016).
- Alberta Environment and Parks has issued guidelines for construction and maintenance of small dams: *Inspection of Small Dams* (AEP 1998). Control of spillways near grassland is of particular importance.
- 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 rough fescue grasslands for future generations.

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 grassland 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 Foothills Fescue, Foothills Parkland and Montane NSRs document that, with few exceptions, vegetation on loamy Black Chernozemic soils throughout the area is intolerant of disturbance, especially Foothills rough fescue grassland (Desserud et al. 2010; Tannas 2011; Sherritt 2012). Although the area has not been subjected to the extent of agriculture conversion found in more easterly natural subregions, mainly due to the undulating and strongly rolling geography, oil and gas development, urban expansion and poor range management have resulted in the loss of native grasslands in southern Alberta. 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 thrive on rich black soils and are major barriers to restoration in the Foothills Fescue, Foothills Parkland and Montane NSRs. These results support the need to avoid development on native grasslands in these subregions 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.

For topsoil disturbances, the primary recovery strategies for native grasslands in the Foothills Fescue, Foothills Parkland and Montane NSRs are assisted natural recovery and the use of native seed mixes.

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 Foothills Fescue, Foothills Parkland and Montane NSRs.

Recovery Strategies for the Foothills Fescue, Foothills Parkland and Montane NSRs

The accompanying flow charts (Figures 9 and 10) for disturbances to grasslands in the Foothills Fescue, Foothills Parkland and Montane NSRs provide a pathway for decision making when considering natural recovery, assisted natural recovery and native seed mixes.

Figure 9 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 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. 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 Foothills Fescue, Foothills Parkland and Montane NSRs 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.

Figure 10 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, 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 AVI). 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 Foothills Fescue, Foothills Parkland and Montane NSRs, reflecting systems developed for forests and grasslands. GVI will identify ecological range sites and AVI 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 weed and invasive plant concerns that are 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 9 and 10).

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” (Desserud et al. 2010). 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.

Figure 9 - Recovery Flow Chart for Minimal Vegetation and Soil Disturbances in Native Grasslands in the Foothills Fescue, Foothills Parkland and Montane Natural Subregions

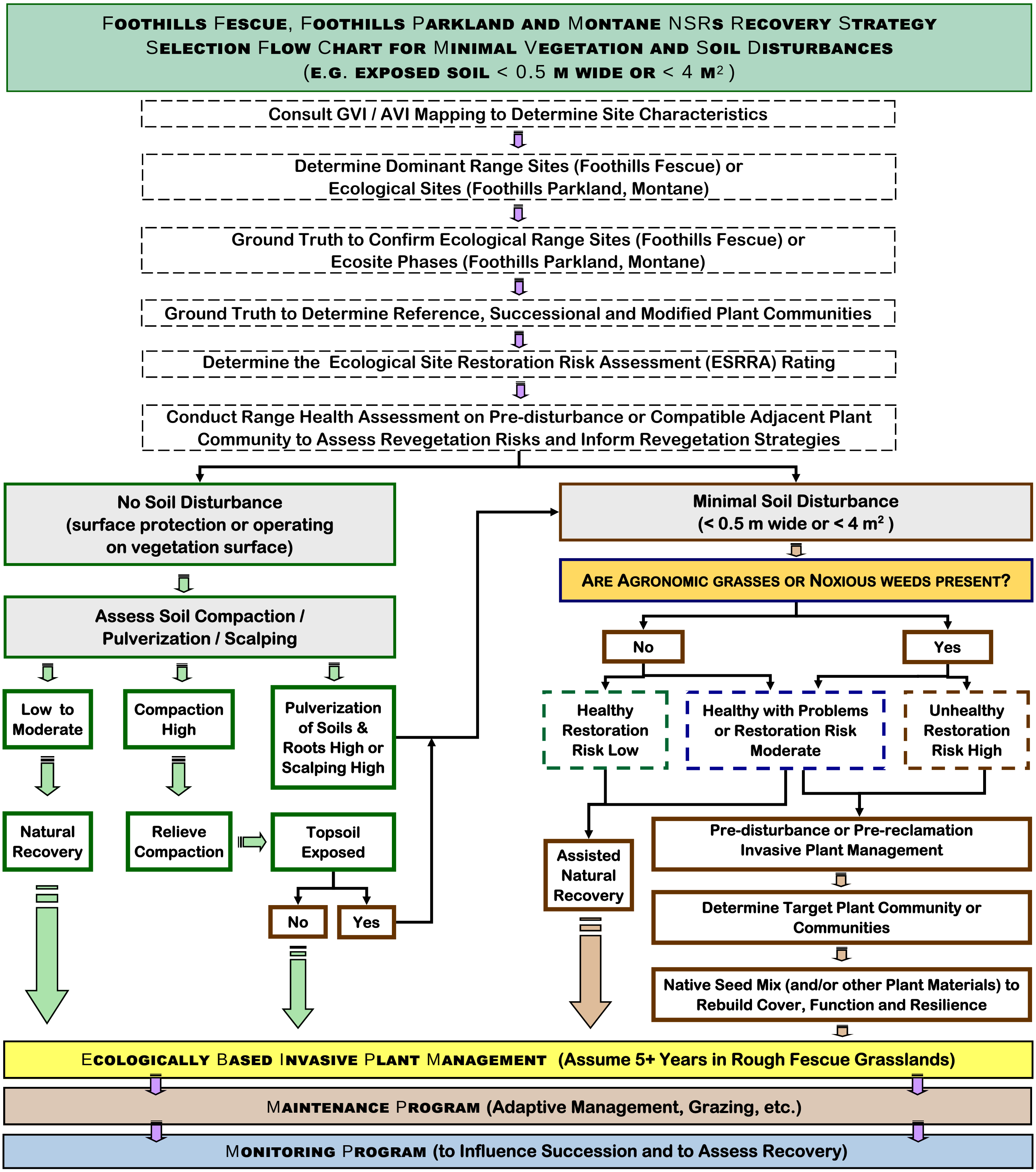
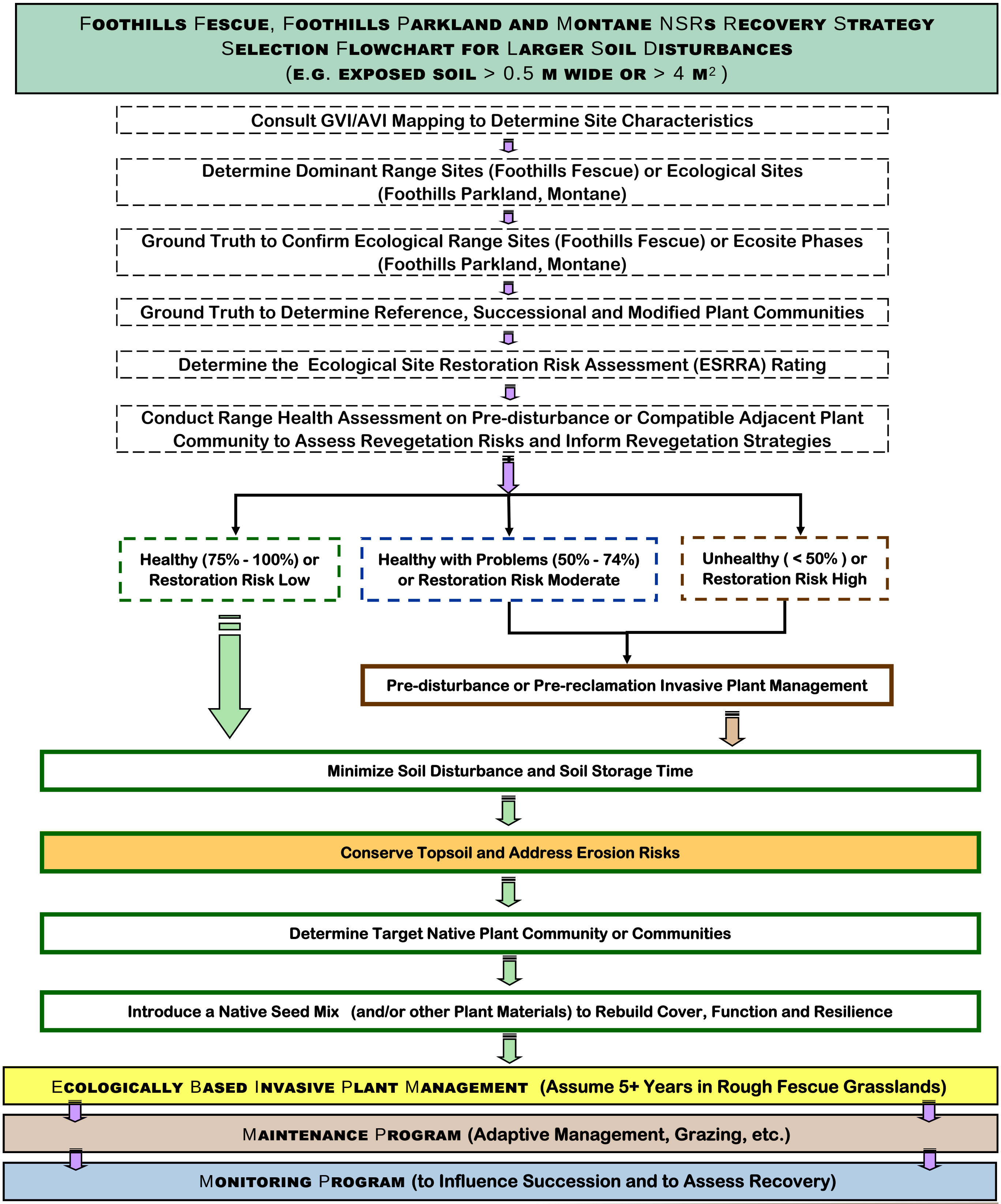


Figure 10 - Recovery Flow Chart for Larger Vegetation and Soil Disturbances in Native Grasslands in the Foothills Fescue, Foothills Parkland and Montane Natural Subregions



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 2016).

Reduce the width and size of surface disturbance. Foothills rough fescue native plant communities are particularly sensitive to soil handling and minimal disturbance practices are clearly advantageous to promote restoration. When burial of utilities is necessary, limit excavations and soil exposures to a small area ($<4m^2$), and linear disturbances from buried utilities to less than 0.5m wide over the trenchline to promote natural infill. Desserud et al. (2010) concluded that narrow disturbances in rough fescue dominated areas may result in native grass infill, including Foothills rough fescue. Larger exposures of topsoil are linked to the high risk of invasive species establishment in the Foothills Fescue, Foothills Parkland and Montane NSRs.

Construction matting or other buffers can be used to conserve vegetation and topsoil on temporary access and work pads. Use of construction matting can extend and improve operability on native grasslands without stripping soils.

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 can result in minimal damage to vegetation and soils. However, periods of warm chinook winds in the Foothills Fescue, Foothills Parkland and Montane NSRs may result in ground thawing, so be cautious when planning winter disturbances.

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 9).

Construction activity timing is also a critical 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. In many parts of the Grassland Natural Region, minimal disturbance construction practices are most successful in reducing impacts to native grasslands when conducted during dry or frozen ground conditions between August and early April (AEP 2010).

Warm chinook winds in the Foothills Fescue, Foothills Parkland and Montane NSRs may result in ground thawing, so be cautious when planning winter disturbances.

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.

However, southwestern Alberta is subject to very strong, warm Chinook winds in the winter that can rapidly thaw soils and cause serious delays in development activity. Rutting of unstripped vegetation and soils may occur and wind erosion, soil loss and admixing may occur on stripped soil piles. For these reasons construction and reclamation activities are most efficiently and effectively conducted between August 1st and December 15th under dry or frozen ground conditions in the Foothills Fescue, Foothills Parkland and Montane NSRs (AEP 2010).

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.

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 2013). 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.

In a Foothills Fescue NSR seeding experiment, Sherritt (2012) found several native species naturally emerged in plots where they were not seeded. The most prominent in the second year of recovery were native forbs, e.g. pasture sagewort (*Artemisia frigida*), non-native dandelion (*Taraxacum officinale*); and, invasive forbs, e.g. yellow sweet clover (*Melilotus officinalis*), annual hawkweed (*Crepis tectorum*), and Canada thistle. Native grasses also established, including June grass (*Koeleria macrantha*), green needle grass (*Stipa viridula*), alkali bluegrass (*Poa juncifolia*), Kentucky bluegrass and slender wheatgrass (*Agropyron trachycaulum ssp. trachycaulum*). Awnless brome, an invasive grass, also appeared (Sherritt 2012). In Woosaree and McKenzie's (2015) Foothills Fescue NSR experiment, natural recovery plots were dominated by prairie sagewort (*Artemisia ludoviciana*) after four years, with foxtail barley (*Hordeum jubatum*), slender wheatgrass, and various forbs also establishing.

In the Foothills Fescue NSR, Desserud et al. (2010) found good Foothills rough fescue establishment on a pipeline left to natural recovery 17 years after construction. On the other hand, despite being in rough fescue grassland, no rough fescue appeared in natural recovery plots in Woosaree and McKenzie's (2015) experiment after four years, nor in Sherritt's (2012) after two years.

Natural recovery works best where there is low erosion potential and good surrounding vegetation. Narrow linear or small disturbances have the best potential recovery. It is not a good option for urban areas due to the ubiquitous presence of invasive species.

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 attractive properties of black soils in the Foothills Fescue, Foothills Parkland and Montane NSRs facilitate invasion by non-native species, therefore care must be taken in natural recovery that invasive species are not nearby.

Invasive plant management and an adaptive management strategy (Figure 9) 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. Temporary fencing may be required in areas that are grazed. Fencing should be removed within three years, depending on vegetation establishment and litter build-up.

The natural recovery strategy for topsoil disturbances represents a significant risk of reclamation and restoration failure in the Foothills Fescue, Foothills Parkland and Montane NSRs.

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. It is required in areas prone to erosion.

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 Foothills Fescue, Foothills Parkland and Montane NSRs. 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 Foothills Fescue, Foothills Parkland and Montane NSRs), 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 common wheat (*Triticum aestivum*) will help utilize soil nitrogen and make the site less prone to invasion by perennial weeds (Sheley et al. 2006; Sherritt 2012; Woosaree and McKenzie 2015). Applying the seed at low seeding rates is essential to limit competition with desirable regeneration (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.

Although Sherritt (2012) had some success seeding Foothills rough fescue with Dahurian rye, other experiments had no success (Sheley et al. 2006; Woosaree and McKenzie 2015). Other species, such as Parry oat grass, June grass and Idaho fescue or bluebunch wheatgrass fared better when seeded with a rye cover crop.

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. 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. Local knowledge and communication with the landowner/grazing leaseholder is very important when considering the implementation of this strategy.

Native Seed Mixes

Long-term monitoring case studies conducted to prepare this manual (Lancaster et al. 2015) have illustrated the need for change in the way seed mixes are designed for native grassland. The native seed industry needs to evolve if the expected outcome is restoration. In the Foothills Fescue, Foothills Parkland and Montane NSRs 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 plant materials of the dominant species in the Foothills Fescue, Foothills Parkland and Montane NSR plant communities including Foothills rough fescue is essential. This will be achieved by changing the way native seed mixes are designed and 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 Foothills Fescue, Foothills Parkland and Montane NSRs. These disturbances include:

- decommissioned areas with significant soil exposure, such as wellsites, reclaimed access roads, large diameter stripped and graded pipelines;
- 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 to meet anticipated demand. Seed mix design considerations used in this publication encompass the species, plant communities and ecological range sites or ecosites currently described in the Foothills Fescue, Foothills Parkland and Montane NSR Range Plant Community Guides (Adams et al. 2005; Willoughby et al. 2008; DeMaere et al. 2012). 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 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 accurately reflect seed lot species composition and ensure high quality seed.

It is important to use and know the scientific name of species being purchased. Common names for plant species can differ by region or nation and scientific names can change over time as well. Appendix D provides lists of species and their corresponding common and scientific names.

Appropriate native seed can be difficult to source and expensive, a cost of disturbing rough fescue grasslands. Be wary of substitutions. Commercially available rough fescue seed is particularly prone to substitutions with inappropriate species such as Rocky Mountain fescue, hard fescue or sheep fescue, whose seeds are very similar. Though the names are similar they have very different structure and performance, with hard fescue and sheep fescue being non-native and invasive. Controlling invasive non-native plants is also expensive and time consuming.

Guidance on selecting and assessing native seed is provided in the publication "Plant *Material Selection and Seed Mix Design for Native Grassland Restoration Projects*" (Tannas and Webb 2016) available on the Foothills Restoration Forum website.

