Long Term Recovery of Native Prairie from Industrial Disturbance

Express Pipeline Revegetation Monitoring Project 2010

Abridged Version - November 2011

Prepared For:

Kinder Morgan Canada
TransCanada PipeLines
ConocoPhillips Canada
ASRD Public Lands Division

Prepared By:

Kestrel Research Inc.
11 Cochrane Lake Place
Cochrane, AB, T4C 2A8

and

Gramineae Services Ltd.
Box 95
Lundbreck, AB, T0K1H0

In Association With:

ASRD Public Lands Division
Alta Rangeland Services Ltd.
Laura Hickman
Ross Adams
CorPirate Services

Sponsorship

Purpose

The purpose of the Express Pipeline Long-term Revegetation Monitoring Project is to provide industry and the Government of Alberta regulatory agencies with a unique opportunity to gather and process much needed data on the long term revegetation success of reclamation techniques used on native prairie. This is an abridged version of the original document. To obtain a pdf version of the entire document, visit the Foothills Restoration Forum website at www.foothillsrestorationforum.com

Do we know if the revegetation strategies used to stabilize the soils post-construction and promote recovery in the early years are successful in the longer term at achieving industry goals to restore native grasslands after disturbance?

Express Pipeline Project Setting and Regulatory History

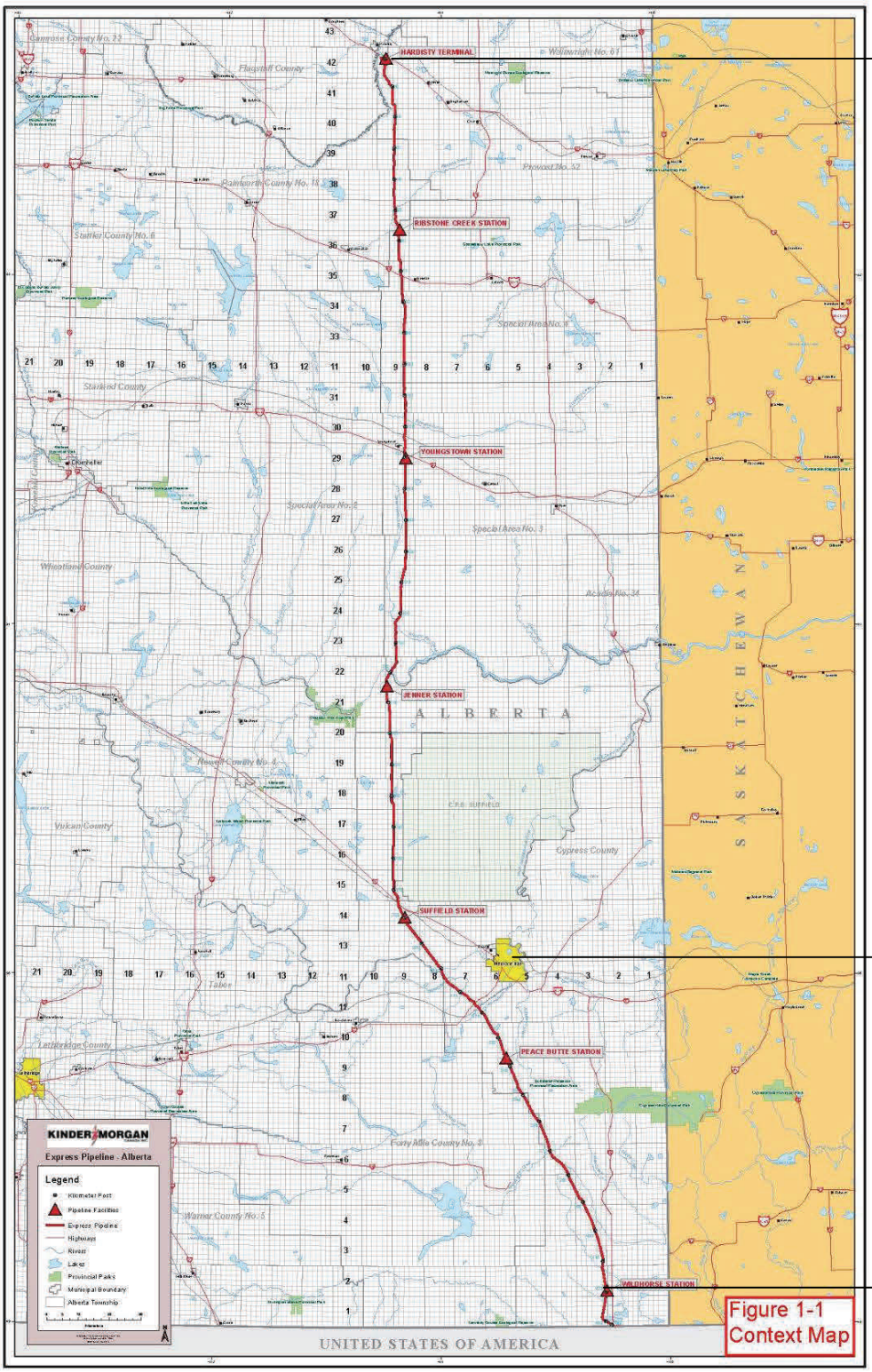
Express Pipeline (Express), owned and operated by Kinder Morgan Canada Inc., is a 24 inch (610 mm) crude oil pipeline that extends from Kinder Morgan's tank farm near Hardisty, Alberta, south 434 kilometres to cross the United States border at Wildhorse, Alberta. (See Figure 1 - Context Map.) The pipeline was constructed during the mid summer and fall months of 1996 and completed in the spring of 1997. The permanent right-of-way (RoW) is 20m wide and an additional 10m of temporary workspace was required for construction. At linear infrastructure crossings, on steep slopes and at water crossings, extra temporary workspace was also required.

