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“When is reclamation success achieved, using the 2010 Reclamation Criteria as a guide?”

Prepared for:

Petroleum Technology Alliance of Canada

Prepared by:

Jay Woosaree and Marshall McKenzie

Land and Water Management

Alberta Innovates – Technology Futures

March 31st 2012

Acknowledgements

We thank the Alberta Upstream Petroleum Research Fund committee members for supporting this project. We appreciate Cenovus Energy, Gear Energy, Special Areas Board, Wainwright Army Base, Alberta Sustainable Resources – Wainwright and Edmonton, Alberta Environment and Water, and Pratum Environmental for providing access to their sites and for providing input into the project.

We would like to thank Tania McDonald (AITF) and Pat Porter (ASRD – Wainwright) for technical input on the project.

Our appreciation also goes to Bonnie Drozdowski (AITF) for her soils expertise and review of the report.

Executive Summary

The 2010 Reclamation Criteria for Wellsites and Associated Facilities for Native Grasslands was released in June of 2011 to relieve then current backlog of processing Reclamation Certificate applications, and to increase the quality of applications and public confidence in the oil and gas industry.

The Record of Observations (RoO) Tool was used in this project to assess reclamation success and to gain an understanding of how past practices such as seeding native species influences reclamation success. An additional objective was to determine the time length after reclamation required to gauge a reclamation certificate as a shorter time period could reduce unwarranted extension of surface leases and costs to industry.

Fourteen sites comprised of five sites in the Central Parkland, six in the Northern Fescue and three in the Dry Mixed Grass subregions were used for the study. Sites ranged from 2.5 years since reclamation to 15 years post reclamation.

Of the fourteen sites assessed all failed the criteria for one or more reasons. Ten sites had failures on invasive species; the young sites under 5 years after reclamation had issues with litter quality and quantity and structural layers. Access roads had soil compaction problems and needed additional vegetation assessments in order to obtain a better species composition. Many of the sites that failed could be passed with a non-routine application using justifications and professional judgment.

We analysed the seed mixtures that were used in this study and those that are sold by commercial seed companies. They had minimal (1-2) structural layers, and were dominated (45-55%) mostly by wheatgrasses and (15-20%) green needle grass. The desirable species representing the climax plant community comprised 10-15% of the seed mix. The various types of wheatgrasses should not be more than 15-20% and green needle no more than 5% of a seed mixture. Seed marketers should become familiar with the criteria and design better seed mixtures that are more representative to controls.

Our intent was not to pass or fail the sites, rather to understand how reclamation practices work. These sites could have passes the criteria using non-routine applications with justifications and professional judgment. Structural layers, third party impacts (continued use of access roads) or the influence of non-native forages, namely smooth brome grass from ditch lines, aspen tree grooves and other surrounding areas were the main reasons for failure.

Those sites that would not pass using professional judgement would necessitate control of invasive species, followed by a time lapse (a year or two) to ensure desired trajectories by prescribed practices. The few sites (three recent seedings in northern fescue, one in Parkland and two in Drymixed grassland) that would not pass the criteria were due to a lack of litter quantity or quality. These sites require more time to mature. However, if the sites have the desired species, one can assume that litter quantity and quality will eventually accrue.

Additionally, many of the fences surrounding these sites were forgotten after reclamation. Removal of the fence 2-3 years after seeding will encourage browsing by herbivores which in turn opens up the plant canopy, facilitating the recruitment of native infill and nutrient cycling.

Access roads posed a difficulty for us in that we did not have sufficient information as to their current status. Many access roads are kept by the land holder for use and therefore reclamation will not hold into perpetuity, bareground, rutting, compaction and compaction related species were common on all access roads. We suggest that even when accesses are reclaimed there are still many individuals using them for many reasons that exacerbate the condition of the roads. Ripping the access road to alleviate compaction while minimizing vegetation damage is a worthwhile practice but keeping vehicles off the roads could be more challenging. Additionally, bulk density could be used as an indicator of compaction. This allows the practioners to fix problems in the early years post-reclamation.

Grazing response has been a tool for measuring range health and to delineate plant communities for decades. This is an indicator from a different industry in Alberta and its use in

the 2010 criteria can impact reclamation success. Plant communities are complex, diverse and variable in nature. How they respond to stresses allows them to build resiliency, which in turn makes them sustainable. Thus having a rating drop due to the presence of Type 4 increasers as a result of grazing or other stress should not constitute failures. Those species classified as class 4 grazing response species are highly adapted to disturbance, usually have good germination and establishment and are well suited for use in reclamation, but they have received a bad reputation due to overgrazed lands being dominated by them. They should rather be used as an indicator of poor practices. These Type 4 species can play a significant role in erosion control and native establishment on a site. Good reclamation practices should include them in a seed mix without exceeding control percentages on adjacent lands.

The effectiveness of the 2010 criteria will depend on the competence and professional judgement of the reclamation practioner. In our study, one of the sites received a reclamation certificate in 2010, yet was found to have failed under bareground, macro-contours, structural layers, litter quality and quantity, noxious weeds and presence of non-native forages. It is anticipated that many DSA's will be submitted using a non-routine application.

The use of the 2010 Reclamation Criteria requires a non-bias and experienced assessor. It provides for a consistent and effective tool to gauge reclamation success and ecosystem functions, as well as forecasting site trajectory in a temporal community composition based scale. The following are some recommendations:

- Control noxious weeds during operational phases and early during post reclamation to limit the amount of seed in the soil.
- Use quality plant materials. Use certified seed where possible and buy all seeds from reputable dealers, inspect seed growers' plots to ensure quality materials.
- Include structural layers, even collecting a handful of forbs, shrubs and legume's seed from the adjacent controls can help accelerate plant community recovery.
- Do not hesitate to use native hay mulch if it is available and ensure it is weed free.
- Seed industry must familiarise themselves and try to better understand the 2010 Reclamation Criteria in order to design better seed mixtures that resemble more closely to site conditions of the natural sub-regions.

- Use competitive species if weeds in the area seem to be a problem. Seed species that are known to compete well with weeds in the reclaimed area. Know this may take a longer time prior to seeking a reclamation certificate.
- Use clean equipment/vehicles when visiting sites.
- Remove the fence line around the lease once plants are established.
- Limit vehicle use on access roads. Some of the vehicle tracks seem like a permanent scar on the landscapes and it increases soil compaction and limits vegetation growth.
- More importantly, do reclamation once and do it right the first time. Redisturbance creates situations for weeds to establish, increases cost and remains a longer liability to the industry.

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1.0 INTRODUCTION

The Alberta Government's new reclamation standards (2010 Reclamation Criteria for Well sites and Associated Facilities for Grasslands) provides a rigorous and science-based process which the upstream oil and gas industry must use to judge if a site is adequately reclaimed and to obtain a reclamation certificate (Alberta Environment 2010).

The 1995 criteria was more site specific and had more emphasis on qualitative assessment such as vegetative cover on the lease and in surrounding control areas. Since the 1995 criteria, reclamation practices and scientific knowledge within native prairies have evolved to include ecological health and function and land operability as indicators of equivalent land capability. "Equivalent land capability" is defined as the ability of the land to support various land uses after conservation and reclamation are similar to the ability that existed prior to an activity being conducted on the land, but that the individual land uses will not necessarily be identical. After a site is contoured to its natural surroundings, it is, most of the time, seeded to a native seed mixture to achieve the desired plant cover or trajectory. How effective are these seeding practices and what is the rate of success? Do they achieve the desired trajectories so that they fit in with the natural surroundings and plant community? Do they deliver similar natural goods and services as prior to disturbances?

The objective of this study was to determine the influence of seed mixes and management practices on reclamation successes, using the "2010 Reclamation Criteria Record of Observation Tool". Additional objectives were to also:

- Identify barriers to reclamation success;
- Determine the required time post reclamation at which oil and gas industries can seek a reclamation certificate; and to
- Recommend seed mixes and best practices that have proved successful in expediting the reclamation trajectory.

Prior to its release, the 2010 Criteria were field tested to validate its rigour as it applied to ecosystem and management functions on a landscape basis. Some of its key features include:

Landscape	Vegetation	Soils
– Drainage	– % Community	– Slope position
– Soil Erosion	– Community structure	– Evidence of disturbance
– Soil Stability	– Litter development	– Topsoil depth
– Bare Areas	– Undesirable plants / weeds	-- Topsoil Colour
– Contour	– Litter quality	– Soil Texture
– Debris		– Soil Consistence

These indicators are measurable and when used properly should lend themselves to whether a site is adequately reclaimed to its pre-disturbed conditions. If the indicators point to a successful trajectory, then the oil and gas industry can seek a reclamation certificate in a much shorter time frame. The length of time required for successful reclamation is often unknown and dependent upon many variables. The sooner a site can pass certification, the less of a liability it is to the oil and gas company. Thus in this project, we will assess sites at different ages after reclamation to look for indicators that can lead to successful reclamation and determine that time frame. The ability to know when and how reclamation success has been achieved using the current criteria will save industry time on assessment and applications and help industry to be more self-regulated. It also allows for a faster audit process.
Additionally, under the 1995 criteria, oil and gas companies have to submit for approval to respective authorities (Canadian Wildlife Service for federal lands and Alberta Sustainable Resource Development for Crown lands) a list of seed mixes to be used following construction of a project. Each company is left to devising its own seed mix and its performance is not clearly known. There is a need for a holistic view of reclamation, the ability of a seed mix to help define reclamation success and to know when one has achieved it. The new 2010 Reclamation Criteria is intended as a tool to measure rangeland health and reclamation success. Based on the history of the site, the seed mixes used and outcomes from using the 2010 “Record of Observation Tools”, we want to be able to recommend standard seed mixes for the various

ecoregions outlined in this project. This will save industry time as we will then know “what does and what does not work”.