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

A shrubby drainage in the Foothills Parkland Natural Subregion

Seed Mixes for 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 grassland landscape. For instance, the current Range Plant Community Guides for the Foothills Fescue, Foothills Parkland and Montane NSRs (Adams et al. 2005; Willoughby et al. 2008; DeMaere et al. 2012) describe 65 native grassland plant communities, 33 native shrubland plant communities and numerous forested plant communities.

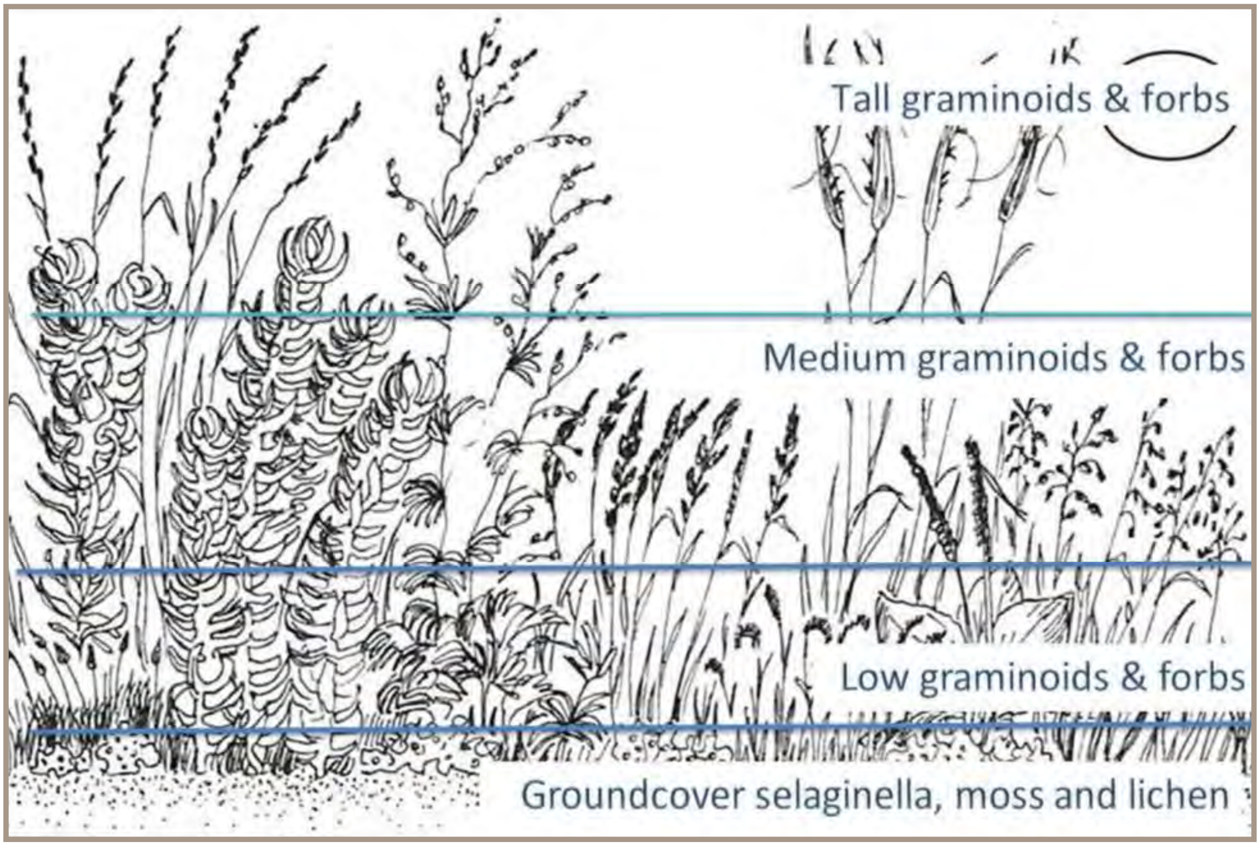
However, a number of ecological range sites support plant communities with common dominant native grass species. To assist with cost effective and practical seed mix design, it is necessary to establish which ecological range sites have similar growing conditions (based on AGRASID soil and landscape 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 A).

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). 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 revegetate disturbances in each ecological range site in the Foothills Fescue, Foothills Parkland and Montane NSRs. Example native seed mixes are provided for each target recovering plant community (Appendix A). When seeded at appropriate seeding rates, 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 Foothills Fescue, Foothills Parkland and Montane NSRs.

Figure 11 - Structural Layers in a Healthy Native Grassland Community



Background Image Courtesy of Alberta Environment and Parks - Rangeland Resource Stewardship Section

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 11). Diversity in the canopy structure provides resilience to herbivory and climate events. Seed mixes can be used to develop vascular plant structure for the low, medium and tall vegetation layers. 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).

Recommendations for seed mixes based on experiences of Recovery Strategies Workshop participants include:

- Select plant materials that are adapted to the range site. Suitable species for revegetating the variety of ecological range sites found in the Foothills Fescue, Foothills Parkland and Montane NSRs are presented in Appendix A: Target Recovering Plant Communities.
- Use a diverse seed mix and incorporate native species including forbs at some stage.
- Exclude rhizomatous wheatgrasses, e.g. Western or Northern wheatgrass from the seed mix or use at low percentages, as they can impede the establishment of slow-growing species such as Foothills rough fescue (Sherritt 2012; Desserud and Naeth 2013b).
- Slender or awned wheatgrass, although useful short-lived colonizers that typically die out within five years, may also impede the establishment of slow-growing species such as Foothills rough fescue.
- When in the seed mix, Foothills rough fescue should comprise at least 50% of the pure live seed in the mix.
- Including rough fescue plugs improves reclamation success.
- Choose species based on the desired trajectory and the role each species plays in stabilizing a site, building structure and resilience and the desired late seral plant community. Selecting only early or mid-seral species may not allow succession to occur. Late seral species for the target plant community must be included, either as seed or other plant materials if their presence is desired in the restoration outcome.
- For range sites where shrubs are common components of the plant community, such as thin breaks in the Montane NSR, include component species such as juniper (*Juniperus sp.*) and kinnikinnik (bear berry) (*Arctostaphylos uva-ursi*).

Seed mix design also requires assessment of seed availability, viability, purity, size, seeding rates and seeding methods (refer to Section 7). 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.

Some additional recommendations include:

- Seeding rate recommendations for native species are traditionally 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. Use a seed mix calculator to balance seed weight versus the proportion of pure live seed desired.
- Adjust the seed mix to accommodate smaller seeds, e.g. increase the proportion by weight.
- Test seed lot for viability, purity and undesirable species (Tannas and Webb 2016).
- Use seeding methods and equipment which allows the incorporation of small native seeds such as broadcast seeding.
- Include a binder such as rice, worm castings, etc. to weigh seeds down.
- Include a carrier to help diverse seed sizes and shapes from separating in the seeder and to improve flow and distribution of the seed into the seed bed.

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 a cultivar may improve the reliability of seed germination, it often results in a loss of species diversity because of genetic shift (Woosaree 2007). In Alberta successful native plant varieties suitable for use in the Foothills Fescue, Foothills Parkland and Montane NSRs have been developed by Alberta Innovates - Technology Futures (now Innotech Alberta) (Table 3). Other varietal releases that may be suitable for higher sites in the Montane or Subalpine are listed in Table 4.

Table 3 - InnoTech Ecological Variety Releases Suitable for Foothills Fescue, Foothills Parkland and Montane NSRs

Varietal Release	Soils Adaptation	Origin
'ARC Mountain View' June grass	Black Chernozem, Brown	Crowsnest Pass
'AEC Hillcrest' awned wheatgrass	Black Chernozem, Dark brown, Brown	Crowsnest Pass
'AEC Highlander' slender wheatgrass	Black Chernozem, Dark brown, Brown	Rocky Mountains of Alberta
'ARC Plateau' Rocky Mountain fescue	Black Chernozem, Brown	Rocky Mountains of Alberta
'ARC Butte' Rocky Mountain fescue	Sandy	Near Waterton Lake Nat'l Park

(Innotech Alberta 2016)

Table 4 - InnoTech Ecological Variety Releases Suitable for Selected Sites in Montane and Subalpine NSRs

Varietal Release	Soils Adaptation	Origin
'AEC Mountaineer' broad-glumed wheatgrass	Mountain soils, nutrient poor soils	Rocky Mountains of Alberta
'AEC Glacier' alpine bluegrass	Black Chernozem, Dark brown, Brown	Lower elevation in the Rocky Mountains of Alberta
'AEC Blueridge' alpine bluegrass	Black Chernozem, Dark brown, Brown	Rocky Mountains of Alberta
'ARC Sentinel' spike trisetum	Black Chernozem, Dark brown, Brown	Rocky Mountains of Alberta
'ARC Vista' alpine fescue	Black Chernozem, Brown	Rocky Mountains of Alberta

(Innotech Alberta 2016)

Seeding Forbs

Recovery of perennial forbs other than the disturbance colonizing sageworts is lacking on sites where grass seed mixes are used (Appendix C and Lancaster et al. 2015). Inclusion of forb 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. Staged introduction of forbs is a useful strategy if reclamation sites are likely to use herbicides initially to control weeds.

Forb seed can be difficult to source in quantity but there are suppliers for a number of species common to the Foothills Fescue, Foothills Parkland and Montane NSRs. The Alberta Native Plant Council maintains a Native Plant Source List (ANPC 2016) as does the Canadian Grassland Native Plant Materials Exchange website (www.Hardgrass.ca). Suitable species will be those found in the surrounding plant community. Possible successful species for the Foothills Fescue, Foothills Parkland and Montane NSRs include pasture sagewort (*Artemisia frigida*), smooth aster (*Aster laevis*), yellow avens (*Geum macrophyllum*), three-flowered avens (*Geum triflorum*) and sticky geranium (*Geranium viscosissimum*).

Wild Harvested Seed

Several important, long-lived, late seral species in Foothills and Montane ecosystems, such as Parry oat grass, Western porcupine grass and Foothills rough fescue, are not grown commercially in large quantities. Wild harvesting these species can be a valuable source of locally adapted species for restoration. "Bi-catch" of other native species during the wild harvesting process can also be useful to add diversity to a site.

Examples of successful use of wild harvested grasses are documented on the Express Pipeline (Kestrel Research Inc. and Gramineae Services Ltd. 2011). For reclamation of Mixedgrass rough fescue sites on the Express Pipeline, rough fescue was wild harvested from two sources, Plains rough fescue "Roes" from the Hand Hills and likely Foothills rough fescue "Petherbridge" from the Milk River Ridge and Hand Hills. Establishment was very slow initially, typical of rough fescue. However, 14 years after seeding, average cover of rough fescue on the seeded RoW was more than 50% of the average cover on the controls.

Wild harvested June grass also performed well on Mixedgrass sites on the Express Pipeline, reaching average cover values close to those of the controls by the third year. It performed comparatively better than the June grass cultivar used in the Dry Mixedgrass seed mix.

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 Foothills rough fescue, seed density can be sufficient for mechanical harvesting. Further guidance on wild harvesting is provided later in this document within the "Guidelines for Wild Harvested Native Plant Material" section.

Native Hay Mulch

Native hay can also be a viable technique for procuring a reliable seed source that is adapted to local site conditions. Native hay also provides mulch to retain moisture and prevent erosion. 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 application methods, such as crimping, to keep the hay in place (Desserud and Naeth 2011). No evidence of using native hay in the Foothills Fescue, Foothills Parkland and Montane NSRs has been found, nevertheless there is no reason preventing its harvesting and application to disturbances.

Foothills Rough Fescue

Foothills rough fescue is almost exclusively available as wild harvested seed. No cultivars have been developed. Foothills rough fescue may not produce large volumes of seed every year; however, when it does, rough fescue often has a mast-flowering event. Mast flowering occurs when all occurrences of a species over a large area flower simultaneously. Nevertheless, occasional rough fescue plants flower every year, and may be harvested by hand (Neville, M., personal communication. 2012., Tannas, S., personal communication. 2010).

Foothills rough fescue does not reliably establish when seeded. Desserud et al. (2010) found little to no rough fescue on pipelines in the Foothills Fescue, Foothills Parkland and Montane NSRs, despite having been seeded with rough fescue seven to twenty years prior. In seeding experiments in Montana, in a Foothills Fescue NSR environment, Foothills rough fescue failed to establish from seed (Sheley et al. 2006; Pokorny and Mangold 2009).

Wheatgrasses may impede the establishment of slow-growing species such as Foothills rough fescue (Sherritt 2012; Desserud and Naeth 2013b). Sherritt (2012) had success seeding Foothills rough fescue on reclaimed sites in the Foothills Fescue NSR; however, he found it established (after two years) only when seeded as a monoculture with little competition from other grasses. On the other hand, Tannas (2011) found good establishment of Foothills rough fescue four years after seeding, including recruitment of seedlings from seed rain.

Infill

Infill is the natural re-establishment of plants on disturbances from propagules in the soil or from the surrounding area. In the Foothills Fescue, Foothills Parkland and Montane NSRs important early seral infill species include June grass, Idaho fescue and bluebunch wheatgrass.

Recovery of perennial forbs other than the disturbance colonizing sageworts is lacking on sites where grass seed mixes are used (Appendix C and Lancaster et al. 2015). Inclusion of forbs 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.

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 same Natural Subregion, 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 climate conditions 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. Climate conditions in the foothills are harsh for young tender plants.

Several Foothills Fescue, Foothills Parkland and Montane species may be propagated from transplants or seedling plugs (Table 5). Considerations for transplants or plug planting include:

- Foothills rough fescue plugs must be at least 4 to 6 months old;
- Fall planted plugs may be susceptible to frost heave, where plugs are pushed out of the soil;
- Plugs and transplants may be susceptible to herbivory, e.g. ground squirrels and other wildlife, especially if newly planted in spring or fall when other species are not yet green; and
- Including native seed with plug planting may provide a back up and improve success.

Table 5 - Species Successfully Propagated as Plugs or Nursery Plantings

Common Name	Scientific Name	Type	Reference
Foothills rough fescue	*Festuca campestris*	plugs	Tannas 2011, Woosaree & MacKenzie 2015
Idaho fescue	*Festuca idahoensis*	plugs	Ewing 2002a
Parry oat grass	*Danthonia parryii*	plugs	Woosaree & MacKenzie 2015
bluebunch wheatgrass	*Agropyron spicatum*	plugs	Page and Bork 2005
Richardson’s needle grass	*Stipa richardsonii*	plugs	Page and Bork 2005
Columbia needle grass	*Stipa columbiana*	plugs	Canada Parks, pers. comm.
bearberry, kinnikinnik	*Arctostaphylos uva-ursi*	plugs	Canada Parks, pers. comm.
creeping juniper	*Juniperus horizontalis*	1 gal tub	Canada Parks, pers. comm.
rose	*Rosa* species	1 gal tub	Cross, J. pers. comm.
wild gooseberry	*Ribes oxycanthoides*	1 gal tub	Cross, J. pers. comm.
Balsam poplar	*Populus balsamifera*	1 gal tub	Cross, J. pers. comm.

Many native plants have specific germination requirements to reduce seed dormancy and increase seedling survival. Seed produced by native plants may be subjected to a number of factors that promote germination, including; freeze thaw cycles, scarification by coarse textured soils and acid treatment from being ingested by wildlife or livestock. Other factors include soil temperature, moisture, or sunlight intensity or duration 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.

Foothills Rough Fescue Seedlings

Importance of Seed Source - Notice the difference in color and size of leaves, both are the rose species Rosa acicularis.
The left is a seed source from south of Pincher Creek, AB in the Montane NSR while the one on the right is a seed source from the Norman Wells area, in the NWT.

Considerations for Fragmented and Heavily Disturbed Sites

In many situations, native grassland near existing disturbances such as wellsites and associated facilities is no longer a uniform, undisturbed native plant community. Native grassland in urban settings may have been invaded by agronomic grasses such as smooth brome, or noxious weeds. Reclaimed old disturbances create a patchwork of well-established invasive plant communities (e.g. Timothy or smooth brome) and native plant communities that create a challenge for restoration. Successful restoration strategies for these hybrid or fragmented sites can be complex. It is important to conduct a detailed vegetation inventory on site, just off site, and in undisturbed areas further away off site. This can help determine the greatest factors of influence on a heavily disturbed site (e.g. pipelines with shared rights-of-way, existing disturbances that have been re-developed to reduce new 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 heavily disturbed and fragmented sites include the following.

- Pre-construction spraying of undesirable invasive species on site. This can kill living plants but a seedbank may persist for older occurrences.
- Remove accumulated litter thatch that may be reducing range health, harbouring undesirable seed or reducing opportunities for infill by native species (e.g. raking or fire).
- Mow the site while the natives are not actively growing.
- Wipe out the invaded sward of native and non-native communities completely and start from scratch.
- Treating the area with high nitrogen fertilizer to break down thatch (however this may give weeds a competitive advantage over native plants, which are adapted to low nitrogen conditions).
- On very depleted soils, seed wild legumes to add soil nitrogen, including Canadian milk vetch (*Astragalus canadensis*), purple prairie clover (*Petalostemon purpureum*) and American vetch (*Vicia americana*).
- Start with a cover crop to allow control of weedy annuals, then seed perennials in subsequent years.
- Seed 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 Foothills rough fescue is in the mix.
- Monitor regularly and often and conduct adaptive management as necessary to promote the establishment of native vegetation (see the section on “Maintaining the Pathway”).

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

Considerations for Wetlands

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 2013b).

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 (Gov't of Alberta 2013).

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 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 2013).

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

During reclamation, replacing stripped subsoils and topsoil so that the original wetland contours are 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 grassland wetlands. Zonation patterns of wetland vegetation communities occur in response to dynamic seasonal moisture conditions. Grassland 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 grassland 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). Most 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 fachines or live staking. Riparian areas are associated with both lentic and lotic water bodies.

Considerations for Shrublands

Shrublands are common in the Foothills Parkland and Montane NSRs and are often associated with the perimeters of grassland areas. Shrubland soils are different than grassland soils and care should be taken on sites that impact both grassland and shrublands to ensure soils are not mixed during disturbance.

In areas where shrubs have encroached into native grasslands, the soils may still be Chernozems, suited to re-establishment of grasslands.

If soils are not exposed during project disturbance, species like willows (*Salix species*), snowberry (*Symphoricarpos albus*), buckbrush (*Symphoricarpos occidentalis*), rose (*Rosa species*), wild gooseberry (*Ribes oxyacanthoides*), silverberry (*Elaeagnus commutata*) and red osier dogwood (*Cornus stolonifera*) can be cut flush with the ground, mulched and left to regenerate naturally. Any shrub plantings should be done as soon as possible post-disturbance. Recovering shrublands need regular monitoring and weed control, particularly for Canada thistle.

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 2013). 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. 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, hence the importance of periodic monitoring.

7 IMPLEMENTNG THE STRATEGY

Findings of the pre-disturbance site assessment (or the area surrounding an old disturbance), the size and the 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, seeding or planting. 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 sufficient volumes of appropriate native seed.

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

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 size of the area where topsoil is 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 grasslands are not flat. Micro-contouring and a roughened surface facilitates seedling survival. A roughened surface retains more moisture, provides shade and shelter for seedling growth, and reduces erosion potential. This is particularly important in windy environments. 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. Hand flipping sod tussocks to promote root to soil contact is effective on smaller disturbances. Snow fences may also help produce micro-climates by blocking wind, collecting snow and increasing moisture capture.

Recommended Timing of Reclamation Activities

Late fall after the first hard frost or early spring as soon as soils can be worked are the best times for seeding cool season grasses such as Foothills rough fescue, native wheatgrasses, Parry oat grass, or Idaho fescue. Sherritt (2012) had success seeding these species in mid-summer, however, risk of failure is greater given the potential for very dry and hot weather.

Selecting Equipment to Suit the Strategy

Native seed mixes usually include a combination of large and small seeds which are difficult to blend evenly and result in uneven seed dispersal and bridging in the seeding equipment. One solution to these problems is to have the small seeds blended and bagged separately from the large seeds. Most drill seeders used in reclamation such as those made by Great Plains, Truax and 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 promotes 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 or Parry oat 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.

There are several reclamation contractors in Alberta with custom equipment and expertise in seeding native grasses. Prairie Habitats Inc., based in Argyle, Manitoba, 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 Foothills Fescue, Foothills Parkland and Montane NSRs 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 Foothills Fescue, Foothills Parkland and Montane NSRs if possible or no farther away than western Canada or the interior or the northwest United States. Table B-1 in Appendix B identifies some seed sources for characteristic species in the Foothills Fescue, Foothills Parkland and Montane NSRs.
- 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 seeded species such as native wheatgrasses or Western porcupine grass requires a minimum 50 gram sample size. Small seeded 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 Parry oat grass, Western porcupine grass or Foothills rough fescue to ensure an adequate supply for the project. Some companies are listed on the Alberta Native Plant Council website (ANPC 2016) and on the Canadian Plant Materials Exchange website (www.hardgrass.ca) through their supplier listings. The MD of Ranchland also has a seed collection program. Specify the ecological range sites from which the material should be harvested. Obtain, review, approve and retain on file Certificates of Seed Analysis for each species harvested.
- When ordering native plant cultivars, preferentially order varieties produced specifically for the Foothills Fescue, Foothills Parkland and Montane NSRs by reputable research institutions such as Alberta Innovates (now Innotech Alberta). Consider forward contracting to ensure an adequate supply of appropriate species.
- Specify source identified seed grown within western Canada or the northwest United States. 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, use the scientific nomenclature as well as the common name, and cultivar/variety or Ecovar if applicable.
- There is zero tolerance of seed lots containing Restricted Noxious Weeds or Noxious Weeds as identified in the Alberta Weed Act Regulation (Gov't of Alberta 2010) or by a municipality.
- Seed lots containing invasive agronomic species such smooth brome, Timothy, orchardgrass, meadow foxtail (*Alopecurus pratensis*), Canada bluegrass, quack grass (*Agropyron repens*, also known as *Elymus repens*), foxtail barley, sweet clover, alfalfa or Kentucky bluegrass should also be rejected. These species will negatively affect reclamation outcomes and increase requirements for control during the adaptive management stage. One exception to this is, if the site already supports Kentucky bluegrass, trace quantities in a seed lot that is otherwise unavailable may be acceptable.
- Be aware that some private landowners and specifically certified organic producers will have specific requirements and specifications for seed mixes and weed control.
- Examples of a Certificate of Seed Analysis and an explanation of interpretation can be found in the document "Plant Material Selection and Seed Mix Design for Native Grassland Restoration Projects" (Tannas and Webb 2016) hosted on the Foothills Restoration Forum website.

Guidelines for Wild Harvested Native Plant Material

Commercial seed sources for several dominant grasses (e.g. Foothills rough fescue, Parry oat grass and Western porcupine grass) and many other grasses and forbs associated with grasslands in the Foothills Fescue, Foothills Parkland and Montane NSRs are either not available or very limited. In order to obtain the plant material for the key dominant species required for restoration projects in rough fescue grasslands, the material may have to be obtained through a process known as "wild harvesting". Considerations for wild-harvesting grassland species include the following.

1. ***Wild harvesting should only be considered on sites that are in healthy range condition*** and free of Prohibited Noxious and Noxious weeds and invasive non-native agronomic species such as Timothy, smooth brome, Kentucky bluegrass, orchard grass, Canada bluegrass, quack grass, alfalfa and sweet clover.
2. ***Harvesting, Care and Processing.*** There is specially designed equipment available that harvests only the seed from mature flowering stems graminoids such as Foothills rough fescue, Western porcupine grass, Parry oat grass, June grass, or Idaho fescue. The target species must be in the mature seed set stage, when it is likely to be most viable. Care must be taken to ensure the collected seed is allowed to dry and cure following the harvest. The seed can then either be spread directly on the area to be restored, tested for composition and stored for future use or sale or cleaned and marketed as a single species. However, suitable "bicatch" of other native species in a harvest can be an added bonus for introducing diversity to a reclaiming site.
3. ***Wild harvested seed collection for storage and future use.*** There is considerable variability in the amount of seed set by native grass species in a given year. This is particularly true for Foothills rough fescue, which can grow for seven or more years without abundant seed set. Planning ahead to ensure a source of seed and taking advantage of years when seed is set in quantity can create a valuable inventory of seed for future reclamation projects.
4. ***Wild harvested seed collection for field propagation and production.*** Wild collections are the foundation for developing locally adapted seed stocks, varieties and cultivars. This can include small scale production to increase supplies of a small collection as well as larger programs like the Ducks Unlimited Ecovar program and the Alberta Research Council (Alberta Innovates) source identified program.
5. ***Seed collection of specific native grasses and forbs for nursery propagation of live plant material.*** Live plants grown from wild-harvested seed can provide a more reliable way of re-establishing species to a reclamation site. Seedlings (plugs) installed throughout a site, or planted in islands on larger sites, can increase diversity, accelerate the establishment of key slow growing species like Foothills rough fescue and Parry oat grass and create a seed source within the disturbed area.
6. ***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 and compensation 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 in Alberta.

1. The proponent will be required to obtain written consent from the grazing leaseholder for the area where the seed harvest is planned.
2. Only healthy range sites will be selected for seed harvest that are free of Prohibited Noxious, Noxious and invasive non-native species.
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 Temporary Field Authority (TFA) will be issued by the Range Agrologist to authorize the harvest.
4. Harvesting equipment must be clean and free of seeds from other areas.
5. Seed harvesting will be done using an alternating strip approach such that only half of the area is harvested.
6. 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).

Consult other jurisdictions to determine if other guidelines are in place and/or if permits are required. It is recommended that these guidelines be implemented as appropriate when harvesting on private lands.

Wild-harvested Silver Sagebrush (Artemisia cana)

Guidelines for Harvesting Native Hay Mulch

Although there are no documented instances of using native hay mulch in foothills rough fescue grasslands, it has been successfully used in plains rough fescue grasslands and may be of value as a locally adapted seed and mulch source.

The Guidelines for Wild Harvesting Native Seed for site access permissions and site selection would be the same for harvesting native hay mulch. Additional guidelines that pertain to native hay cutting are as follows.

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 essential.
2. Mechanical harvesters should be adjusted to accommodate rough fescue tussocks, harvesting only the seed heads.
3. Native grassland should be cut in strips, leaving uncut strips to act as a seed rain source for the cut areas.
4. The amount of native grassland required for harvesting varies between Natural Subregions. In moister rough fescue dominant areas, roughly 2.5 times the disturbance area may suffice. This includes sufficient area for uncut strips.
5. Native hay should be crimped or harrowed into the soil to ensure good contact and prevent being blown away.
6. Chopped material may also adhere better to the soil if wet, from a rainfall or from watering.
7. If the source 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.
8. Native hay mulch harvesting should not occur on the same site for a period of 7-10 years following the harvest (depending on climate and range health conditions).

Finally, wild harvested native plant material is a precious resource. Before harvesting, make sure there is a specific need and/or market for the material. Never take more than is required to meet the need and ensure careful handling and storage of the plant material in cool dry conditions.

Native hay can be a source of locally adapted seed, including species that are not available commercially.

Certificates of Analysis versus Certified Seed - What is the difference?

An emerging misunderstanding in conditions applied to some reclamation projects is that native seed can and should be “certified” to be used for revegetation. There are very few native reclamation species that have this designation under the Canada Seeds Regulation (Government of Canada 2017). Applying this condition would prevent the use of many species, including any wild-harvested local seed, a potentially valuable seed source for reclaiming native ecosystems.

The Seeds Act and Seeds Regulations of Canada establish the standards for the grading of crop seeds as described in the Seeds Regulation Grade Tables. Crop seeds include the majority of cultivated crops (including forage crops) grown in Canada. In the Canada Seeds Act, certified status, with respect to seed, means that:

a) *where the crop from which the seed is derived was grown in Canada,*

   i. *a crop certificate designated “Certified” has been issued for that crop by the Association, and*

   ii. *the seed meets the standards for varietal purity established by the Association for seed of that kind or species, or*

b) *where the crop from which the seed is derived was not grown in Canada,*

   i. *the crop meets the standards established by an official certifying agency and approved by the Association, and*

ii. *the seed meets the standards for varietal purity established by the official certifying agency for seed of that kind or species and approved by the Association; (qualité Certifiée) (Government of Canada 2017).*

Some of the native wheatgrasses and blue grasses developed as varieties for forage and reclamation are included in the list of registered crop seed (e.g. Northern wheatgrass, Western wheatgrass, Slender wheatgrass, Fowl bluegrass). However, there are many native species (or non-crop seeds) produced and traded in low volumes for reclamation and restoration of native ecosystems that do not have grading standards.

What is important and necessary is that all reclamation seed lots, whether wild harvested or otherwise, are tested by a laboratory for species composition (purity) and documented with a "**Report of Analysis**", the document issued by the laboratory, giving the final results of laboratory tests. Other names for the report include Report of Seed Analysis, Certificate of Seed Analysis and Laboratory Report of Analysis.

This **Report of Analysis** is also based on the standards for grading crop seed and is not well adapted to the needs of the native plant reclamation industry. Categories of the analysis methodology that are applicable to native species seed testing include the assessment of; pure seed, ergot, weed seed count, (individual seeds per sample), inert matter, pure living seed, germination and the tetrazolium chloride (tz test) for seed viability. Categories of the analysis methodology that need revision for native species seed testing are the "other weed seeds" and "other crop seeds" categories. These categories can often include species that are either also native and may be beneficial to the reclamation or species that are invasive and must be avoided.

An additional step, worthwhile for seed that is easily misidentified such as Rocky mountain fescue (which is frequently confused with invasive non-native sheep fescue), is double-checking the validity of the seed identification. This can be done by; obtaining a "Certificate of Authenticity" for the seed lot, supplied by a qualified plant taxonomist who obtains a sample plant or inspects the field or harvest location to ensure the species identification is accurate (Tannas and Webb 2016).

8 Maintaining the Pathway

Restoration projects 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 planning phase. The program should incorporate all of the relevant pre-disturbance site assessment information, details of the restoration plan, seed sources 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 plant 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 aware of the desired long-term outcome of native grassland restoration and familiar with the 2010 Reclamation Criteria for Wellsites and Associated Facilities for Native Grasslands (Updated July 2013) (AEP 2013), which identifies measurable goals for species diversity and cover. Control of specific weed/ invasive species at identified locations by spot spraying with targeted herbicides 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. However, blanket spraying or wick application is sometimes necessary. Careful timing when desirable species are dormant or shorter in stature can be effective and reduce collateral impacts to desirable species.

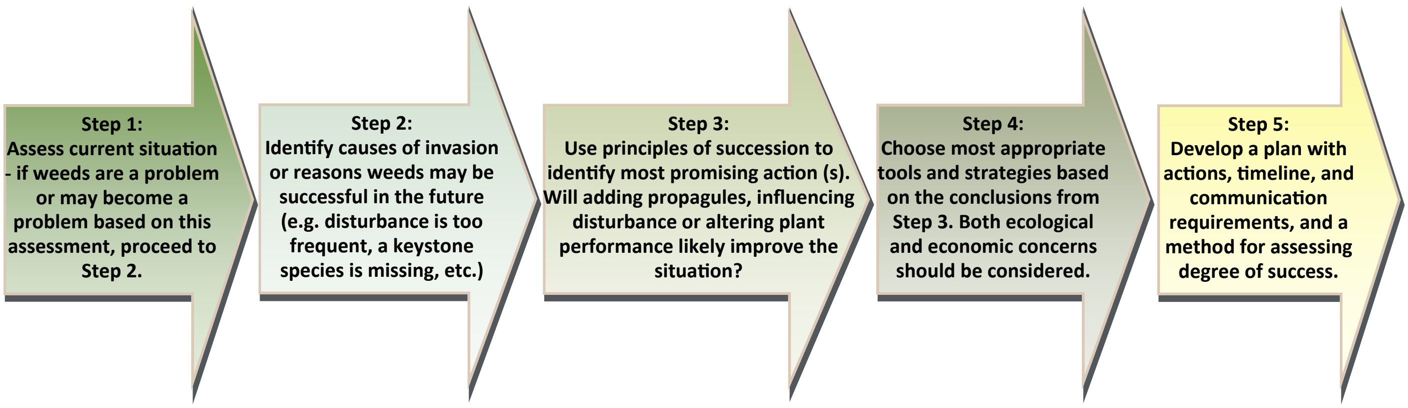
On private lands discuss invasive plant management with the landowner. Be aware that certified organic producers will have specific requirements and specifications for weed control.

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 12) (Rangelands 2012).

Figure 12 - 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 Foothills Fescue, Foothills Parkland and Montane NSRs of Alberta.

The Noxious Weeds section of the Range Health Assessment Workbook (Adams et al. 2016) 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 - 'Understanding the Process of Succession' of this manual 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 Foothills Fescue, Foothills Parkland and Montane NSRs are identified in Appendix C. 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. 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 C-1 (Appendix C) indicates if cattle grazing is an option to assist with 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 (e.g. 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.

- Controlled burns are a possibility for willow encroachment and weed invasions. However, they require municipality or provincial approval.
- Some native species can persist and compete with invasive species (Table 6). Increasing seeding rate of competitive native species may help, but be careful of the seed rate of species that compete with other native species.