This project will give insight into the ease of use of the new Record of Observation (RoO) tool, its cost, and will identify any efficiencies or recommendations in expediting a reclamation certificate. Other potential benefits are:

- The findings can provide the oil and gas industry assurance of whether or not current revegetation methods can meet equivalent land capability.
- It is intended that the new criteria will provide both industry and government a more effective method to determine reclamation success. Any new information gained from this study can help this process of “pulling back” by government in monitoring and placing more responsibility on industry.

2.0 METHODOLOGY

Alberta Sustainable Resources Development (ASRD) and individual oil & gas companies were contacted to obtain suitable sites. Fourteen sites were selected in three ecoregions representing the drymixed grassland, the Northern Fescue and the Central Parkland Region. We requested background information and permission to access the sites from respective lease owners. We were looking for three sites within each ecoregion, having similar reclamation timeframe and post reclamation practices. It was difficult to locate sites with same age and management practices during post reclamation. This makes it difficult to correlate outcomes among sites.

The sites were assessed (Table 1) using the 2010 reclamation criteria assessment tool as outlined in Alberta Environment 2010 Reclamation Criteria for Wellsites and Associated Facilities for Grasslands, (Version 2.0 June, 2011) using the:

- Record of Observation (RoO) Soil Datasheets (Level 1 and Level 2 soil assessments (Appendix D)).
- Record of Observation (RoO) - Vegetation Datasheets

Table 1. Vegetation methodology parameters and their respective Assessment Tool Questions

Parameter:	RoO Assessment Tool Questions	ǂ Information Required (Yes / No)		Pass / Fail Point
		Measurement	***Rating***	
Desired Plants Presence and Cover	Undisturbed Assessment; Disturbed Assessment	Yes, Document Species Type	No	Yes
Plant Community Structure	Structural Layers	Yes	Yes	Yes
Weeds	Prohibited Noxious Noxious Problem/Volunteer	Yes	Yes	Yes
Litter Production	Litter Quantity	Yes	Yes	Yes
	Litter Quality	Yes	Yes	Yes

ǂ Yes = Assessment Tool question plus a measurement or rating are required; No = only an answer to the Assessment Tool question is required (Alberta Environment & Water 2010).

All sites were reclaimed wellsites, the oldest sites were reclaimed in 1997 and the latest was reclaimed in 2009. Four sites were in sandy soil, one in clay loam and the other nine were in silty loam. All sites were within native landscapes and were seeded to native species seed mixes.

Two assessors participated in a three day workshop on the 2010 criteria to ensure understanding of the criteria and to be familiarized with the RoO (Record of Observations). One assessor attended a workshop where the 2010 criteria "frequently asked questions" on how to use the criteria were discussed. After assessing the sites we met with Alberta Environment & Water and Alberta Sustainable Resources Development to clarify questions and ensure proper use of the tool. Common names of plant species were used throughout this document as most

practitioners are familiar with common names. Their respective scientific names are listed in appendix 3.

Figure 1 illustrates an example of a site sketch, showing stratification of the site in order to capture most variability within the site (number of sampling points depends on size of the lease and variability).

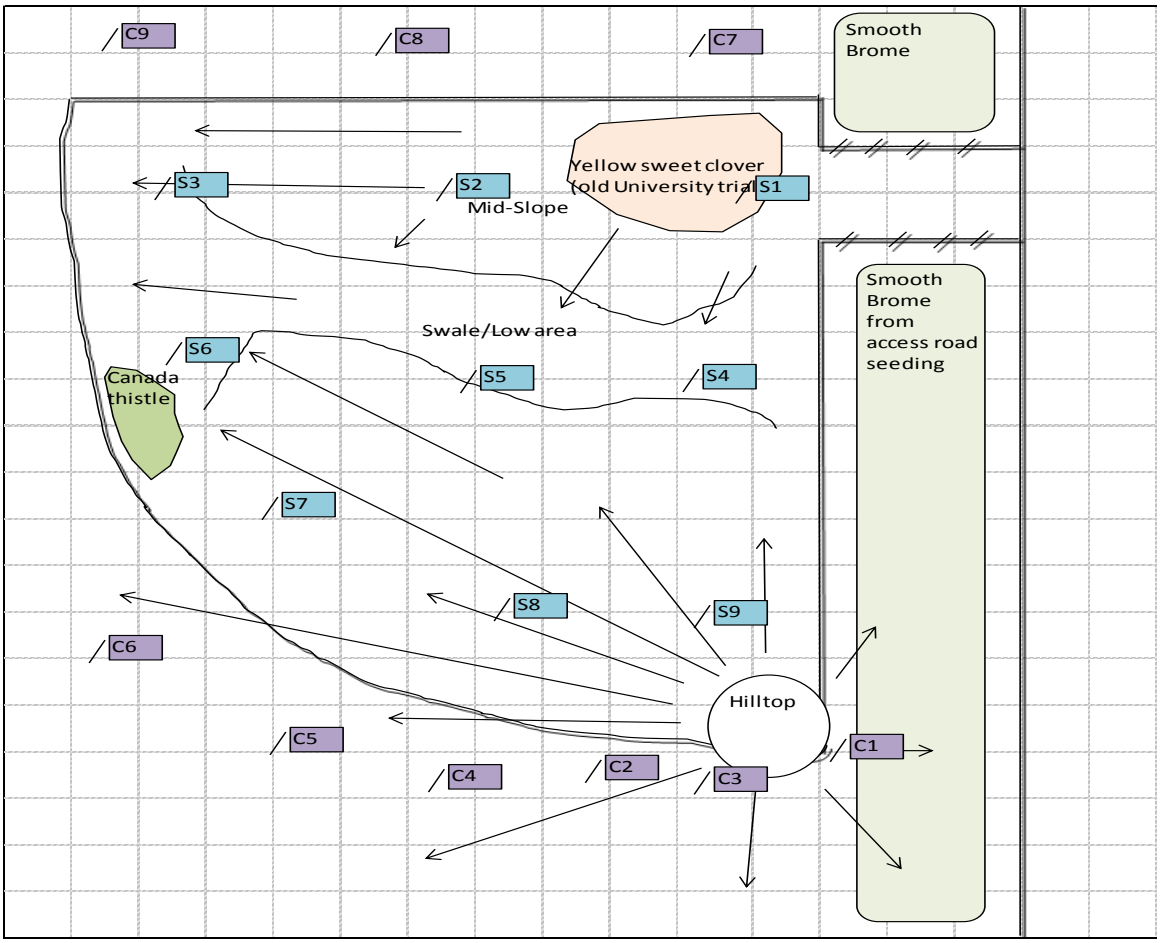

Figure 1. Site sketch of a lease area, showing vegetation and soil sampling points
Note. C = control
S= sampling point on lease.

2.1 Equipment Used

The following represents a list of equipment used for conducting the detailed site assessments:

Plant identification books and range plant community guides
Magnifying lens

Daubenmire frame
Toughbook laptop
GPS
Digital camera
Munsell soil colour chart
AGRASID Version 3.0: Soil Landscapes User's Manual.
http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/sag3254
Shovel
Soil knife
Tape measure
Water bottle
Rating tables from RoO (2010 Criteria Assessment)
High visibility tape

2.2 Definition of Key Terms

These definitions are taken from the 2010 Reclamation Criteria for Wellsites and Associated Facilities for Native Grassland;

Type 1 Species (Decreasers): These native species decrease in abundance due to disturbance. These are normally considered as the most desirable and productive native species in the native plant community.

Type 2 Species (Increaser – Sub Type 1): These species increase in abundance as decreasers decline. They are commonly shorter, less productive species more resistant to grazing and other disturbances. Initially, Type 1 species increase with disturbance but then decrease in abundance later on as grazing or other disturbance pressures continue to increase.

Type 3 Species (Invaders): Invaders are introduced non-native species and not normally a component of the reference plant community.

Type 4 Species (Increaser – Sub Type 2**):** This is a minor group of native increasers that increase in abundance as grazing or other disturbances increase (e.g. low sedge, fringed sage or blue grama grass). These species are highly adapted to disturbance. A high abundance of these species on a reclaimed site may provide a false indication of successful reclamation indicating that the plant community remains at a juvenile stage of succession. Type 4 species are used in

the criteria (sites constructed after 1993, reclaimed after 2010) as an indicator of ecological health.

Infilling species: are native species existing offsite that are re-establishing on the disturbed areas or were seeded. They are considered desirable as they are part of the local native plant community and their presence is a measure of native species recruitment and progress along a successional pathway.