Table 6 – Native Species that Compete with Invasive Species

Common Name	Scientific Name	Common Name	Scientific Name
Competition with weeds in general		**Competition with Kentucky bluegrass**	
wild blue flax	*Linum lewisii*	Northern wheatgrass	*Agropyron dasystachyum*
tickle grass	*Agrostis scabra*	Western wheatgrass	*Agropyron smithii*
Northern wheatgrass	*Agropyron dasystachyum*	low goldenrod	*Solidago missouriensis*
green needle grass	*Stipa viridula*	June grass	*Koelaria macrantha*
Rocky mountain fescue	*Festuca saximontana*		
Idaho fescue	*Festuca idahoensis*	**Competition with Canada thistle**	
pasture sagewort	*Artemesia frigida*	fireweed	*Epilobium angustifolium*
annual rye*	*Lolium* spp.	yarrow	*Achillea millefolium*
tufted white prairie aster	*Aster ericoides*	three-flowered avens	*Geum triflorum*
		blue grama	*Bouteloua gracilis*
Competition with smooth brome			
Canada wild rye	*Elymus canadensis*	**For wet areas**	
blue wild rye	*Elymus glaucus*	tickle grass	*Agrostis scabra*
smooth aster	*Aster laevis*	tufted hair grass	*Deschampsia caespitosa*
keeled brome	*Bromus carinatus*		
fireweed	*Epilobium angustifolium*		
goldenrod	*Solidago canadensis*		

** Seed as a cover crop; mow before seeding as it may persist*

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 under historic disturbance regimes dominated by fire and 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. 2016). Restoration sites located in fields with unhealthy range health scores may 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 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, usually within 3 years in the Foothills Fescue, Foothills Parkland and Montane NSRs. The AEP *Range Health Assessment Field Workbook* (Adams et al. 2016) (Figure 7, Page 36 of the Field Workbook) provides litter data for Foothills Fescue soil types. 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. 2006).

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

Set Measurable Goals and Objectives

The goal for restoration of native rangelands is to re-establish mature native plant communities on a disturbance that are suited to the ecological range site and equivalent in composition, structure and successional stage to the surrounding native grassland. The process of recovery evolves over time through initial establishment 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 2013) provide established methods that can be used as a baseline for monitoring and targets for defining successful recovery.
- Set goals for Range Health, referring to Adams et al. (2016) Range Health Assessment for Grassland, Forest and Tame Pasture.
- Refer to the relevant Range Plant Community Guides 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 extrapolationg 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.

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 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.

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 Foothills 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.
- It is not possible to estimate an accurate timeframe at this time. Drier range sites and areas recovering from minimal disturbance such as matting, may recover in about 5 to 10 years. Moister areas, areas with friable soils, and rich black Chernozemic soils may require 15 - 30 years or more and ongoing adaptive management to keep successional processes on track. Restoration to the pre-disturbance foothills rough fescue plant community on industrial topsoil disturbances has not been documented to date but is estimated to be more than 30 years (AEP 2010).

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 2016) for all proposed disturbances.

- For wellsites, the 2010 Reclamation Criteria for Wellsites and Associated Facilities for Native Grassland (AEP 2013) 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 (Adams et al. 2016).

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

Vegetation establishment on disturbed topsoil should be monitored for seedling composition, rather than determining percent foliar cover of each species, for the first few years after disturbance when seedlings are small.

- Observations are typically collected for 10 to 15 ¼ m^2 subplots (frames) and averaged. More subplots are recommended for sites with greater variability. For smaller topsoil disturbances such as a contruction pad or wellsite, frames are placed randomly or along a transect. For a linear disturbance, such as a pipeline or transmission trench, set out 30 m transects and place ¼ m^2 subplots every 2-3 metres. Count the young plants for each species in each subplot and average the count. Compare the species composition on site to the seed mix. Low counts may require re-seeding (Hecker and Neufeld 2006). However, large areas of bare ground around and under seedlings is normal in the first three years, and will potentially infill native species from surrounding undisturbed areas.
- Conduct Range Health Assessments using the current manual (Adams et al. 2016 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), soil issues 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. Following are some beneficial adaptive management considerations early in the restoration process.

- Fencing to prevent grazing by livestock or wildlife can be useful in the first 1 to 3 years to allow plant germination and establishment (see Grazing Management section).
- A flush of annual weeds and native forb species during the first couple of growing seasons following soil disturbance is normal. These species provide microclimate niches for small grasses, such as June grass, which may be sheltered by annual weeds until they become established. Spraying these so-called weedy species and re-seeding the site may promote aggressive colonizers and reduce the potential for native species infill. If infestations of annual weeds are heavy, mowing before seed set can be used to reduce competition while retaining the erosion mitigation they provide.
- Noxious weeds must be removed; by hand-picking, herbicide application or other methods (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 Table 2) 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. 2013). 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 3+ 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. 2016 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 include the following.

- Litter may start to build up, especially if the area has been fenced for too long. 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 (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 principles and benchmarks of the 2010 Reclamation Criteria for Wellsites and Associated Facilities for Native Grasslands (AEP 2013), the site is considered to be on a sustainable trajectory towards a mature native grassland plant community compatible with the surrounding area. These benchmarks are suitable for any disturbance on native grasslands, but have been best identified for the oil and gas industry for wellsites in grasslands. If vegetation cover and composition do not meet these benchmarks, update the plan.
- Document the monitoring and maintenance program. Share successes and failures with colleagues through organizations such as the Canadian Land Reclamation Association and the Foothills Restoration Forum.

The 2010 Reclamation Criteria – Native Grasslands (AEP 2013) 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 Long-term Monitoring & Future Research Required

The Importance of Long-Term Monitoring

To conserve what remains of native grasslands for future generations, recovery practices in native grasslands 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 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 (including recovery strategies, plant materials and timing) and reclamation maintenance procedures.
- Use standardized methods of data collection so results are comparable between projects. AEP MF5 Range Survey Manual procedures and forms (ASRD 2007) provide a recognized method and easily transferrable data format that can be collected in the AEP 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 Range Resource Stewardship Section of AEP.
- Publish findings in journals and/or on publicly accessible websites such as the Foothills Restoration Forum.

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 disturbances in native grasslands to promote industry stewardship on increasingly pressured native grasslands.

Future Research Required

Research is needed to improve restoration potential and expected outcomes for disturbances in native grasslands in the Foothills Fescue, Foothills Parkland and Montane NSRs. We need to encourage and promote applied, ongoing, and coordinated research with the objective to develop locally sourced plant materials and identify techniques that will produce a positive trajectory of plant community development and succession following disturbance over time. With a view to updating this document with a new approximation periodically, the Recovery Strategies Project is interested in receiving any results and ideas for new questions. Research priorities proposed by stakeholders include the following.

Plant Materials

- Several of the dominant grasses important in the development of late seral plant communities in the Foothills Fescue, Foothills Parkland and Montane NSRs are not readily available. Methods to supply quantities of plant materials for species listed in Table 7 are urgently needed.

Table 7 - Important Grasses for Restoration of Foothills Fescue, Foothills Parkland and Montane Grassland Plant Communities

Common Name	Scienific Name (RRSS)	Scientific Name (ACIMS)
Foothills rough fescue	*Festuca campestris*	*Festuca campestris*
Parry oat grass	*Danthonia parryi*	*Danthonia parryi*
Western porcupine grass	*Stipa curtiseta*	*Hesperostipa curtiseta*
intermediate oat grass	*Danthonia intermedia*	*Danthonia intermedia*
Hooker's oat grass	*Helictotrichon hookeri*	*Avenula hookeri*
Columbia needle grass	*Stipa columbiana*	*Achnatherum nelsonii ssp. dorei*
Richardson needle grass	*Stipa richardsonii*	*Achnatherum richardsonii*
bluebunch wheatgrass	*Agropyron spicatum*	*Pseudoroegneria spicata*

- Develop seed stocks for Foothills rough fescue that establish more reliably and are more competitive.
- Seed is available for several of the dominant grasses important in the development of late seral plant communities in the Foothills Fescue, Foothills Parkland and Montane NSRs, but they are not locally sourced and often contaminated with undesirable species. For example, Idaho fescue can be contaminated with invasive sheep fescue. Development of locally sourced plant materials for species listed in Table 8 is urgently needed.

Table 8 - Improved Sources Required for Important Grasses used for Restoration of Foothills Fescue, Foothills Parkland and Montane Grassland Plant Communities

Common Name	Scienific Name (RRSS)	Scientific Name (ACIMS)
Idaho fescue	*Festuca idahoensis*	*Festuca idahoensis*
northern wheatgrass	*Agropyron dasystachyum*	*Elymus lanceolatus*
bluebunch wheatgrass	*Agropyron spicatum*	*Pseudoroegneria spicata*

- Further study on the successful use of wild harvested hay to revegetate topsoil disturbances is required, including an assessment of infill. Development of guidelines is needed to ensure recovery of harvested areas. The potential for regionally located, designated areas to supply native hay should be investigated.
- What methods will stimulate seed production in healthy areas surrounding disturbance?
- What is the function of the awn and how can damage to the seed be reduced during processing to remove the awn, which can damage up to 50% of the seed, increasing the cost

Establishment

- More monitoring and research is required to define appropriate seeding rates for sites that require seeding. This includes seeding rates for sites that are in healthy grassland and areas where there is an existing seedbank of undesirable species such as the invasive agronomic grasses.
- What are effective methods of applying seed mulch to incorporate species with fluffy or long-awned seed?
- What is the success rate of planting 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)?
- What cover crops are suitable for site stabilization and will not inhibit establishing native grasses?
- What role do forbs play in plant community succession?
- How did rough fescue communities originally develop and what insight could that provide for restoration efforts?

Soils

- Native species have a competitive advantage over many introduced species in nutrient poor soils. What are effective means of reducing soil fertility to promote establishment of native species?

- What role does soil compaction play in the recovery of unstripped minimal disturbance sites? Sites where soil compaction has taken place should be monitored and research questions defined. How can compacted soil be ameliorated while minimizing further impacts to native vegetation cover?
- What are the effects of soil disturbance on mycorrhizal populations and does inoculating disturbances improve restoration potential?
- What effect does soil disturbance have on soil microbes and does this affect the ability of native vegetation to re-establish?
- Does uneven distribution of replaced topsoil on a disturbance promote more species diversity?
- Further research and monitoring is needed regarding the value of the two-lift stripping procedure to manage seed banks for native plant community restoration.

Reclamation Management

- 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?
- Develop best practices for use of matting as a method to reduce impacts to native vegetation and soils.
- What are the best methods to manage invasive agronomic species, (smooth brome, Timothy, Kentucky bluegrass, orchard grass, meadow foxtail, Canada bluegrass, alfalfa etc.) including: herbicidal products, alternatives to chemical treatment, and the timing of chemical application or alternative treatments?
- What practices are available to remediate the impacts of invasive agronomic species?
- A system needs to be developed to set benchmarks to measure successful recovery or restoration.
- A system or public database needs to be developed to capture reclamation monitoring and assessment data so others can access it in the future.
- Is there a role for fire in reducing impacts of invasive species on rough fescue grasslands?

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 gathering input to update Revegetation Strategies for each Grassland Natural Subregion and look forward to future research and technology that will yield a need for the Second Approximation of the Revegetation Strategies for the Foothills Fescue, Foothills Parkland and Montane Natural Subregions 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 SEED MIXES FOR TARGET RECOVERING PLANT COMMUNITIES

Introduction

Designing native grassland seed mixes for soils disturbances not suited to natural recovery or assisted natural recovery in the Foothills Fescue, Foothills Parkland and Montane Natural Subregions is as much an art as it is a science. The purpose of a native seed mix is to revegetate the disturbance with native grass 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.

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, to provide structural diversity and resilience to seasonal precipitation variation and grazing.

Plant community composition is linked to environmental variables including: ecological range site, soils, elevation, soil drainage, slope and aspect. The Range Plant Community Guides for the Foothills Fescue NSR (Adams et al. 2005), Foothills Parkland NSR (DeMaere et al. 2012) and Montane NSR (Willoughby et al. 2008) provide detailed discussions 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 common component species, the range of cover values expressed by each common species and the percent constancy of occurrence for each species within the dataset.

The following Appendix, Target Recovering Plant Communities, have been developed from the Range Plant Community Guides for the Foothills Fescue, Foothills Parkland and Montane NSRs. This document is intended to be used as a companion document to the Range Plant Community Guides 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 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 an NSR or sub-area like an ecodistrict.

To develop descriptions of target recovering plant communities, ecological range sites with common dominant native grass species are grouped 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 that are drivers in the successional process. The average combined percent cover of the native forb species and native shrub species, and exposed soil is 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 dataset 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 (including the native forb component) over time. Reference material used to compile the recommendations include: the results of the literature review and monitoring studies conducted for this project (Lancaster et al. 2015),*Common Plants of the Western Rangelands Volume 1: Grasses and Grass-like Species* (Tannas 2003), *Manual of Plant Species Suitability for Reclamation in Alberta 2nd Edition* (Hardy 1989), *Native Plant Revegetation Guidelines for Alberta* (Native Plant Working Group 2000) and *Forage and Reclamation Grasses of the Northern Great Basin and Rocky Mountains* (Majerus 2009).

Examples of native seed mixes, based on the target recovering plant community are given as percent (%) Pure Live Seed by Weight. The value for each recommended species has been 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?

It is important to note that this is only the first step in seed mix design. 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. It is recommended that qualified professionals with experience in native prairie restoration be consulted for native seed mix design.

The Target Recovering Plant Communities
are to be used
as companions to the corresponding
Range Plant Community Guides

A.1 Target Recovering Plant Communities for the Foothills Fescue Natural Subregion

The composition of plant communities in the Foothills Fescue NSR is influenced primarily by soil type and depth, unlike the Foothills Parkland and Montane NSRs, where plant communities are influenced primarily by topography, elevation and aspect, and secondarily by soils. The Range Plant Community Guide for the Foothills Fescue lists the plant communities by ecological range site (Adams et al. 2005).

A.1.1 Foothills Rough Fescue- Parry Oatgrass Communities

Foothills Rough Fescue- Parry Oatgrass plant communities are associated primarily with **Loamy 1** and **Thin Breaks 1** ecological range sites. These range sites are typically in the northerly and westerly portions of the Foothills Fescue NSR, in the Delacourt Plain, the Willow Creek Upland and western areas of the Cardston Plain Ecodistricts. Soils are moister and temperatures cooler than for other Loamy range sites. Plant communities in the grouping include; FFA19, FFA5, FFA6, FFA18 and FFA17 (Adams et al. 2005).

The group includes mid-seral, late seral and reference plant communities. Common dominant species include Foothills rough fescue and Parry oatgrass. The average cover of dominant and common graminoids in the grouping is illustrated in Table A1 .

Table A1 - Target Native Plant Community Composition on Foothills Fescue NSR: Loamy 1; Thin Breaks 1 Ecological Sites

Common Species Name	Scientific Name	Average % Cover
Parry's oat grass	*Danthonia parryi*	27.4
Foothills rough fescue	*Festuca campestris*	21.8
Western porcupine grass	*Stipa curtiseta*	3.0
Awned wheatgrass	*Elymus trachycaulus var. subsecundus*	2.6
Sedges species	*Carex spp.*	2.6
June grass	*Koeleria macrantha*	2.6
Idaho fescue	*Festuca idahoensis*	2.2
Northern wheatgrass	*Elymus lanceolatus ssp. lanceolatus*	0.6
Pumpelly brome	*Bromus inermis ssp. pumpellianus*	0.4
Shrubs		3.2
Forbs		6.0
Bare Soil		6.0

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

This information can be used to design a native seed mix based on the common grasses in Foothills Fescue NSR: Loamy 1; Thin Breaks 1 Ecological SItes. Table A2 provides an example of the 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 A2 - Recommended Reclamation Grasses for Foothills Fescue NSR: Loamy 1; Thin Breaks 1 Ecological Range Sites

Species	Proportion of Seed Mix % PLS by Weight	
Parry's oat grass	*Danthonia parryi*	40%
Foothills rough fescue	*Festuca campestris*	35%
Western porcupine grass	*Stipa curtiseta*	5%
Awned wheatgrass	*Elymus trachycaulus var. subsecundus*	5%
June grass	*Koeleria macrantha*	5%
Idaho fescue	*Festuca idahoensis*	5%
Northern wheatgrass	*Elymus lanceolatus ssp. lanceolatus*	5%

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. Northern wheatgrass will help stabilize the soils and provide structure in the stand. The proportion of Foothills rough fescue has been increased based on results of the long-term monitoring projects and a literature review conducted for this project (Lancaster et al. 2015). The proportions of Parry oatgrass and Western porcupine grass have been increased to compensate for the variability in viable wild harvested seed. June grass and Idaho fescue will provide diversity and lower structural elements in the stand.