Acceptable Substitutions: These include seeded native species (Type 1 and 2) that are not present on the control but are part of the natural subregion (See the RoO for a species list of native species to individual subregions).Their presence is considered temporary as succession proceeds, but in the short-term they are considered desirable species as they provide ecological benefits such as sheltering canopy, site stabilization and litter accumulation.

Allowable Acceptable Substitutions: Is the percent cover of "Acceptable Substitutions" that are allowed to contribute to the percent cover requirement, (sites constructed after 1993 and reclaimed after 2010). The presence of Type 4 species in the controls is used as the indicator of ecological health and the amount of "Allowable Acceptable Substitutions" that can contribute to the percent cover requirement.

Structural Layers: native grassland communities contain a diversity of plant species varying in breadth, height and rooting depth that occupy different layers as they access the sunlight, water and nutrients from their respective zone.

Litter Quality: represents decomposing organic matter, which is a characteristic of functional litter. It accumulates from previous growing seasons and is the product of established and establishing desirable native perennial vegetation. It will appear gray and oxidized in colour.

Step-Out: a step-out consists of assessing a minimum of 3 additional points, located up to 10 m in a triangular shape from the original assessment point.

3.0 RESULTS

3.1 Parkland Ecoregion

Tables 2 to 4 summarize the sites characteristics, reclamation date and outcomes of the vegetation and soils assessment at each site within the three ecoregions.

In the Central Parkland region, site one failed the vegetation assessment due to the presence of smooth brome grass on the lease site (rating of 0.2 compared to none for the control). The control subsoil had a rating of 1 for texture, while the site had a rating of 1.67 meaning there was some admixing of clay into topsoil during re-contouring/topsoil placement. Subsoil Rooting Restriction for control had a rating of 1 with the site at 1.61 meaning there was sub-soil compaction onsite.

Ripping the compacted areas cures compaction as far as the tines reach, and is the best practice even though it causes some vegetative damage. Selectively applying glyphosate will also facilitate getting this site closer to a reclamation certificate.

Due to the small amount of smooth brome grass found on the lease, a practitioner may try vegetation over ride, but it would be left to the practitioner's professional judgement.

Other factors contributing to a site failing the vegetation assessment in the Parkland region is the influence of non-native forage such as smooth bromegrass from aspen grooves (Figure 2).

Figure 2. Influence of smooth bromegrass into the lease site.

This site in the Parkland has more than adequate litter compared to the control (Figure 3), showing both litter quantity and quality.

Figure 3. Litter on lease site (left) compared to control (right).

Site 2 failed the vegetation assessment for having more smooth bromegrass than the control. The access road showed more compaction compared to the control (Figure 4).

Figure 4. Visual effect of motor vehicles from the access road.

Selectively applying glyphosate will facilitate getting this site closer to a reclamation certificate. Additionally, this site also failed on top soil depth.

Site 3 had a dominance of toad flax (*Linaria vulgaris*) and as a result failed the assessment on noxious weeds (Figure 5). Other factors contributing to site failure include topsoil depth on the hilltop. A vegetation override could have overcome the problem. Applying herbicides for control of toadflax and re-assessing in the following year could result in the site passing the reclamation criteria.

Figure 5. Lease site with an abundance of toad flax.

Site 4 was located in the sandy soils and despite being seeded three times with a range of native species in the seed mix; the site was dominated by Rocky Mountain fescue. Although a reclamation certificate was issued for this site in 2010, the site failed the assessment due to amount of bareground, lack of litter (both quantity and quality), presence of smooth bromegrass and lack of structural layers (Figures 6 & 7).

It will be best to reseed this site and allow at least three years prior to seeking a reclamation certificate. In the meantime, selective treatment of the smooth bromegrass with glyphosate will help.

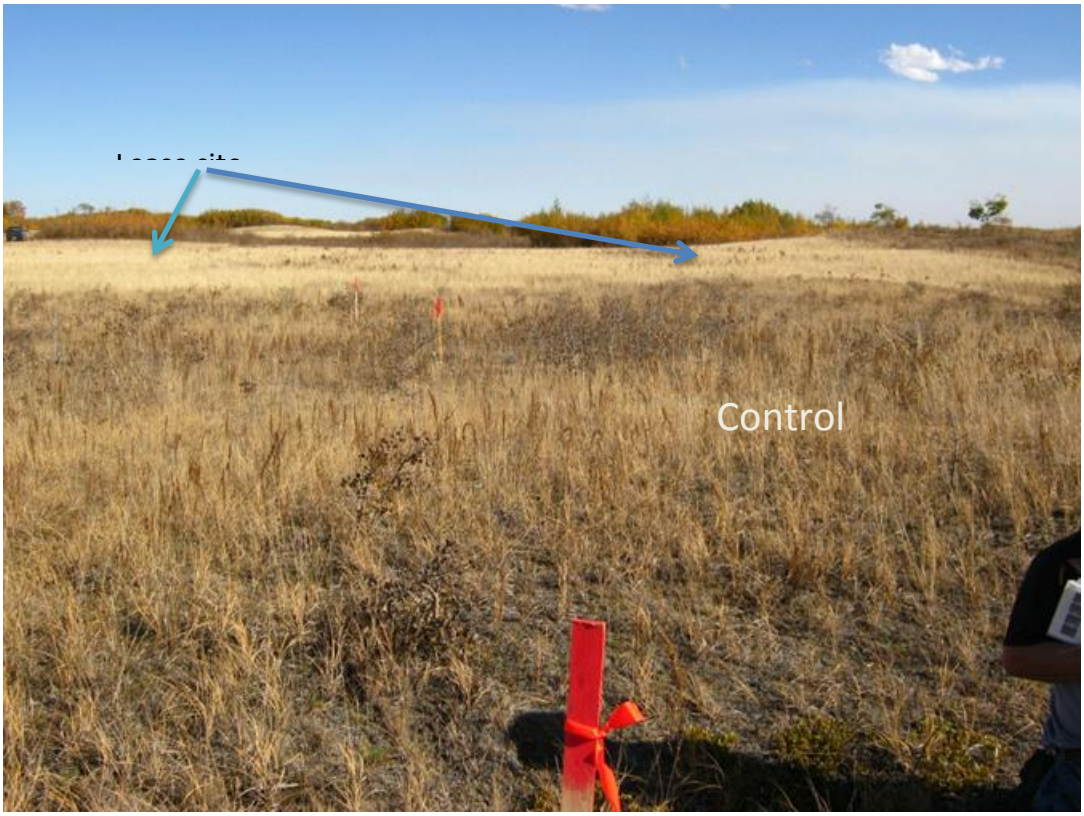

Figure 6. **Vegetation on lease site does not blend with the natural surroundings.**

Figure 7. **Lease site showing one structural layer (L), lack of litter and bareground (R).**

Site 5 provides an example of good reclamation with desirable plant communities that resembled the natural area (Figure 8).

Figure 8. **Successful reclamation site in the sandy soils, within the Parkland Region.**

However, Site 5 failed the vegetation assessment due to occasional occurrence of Canada thistle (*Cirsium arvense*), a noxious weed on the lease (Figure 8). Selective treatment to eradicate Canada thistle is recommended. There was also more "Type 4 increaser" within the sample points on the access road. Collecting more data samples to even out single quadrat Type 4 increaser on the access road could have alleviated the problem and resulted in passing the site.

Table 2. Summary of the Detailed Site Assessment using the Record of Observation Tool - Parkland Region.

Ecoregion	Ecosite	Soil Texture	Seed Mix	Reclamation Date	2010 Criteria results	What failed and Ratings
Parkland Site 1	CPA 26-Plains Rough Fescue Kentucky Bluegrass	SiL	10% Green needle 10% Northern Wheatgrass 5% Slender wheatgrass 5% June grass 10% Western wheatgrass 50% Plains rough fescue 10% Western porcupine	May 25-2007	Failed on rooting restrictions, topsoil depth, and problem weeds	Subsoil texture C=1, S=1.67 Subsoil Rooting Restriction C=1 S=1.61 Problem Weeds - Had more smooth bromegrass, C=0 S=0.2
Parkland Site 2	CPC32-Snowberry Kentucky Bluegrass	Loamy Sand	No seed mix list was available from contractor		Failed on problem weeds (Had more smooth bromegrass)	Problem weeds C=20, S=26.3 Compaction on access road
Parkland Site 3	CPA4 upland sedge-western wheat	SiL	20% Green needle- 20%Northern Wheat 20% Slender wheat 20% Western wheat 10% Blue grama 10% plains rough fescue	Jun-09	Failed landscape assessment for bareground. 1 failure on structure but consistence passed, one topsoil depth failed-hilltop Vegetation failed on prohibited noxious (toadflax) and problem weeds (quackgrass)	Problem weeds: C=0 S=10 Noxious weed: C=0S=5.6. Fail on cover if constructed before 1993 but reclaimed before and after 2001- One topsoil depth (hilltop) 77% of control

Ecoregion	Ecosite	Soil Texture	Seed Mix	Reclamation Date	2010 Criteria results	What failed and Ratings
Parkland Site 4	CPC16-juniper-sedge-plains rough fescue	Loamy Sand	July 2005 45% Canada wildrye, 15% Sheep fescue, 10% Green needlegrass, 10% Blue grama 10% Sand dropseed 5% Hillcrest awned wheat, 5% June grass. Nov 11, 2007 and June 23 2009 15% Blue grama 25% Canada bluegrass 20% Sheep fescue 20% Sand dropseed 20% Awned wheat	Jul 15-2005, Nov 11-2007 and Jun 23-2009	Should have failed landscape assessment on Bareground and Macro-contouring, Failure on topsoil colour, litter quantity, Structural layers, problem weeds-Smooth bromegrass	Structural Layers: C=3 Site=1 Topsoil Colour: C=2 S=2.78 Problem Weeds: C=0 S=1.1
Parkland Site 5	CPA7 sand grass-needle and thread grass-June grass	Loamy Sand	See Appendix 2 (too many specie to list)	Spring 1997	Failed on noxious weeds (*Canada thistle*)	Noxious weeds C=5, S=7.6

Note: C= control; S=sampling point on the lease site

3.2 Northern Fescue Region

Sites 6 and 7 were of 15 years post reclamation. Both sites had good structural layers and litter (quality and quantity); however both sites had more smooth bromegrass than control areas. In Site 6 the lease area had 26.7 % smooth bromegrass compared to 18.3% for the control. For Site 7, smooth brome grass cover was 3.8%, compared to 0% for the control.
Selectively application of glyphosate is recommended. Professional judgement could be used to pass the sites as they were reclaimed before 2010 and there is much smooth bromegrass invasion occurring in surrounding areas and within the access roads.

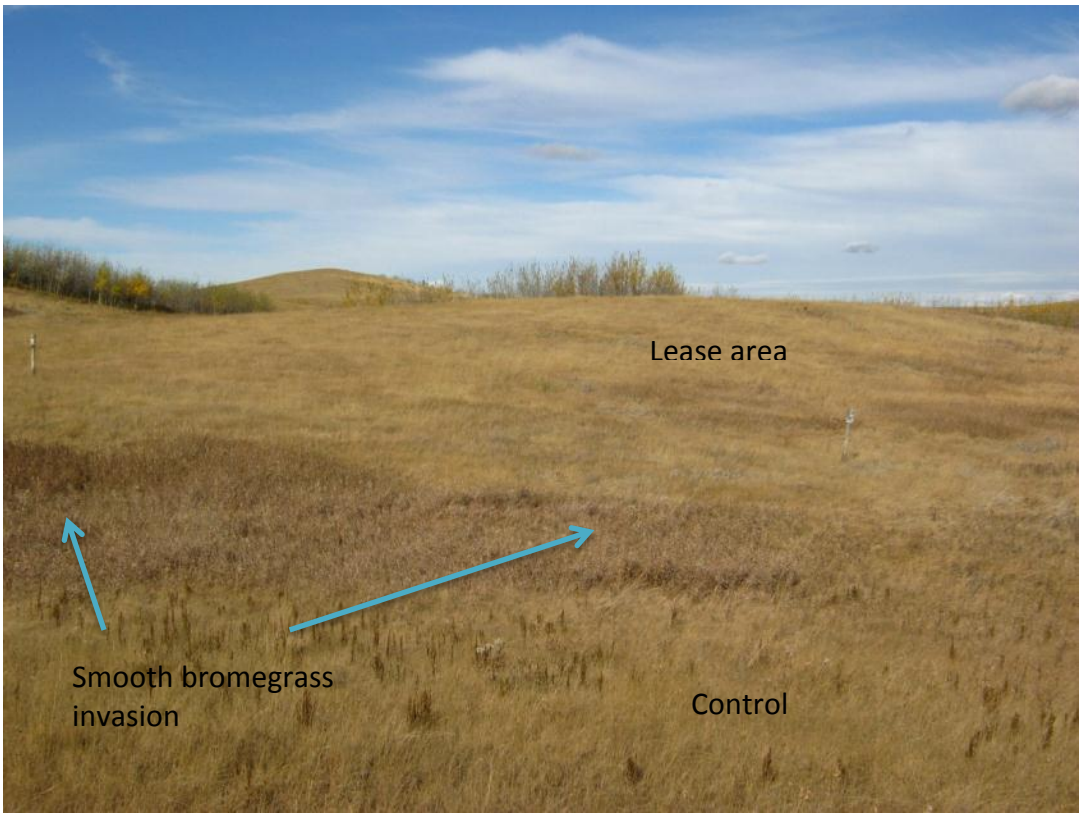

Figure 9. Reclaimed plains rough fescue grassland in the Neutral Hills area, 15 years after reclamation.

Site 8 and 9 were seeded in spring of 2009 while Site 10 was seeded in late summer of 2009, all of them failed on one or more factors such as problem weeds (Figures 10 and 11), noxious weeds and structural layers (Figures 10 and 11). The control had zero cover for smooth

bromegrass whereas the lease site had 18.3% cover (Figure 10). Additionally, the access road failed on vegetation cover as a result of grazing response.

Site 8 also had noxious weeds (Canada thistle) on the lease (C=0, S=5%). Occurrence of Kentucky bluegrass also remains a concern on these sites.

Figure 10. **Occurrence of smooth brome grass on seeded lease three years after reclamation.**

Figure 11. **An inconspicuous lack of structural layers 2.5 years after reclamation.**

Continued maintenance of these sites is a must, with more attention toward control of Canada thistle and smooth bromegrass.

More sampling on the access road could result in lower averages for Type 4 increasers.

Site 11 was seeded in summer of 2009 and only had 2.5 growing seasons. One sampling point on the access road failed on topsoil depth, but again the major issue was problem weeds (Smooth brome). Ripping the problem area on the access road, along with restricting vehicles access will facilitate vegetation regrowth and lead the site to a successful trajectory.

Table 3. Summary of the Detail Site Assessment using the Record of Observation Tools – Northern Fescue Region.

Ecoregion	Ecosite	Soil Texture	Seed Mix	Reclamation Date	2010 Criteria results	What failed and Ratings
Northern Fescue Site 6	CPA 32- Kentucky bluegrass-sedge-W. porcupine grass	SiL	See Appendix 1	Spring 1996	Failed on problem weeds smooth brome grass	Problem Weeds (Had more smooth brome grass) C=18.3, S= 26.7
Northern Fescue Site 7	CPA3 Rough fescue-upland sedge	SiL	See Appendix 1	Spring 1996	Failed on problem weeds	Problem Weeds (Had more smooth bromegrass) C=0, S= 3.8
Northern Fescue Site 8	NFA1 Rough fescue western porcupine	SiL	25% Plains rough fescue 5% Green needle grass 15.5% June grass 12.5% Rocky mountain fescue 0.5% Hooker's oat grass 5% Northern wheatgrass 15% Slender wheatgrass 3% Yarrow 2.5% Golden rod 1% Sedges	Summer 2009	Failed on: Problem weeds, Noxious weeds, Structural layers, Access road both pairs failed Vegetation cover due to grazing response	Problem weeds: C=0, S=18.3 , smooth bromegrass Noxious weeds C=0, S=5 (Canada thistle) Structural Layer; S=1.6, C= 2.7
Northern Fescue Site 9	NFA9 Blue grama Western porcupine Plains rough	SiL	25% Plains rough fescue 5% Green needle grass 15.5%June grass 12.5% Rocky Mountain fescue 15% Blue grama 0.5% Hooker's oat grass 5% Northern wheatgrass 15% Slender wheatgrass 3% Yarrow 2.5% Golden rod 1% Sedges	Summer 2009	Failed on Problem weeds: Yellow sweet clover and smooth bromegrass, Structural layers	Problem weeds C=8.3 S=18 Structural Layers C=2.7 S=1.6

Ecoregion	Ecosite	Soil Texture	Seed Mix	Reclamation Date	2010 Criteria results	What failed and Ratings
Northern Fescue Site 10			30%Western wheatgrass 25%Northern wheatgrass 5% slender wheatgrass 10% June grass 10% Plains rough fescue 20% Green needle grass	Nov 28-2008 then Aug 31-09	Failed landscape assessment for bareground- would have failed for problem forages (smooth bromegrass)	DSA stopped after landscape failure
Northern Fescue Site 11	NFA3 Kentucky bluegrass plains rough fescue	SiL	25% Plains rough fescue 5% Green needle grass 15.5%June grass 12.5% Rocky Mountain fescue 15% Blue grama 0.5% Hooker's oat grass 5% Northern wheatgrass 15% Slender wheatgrass 3% Yarrow	Summer 2009-2.5 growing seasons	Lower- failed one topsoil depth, problem weeds: smooth bromegrass & dandelion. Middle of site- failed consistence, passed on structure. Subsoil failed texture. Failed structural layers and problem weeds. Upper Site- failed on structural layers and problem weeds	Upper- structural layers- C=3, S=1.8 Problem weeds C=21.4, S=22 Middle- Structural layers C=3.6, S=2 Problem weeds: C=13, S=18 Lower site- Problem weeds C=12.6, S=18.8

Table 4 summarizes the detail site assessment for sites 12-14 in the drymixed grassland. Site 12 and 13 were seeded in summer of 2006 and Site 14 was seeded in fall of 2007. Site 12 represents “blow-out” soils and had adequate plant cover, but need selective control of Canada thistle and sweet clover (Figure 12). Site 12 and 13 also failed on litter quality.