A.1.2 Foothills Rough Fescue – Idaho Fescue Communities

The Foothills Rough Fescue- Idaho Fescue group of plant communities are associated primarily with **Loamy 2, Shallow-to-Gravel** and **Gravel** ecological range sites. These communities are common in southern portions of the Foothills Fescue NSR, where temperatures are warmer and soils more droughty. Plant communities in the grouping include; FFA2, FFA3, FFA9, FFA10, FFA13 and FFA23 (Adams et al. 2005).

The grouping includes mid- and late- seral and reference plant communities. Dominant species include Foothills rough fescue, Idaho fescue and Parry oatgrass. The average cover of dominant and common graminoids in the grouping is illustrated in Table A3.

Table A3 - Target Recovering Plant Community for Foothills Fescue NSR: Loamy 2; Shallow to Gravel; Gravel Ecological Range Sites

Common Species Name	Scientific Name	Average % Cover
Foothills rough fescue	*Festuca campestris*	24.2
Idaho fescue	*Festuca idahoensis*	11.8
Parry's oat grass	*Danthonia parryi*	9.5
Sedge species	*Carex spp.*	6.7
June grass	*Koeleria macrantha*	4.5
Northern wheatgrass	*Elymus lanceolatus ssp. lanceolatus*	4.3
Western porcupine grass	*Stipa curtiseta*	3.8
Richardson's needle grass	*Stipa richardsonii*	2.0
Awned wheatgrass	*Elymus trachycaulus var. subsecundus*	1.0
California Oatgrass	*Danthonia californica*	1.0
Bluebunch wheatgrass	*Pseudoroegneria spicata*	0.3
Alkali bluegrass	*Poa juncifolia*	0.3
Forbs		6.2
Shrubs		1.3

Foothills rough fescue plant communities are difficult to restore. A slow growing, deeply rooted perennial species, rough fescue is slow to establish. It does not compete well with other species. Observations indicate restoration potential is greater on drier sites such as shallow-to-gravel or gravel range sites than loamy range sites. Rough fescue seed and Parry oatgrass seed must be wild harvested and the supply is often limited. Seed set is erratic and often seed is not available. Cultivars of Idaho fescue are available and seed can also be wild harvested.

Northern wheatgrass, Western porcupine grass and June grass play an important role in the process of succession in this group as drivers in the mid- to late- seral successional stages. The rhizomatous wheatgrasses can fracture the clay soils, improving water infiltration.

This information can be used to design a native seed mix based on the common grasses in Foothills Fescue NSR; Loamy 2, Shallow-to-Gravel and Gravel ecological range sItes. Table A4 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 A4 - Recommended Reclamation Grasses for Foothills Fescue NSR: Loamy 2; Shallow to Gravel; Gravel Ecological Range Sites

Species	Proportion of Seed Mix % PLS by Weight	
Foothills rough fescue	*Festuca campestris*	35%
Idaho fescue	*Festuca idahoensis*	15%
Parry's oat grass	*Danthonia parryi*	20%
June grass	*Koeleria macrantha*	5%
Northern wheatgrass	*Elymus lanceolatus ssp. lanceolatus*	5%
Western porcupine grass	*Stipa curtiseta*	10%
Awned wheatgrass	*Elymus trachycaulus var. subsecundus*	5%
Bluebunch wheatgrass	*Pseudoroegneria spicata*	5%

Awned wheatgrass will 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. Northern wheatgrass will help stabilize the soils and provide structure in the stand. Bluebunch wheatgrass is adapted to dry, medium textured and gravelly soils and will provide cover at a mid-seral stage and later. The proportions of Foothills rough fescue, Parry oatgrass and Western porcupine grass have been increased to compensate for the variability in viable wild harvested seed. June grass and Idaho fescue will provide diversity and lower structural elements in the stand. Early bluegrass (Poa cusickii) could also be considered as a low structural element in this seed mix.

A.1.3 Foothills Rough Fescue – Wheatgrass Communities

The Foothills Rough Fescue- Wheatgrasses group of plant communities are associated primarily with Loamy **3, Loamy 4, Limy 1** and **Clay** ecological range sites. They are generally found in southerly and easterly portions of the Foothills Fescue NSR. Loamy 3 range sites occur primarily on the Milk River Ridge and along the eastern boundary with the Mixedgrass NSR. Loamy 4 range sites are the driest of the Loamy range sites and are also found along the eastern boundary with the Mixedgrass NSR. Limy range sites are characterized by immature or eroded soils with free lime at or near the soil surface. The Plant communities in the grouping include; FFA1, FFA14, FFA24, FFA25, FFA27, FFA28 and FFA29, as described in the Range Plant Community Guide for the Foothills Fescue (Adams et al. 2005).

The grouping includes mid- and late- seral and reference plant communities. Dominant species include Northern wheatgrass, Foothills rough fescue and green needle grass. The average cover of dominant and common species in the grouping is listed in Table A5.

Table A5 - Target Native Plant Community Composition on Foothills Fescue NSR: Loamy 3; Loamy 4; Limy 1; Clay Ecological Sites

Common Species Name	Scientific Name	Average % Cover
Northern wheatgrass	*Elymus lanceolatus ssp. lanceolatus*	17.4
Foothills rough fescue	*Festuca campestris*	15.5
Green needle grass	*Stipa viridula*	10.5
June grass	*Koeleria macrantha*	7.3
Western porcupine grass	*Stipa curtiseta*	4.1
Sedge species	*#N/A*	4.0
Idaho fescue	*Festuca idahoensis*	2.0
Needle-&-thread	*Stipa comata*	1.0
Western wheatgrass	*Agropyron smithii*	0.8
Pumpelly brome	*Bromus inermis ssp. pumpellianus*	0.6
Bluebunch wheatgrass	*Pseudoroegneria spicata*	0.3
Sand reed grass	*Calamovilfa longifolia*	0.3
Slender wheatgrass	*Elymus trachycaulus var. trachycaulus*	0.1
Forbs		5.6
Shrubs		3.4

Northern wheatgrass, green needle grass, Western porcupine grass and June grass play an important role in the process of early succession in this grouping. Foothills fescue will establish slowly and if not outcompeted, will establish more prominence over time. More arid sites favour the establishment of rough fescue over richer, moister soils.

Table A6 - Recommended Reclamation Grasses for Foothills Fescue NSR: Loamy 3; Loamy 4; Limy 1; Clay Ecological Sites

Species	Proportion of Seed Mix % PLS by Weight	
Northern wheatgrass	Elymus lanceolatus ssp. lanceolatus	10%
Foothills rough fescue	Festuca campestris	30%
Green needle grass	Stipa viridula	5%
June grass	Koeleria macrantha	10%
Western porcupine grass	Stipa curtiseta	20%
Idaho fescue	Festuca idahoensis	10%
Needle-&-thread	Stipa comata	5%
Western wheatgrass	Agropyron smithii	5%
Bluebunch wheatgrass	Pseudoroegneria spicata	5%

The relative proportions of Northern wheatgrass and green needle grass are reduced in the seed mix compared to their average cover for a mature plant community summarized in Table A6. These species establish quickly and can spread to occupy more cover than targeted. Seeding levels of Western porcupine grass, needle-and-thread and rough fescue are increased to account for the variability in viability of wild harvested seed.

A.2 Target Recovering Plant Communities for the Foothills Parkland Natural Subregion

Ordination native grassland range assessment plots (supplied by the Range Resource Stewardship Section, AEP) based on species composition and cover identified four clusters of grassland plant communities within the Foothills Parkland NSR. A combination of Foothills rough fescue and Parry oatgrass provide the dominant cover in all four clusters. Two clusters are dominated by Parry oatgrass and two by Foothills rough fescue. All four have the same suite of component species including the early- to mid-seral infill species June grass, Idaho fescue and wheatgrasses. Given the suites of reclamation species available and the subtleties between clusters, two target recovering plant communities were identified by combining similar datasets.

Forbs make up a significant proportion of the vegetation cover in these Foothills Parkland grassland communities (on average 17% - 18%). Introducing common forbs such as golden bean, wild vetch, silky perennial lupine, bedstraw, three-flowered avens or smooth aster, either as seed or seedlings is important to increase community diversity, particularly in large disturbances where infill from the edges is less likely.

Shrubs also make up 4% - 9% of the vegetation cover. Dominant shrubs in these communities tend to be buckbrush and wild rose, which will re-establish naturally.

A.2.1 Foothills Rough Fescue - Parry Oatgrass Communities

Foothills Rough Fescue - Parry Oatgrass communities identified in the cluster analysis are associated primarily with Loamy range sites in the Foothills Parkland NSR. Associated ecological sites are submesic to subhygric and nutrient regimes are rich. They are typically found on mid to lower slope positions on Orthic Black Chernozems.

Table A7 - Target Native Plant Community Composition on Foothills Parkland NSR: Rich Loamy Ecological Sites

Common Species Name	Scientific Name	Average % Cover
foothills rough fescue	*Festuca campestris*	29.2
Parry oatgrass	*Danthonia parryi*	16.0
Kentucky bluegrass	*Poa pratensis*	3.6
Idaho fescue	*Festuca idahoensis*	3.6
awned wheatgrass	*Elymus trachycaulus ssp. subsecundus*	2.6
sedge species	*Carex* species	2.0
June grass	*Koeleria macrantha*	2.0
golden bean	*Thermopsis rhombifolia*	1.8
Western porcupine grass	*Stipa curtiseta*	1.7
Pumpelly brome	*Bromus pumpellianus*	1.7
Northern wheatgrass	*Agropyron dasystachyum*	1.6
silky perennial lupine	*Lupinus sericeus*	1.6
northern bedstraw	*Galium boreale*	1.5
three-flowered avens	*Geum triflorum*	1.1
smooth aster	*Aster laevis*	1.1
wild vetch	*Vicia americana*	1.1
wild bergamot	*Monarda fistulosa*	0.8
death camas	*Zigadenus venenosus*	0.7
cream-colored vetchling	*Lathyrus ochroleucus*	0.7
forbs including above		17.1
shrubs		8.8

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

Table A8 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 A8 - Recommended Reclamation Grasses for Foothills Parkland NSR: Rich Loamy Ecological Sites - Foothills Rough Fescue - Parry Oatgrass Communities

Species	Proportion of Seed Mix % PLS by Weight	
Foothills rough fescue	*Festuca campestris*	40%
Parry oatgrass	*Danthonia parryi*	20%
Western porcupine grass	*Stipa curtiseta*	10%
Awned wheatgrass	*Elymus trachycaulus var. subsecundus*	10%
June grass	*Koeleria macrantha*	5%
Idaho fescue	*Festuca idahoensis*	5%
Northern wheatgrass	*Elymus lanceolatus ssp. lanceolatus*	10%

Awned wheatgrass will 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. Northern wheatgrass will help stabilize the soils and provide structure in the stand. June grass and Idaho fescue are early seral species that should establish initial cover and provide lower structural elements. The proportion of Foothills rough fescue has been increased based on results of the long-term monitoring projects and a literature review conducted for this project (Lancaster et al. 2015). The proportions of Parry oatgrass and Western porcupine grass have been increased to compensate for the variability in viable wild harvested seed.

Introduction of Foothills rough fescue and Parry oatgrass as seedlings is another option to increase the ability of these species to compete with other seeded species and invaders.

A.2.2 Parry Oatgrass - Foothills Rough Fescue Communities

Parry Oatgrass - Foothills Rough Fescue communities identified in the cluster analysis are associated with **Thin Breaks**, **Shallow-to-Gravel** and **drier, shallower Loamy** range sites. Associated ecological sites are submesic and nutrient regimes are poor to medium .

Table A9 - Target Native Plant Community Composition on Foothills Parkland NSR: Thin Breaks, Shallow-to-Gravel and Drier, Shallower Loamy Ecological Sites

Common Species Name	Scientific Name	Average % Cover
Parry oatgrass	*Danthonia parryi*	37.9
foothills rough fescue	*Festuca campestris*	12.8
Kentucky bluegrass	*Poa pratensis*	4.6
Western porcupine grass	*Stipa curtiseta*	4.1
golden bean	*Thermopsis rhombifolia*	3.5
June grass	*Koeleria macrantha*	3.4
sedge species	*Cares species*	3.0
Northern wheatgrass	*Agropyron dasystachyum*	2.6
Idaho fescue	*Festuca idahoensis*	2.5
awned wheatgrass	*Elymus trachycaulus sp. subsecundus*	2.0
northern bedstraw	*Galium boreale*	1.5
silky perennial lupine	*Lupinus sericeus*	1.3
death camas	*Zigadenus venenosus*	1.2
three-flowered avens	*Geum triflorum*	1.1
pasture sagewort	*Artemisia frigida*	0.8
Hooker's oatgrass	*Helictotrichon hookeri*	0.8
cut-leaved anemone	*Anemone multifida*	0.8
Western wheatgrass	*Agropyron smithii*	0.8
Forbs including above		18.0
Shrubs		3.8

Table A10 includes 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 A10 – Recommended Reclamation Grasses for Foothills Parkland NSR: Thin Breaks, Shallow-to-Gravel and Drier, Shallower Loamy Ecological Sites

Species	Proportion of Seed Mix % PLS by Weight	
Parry oatgrass	*Danthonia parryi*	40%
Foothills rough fescue	*Festuca campestris*	20%
Western porcupine grass	*Stipa curtiseta*	10%
Awned wheatgrass	*Elymus trachycaulus var. subsecundus*	10%
June grass	*Koeleria macrantha*	5%
Idaho fescue	*Festuca idahoensis*	5%
Northern wheatgrass	*Elymus lanceolatus ssp. lanceolatus*	10%

Awned wheatgrass will 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. Northern wheatgrass will help stabilize the soils and provide structure in the stand. June grass and Idaho fescue are early seral species that should establish initial cover and provide lower structural elements. The proportion of Foothills rough fescue has been increased based on results of the long-term monitoring projects and a literature review conducted for this project (Lancaster et al. 2015). The proportions of Parry oatgrass and Western porcupine grass have been increased to compensate for the variability in viable wild harvested seed.

Introduction of Foothills rough fescue and Parry oatgrass as seedlings is another option to increase the ability of these species to compete with other seeded species and invaders.

A.3 Target Recovering Plant Communities for the Montane Natural Subregion

The composition of plant communities in the Montane NSR is influenced primarily by topography, elevation and aspect, and secondarily by soils, unlike the Foothills Fescue NSR, where the opposite is the norm. For example, in the Montane, rough fescue communities can have similar species composition (Willoughby et al. 2008) but deeper, more nutrient rich soils affect the way they respond successionally. This also affects the way they resond to disturbance:

- Deeper, richer soils (cc1) are vulnerable to invasive species;
- Thinner, less nutrient rich soils (aa, c5) show better re-stablishment of native species and positive succession.

A.3.1 Subxeric/Medium Ecological Sites – (aa) Bluebunch Wheatgrass

Bluebunch wheatgrass plant communities are found on subxeric, nutrient -medium to -poor sites often on slopes, between 1400m and 1800m elevation in the Montane NSR. Shrubs and forbs are a significant component of these communities, averaging 35% cover for shrubs and 33% cover for forbs (Table A11).

Table A11 - Target Native Plant Community Composition on Montane NSR: Subxeric/Medium Bluebunch Wheatgrass Ecological Sites

Common Species Name	Scientific Name	Average % Cover
bluebunch wheatgrass	*Agropyron spicatum*	17.7
June grass	*Koeleria macrantha*	10.5
sedge species	*Carex species*	6.6
foothills rough fescue	*Festuca campestris*	6.3
pasture sagewort	*Artemisia frigida*	4.0
field mouse-ear chickweed	*Cerastium arvense*	3.3
silky perennial lupine	*Lupinus sericeus*	2.8
wild vetch	*Vicia americana*	2.1
fringed brome	*Bromus ciliatus*	2.1
northern bedstraw	*Galium boreale*	2.0
Idaho fescue	*Festuca idahoensis*	1.9
slender wheatgrass	*Elymus trachycaulus*	1.9
small-leaved everlasting	*Antennaria parvifolia*	1.8
common yarrow	*Achillea millefolium*	1.8
blunt sedge	*Carex obtusata*	1.4
Rocky Mountain fescue	*Festuca saximontana*	1.1
smooth aster	*Aster laevis*	1.0
Shrubs		**35.1**
Forbs (including above)		**32.8**

Common shrubs in these communites are snowberry and wild rose, which may re-establish naturally. Shrubs that may be more difficult to re-establish are bearberry, shrubby cinquefoil, and creeping juniper.