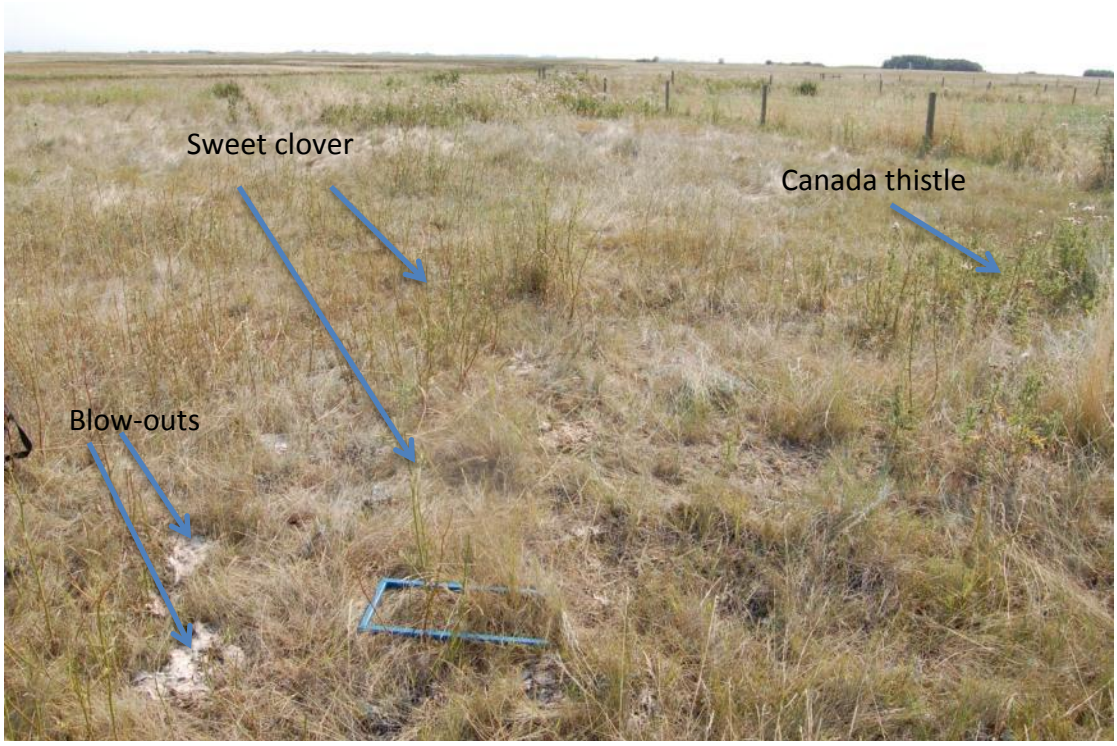

Figure 12. Reclaimed site in a saline area in the drymixed grass, 5 years after reclamation.

Site 13 should have failed on the landscape assessment. Mowing was done to control weeds (Figure 13). One has to wait for vegetation regrowth to do a proper assessment. Mowing too close to the ground also exposes more bare soil. The best option is to control the weeds and wait a year to do another assessment.

Figure 13. Mowing to control weeds.

Figure 14. Litter quality, 5 years after reclamation (L=control, R=lease site).

Site 14 had good vegetation cover, growth and litter quantity but lacked structural layers (Figure 15).Litter quality is almost comparable (Figure 14) to the control, showing the oxidizing colour. Removing the fence or mowing high will facilitate native infill. The site might be ready for certification in 3-5years. There is also a strong influence of alfalfa on this site as the adjacent areas were seeded to alfalfa for forages.

Figure 15. **Reclaimed site in the Drymixed Grassland, 4 years after reclamation.**

Figure 16. **Compaction on the access road in the sandy soils, showing platy structure.**

Table 4. Summary of the Detail Site Assessment using the Record of Observation Tools –Drymixed Grassland Region.

Ecoregion	Ecosite	Soil Texture	Seed Mix	Reclamation Date	2010 Criteria results	What failed and Ratings
Drymixed Grassland Site 12	DMGA40 western wheatgrass Low sedge	SiL	25%green needle 25% Blue grama 15% Northern wheatgrass 15% Western wheatgrass 15% June grass 5% Needle and thread	Sep-06	Failed litter quality class	litter quality- not decomposing (>1)
Drymixed Grassland Site 13	DMGA40 western wheatgrass Salt grass-Gum weed	CL	30% Needle and Thread 25% Northern Wheatgrass 25% Western Wheatgrass 10% Blue grama 10% June grass	Aug-06	Failed litter quantity, should fail on landscape assessment for bareground	Litter Quantity under 15% control (site mowed) should have failed landscape for bareground, failed after 2010 due to grazing response
Drymixed Grassland Site 14	DMGA14 Western wheatgrass needle and thread	SL	30%Western wheatgrass 25%Northern wheatgrass 20% Slender wheatgrass 10% June grass 5% sheep fescue 20% Green needle	Oct-07	Site 1 failure on soil structure but consistence passed	

4.0 DISCUSSION

Alberta's new reclamation criteria for wellsites and associated facilities for grassland provide a robust tool by which reclamation success must be judged. It provides practitioners a standard and a defined protocol to conduct "Detailed Site Assessments" on species present and a grouping according to their grazing responses. In this study professional judgement could plausibly have been used to pass all the sites. However, the intent of this project was not to pass or fail a site, but rather to understand the practices that lead to reclamation success. Most sites could have passed the 2010 criteria if it was not for invasive/noxious weeds and structural layers. According to our results these represent the main barriers to reclamation success.

4.1 Noxious Weeds

It is preferable to deal with noxious weeds and re-occurrence of non-native forages the moment they are found on the lease site. Basically, deal with the problem when it is small rather than when it is time to seek reclamation certification. The example below shows occurrence of smooth brome grass bordering a lease site, giving rise to new propagules spreading into the lease. Many of the roadsides and ditches were previously seeded to smooth bromegrass that has invaded into aspen communities (Holcroft 2001). Controlling smooth bromegrass onto the lease is not effective unless control is also conducted on affected areas outside of the lease.

Figure 17. **Smooth brome grass occurrence on one of the lease site in the Parkland ecoregion.**

Figure 18 shows toad flax invasion on both the lease and the control. Apparently, neither the reclamation practitioner representing the oil and gas industry nor the land manager nor the lessee is doing anything for its management. This site had enough litter in decomposition, varied native infill, but it failed on weed issues.

Figure 18. Toad flax occurrence on both the lease and the control area.

The spread of invasive species into surrounding native grassland hampers reclamation success and if not controlled early enough leads to more challenges when it comes time for certification. There should have been an adaptive management approach to reclamation that whereby modifications (cosmetic application of herbicides) can be based on on-site monitoring that will guide reclamation trajectory to the desired plant community. A delay in solving the issue costs the industry and the environment.

4.2 Structural Layers

Native plant communities contain a diversity of plant species which occupy different layers (structure) as they access the sunlight, water and nutrients. These different plant layers provide forage production, are important for wildlife habitat and build resiliency in a plant community. Most of the sites we assessed also failed on structural layers, except for sites that were seeded more than 10 years ago. Thus it is next to impossible to pass the criteria if a site was reclaimed 3-5 years ago. What are the factors that contribute to a low structural layer rating?

In the Northern fescue and Central Parkland subregions current seed mixes were based on two structural layers in unequal proportions. The average number of structural layers in control areas at all of the sites in this study was 2.15 (n=13, min 1.1 max 3.0,) while on lease structural layer average was 1.59 (n=13 min 1.0 max 2.4). This means that sites are expected to not only have 15% infill species, but to pass on structural layers those species must be either short, having a structural layer of 4 e.g. Small Leaved Everlasting (*Antennaria parvifolia*) or very tall having a structural layer of 1 such as Buckbrush (*Symphoricarpos occidentalis*).
Most native seed available on the market in Alberta is of structural layer 3, most mixes have some species of structural layer 2 e.g. Plains rough fescue (*Festuca hallii*) or Green needle grass (*nasella viridula*) but they do not usually make up a significant portion of any one mix. To better account for structural layers a seed mix could have a higher percentage of structural layer 2 or a higher diversity of structural layers. The structural layer class in the mixedgrass and Dry mixedgrass regions are changed for most species as the common amount of structural layers on the landscape changes, so these subregions do not seem to have the same restrictions. Site 5 in the sandy soils in the Parkland and site 6 and 7 were subdivided into three areas and were

seeded to three different seed mixtures, 15 years ago. Each seed mix differed by the number species included in the mixture, ranging from two species in a seed mix to about 30 species in another seed mix. After 15 years, we could not detect seed mix differences as the whole area is dominated by similar species. Thus if the reclamation industry wants to avoid delays in seeking a reclamation certificate, a seed mix containing a diverse number of species may offer the best solution.

Table 5 shows all species seeded onto all sites in this project, including their grazing response, structural layer and how many times they were included in a seed mix.

Table 5. Species found in 14 seed mixes of the 2010 Criteria sites

Grazing Response	Structural Layer	Scientific Name	Common Name	Occurrence (n=14)
2	3	*Agropyron dasystachyum*	Northern wheat grass	12
1	2	*Stipa viridula*	Green needle grass	12
4	3	*Koeleria macrantha*	June grass	11
2	3	*Agropyron smithii*	Western wheat grass	9
2	3	*Agropyron trachycaulum*	Slender wheat grass	9
1	2	*Festuca hallii*	Plains rough fescue	9
4	3	*Bouteloua gracilis*	Blue grama	7
2	3	*Festuca saximontana*	Rocky Mountain fescue	5
2	3	*Stipa curtiseta*	Western porcupine grass	4
Grazing Response	**Structural Layer**	**Scientific Name**	**Common Name**	**Occurrence (n=14)**
2	3	*Helictotrichon hookeri*	Hooker's oat grass	3
2	3	*Agropyron subsecundum*	Awned Wheatgrass	2
1	3	*Elymus canadensis*	Canada wild rye	2
2	3	*Stipa comata*	Needle-and-thread	2
3	0	*Festuca ovina*	Sheep fescue	2‡

2	3	*Calamovilfa longifolia*	Sand grass	1
1	2	*Deschampsia cespitosa*	Tufted hair grass	1
1	2	*Oryzopsis hymenoides*	Indian rice grass	1
1	2	*Sporobolus cryptandrus*	Sand dropseed	1

‡ Grazing response type 3-"Invasive" has no structural layer does not contribute to cover

A typical seed mix for the Parkland Ecoregion will include: Northern Wheatgrass -25%, Green Needlegrass – 20%, Slender wheatgrass – 20%, Western wheatgrass – 20%, June grass – 10% and Needle & thread grass – 5%. Table 6 illustrates species composition for ASRD Benchmark sites in the grassland (Kupsch et al. 2011) which reclamation practitioners could use to design seed mixes.

Table 6. Examples of ASRD benchmark sites in proximity of the sites used in this study showing percent species composition. Grazed benchmarks were used as all our site controls were grazed.

Paradise Valley Grazed CPA26	**Castor Grazed CPA4**
21.0 Sedge	20.5 Sedge spp.
20.6 Fringed Sage	14.2 Western Wheat Grass
20.3 Northern Wheat Grass	13.5 Early Bluegrass
17.3 Kentucky Bluegrass	10.3 June Grass
10.3 Prairie Crocus	4.8 Common Yarrow
9.3 Plains Rough Fescue	4.2 Hair Grass/Tickle Grass
6.1 Smooth Fleabane	3.7 Kentucky Bluegrass
3.8 Hooker's Oat Grass	2.5 Gumweed
3.1 June Grass	2.5 Creeping White Prairie Aster

If one compared a benchmark community in the same area, it would be comprised mostly of: Blue grama – 20%, Needle & Thread – 4%, Western wheatgrass – 3%, Sandberg bluegrass – 3%, sedge sp. – 6%, other wheatgrass – 1% and June grass – 1%.

It appears that the reclamation industry is constrained by the number of species that is commercially available. Despite milestones being made in improving reclamation practices, the

lack of ecological variety of commercially available native species including forbs and shrubs hampers the reclamation industry in its ability to meet the 2010 criteria. To date, seed mixes sold by seed companies represent a low diversity of structural layer (Table 7). Wheatgrasses comprised of 45-55% of a seed mix (Brett-Young Seed 2011, Pickseed 2011). Although they provide rapid site stability and compete with weeds they will not lead to the appropriate trajectory on their own until 5-6 years later with infill. Thus, the reclamation can forgo seeking a reclamation certificate in a faster time period (<5 years), unless more climax species are included in the seed mix.

Table 7. A commercially available seed mixture for the Parkland and Grassland Region by Two Major Seed Companies.

Parkland Natural Region	Brett-Young Seeds	Pickseeds
	20% Western wheatgrass	15% Western wheatgrass
	20% Slender wheatgrass	15% Slender wheatgrass
	5% Awned wheatgrass	15% Awned Wheatgrass
	10% Northern wheatgrass	5% Slough grass
	20% Green needle grass	20% Green Needle Grass
	10%Rough fescue	10% Plains Rough Fescue
	5% Rocky Mountain fescue/Idaho fescue	5% Rocky Mountain Fescue
	10% June grass	5% June grass
		5% Alkali Bluegrass

		5% Sandberg Bluegrass
Grassland Natural Region		
	20% Western wheatgrass	15% Western Wheatgrass
	10% Slender wheatgrass	25% Slender Wheatgrass
	15% Awned wheatgrass	5% Alkali Bluegrass
	20% Northern wheatgrass	15% Northern Wheatgrass
	15% Green needle grass	20% Green Needlegrass
	10% Needle and thread	5% Sandberg Bluegrass
	10% June grass	5% June grass
		10% Purple Prairie Clover

Table 8 provides an example of suitable species that be used to improve seed mixtures performance. Seeding these species into a standard native mix may help to introduce structural layer diversity and limit seed mix percent of increaser type 4 species. These additions are based on the Central Parkland subregion and may have to be adapted further for other subregions.

Table 8. Suggested species to add to seed mixes for better reclamation success

Grazing Response	**Structural Layer**	**Scientific name**	**Common Name**
1	2	*Bromus anomalus*	nodding brome
1	2	*Bromus ciliatus*	fringed brome
1	2	*Deschampsia cespitosa*	tufted hair grass
2	2	*Gaillardia aristata*	gaillardia

2	2	*Helianthus annuus*	common annual sunflower
2	2	*Ratibida columnifera*	prairie coneflower
2	1	*Ribes species*	undifferentiated current
2	1	*Rosa arkansana*	prairie rose
2	1	*Rosa woodsii*	common wild rose

4.3 Grazing Response

Grazing response is a limiting factor when taking limited sampling points (Table 5). Without averaging a large number of sampling points (Quadrat), an assessor may miss the diversity on a site and accidentally concentrate on species with an undesired grazing response, thereby failing a site on lack of cover. Many early serial species are highly adapted to disturbance and as a result are ideal for revegetation. However, this lends them an undesirable grazing response; type 4 increasers. In the RoO type 4 increasers are a restricted factor for sites constructed after 1993 and reclaimed after 2010.

The grazing response classification is based on previous and future land use. It is unfortunate that the criteria rely on grazing response. Other intrinsic values such as plant community diversity and plant community resemblance should be taken into account. Those species given class 4 grazing response are valuable to reclamation, a knowledgeable practitioner can base the percent composition of a seed mix based on the health of the surrounding land to increase seed mix efficacy.

Two species commonly available and seeded onto reclamation sites are Type 4 grazing response (June grass and Blue grama grass). Thus a reclamation practitioner requires knowledge of the control area to not include and over-seed the species compared to the adjacent land.

4.4 Bareground

Bareground is assessed during the first phase of the RoO in the landscape assessment, and then is quantified during the vegetative assessment. The question of equality between the control and lease for bareground was somewhat difficult to accurately rate, until after the vegetative

assessment is completed. There is an average of bareground percentages for the control and lease and it can then be shown to be significantly lower or higher though the actual acceptable differences have not been expressed. Bareground and litter are negatively correlated, and in this study a lease site, three years after reclamation can pass on litter values. Litter quality might be a limiting factor any sooner than three seasons after seeding. As litter has to be of "quality" to pass the criteria, it needs to be from the previous growing season and be in some form of decay.

Figure 19. **Comparison of onsite (left) and control (right) litter in a failing site**

4.5 Native Infill

Native infill species are part of the local plant community and their presence is an indicator of native species recruitment and success along a successional pathway. Table 9 shows the trend from seed mixes seeded onto the lease and the current species dominating the site on both the lease and the control. Sites that have been reclaimed for a longer time (>10 years) definitively had more native species and structural layers than those 2 years after reclamation. While a few native species that were not seeded such as pasture sagewort, prairie sage or prickly rose are commonly found on the lease sites within a couple of year after reclamation, management practices (e.g. herbicide application, early removal of fence line) and environmental variables

will dictate whether the lease can be certified earlier. Five years after reclamation may not be enough to certify a site, unless the desirable species are included in the seed mix. Native infill invasion into the lease site will also depend on biotic factors occurring on the outside area of the lease. Perennial grasses are poor invaders by seeds and forbs are the best invaders (Tilman, 1997). In many cases, the fences (Figure 19) surrounding the lease site is still up, even 10 years after reclamation. Removal of the fences, once the site is stabilised should be encouraged. Other practices, such as the use of native hay have shown good success in the drymixed grassland and need further investigation.

Figure 20. Fences surrounding lease area and heavy grazing hamper native infill.