Table A12 provides an example of the 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 A12 - Recommended Reclamation Grasses for Montane NSR: Subxeric/Medium Bluebunch Wheatgrass Ecological Sites

Species	Proportion of Seed Mix % PLS by Weight	
bluebunch wheatgrass	*Agropyron spicatum*	30%
June grass	*Koeleria macrantha*	20%
foothills rough fescue	*Festuca campestris*	20%
fringed brome	*Bromus ciliatus*	10%
Idaho fescue	*Festuca idahoensis*	10%
Slender wheatgrass	*Agropyron trachyculum*	10%

Although Rocky mountain fescue is a minor component of these plant communities, many seed lots for cultivars of this species are contaminated with and indistinguishable from the non-native invasive sheep fescue (*Festuca ovina*) (Tannas and Webb 2016). Seeding this species is not recommended without a certificate of authenticity (see the section on Certificates of Analysis versus Certified Seed).

Slender wheatgrass will 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. Fringed brome is also early successional and establishes quickly. Bluebunch wheatgrass is drought tolerant and adapted to nutrient poor soils. June grass and Idaho fescue are early- to mid-seral species that will provide lower structural elements. The proportion of Foothills rough fescue has been increased to compensate for the variability in viable wild harvested seed.

Introduction of Foothills rough fescue as seedlings is another option to increase the ability of these species to compete with other seeded species and invaders.

Submesic/Medium Ecological Sites – (c5) Grasslands

A.3.2 Submesic/Medium (c5) Parry Oat Grass – Foothills Rough Fescue – Idaho Fescue

This ecological site is associated with **dry Loamy, Shallow-to-Gravel** and **Thin Breaks** range sites on mid-slope, upper slope and crest positions. These higher, drier sites are less prone to invasion by agronomic grasses than richer moister sites lower in the valleys.

Table A13 - Target Native Plant Community Composition for Montane NSR: Parry Oat Grass – Foothills Fescue – Idaho Fescue Communities

Common Species Name	Scientific Name	Average % Cover
Parry oat grass	*Danthonia parryi*	28.9
foothills rough fescue	*Festuca campestris*	14.3
Idaho fescue	*Festuca idahoensis*	6.6
sedge species	*Carex species*	4.0
June grass	*Koeleria macrantha*	2.0
northern wheatgrass	*Agropyron dasystachyum*	2.0
northern bedstraw	*Galium boreale*	1.9
golden bean	*Thermopsis rhombifolia*	1.6
silky perennial lupine	*Lupinus sericeus*	1.5
awned wheatgrass	*Elymus trachycaulus ssp. subsecundus*	1.3
western wheatgrass	*Agropyron smithii*	1.2
Richardson needle grass	*Stipa richardsonii*	1.2
three-flowered avens	*Geum triflorum*	1.2
Kentucky bluegrass	*Poa pratensis*	1.1
pasture sagewort	*Artemisia frigida*	1.1
bluebunch wheatgrass	*Agropyron spicatum*	1.0
balsamroot	*Balsamorhiza sagittata*	1.0
Shrubs		**8.2**

Table A14 provides an example of the 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 A14 - Recommended Reclamation Grasses for Montane NSR: (c5) Parry Oat Grass – Foothills Fescue – Idaho Fescue Communities

Species	Proportion of Seed Mix % PLS by Weight	
Parry oat grass	*Danthonia parryi*	40%
Foothills rough fescue	*Festuca campestris*	20%
Idaho fescue	*Festuca idahoensis*	5%
Northern wheatgrass	*Elymus lanceolatus ssp. lanceolatus*	10%
Awned wheatgrass	*Elymus trachycaulus var. subsecundus*	10%
June grass	*Koeleria macrantha*	5%
Bluebunch wheatgrass	*Agropyron spicatum*	10%

Awned wheatgrass will 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. Fringed brome is also early successional and establishes quickly. Bluebunch wheatgrass is drought tolerant and adapted to nutrient poor soils. Rhizomatous Northern wheatgrass will help stabilize the soils and provide structure in the stand. June grass and Idaho fescue are early- to mid-seral species that will provide lower structural elements. The proportions of late seral Parry oatgrass and Foothills rough fescue have been increased to compensate for the variability in viable wild harvested seed.

Introduction of Foothills rough fescue and Parry oatgrass as seedlings is another option to increase the ability of these species to compete with other seeded species and invaders.

A.3.3 Submesic/Medium (c5) Foothills Rough Fescue – Intermediate Oat Grass

This target plant community is associated with **dry Loamy, Shallow-to-Gravel** and **Thin Breaks** range sites in the Montane NSR. Forbs contribute an average of 22% cover and shrubs make up an average of 11% cover.

Table A15 - Target Native Plant Community Composition for Montane NSR: Foothills Fescue – Intermediate Oat Grass Communities

Common Species Name	Scientific Name	Average % Cover
foothills rough fescue	*Festuca campestris*	33.8
intermediate oat grass	*Danthonia intermedia*	5.8
Idaho fescue	*Festuca idahoensis*	4.8
three-flowered avens	*Geum triflorum*	3.2
Richardson needle grass	*Stipa richardsonii*	2.7
northern bedstraw	*Galium boreale*	2.7
Northern wheatgrass	*Agropyron dasystachyum*	2.2
Parry oat grass	*Danthonia parryi*	2.0
golden bean	*Thermopsis rhombifolia*	1.9
silvery perennial lupine	*Lupinus argenteus*	1.9
sun-loving sedge	*Carex pensylvanica*	1.7
sedge species	*Carex species*	1.6
graceful cinquefoil	*Potentilla gracilis*	1.5
Kentucky bluegrass	*Poa pratensis*	1.5
wild strawberry	*Fragaria virginiana*	0.9
June grass	*Koeleria macrantha*	0.9
slender wheatgrass	*Elymus trachycaulus*	0.8
awned wheatgrass	*Elymus trachycaulus ssp. subsecundus*	0.8
Shrubs		**11.0**
Forbs (including above)		**21.8**

Table A16 provides an example of the 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 A16 - Recommended Reclamation Grasses for Montane NSR: Foothills Fescue – Intermediate Oat Grass Communities

Species	Proportion of Seed Mix % PLS by Weight	
Foothills rough fescue	*Festuca campestris*	50%
Idaho fescue	*Festuca idahoensis*	10%
Awned wheatgrass	*Elymus trachycaulus var. subsecundus*	10%
Intermediate oat grass	*Danthonia intermedia*	5%
Parry oat grass	*Danthonia parryi*	5%
June grass	*Koeleria macrantha*	10%
Northern wheatgrass	*Elymus lanceolatus ssp. lanceolatus*	10%

Intermediate oat grass becomes more common at higher elevations and can be the dominant species in montane and subalpine meadows. Both intermediate oat grass and Richardson's needle grass are not readily available as seed. Wild harvesting, wild hay or seedling production will be required.

Awned wheatgrass will 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. Rhizomatous Northern wheatgrass will help stabilize the soils and provide structure in the stand. June grass and Idaho fescue are early- to mid-seral species that will provide lower structural elements. The proportions of late seral Parry oatgrass and Foothills rough fescue have been increased to compensate for the variability in viable wild harvested seed.

Introduction of Foothills rough fescue and Parry oatgrass as seedlings is another option to increase the ability of these species to compete with other seeded species and invaders.

Submesic/Rich Ecological Sites – (cc1) Grasslands

A.3.4 Submesic/Rich (cc1) Foothills Rough Fescue – Idaho Fescue - Parry Oat Grass

This plant community is associated with **moist Loamy, Shallow-to-Gravel** and **Thin Breaks** range sites in the Montane. Forbs contribute an average of 14% cover and shrubs make up an average of 9% cover.

Table A17 - Target Native Plant Community Composition for Montane NSR: (cc1) Foothills Fescue – Idaho Fescue - Parry Oat Grass Communities

Common Species Name	Scientific Name	Average % Cover
Foothills rough fescue	*Festuca campestris*	29.2
Parry oat grass	*Danthonia parryi*	28.8
Idaho fescue	*Festuca idahoensis*	4.4
sedge species	*Carex species*	2.4
silky perennial lupine	*Lupinus sericeus*	1.6
Pumpelly brome	*Bromus inermis ssp. pumpellianus*	1.5
Northern wheatgrass	*Agropyron dasystachyum*	1.4
Richardson needle grass	*Stipa richardsonii*	1.4
golden bean	*Thermopsis rhombifolia*	1.3
awned wheatgrass	*Elymus trachycaulus ssp. subsecundus*	1.2
June grass	*Koeleria macrantha*	1.2
northern bedstraw	*Galium boreale*	1.2
three-flowered avens	*Geum triflorum*	1.0
Shrubs		**8.6**
Forbs (including above)		**13.6**

Table A18 provides an example of the 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 A18 - Recommended Reclamation Grasses for Montane NSR: (cc1) Foothills Fescue – Idaho Fescue - Parry Oat Grass Communities

Species	Proportion of Seed Mix % PLS by Weight	
Foothills rough fescue	*Festuca campestris*	30%
Parry oat grass	*Danthonia parryi*	30%
Idaho fescue	*Festuca idahoensis*	15%
June grass	*Koeleria macrantha*	5%
Northern wheatgrass	*Elymus lanceolatus ssp. lanceolatus*	5%
Awned wheatgrass	*Elymus trachycaulus var. subsecundus*	10%

Awned wheatgrass will 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. Northern wheatgrass will help stabilize the soils and provide structure in the stand. June grass and Idaho fescue are early- to mid-seral species that should establish initial cover and provide lower structural elements. The proportion of Foothills rough fescue has been increased based on results of the long-term monitoring projects and a literature review conducted for this project (Lancaster et al. 2015). Foothills rough fescue and Parry oatgrass provide most of the cover in this community.

Introduction of Foothills rough fescue and Parry oat grass as seedlings is advisable to promote their early establishment.

Appendix B Seed Sources for Characteristic Plant Species

Table B1 - Seed Sources for Characteristic Species in the Foothills Fescue, Foothills Parkland and Montane NSRs

Common Name	Scientific Name	Cultivar or Variety	Source Area	Wild-harvested in Alberta
California oat grass	*Danthonia californica*	No known sources		
intermediate oat grass	*Danthonia intermedia*	No known sources		
Parry oat grass	*Danthonia parryi*	No known sources		Yes
Northern wheatgrass	*Agropyron dasystachyum*	Elbee (1980)	Alberta	
		Polar Ecovar	Saskatchewan	
		Critana (1971)	Montana	
Awned wheatgrass	*Agropyron trachycaulum var. subsecundus*	AEC Hillcrest	Alberta, Crowsnest Pass	
		ARC Metisko	Alberta, Metisko	
Slender wheatgrass	*Agropyron trachycaulum var. trachycaulum*	AEC Highlander	Alberta Rocky Mtns	
		Primar (1946)	Montana	
		Pryor (1988)	Montana	
		Copperheard (2006)	Montana	
Foothills rough fescue	*Festuca campestris*	None		Yes
Idaho fescue	*Festuca idahoensis*	Joseph (1983)	Pacific NW	
		Nezpurs (1983)	Pacific NW	
		Winchester	Idaho	
June grass	*Koeleria macrantha*	ARC Mountain View (2010)	Alberta, Crowsnest Pass	Yes
		Keystone Ecovar	Manitoba	
		Battle River Ecovar	Manitoba	

Common Name	Scientific Name	Cultivar or Variety	Source Area	Wild-harvested in Alberta
Western wheatgrass	*Agropyron smithii*	Walsh (1982)	Alberta/ Saskatchewan	
		W.R. Poole Ecovar	Manitoba	
Sandberg bluegrass	*Poa sandbergii*	Canbar (1979)	Washington	
Bluebunch wheat-grass	*Agropyron spicatum*	Whitmar (1946)	Washington	
		Secar (1980)	Idaho	
		Goldar (1989)	Washington	
		P-7 (2001)	Pacific NW	
		Antone (2004)	Idaho	
Western porcupine grass	*Stipa curtiseta*	None		Yes
Richardson's needle grass	*Stipa richardsonii*	No known sources		
Green needle grass	*Stipa viridula*	ARC Grouse	Alberta, Wain-wright area	
Purple prairie clover	*Petalostamon pur-pureum*	Available – variety un-known	Unknown	
American vetch	*Vicia americana*	Available – variety un-known	Unknown	

Appendix C Non-native Invasive Plants and Grazing Response

Table C1 - Grazing Potential of Non-native Invasive Plants in the Foothills Fescue, Foothills Parkland and Montane NSRs

Common Name	Scientific Name	Life Form and Growth Habit	Grazing Suitability
Forbs			
Absinthe***	*Artemisia absinthium*	perennial, mat-forming	Poor
biennial campion	*Silene cserei*	perennial, taproot	Poor
bird vetch	*Vicia cracca*	perennial, vine	Good
bladder campion	*Silene cucubalus*	perennial, taproot	Poor
bluebur	*Lappula echinata*	annual, taproot	Poor
blueweed*	*Echium vulgare*	biennial, taproot	Poor – cattle avoidance
bull thistle†	*Cirsium vulgare*	perennial, rhizomes	Poor – cattle avoidance
burdock*†	*Arctiu minus*	biennial	Poor – cattle avoidance
Canada thistle*†	*Cirsium arvense*	Perennial, rhizomes	Poor – cattle avoidance
caraway	*Carum carvi*	biennial, taproot	Fair
cinquefoil, rough	*Potentilla norvegica*	perennial, rhizomes	Poor
cinquefoil, sulphur**	*Potentilla recta*	perennial	Poor
clover, white sweet	*Melilotus alba*	biennial, taproot	Good – spring grazing
clematis, yellow*	*Clematis langulca*	perennial vine	Poor to fair
clover, yellow sweet	*Melilotus officinalis*	biennial, taproot	Good – spring grazing
cockle, white*	*Silene latifolia*	perennial, taproot	Poor
cress, hoary*	*Cardaria draba*	perennial, rhizomes	Poor
goat's beard†	*Tragopogon dubius*	perennial, taproot	Fair
hawkweed, meadow, mouse-eared, orange***	*Hieracium spp.*	perennial, fibrous	Good
hemp nettle	*Galeopsis tetrahit*	annual	Poor
henbane, black	*Hyoscyamus niger*	Annual, biennial	Poor – cattle avoidance
henbit	*Lamium amplexicaule*	annual	Poor
hound's tongue*	*Cynoglossum officinale*	biennial, taproot	Poor
field bindweed*	*Convolvulus arvensis*	perennial, vine	Poor

Common Name	Scientific Name	Life Form and Growth Habit	Grazing Suitability
knapweed, diffuse, Russian, spotted **†	*Centaurea spp.*	biennial	Poor – unpalatable
leafy spurge*†	*Euphorbia esula*	perennial, rhizomes	Poor - unpalatable
Kochia	*Kochia scoparia*	annual	Poor - unpalatable
mullein, common*	*Verbascum thapsus*	biennial, taproot	Poor – cattle avoidance
mustard, ball	*Neslia paniculata*	annual	Poor
mustard, dog	*Erucastrum gallicum*	annual	Poor
mustard, tall hedge	*Sysmbrium loeselli*	annual	Poor - unpalatable
mustard, wild	*Sinapis arvensis*	annual	Poor
mustard, wormseed	*Erysimum cheiran-thoides*	annual	Poor
night-flowering catchfly	*Silene noctiflora*	perennial, taproot	Poor
nodding thistle**†	*Cardus nutans*	Biennial, taproot	Poor – unpalatable
oxeye daisy*	*Leucanthemum vulgare*	perennial, rhizomes	Poor – cattle avoidance
round-leaved mallow	*Malva rotundifolia*	annual	Poor
Russian thistle	*Salsola pestifer*	annual, taproot	Poor, except when young
rocket	*Erysimum spp.*	perennial, taproot	Poor – cattle avoidance
scentless chamomile*	*Tripleurospermum ino-dorum*	perennial, rhizomes	Poor – cattle avoidance
sow-thistle, perennial*	*Sonchus arvense*	perennial, rhizomes	Fair – when young
sow-thistle, smooth	*Sonchus uliginosus*	perennial, rhizomes	Fair – when young
St. John's wort	*Hypericum perforatum*	perennial	Poor - cattle avoidance
tall buttercup	*Ranunculus acris*	perennial, fibrous	Poor – unpalatable
tansy, common*	*Tanacetum vulgar*	perennial,rhizomes, seed	Poor – unpalatable
thesium***†	*Thesium arvense*	biennial, tap rooted	Poor
toadflax, Dalmation*	*Linaria dalmatica*	perennial, rhizomes	Poor
toadflax, yellow*	*Linaria vulgaris*	perennial, rhizomes	Poor