Table 9. Seed mix and dominant species on and off lease on a temporal scale

Site Name	Ecosite	Years after seeding	Seed Mix	Current Dominant Species on Lease	Current Dominant Species on Control
Parkland Region	CPA 26- Rough Fescue Kentucky Bluegrass	5 years	10% Green needle 10% Northern Wheatgras 5% Slender wheatgrass 5% June grass 10% Western wheatgrass 50% Plains rough fescue 10% Western porcupine	25.6% Kentucky Bluegrass 23.9% Western Porcupine 8.3% Prairie cinquefoil 7.2 % Prairie sage 5.6% Slender wheatgrass 3.6% Pasture sagewort 2.4 % Western wheatgrass 2.8% Yarrow 2.3 % Tickle grass	46.7 % Plains rough fescue 10.6 %Buckbrush 7.8 % Western porcupine grass 6.1% Three flowered avens 4.4 % Pasture sagewort 2.8% Creeping white prairie aster 2.9% Low goldenrod
Parkland region	CPC32- Snowberry Kentucky Bluegrass	10 years	No information on seed mix was available	36.3% Kentucky bluegrass 26.3% Smooth bromegrass 6.3% Blue grama grass 5 % Three flowered avens 3.8% Upland sedge 3.8 % Needle and thread 3.8% Pasture sagewort 2.5% Prairie sage 2.5% Buckbrush 2.5% Prickly rose 2.5 % Strawberry 2.5 % Slender wheat	20% Smooth brome 16.3% Needle and thread 11.3 %Kentucky bluegrass 10 % Upland sedge 7.5 % Blue grama grass 6.3% Tickle grass 6.3% Strawberry 5% June grass 5 % Awned wheatgrass 3.8% Common wild rose 2.5% Three flowered avens 2.5% Prickly rose

Site Name	Ecosite	Years after seeding	Seed Mix	Current Dominant Species on Lease	Current Dominant Species on Control
Parkland Sandy soils	CPC16-juniper-sedge-plains rough fescue	2 years	July 2005 45% Canada wildrye, 15% Sheep fescue, 10% Green needlegrass, 10% Blue grama 10% Sand dropseed 5% Hillcrest awned wheat, 5% June grass Nov 11, 2007 and June 23 2009 15% Blue grama 25% Canada bluegrass 20% Sheep fescue 20% Sand dropseed 20% Awned wheat	37.8 % Rocky mountain fescue 3.9 % Pasture sagewort	16.7 % Plains rough fescue 14.4 %Upland sedge 12.2 % Sand drop seed 9.4 % Bearberry 7.8% Calamagrostis inexpansa 6.7 % Low everlasting/pussytoes 3.9 % June grass 3.3 % Rocky mountain fescue 3.3 % Awned wheatgrass 3.3 % Plains wormwood 2.2% Poa spp native 2.2 % Mouse eared chickweed

Site Name	Ecosite	Years after seeding	Seed Mix	Current Dominant Species on Lease	Current Dominant Species on Control
Parkland Sandy loam	CPA7 sand grass-needle and thread grass-June grass	14 years	See appendix 2 for seed list	15.6% Upland carex 13.1% Prairie sage 12.8% Sand dropseed 12.4 % Awned wheatgrass 7.6 % Canada thistle 7.2% Needle and thread grass 6.7 % Yarrow 4.1% Common wild rose 3.9% Rocky mountain fescue 3.6% Upland carex 3.3% June grass 3.3% Low goldenrod 2.8% Tickle grass	19.1% June grass 17.7 % Prairie sage 15.1% Low goldenrod 10 % Upland carex 8.3 % Pasture sagewort 7.8% Sand reed grass 6.1% Fowl bluegrass 5.6% Upland carex 5% Canada thistle 2.8 % Awned wheatgrass 2.2% Needle and thread grass
Parkland Sandy loam	CPA4 upland sedge-western wheat	2 years	20% Green needle- 20%Northern Wheat 20% Slender wheat 20% Western wheat 10% Blue grama 10% plains rough fescue	27.2% Slender wheatgrass 12.2% Blue grama grass 10 % Quackgrass 5.6% Toadflax 4.6% Pasture sagewort 2.6% Western wheatgrass 2.3% Early blue violet	30% Upland sedge 26.7% Blue grama grass 20% Western wheat 13.3% Pasture sagewort

Site Name	Ecosite	Years after seeding	Seed Mix	Current Dominant Species on Lease	Current Dominant Species on Control
Northern Fescue Region	CPA 32-Kentucky bluegrass-sedge-W. porcupine grass	15 years	See Appendix 1 for seed list	30 % Smooth brome 26.7% Kentucky bluegrass 18.3 % Northern wheat 6.7% Needle and thread 5% Upland sedges 3.3% Plains rough fescue 3.3% June grass 5 % Buckbrush	18.3% Kentucky bluegrass 15% other forb 11.7% June grass 10.7% Smooth Brome 10 % Needle and Thread 8.3 % Awned Wheatgrass 6.7 % Yarrow 5 %Pasture sagewort 5% Northern bedstraw 3.3 % Locoweed 2.7 % Upland sedges
Northern Fescue Region	CPA3 Rough fescue-upland sedge	15 years	See Appendix 1 for seed list	22.5 % Slender wheat grass 16.3 % Plains rough fescue 10 % Smooth brome 10 % Rocky mountain fescue 8 % Pasture sagewort 6.3% Buckbrush 6.3 % Kentucky bluegrass 6.3% Awned wheatgrass 5.8% Creeping white prairie aster 2.5% Western porcupine grass 2.5% Common wild rose 2.5 % Prickly pear cactus	22.5 %Western porcupine 22.5% June grass 13 % Upland carex 9.3 % Pasture sagewort 7.5 % Rocky mountain fescue 7 % Plains rough fescue 6.3 % Blue grama grass 5.5 % Prickly pear cactus 4.5 % Creeping white Prairie aster 2.5% Kentucky bluegrass

Site Name	Ecosite	Years after seeding	Seed Mix	Current Dominant Species on Lease	Current Dominant Species on Control
Northern Fescue	NFA1 Rough fescue western porcupine	2 years	25% Plains rough fescue 5% Green needle grass 15.5% June grass 12.5% Rocky mountain fescue 0.5% Hooker's oat grass 5% Northern wheatgrass 15% Slender wheatgrass 3% Yarrow 2.5% Golden rod 1% Sedges	32.2 Slender wheatgrass 15.2 Kentucky bluegrass 8.9 Green needle grass 4.4 Annual hawksbeard 3.1% Yarrow 2.8% Pasture sagewort 2.8% Small leaved everlasting/pussytoes 2.8% June grass 2.8% Dandelion	18.9 Needle and thread 28.4 Plains rough fescue 8.3 Kentucky bluegrass 6 Western Wheatgrass 4.4% June grass 4.4% Slender wheatgrass 3.6% Silverweed 3.3% Small leaved everlasting/pussytoes 3.3% Low goldenrod 3.3% Prairie sage 3.3% Strawberry 3.3% Buckbrush 2.6% Upland sedge 2.4% Pasture sagewort

Site Name	Ecosite	Years after seeding	Seed Mix	Current Dominant Species on Lease	Current Dominant Species on Control
Northern Fescue	NFA9 Blue grama Western porcupine Plains rough	2 years	25% Plains rough fescue 5% Green needle grass 15.5% June grass 12.5% Rocky mountain fescue 0.5% Hooker's oat grass 5% Northern wheatgrass 15% Slender wheatgrass 3% Yarrow 2.5% Golden rod 1% Sedges	18.9 June grass 13.3 Slender wheat grass 11.7 Green needle grass 9.7 Smooth brome grass 8.3 Yellow sweet clover 7.6 Foxtail barley 3.3 Prairie sage 2.8 Ticklegrass 2.8 Fowl bluegrass 2.2 Blue grama grass	15.6 % Needle and thread 15.6% Fowl bluegrass 12 % Small leaved everlasting/pussytoes 9.1% June grass 8.3% Smooth brome grass 7.2 % Blue grama grass 6.1% Upland sedge 5.8% Pasture sagewort 5.6% Tickle grass 5.6 % Strawberry 2 % Prairie sage
Northern Fescue	NFA3 Kentucky bluegrass plains rough fescue	2 years	25% Plains rough fescue 5% Green needle grass 15.5% June grass 12.5% Rocky mountain fescue 0.5% Hooker's oat grass 5% Northern wheatgrass 15% Slender wheatgrass 3% Yarrow 2.5% Golden rod 1% Sedges	27% Slender wheatgrass 18% Kentucky bluegrass 14% Plains rough fescue 11% Smooth brome 7% June grass 5.4% Dandelion 5% Hooker's oatgrass 4.4% Pasture sagewort 2.4% Foxtail barley	16.6 Plains rough fescue 12.6% June grass 13% Kentucky bluegrass 13% Green needle grass 8% Pasture sagewort 7.4% Prairie sage 6% Prairie rose 5.4% Buckbrush 4.2% Pale comandra 3.2% Hooker's oatgrass 3% Mat muhly