Common Name	Scientific Name	Life Form and Growth Habit	Grazing Suitability
Grasses			
brome, smooth†	*Bromus inermis*	perennial, rhizomes	Good – very palatable
brome, downy*†	*Bromus tectorum*	perennial, rhizomes	Poor
brome, Japanese*†	*Bromus tectorum*	perennial, rhizomes	Poor
Canada bluegrass	*Poa compressa*	perennial, rhizomes	Ineffective for suppression
Kentucky bluegrass†	*Poa pratensis*	perennial, rhizomes	Ineffective for suppression
creeping red fescue†	*Festuca rubra*	perennial, rhizomes	Ineffective for suppression
crested wheatgrass†	*Agropyron cristatum*	perennial, tufted	Good – spring grazing
hard fescue	*Fesctuca duriuscula*	perennial, tufted	Good
meadow foxtail	*Alopercurus pratensis*	perennial, tufted	Good
sheep fescue	*Festuca ovina*	perennial, tufted	Good
orchard grass	*Dactylis glomerata*	perennial, tufted	Good until maturity
quack grass	*Elytrigea repens*	perennial, rhizomes	Good
red top	*Agrostis stolinifera*	perennial, tufted	Fair – early season
ryegrass, annual	*Lolium multiflorum*	perennial, tufted	Good
Timothy	*Phleum pratense*	perennial, tufted	Good – spring grazing
Shrubs			
caragana†	*Caragana arborescens*	perennial shrub	Poor
cotoneaster***†	*Cotoneaster spp*	Perennial shrub	Poor

* noxious, ** prohibited noxious, *** unclassified, † encroaches into disturbed topsoil

Appendix D Plant Species Names and Synonyms

Table D1 - Plant Species Listed by Common Name

Common Name (RRSS)	Scientific Name (RRSS)	New Scientific Name (ACIMS)
alpine goldenrod	*Solidago multiradiata*	*Solidago multiradiata*
alpine hedysarum	*Hedysarum alpinum*	*Hedysarum alpinum*
annual rye	*Lolium multiflorum*	*Loium multiflorum*
aspen	*Populus tremuloides*	*Populus tremuloides*
aster species	*Aster species*	*Aster species*
awned wheatgrass	*Agropyron trachycaulus spp. trachycaulus*	*Elymus trachycaulus ssp. subsecundus*
awnless brome	*Bromus inermis*	*Bromus inermis*
balsam poplar	*Populus balsamifera*	*Populus balsamifera*
bastard toadflax	*Comandra umbellata*	*Comandra umbellata*
black medick	*Medicago lupulina*	*Medicago lupulina*
blue grama	*Bouteloua gracilis*	*Bouteloua gracilis*
Bluegrass species	*Poa species*	*Poa species*
blue wild rye	*Elymus glaucus*	*Elymus glaucus*
blunt sedge	*Carex obtusata*	*Carex obtusata*
branched pepper-grass	*Lepidium ramosissimum*	*Lepidium ramosissimum*
bristle-stalked sedge	*Carex leptalea*	*Carex leptalea*
broad-leaved everlasting	*Antennaria neglecta*	*Antennaria neglecta*
Buckbrush	*Symphoricarpos occidentalis*	*Symphoricarpos occidentalis*
bull thistle	*Cirsium vulgare*	*Cirsium vulgare*
buttercup species	*Ranunculus species*	*Ranunculus species*
Canada bluegrass	*Poa compressa*	*Poa compressa*
Canada buffaloberry	*Shepherdia canadensis*	*Shepherdia canadensis*
Canada goldenrod	*Solidago canadensis*	*Solidago canadensis*
Canada thistle	*Cirsium arvense*	*Cirsium arvense*
Canada wild rye	*Elymus canadaensis*	*Elymus canadensis*
caraway	*Carum carvi*	*Carum carvi*
chamaerhodos	*Chamaerhodos erecta*	*Chamaerhodos erecta*
Cicer milk vetch	*Astragalus cicer*	*Astragalus cicer*
clover species	*Trifolium species*	*Trifolium species*

Common Name (RRSS)	Scientific Name (RRSS)	New Scientific Name (ACIMS)
Cocklebur	*Xanthium strumarium*	*Xanthium strumarium*
Columbia needle grass	*Stipa columbiana*	*Achnatherum nelsonii ssp. dorei*
common bearberry	*Arctostaphylos uva-ursi*	*Arctostaphylos uva-ursi*
common blue lettuce	*Lactuca pulchella*	*Mulgedium pulchellum*
common blue-eyed grass	*Sisyrinchium montanum*	*Sisyrinchium montanum*
common dandelion	*Taraxacum officinale*	*Taraxacum officinale*
common fireweed	*Epilobium angustifolium*	*Chamerion angustifolium*
common goat's-beard	*Tragopogon dubius*	*Tragopogon dubius*
common knotweed	*Polygonum arenastrum*	*Polygonum aviculare*
common plantain	*Plantago major*	*Plantago major*
common yarrow	*Achillea millefolium*	*Achillea millefolium*
cream-colored vetchling	*Lathyrus ochroleucus*	*Lathyrus ochroleucus*
creeping juniper	*Juniperus horizontalis*	*Juniperus horizontalis*
creeping white prairie aster	*Aster falcatus*	*Symphyotrichum falcatum*
cress species	*Arabis species*	*Arabis species*
crested wheatgrass	*Agropyron cristatum*	*Agropyron cristatum ssp. pectinatum*
cut-leaved anemone	*Anemone multifida*	*Anemone multifida*
dotted blazingstar	*Liatris punctata*	*Liatris punctata*
Drummond's thistle	*Cirsium drummondii*	*Cirsium drummondii*
early blue violet	*Viola adunca*	*Viola adunca*
early cinquefoil	*Potentilla concinna*	*Potentilla concinna*
early yellow locoweed	*Oxytropis sericea*	*Oxytropis sericea*
felwort	*Gentianella amarella*	*Gentianella amarella*
few-flowered milk vetch	*Astragalus vexilliflexus*	*Astragalus vexilliflexus*
field mouse-ear chickweed	*Cerastium arvense*	*Cerastium arvense*
fleabane species	*Erigeron species*	*Erigeron species*
Flodman's thistle	*Cirsium flodmanii*	*Cirsium flodmanii*
Foothills rough fescue	*Festuca campestris*	*Festuca campestris*
fowl bluegrass	*Poa palustris*	*Poa palustris*
foxtail barley	*Hordeum jubatum*	*Hordeum jubatum*
fringed brome	*Bromus ciliatus*	*Bromus ciliatus*
gaillardia	*Gaillardia aristata*	*Gaillardia aristata*
golden bean	*Thermopsis rhombifolia*	*Thermopsis rhombifolia*
goldenrod species	*Solidago species*	*Solidago species*
goosefoot	*Chenopodium pratericola*	*Chenopodium pratericola*
graceful cinquefoil	*Potentilla gracilis*	*Potentilla gracilis*

Common Name (RRSS)	Scientific Name (RRSS)	New Scientific Name (ACIMS)
graceful sedge	*Carex praegracilis*	*Carex praegracilis*
green needle grass	*Stipa viridula*	*Nassella viridula*
green sorrel	*Rumex acetosa*	*Rumex acetosa*
gumweed	*Grindelia squarrosa*	*Grindelia squarrosa*
harebell	*Campanula rotundifolia*	*Campanula rotundifolia*
heart-leaved Alexanders	*Zizia aptera*	*Zizia aptera*
hemp-nettle	*Galeopsis tetrahit*	*Galeopsis tetrahit*
Hooker's oat grass	*Helictotrichon hookeri*	*Avenula hookeri*
Idaho fescue	*Festuca idahoensis*	*Festuca idahoensis*
intermediate oat grass	*Danthonia intermedia*	*Danthonia intermedia*
June grass	*Koeleria macrantha*	*Koeleria macrantha*
keeled brome	*Bromus carinatus*	*Bromus carinatus*
Kentucky bluegrass	*Poa pratensis*	*Poa pratensis*
Kochia	*Kochia scoparia*	*Kochia scoparia*
knot-weed	*Polygonum aviculare*	*Polygonum aviculare*
knot-weed	*Polygonum species*	*Polygonum species*
lamb's-quarters	*Chenopodium album*	*Chenopodium album*
lance-leaved ironplant	*Haplopappus lanceolatus*	*Pyrrocoma lanceolata*
large-leaved yellow avens	*Geum macrophyllum*	*Geum macrophyllum*
late yellow locoweed	*Oxytropis monticola*	*Oxytropis monticola*
Lindley's aster	*Aster ciliolatus*	*Symphyotrichum ciliolatum*
locoweed species	*Oxytropis species*	*Oxytropis species*
long-stalked chickweed	*Stellaria longipes*	*Stellaria longipes*
low everlasting	*Antennaria aprica*	*Antennaria parvifolia*
low goldenrod	*Solidago missouriensis*	*Solidago missouriensis*
low larkspur	*Delphinium bicolor*	*Delphinium bicolor*
low sedge	*Carex stenophylla*	*Carex duriuscula*
marsh hedge-nettle	*Stachys palustris*	*Stachys palustris*
meadow brome	*Bromus biebersteinii*	*Bromus biebersteinii*
meadow foxtail	*Alopercurus pratensis*	*Alopercurus pratensis*
milk vetch species	*Astragalus species*	*Astragalus species*
moss phlox	*Phlox hoodii*	*Phlox hoodii*
mountain shooting star	*Dodecatheon conjugens*	*Dodecatheon conjugens*
narrow-leaved collomia	*Collomia linearis*	*Collomia linearis*
narrow-leaved goosefoot	*Chenopodium leptophyllum*	*Chenopodium leptophyllum*
narrow-leaved puccoon	*Lithospermum incisum*	*Lithospermum incisum*

Common Name (RRSS)	Scientific Name (RRSS)	New Scientific Name (ACIMS)
nodding onion	*Allium cernuum*	*Allium cernuum*
northern bedstraw	*Galium boreale*	*Galium boreale*
Nodding thistle	*Cardus nutans*	*Cardus nutans*
northern fairy candelabra	*Androsace septentrionalis*	*Androsace septentrionalis*
northern gooseberry	*Ribes oxyacanthoides*	*Ribes oxyacanthoides*
northern hedysarum	*Hedysarum boreale*	*Hedysarum boreale*
Northern wheatgrass	*Agropyron trachycaulus spp. trachy-caulus*	*Elymus lanceolatus*
one-sided wintergreen	*Orthilia secunda*	*Orthilia secunda*
orchard grass	*Dactylis glomerata*	*Dactylis glomerata*
owl-clover	*Orthocarpus luteus*	*Orthocarpus luteus*
pale blue-eyed grass	*Sisyrinchium septentrionale*	*Sisyrinchium septentrionale*
Parry oat grass	*Danthonia parryi*	*Danthonia parryi*
pasture sagewort	*Artemisia frigida*	*Artemisia frigida*
perennial sow-thistle	*Sonchus arvensis*	*Sonchus arvensis*
pine reed grass	*Calamagrostis rubescens*	*Calamagrostis rubescens*
plains bluegrass	*Poa arida*	*Poa arida*
plains muhly	*Muhlenbergia cuspidata*	*Muhlenbergia cuspidata*
plains reed grass	*Calamagrostis montanensis*	*Calamagrostis montanensis*
plains wormwood	*Artemisia campestris*	*Artemisia campestris*
prairie cinquefoil	*Potentilla pensylvanica*	*Potentilla pensylvanica*
prairie coneflower	*Ratibida columnifera*	*Ratibida columnifera*
prairie crocus	*Anemone patens*	*Anemone patens*
prairie rose	*Rosa arkansana*	*Rosa arkansana*
prairie sagewort	*Artemisia ludoviciana*	*Artemisia ludoviciana*
prairie selaginella	*Selaginella densa*	*Selaginella densa*
prickly rose	*Rosa acicularis*	*Rosa acicularis*
Primula species	*Primula species*	*Primula species*
pumpelly brome	*Bromus inermis ssp. pumpellianus*	*Bromus pumpellianus*
purple milk vetch	*Astragalus dasyglottis*	*Astragalus agrestis*
quack grass	*Elytrigea repens var. repens*	*Elymus repens*
ragwort species	*Senecio species*	*Senecio species*
red clover	*Trifolium pratense*	*Trifolium pratense*
red fescue	*Festuca rubra*	*Festuca rubra*
reflexed locoweed	*Oxytropis deflexa*	*Oxytropis deflexa*
Richardson's needle grass	*Stipa richardsonii*	*Achnatherum richardsonii*

Common Name (RRSS)	Scientific Name (RRSS)	New Scientific Name (ACIMS)
Richardson's alumroot	*Heuchera richardsonii*	*Heuchera richardsonii*
Rocky mountain fescue	*Festuca saximontana*	*Festuca saximontana*
Ross' sedge	*Carex rossii*	*Carex rossii*
rough cinquefoil	*Potentilla norvegica*	*Potentilla norvegica*
rough hair grass	*Agrostis scabra*	*Agrostis scabra*
Russian pigweed	*Axyris amaranthoides*	*Axyris amaranthoides*
saskatoon	*Amelanchier alnifolia*	*Amelanchier alnifolia*
seaside arrow-grass	*Triglochin maritima*	*Triglochin maritima*
sedge species	*Carex species*	*Carex species*
sheep fescue	*Festuca ovina*	*Festuca ovina*
shepherd's-purse	*Capsella bursa-pastoris*	*Capsella bursa-pastoris*
shining arnica	*Arnica fulgens*	*Arnica fulgens*
showy locoweed	*Oxytropis splendens*	*Oxytropis splendens*
shrubby cinquefoil	*Potentilla fruticosa*	*Dasiphora fruticosa*
silky perennial lupine	*Lupinus sericeus*	*Lupinus sericeus*
silvery cinquefoil	*Potentilla argentea*	*Drymocallis arguta*
slender wheatgrass	*Elymus trachycaulus var. trachycaulus*	*Elymus trachycaulus*
small-leaved everlasting	*Antennaria parvifolia*	*Antennaria parvifolia*
smooth aster	*Aster laevis*	*Symphyotrichum laeve*
Snowberry	*Symphoricarpos albus*	*Symphoricarpos albus*
spear-leaved goosefoot	*Monolepis nuttalliana*	*Monolepis nuttalliana*
Sprengel's sedge	*Carex sprengelii*	*Carex sprengelii*
squawroot	*Perideridia gairdneri*	*Perideridia gairdneri*
star-flowered Solomon's-seal	*Smilacina stellata*	*Maianthemum stellatum*
sticky purple geranium	*Geranium viscosissimum*	*Geranium viscosissimum*
Stinkweed	*Thlaspi arvense*	*Thlaspi arvense*
streambank wheatgrass	*Elymus lanceolatus ssp. lanceolatus*	*Elymus lanceolatus*
sun-loving sedge	*Carex pensylvanica*	*Carex inops*
Sweetgrass	*Hierochloe odorata*	*Anthoxanthum hirtum*
tall buttercup	*Ranunculus acris L.*	*Ranunculus acris*
tall buttercup	*Ranunculus acris*	*Ranunculus cardiophyllus*
tall hedge mustard	*Sysmbrium loeselli*	*Sysmbrium loeselli*
tall lungwort	*Mertensia paniculata*	*Mertensia paniculata*
thin-leaved ragwort	*Senecio pseudaureus*	*Packera pseudaurea*
three-flowered avens	*Geum triflorum*	*Geum triflorum*

Common Name (RRSS)	Scientific Name (RRSS)	New Scientific Name (ACIMS)
timberline bluegrass	*Poa glauca*	*Poa glauca*
timothy	*Phleum pratense*	*Phleum pratense*
Toadflax	*Linaria vulgaris*	*Linaria vulgaris*
toadflax species	*Linaria species*	*Linaria species*
tufted fleabane	*Erigeron caespitosus*	*Erigeron caespitosus*
Tufted hair grass	*Deschampsia cespitosa*	*Deschampsia cespitosa*
tufted white prairie aster	*Aster ericoides*	*Symphyotrichum ericoides*
veiny meadow rue	*Thalictrum venulosum*	*Thalictrum venulosum*
violet species	*Viola species*	*Viola species*
western bluebur	*Lappula occidentalis*	*Lappula occidentalis*
western Canada violet	*Viola canadensis*	*Viola canadensis*
western fairy candelabra	*Androsace occidentalis*	*Androsace occidentalis*
Western porcupine grass	*Stipa curtiseta*	*Hesperostipa curtiseta*
Western wheatgrass	*Agropyron smithii*	*Pascopyrum smithii*
wheatgrass species	*Agropyron species*	
white camas	*Zigadenus elegans*	*Zigadenus elegans*
white clover	*Trifolium repens*	*Trifolium repens*
white spruce	*Picea glauca*	*Picea glauca*
white sweet-clover	*Melilotus alba*	*Melilotus alba*
Whitlow-grass species	*Draba species*	*Draba species*
wild bergamot	*Monarda fistulosa*	*Monarda fistulosa*
wild blue flax	*Linum lewisii*	*Linum lewisii*
wild red raspberry	*Rubus idaeus*	*Rubus idaeus*
wild strawberry	*Fragaria virginiana*	*Fragaria virginiana*
wild vetch	*Vicia americana*	*Vicia americana*
wild white geranium	*Geranium richardsonii*	*Geranium richardsonii*
wire rush	*Juncus balticus*	*Juncus balticus*
woolly gromwell	*Lithospermum ruderale*	*Lithospermum ruderale*
Woolly sedge	*Carex lanuginosa*	*Carex pellita*
yellow avens	*Geum aleppicum*	*Geum aleppicum*
yellow false dandelion	*Agoseris glauca*	*Agoseris glauca*
yellow hedysarum	*Hedysarum sulphurescens*	*Hedysarum sulphurescens*
yellow sweet-clover	*Melilotus officinalis*	*Melilotus officinalis*

Table D2 - Plant Species Listed by Scientific Name

Scientific Name (RRSS)	New Scientific Name (ACIMS)	Common Name (RRSS)
Achillea millefolium	*Achillea millefolium*	common yarrow
Agoseris glauca	*Agoseris glauca*	yellow false dandelion
Agropyron dasystachyum	*Elymus lanceolatus*	Northern wheatgrass
Agropyron cristatum	*Agropyron cristatum ssp. pectina-tum*	crested wheatgrass
Agropyron repens var. repens	*Elymus repens*	quack grass
Agropyron trachycalumssp.riparum,	*Elymus lanceolatus*	streambank wheatgrass
Agrostis scabra	*Agrostis scabra*	rough hair grass
Agropyron smithii	*Pascopyrum smithii*	western wheatgrass
Agropyron species		wheatgrass species
Agropyron trachycalum	*Elymus trachycaulus ssp. subsecun-dus*	awned wheatgrass
Agropyron trachycalum var. unilata-terale	*Elymus trachycaulus*	slender wheatgrass
Allium cernuum	*Allium cernuum*	nodding onion
Alopercurus pratensis	*Alopercurus pratensis*	meadow foxtail
Amelanchier alnifolia	*Amelanchier alnifolia*	Saskatoon
Androsace occidentalis	*Androsace occidentalis*	western fairy candelabra
Androsace septentrionalis	*Androsace septentrionalis*	northern fairy candelabra
Anemone multifida	*Anemone multifida*	cut-leaved anemone
Anemone patens	*Anemone patens*	prairie crocus
Antennaria aprica	*Antennaria parvifolia*	low everlasting
Antennaria neglecta	*Antennaria neglecta*	broad-leaved everlasting
Antennaria parvifolia	*Antennaria parvifolia*	small-leaved everlasting
Arabis species	*Arabis species*	cress species
Arctostaphylos uva-ursi	*Arctostaphylos uva-ursi*	common bearberry
Arnica fulgens	*Arnica fulgens*	shining arnica
Artemisia campestris	*Artemisia campestris*	plains wormwood
Artemisia frigida	*Artemisia frigida*	pasture sagewort
Artemisia ludoviciana	*Artemisia ludoviciana*	prairie sagewort
Aster ciliolatus	*Symphyotrichum ciliolatum*	Lindley's aster
Aster ericoides	*Symphyotrichum ericoides*	tufted white prairie aster
Aster falcatus	*Symphyotrichum falcatum*	creeping white prairie aster
Aster laevis	*Symphyotrichum laeve*	smooth aster

Scientific Name (RRSS)	New Scientific Name (ACIMS)	Common Name (RRSS)
Aster species	*Aster species*	aster species
Astragalus cicer	*Astragalus cicer*	Cicer milk vetch
Astragalus dasyglottis	*Astragalus agrestis*	purple milk vetch
Astragalus species	*Astragalus species*	milk vetch species
Astragalus vexilliflexus	*Astragalus vexilliflexus*	few-flowered milk vetch
Axyris amaranthoides	*Axyris amaranthoides*	Russian pigweed
Bouteloua gracilis	*Bouteloua gracilis*	blue grama
Bromus biebersteinii	*Bromus biebersteinii*	meadow brome
Bromus carinatus	*Bromus carinatus*	keeled brome
Bromus ciliatus	*Bromus ciliatus*	fringed brome
Bromus inermis	*Bromus inermis*	awnless brome
Bromus inermis ssp. pumpellianus	*Bromus pumpellianus*	pumpelly brome
Calamagrostis montanensis	*Calamagrostis montanensis*	plains reed grass
Calamagrostis rubescens	*Calamagrostis rubescens*	pine reed grass
Campanula rotundifolia	*Campanula rotundifolia*	harebell
Capsella bursa-pastoris	*Capsella bursa-pastoris*	shepherd's-purse
Cardus nutans	*Cardus nutans*	nodding thistle
Carex lanuginosa (Michx.)	*Carex pellita*	Woolly sedge
Carex leptalea	*Carex leptalea*	bristle-stalked sedge
Carex obtusata	*Carex obtusata*	blunt sedge
Carex pensylvanica	*Carex inops*	sun-loving sedge
Carex praegracilis	*Carex praegracilis*	graceful sedge
Carex rossii	*Carex rossii*	Ross' sedge
Carex species	*Carex species*	sedge species
Carex sprengelii	*Carex sprengelii*	Sprengel's sedge
Carex stenophylla	*Carex duriuscula*	low sedge
Carum carvi	*Carum carvi*	caraway
Cerastium arvense	*Cerastium arvense*	field mouse-ear chickweed
Chamaerhodos erecta	*Chamaerhodos erecta*	chamaerhodos
Chenopodium album	*Chenopodium album*	lamb's-quarters
Chenopodium leptophyllum	*Chenopodium leptophyllum*	narrow-leaved goosefoot
Chenopodium pratericola	*Chenopodium pratericola*	goosefoot
Cirsium arvense	*Cirsium arvense*	Canada thistle
Cirsium drummondii	*Cirsium drummondii*	Drummond's thistle
Cirsium flodmanii	*Cirsium flodmanii*	Flodman's thistle
Cirsium vulgare	*Cirsium vulgare*	bull thistle

Scientific Name (RRSS)	New Scientific Name (ACIMS)	Common Name (RRSS)
Collomia linearis	*Collomia linearis*	narrow-leaved collomia
Comandra umbellata	*Comandra umbellata*	bastard toadflax
Dactylis glomerata	*Dactylis glomerata*	orchard grass
Danthonia intermedia	*Danthonia intermedia*	intermediate oat grass
Danthonia parryi	*Danthonia parryi*	Parry oat grass
Delphinium bicolor	*Delphinium bicolor*	low larkspur
Deschampsia cespitosa	*Deschampsia cespitosa*	tufted hair grass
Dodecatheon conjugens	*Dodecatheon conjugens*	mountain shooting star
Draba species	*Draba species*	Whitlow-grass species
Elymus canadensis	*Elymus canadensis*	Canada wild rye
Elymus glaucus	*Elymus glaucus*	blue wild rye
Elymus piperi	*Leymus cinerus*	giant wild rye
Epilobium angustifolium	*Chamerion angustifolium*	common fireweed
Erigeron caespitosus	*Erigeron caespitosus*	tufted fleabane
Erigeron species	*Erigeron species*	fleabane species
Festuca campestris	*Festuca campestris*	Foothills rough fescue
Festuca idahoensis	*Festuca idahoensis*	Idaho fescue
Festuca ovina	*Festuca ovina*	sheep fescue
Festuca rubra	*Festuca rubra*	red fescue
Festuca saximontana	*Festuca saximontana*	Rocky mountain fescue
Fragaria virginiana	*Fragaria virginiana*	wild strawberry
Gaillardia aristata	*Gaillardia aristata*	gaillardia
Galeopsis tetrahit	*Galeopsis tetrahit*	hemp-nettle
Galium boreale	*Galium boreale*	northern bedstraw
Gentianella amarella	*Gentianella amarella*	felwort
Geranium richardsonii	*Geranium richardsonii*	wild white geranium
Geranium viscosissimum	*Geranium viscosissimum*	sticky purple geranium
Geum aleppicum	*Geum aleppicum*	yellow avens
Geum macrophyllum	*Geum macrophyllum*	large-leaved yellow avens
Geum triflorum	*Geum triflorum*	three-flowered avens
Grindelia squarrosa	*Grindelia squarrosa*	gumweed
Haplopappus lanceolatus	*Pyrrocoma lanceolata*	lance-leaved ironplant
Hedysarum alpinum	*Hedysarum alpinum*	alpine hedysarum
Hedysarum boreale	*Hedysarum boreale*	northern hedysarum
Hedysarum sulphurescens	*Hedysarum sulphurescens*	yellow hedysarum
Helictotrichon hookeri	*Avenula hookeri*	Hooker's oat grass

Scientific Name (RRSS)	New Scientific Name (ACIMS)	Common Name (RRSS)
Heuchera richardsonii	*Heuchera richardsonii*	Richardson's alumroot
Hierochloe odorata	*Anthoxanthum hirtum*	Sweetgrass
Hordeum jubatum	*Hordeum jubatum*	foxtail barley
Juncus balticus	*Juncus balticus*	wire rush
Juniperus horizontalis	*Juniperus horizontalis*	creeping juniper
Koeleria macrantha	*Koeleria macrantha*	June grass
Kochia scoparia	*Kochia scoparia*	Kochia
Lactuca pulchella	*Mulgedium pulchellum*	common blue lettuce
Lappula occidentalis	*Lappula occidentalis*	western bluebur
Lathyrus ochroleucus	*Lathyrus ochroleucus*	cream-colored vetchling
Lepidium ramosissimum	*Lepidium ramosissimum*	branched pepper-grass
Liatris punctata	*Liatris punctata*	dotted blazingstar
Linaria species	*Linaria species*	toadflax species
Linaria vulgaris	*Linaria vulgaris*	Toadflax
Linum lewisii	*Linum lewisii*	wild blue flax
Lithospermum incisum	*Lithospermum incisum*	narrow-leaved puccoon
Lithospermum ruderale	*Lithospermum ruderale*	woolly gromwell
Lolium multiflorum	*Lolium multiflorum*	annual rye
Lupinus sericeus	*Lupinus sericeus*	silky perennial lupine
Medicago lupulina	*Medicago lupulina*	black medick
Melilotus alba	*Melilotus alba*	white sweet-clover
Melilotus officinalis	*Melilotus officinalis*	yellow sweet-clover
Mertensia paniculata	*Mertensia paniculata*	tall lungwort
Monarda fistulosa	*Monarda fistulosa*	wild bergamot
Monolepis nuttalliana	*Monolepis nuttalliana*	spear-leaved goosefoot
Muhlenbergia cuspidata	*Muhlenbergia cuspidata*	plains muhly
Orthocarpus luteus	*Orthocarpus luteus*	owl-clover
Orthilia secunda	*Orthilia secunda*	one-sided wintergreen
Oxytropis deflexa	*Oxytropis deflexa*	reflexed locoweed
Oxytropis monticola	*Oxytropis monticola*	late yellow locoweed
Oxytropis sericea	*Oxytropis sericea*	early yellow locoweed
Oxytropis splendens	*Oxytropis splendens*	showy locoweed
Oxytropis species	*Oxytropis species*	locoweed species
Perideridia gairdneri	*Perideridia gairdneri*	squawroot
Phleum pratense	*Phleum pratense*	timothy
Phlox hoodii	*Phlox hoodii*	moss phlox

Scientific Name (RRSS)	New Scientific Name (ACIMS)	Common Name (RRSS)
Picea glauca	*Picea glauca*	white spruce
Plantago major	*Plantago major*	common plantain
Poa arida	*Poa arida*	plains bluegrass
Poa compressa	*Poa compressa*	Canada bluegrass
Poa glauca	*Poa glauca*	timberline bluegrass
Poa palustris	*Poa palustris*	fowl bluegrass
Poa pratensis	*Poa pratensis*	Kentucky bluegrass
Poa species	*Poa species*	Bluegrass species
Polygonum arenastrum	*Polygonum aviculare*	common knotweed
Polygonum aviculare	*Polygonum aviculare*	knot-weed
Polygonum species	*Polygonum species*	knot-weed
Populus balsamifera	*Populus balsamifera*	balsam poplar
Populus tremuloides	*Populus tremuloides*	aspen
Potentilla argentea	*Drymocallis arguta*	silvery cinquefoil
Potentilla concinna	*Potentilla concinna*	early cinquefoil
Potentilla fruticosa	*Dasiphora fruticosa*	shrubby cinquefoil
Potentilla gracilis	*Potentilla gracilis*	graceful cinquefoil
Potentilla norvegica	*Potentilla norvegica*	rough cinquefoil
Potentilla pensylvanica	*Potentilla pensylvanica*	prairie cinquefoil
Primula species	*Primula species*	Primula species
Ranunculus species	*Ranunculus species*	buttercup species
Ranunculus acris L.	*Ranunculus acris*	Tall buttercup
Ranunculus acris	*Ranunculus cardiophyllus*	tall buttercup
Ratibida columnifera	*Ratibida columnifera*	prairie coneflower
Ribes oxyacanthoides	*Ribes oxyacanthoides*	northern gooseberry
Rosa acicularis	*Rosa acicularis*	prickly rose
Rosa arkansana	*Rosa arkansana*	prairie rose
Rubus idaeus	*Rubus idaeus*	wild red raspberry
Rumex acetosa	*Rumex acetosa*	green sorrel
Selaginella densa	*Selaginella densa*	prairie selaginella
Senecio pseudaureus	*Packera pseudaurea*	thin-leaved ragwort
Senecio species	*Senecio species*	ragwort species
Shepherdia canadensis	*Shepherdia canadensis*	Canada buffaloberry
Sysmbrium loeselli	*Sysmbrium loeselli*	tall hedge mustard
Sisyrinchium montanum	*Sisyrinchium montanum*	common blue-eyed grass
Sisyrinchium septentrionale	*Sisyrinchium septentrionale*	pale blue-eyed grass

Scientific Name (RRSS)	New Scientific Name (ACIMS)	Common Name (RRSS)
Smilacina stellata	*Maianthemum stellatum*	star-flowered Solomon's-seal
Solidago canadensis	*Solidago canadensis*	Canada goldenrod
Solidago missouriensis	*Solidago missouriensis*	low goldenrod
Solidago multiradiata	*Solidago multiradiata*	alpine goldenrod
Solidago species	*Solidago species*	goldenrod species
Sonchus arvensis	*Sonchus arvensis*	perennial sow-thistle
Stachys palustris	*Stachys palustris*	marsh hedge-nettle
Stellaria longipes	*Stellaria longipes*	long-stalked chickweed
Stipa columbiana	*Achnatherum nelsonii ssp. dorei*	Columbia needle grass
Stipa curtiseta	*Hesperostipa curtiseta*	Western porcupine grass
Stipa richardsonii	*Achnatherum richardsonii*	Richardson’s needle grass
Stipa viridula	*Nassella viridula*	green needle grass
Symphoricarpos albus	*Symphoricarpos albus*	Snowberry
Symphoricarpos occidentalis	*Symphoricarpos occidentalis*	Buckbrush
Taraxacum officinale	*Taraxacum officinale*	common dandelion
Thalictrum venulosum	*Thalictrum venulosum*	veiny meadow rue
Thermopsis rhombifolia	*Thermopsis rhombifolia*	golden bean
Thlaspi arvense	*Thlaspi arvense*	Stinkweed
Tragopogon dubius	*Tragopogon dubius*	common goat's-beard
Trifolium pratense	*Trifolium pratense*	red clover
Trifolium repens	*Trifolium repens*	white clover
Trifolium species	*Trifolium species*	clover species
Triglochin maritima	*Triglochin maritima*	seaside arrow-grass
Vicia americana	*Vicia americana*	wild vetch
Viola adunca	*Viola adunca*	early blue violet
Viola canadensis	*Viola canadensis*	western Canada violet
Viola species	*Viola species*	violet species
Xanthium strumarium	*Xanthium strumarium*	Cocklebur
Zigadenus elegans	*Zigadenus elegans*	white camas
Zizia aptera	*Zizia aptera*	heart-leaved Alexanders
yellow avens	*Geum aleppicum*	*Geum aleppicum*
yellow false dandelion	*Agoseris glauca*	*Agoseris glauca*
yellow hedysarum	*Hedysarum sulphurescens*	*Hedysarum sulphurescens*
yellow sweet-clover	*Melilotus officinalis*	*Melilotus officinalis*