Site Name	Ecosite	Years after seeding	Seed Mix	Current Dominant Species on Lease	Current Dominant Species on Control
Northern Fescue		3 years	30%Western wheatgrass 25%Northern wheatgrass 5% slender wheatgrass 10% June grass 10% Plains rough fescue 20% Green needle grass	NO INFO	NO INFO
Drymixed Grassland	DMGA40 western wheat-Low sedge	5 years	25%green needle 25% Blue grama 15% Northern wheatgrass 15% Western wheatgrass 15% June grass 5% Needle and thread	18.9% Kentucky bluegrass 17.2% Western Wheat grass 9.6% Tufted white prairie aster 8.9% Slender wheat grass 8.3% Pasture sagewort 7.2% Western wheat grass 5% Green needle grass 2.8% Forb not on list	41.1% Kentucky bluegrass 11.1% Foxtail barley 8.4% Western wheatgrass 5% Needle and thread grass 4.4 % Blue grama 3% Tufted white prairie aster 2.4 % Alfalfa 2.4% Low goldenrod 2.2% Prairie sage 2.2%Canada thistle

Site Name	Ecosite	Years after seeding	Seed Mix	Current Dominant Species on Lease	Current Dominant Species on Control
Drymixed Grassland	DMGA40 western wheat-Salt grass-Gumweed	5 years	30% Needle and Thread 25% Northern Wheatgrass 25% Western Wheatgrass 10% Blue grama 10% June grass	81% Foxtail Barley 14.5% Green needle grass	27.2 % Quackgrass 12.8 % Blue grama grass 11.1% Kentucky Bluegrass 8.6% June grass 7 % Yellow sweet clover 6.7 % Scarlet butterfly weed 5% Salt grass 3.9% Western Wheat 3.6% Pasture sagewort 2.4% Creeping white prairie aster 2% Gum weed 2% Foxtail barley
Drymixed Grassland	DMGA14 Western wheat-needle and thread	4 years	30%Western wheatgrass 25%Northern wheatgrass 20% Slender wheatgrass 10% June grass 5% sheep fescue 20% Green needle	14.4 Awned wheatgrass 13.3% Needle and thread grass 12.2% Rocky mountain fescue 11.1 % Slender wheat grass 4.4% Quackgrass 3.3% Western Wheat 2.8% Small leaved everlasting/pussytoes 2.2% Wild begonia 2.2% Small leaved goosefoot	30% Western wheatgrass 28.9% Pasture sagewort 5.6% Quackgrass 5% Needle and thread grass 4.45% Yellow sweet clover 2.2% Prairie sage 2.2 %Scarlet butterfly weed

4.6 Key Points to Remember When Using the Criteria

When applying the criteria care must be taken to accurately represent what is happening within the lease area compared to the control. Nine sampling points on a lease one hectare in size can show overly positive or overly negative results if the site is not stratified and representative sampling is used accurately. It seems that a reclamation practitioner can pass any sites depending on where the quadrat is placed for the vegetation assessment. However, success whether a site pass the criteria should not be blindsided by professional bias.

Adept knowledge of soils, vegetation, and of the record of observations (RoO) is necessary to realize when step-outs need to be done, when a sampling point is failing due to species' grazing response, or when a site needs additional maintenance or if justifications can be used.
Within the "RoO" vegetation worksheets, additional rows needed to be added. We needed to add rows to the vegetation worksheet to fill in all the species we found. We also found that access road sampling point failures can be misrepresented because there are no averages involved; one sampling point on the access road full of June grass (*Koeleria macrantha*) will fail the access road on cover because June grass is a type 4 increaser and does not contribute to cover percentages over what is in the control. One can take multiple paired sampling points along the access road and use the vegetative worksheet in the tool instead of the access worksheet to get an average of all control points and all access road points which would better represent the two areas, or use step outs (Personal communication with ASRD, 2012).
We also found that there are some species found in a subregion that may not be included in the dropdown list, these are not considered native to the area and therefore should not contribute to cover. The species we found out of place were; Fowl bluegrass (*Poa palustris*), and Spear Leaved Goosefoot (*Chenopodium pratericola*). Whenever an assessor finds a species on a site not found in the dropdown list for that site's subregion the species must be classified as OTHERGRASS or OTHERFORB with the correct grazing response and structural layer and a note made in the comments section as to the exact species referred to.

Problem weeds such as Kentucky bluegrass are given a grazing response of 3 in the RoO tool but not explained in the 2010 criteria. Should Kentucky bluegrass be accepted as a naturalised species as it is most common during rainy seasons than during a dry period? What is the standard for problem weeds?

5.0 CONCLUSION

The 2010 Reclamation Criteria for Wellsites and Associated Facilities for Native Grassland does "raise the bar" as it was intended to do. It is a more systematic and quantitative assessment compared to its 1995 counterpart. It demands a resemblance to surrounding vegetation and through litter and bareground assessments ensures a sustainable, modified/comparable ecological system. As with any tool it is only as good as its operator and due to its complex nature demands a high level of experience, competency and good professional judgement to properly assess sites and have them pass or fail accurately.

It requires the practitioner to be competent with native and invasive species identification and familiar with grassland plant community succession. Familiarity with soils is also essential. It's preferred to have both a vegetation and soils specialist do the assessment respectively.

Our intent was not to fail or passed the sites, rather to understand how reclamation practices work. Although all the sites we assessed failed in one form or another most practitioners would probably pass them using non-routine applications with justifications and professional judgment. Structural layers, third party impacts (continued use of access roads) or the influence of non-native forages, namely smooth brome grass from ditch lines, aspen tree grooves and other surrounding areas were the main reasons for failure. When designing seed mixes, it is important to consider structural layers if a practioner is going to seek a reclamation certificate anytime soon.

Those sites that would not pass using professional judgement would necessitate control of invasive species, followed by a time lapse (a year or two) to ensure desired trajectories by prescribed practices. The few sites (three recent seedings in northern fescue, one in Parkland and two in Drymixed grassland) that would not pass the criteria were due to a lack of litter

quantity or quality. These sites require more time to mature. However, if the sites have the desired species, one can assume that litter quantity and quality will eventually accrue.

Additionally, many of the fences surrounding these sites are forgotten after reclamation. Removal of the fence 2-3 years after seeding (provided there is no risk of erosion) will encourage browsing by herbivores which in turn opened up the plant canopy, facilitating the recruitment of native infill and nutrient cycling.

Access roads posed a difficulty for us in that we did not have sufficient information as to their current status. Many access roads are kept by the land holder for use and therefore reclamation will not hold into perpetuity, bareground, rutting, compaction and compaction related species were common on all access roads. We suggest that even when accesses are reclaimed there are still many individuals using them for many reasons that exacerbate the condition of the roads. Ripping the access road to alleviate compaction while minimizing vegetation damage is a worthwhile practice but keeping vehicles off the roads could be more challenging. Additionally, bulk density could be used as an indicator of compaction. This allows the practitioners to fix problems in the early years of post-reclamation.

Grazing response has been a tool for measuring range health and to delineate plant communities for decades. This is an indicator from a different industry in Alberta and its use in the 2010 criteria can impact reclamation success. Plant communities are complex, diverse and variable in nature. How they respond to stresses allowed them to build resiliency, which in turn makes them sustainable. Thus having a rating drop due to the presence of Type 4 increasers as a result of grazing or other stress should not constitute failures. Those species classified as class 4 grazing response species are highly adapted to disturbance, have good germination and establishment and are well suited for use in reclamation, but they have a bad reputation due to overgrazed lands being dominated by them. They can play a significant role in erosion control and native establishment on a site. Good reclamation practices should include them in a seed mix without exceeding control percentages.

The effectiveness of the 2010 criteria will depend on the competence and professional judgement of the reclamation practitioner. In our study, one of the sites received a reclamation certificate in 2010, yet was found to have failed under bareground, macro-contours, structural

layers, litter quality and quantity, noxious weeds and presence of non-native forages. It is anticipated that many DSA's will be submitted using a non-routine application.

Like William Wilberforce said "You may choose to look the other way but you can never say again you did not know".

6.0 KEY REMARKS AND RECOMMENDATIONS

- Control noxious weeds during operational phases and early during post reclamation to limit the amount of seed in the soil.
- Use quality plant materials. Use certified seed where possible and buy all seeds from reputable dealers, inspect seed growers' plots to ensure quality materials.
- Include structural layers in your seed mixes, even collecting a handful of forbs, shrubs and legume's seed from the adjacent controls can help accelerate plant community recovery.
- Seed growers need to be familiar with the 2010 criteria to better design seed mixtures that mimic and better suited to site conditions.
- Use clean equipment/ vehicles when visiting sites.
- Do not hesitate to use native hay mulch if it is available and ensure it is weed free.
- Seed industry must familiarise themselves and try to better understand the 2010 Reclamation Criteria in order to design better seed mixtures that resemble more closely to site conditions of the natural sub-regions.
- Use competitive species if weeds in the area seem to be a problem. Seed species that are known to compete well with weeds in the reclaimed area. Know this may take a longer time prior to seeking a reclamation certificate.
- Remove the fence line around the lease once plants are established.
- Limit vehicle use on access roads. Some of the vehicle tracks seem like a permanent scar on the landscapes and it increases soil compaction and limits vegetation growth.

- More importantly, do reclamation once and do it right the first time. Redisturbance creates situations for weeds establish, increases cost and remains a longer liability to the industry.

7.0 REFERENCES

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