Express crosses large contiguous tracts of native prairie along its alignment. Portions of the RoW cross native prairie in the Central Parkland, Northern Fescue, Mixedgrass and Dry Mixedgrass Natural Subregions of Alberta. The long term impact of pipeline construction and reclamation on native prairie ecosystems was an issue identified by stakeholders early in the planning process in 1994. Express Pipeline's regulatory commitment was to reclaim the RoW in native prairie areas with the goal of establishing a positive successional trend towards the native plant community present prior to construction. To pursue this goal, native seed mixes were developed, specialized seeding equipment was used, and erosion control procedures were implemented. Revegetation trials such as natural recovery and sod salvage were also implemented to test the response of unconventional revegetation techniques. This was an early opportunity to demonstrate minimum disturbance practices in the Grassland Natural Region.

A five year post-construction monitoring program was conducted between 1997 and 2001. Monitoring sites included; a diversity of soil types and native rangeland plant communities, construction practices areas where spoil was stored directly on prairie vegetation and areas where construction vehicles were driven on the grass, and areas where disturbed soils were seeded or left to recover naturally. Each monitoring site includes a pair of observations including an undisturbed control and a treatment area on the RoW. Quantitative data on species composition and cover was collected at 63 monitoring sites along the pipeline.

Over the years stakeholders and regulatory agencies recognized that further monitoring of Express could provide a valuable contribution to reclamation science regarding the long term performance of the cultivars and wild harvested seed used in the seed mixes, and the plant community succession of seeded sites, natural recovery trials and the sod salvage sites.

Figure 1 - Context Map



Hardisty

Medicine Hat

Wildhorse

Figure 1-1 Context Map

Long Term Monitoring Program Scope

The objectives of the study in 2010 are to assess whether current reclamation methods are achieving the desired long-term goal of restoring native prairie (successes and areas to improve) by providing data on:

- Long term performance of the native cultivars used in the native seed mixes; and
- Recovery and succession of seeded sites, natural recovery trials and the sod salvage trials.

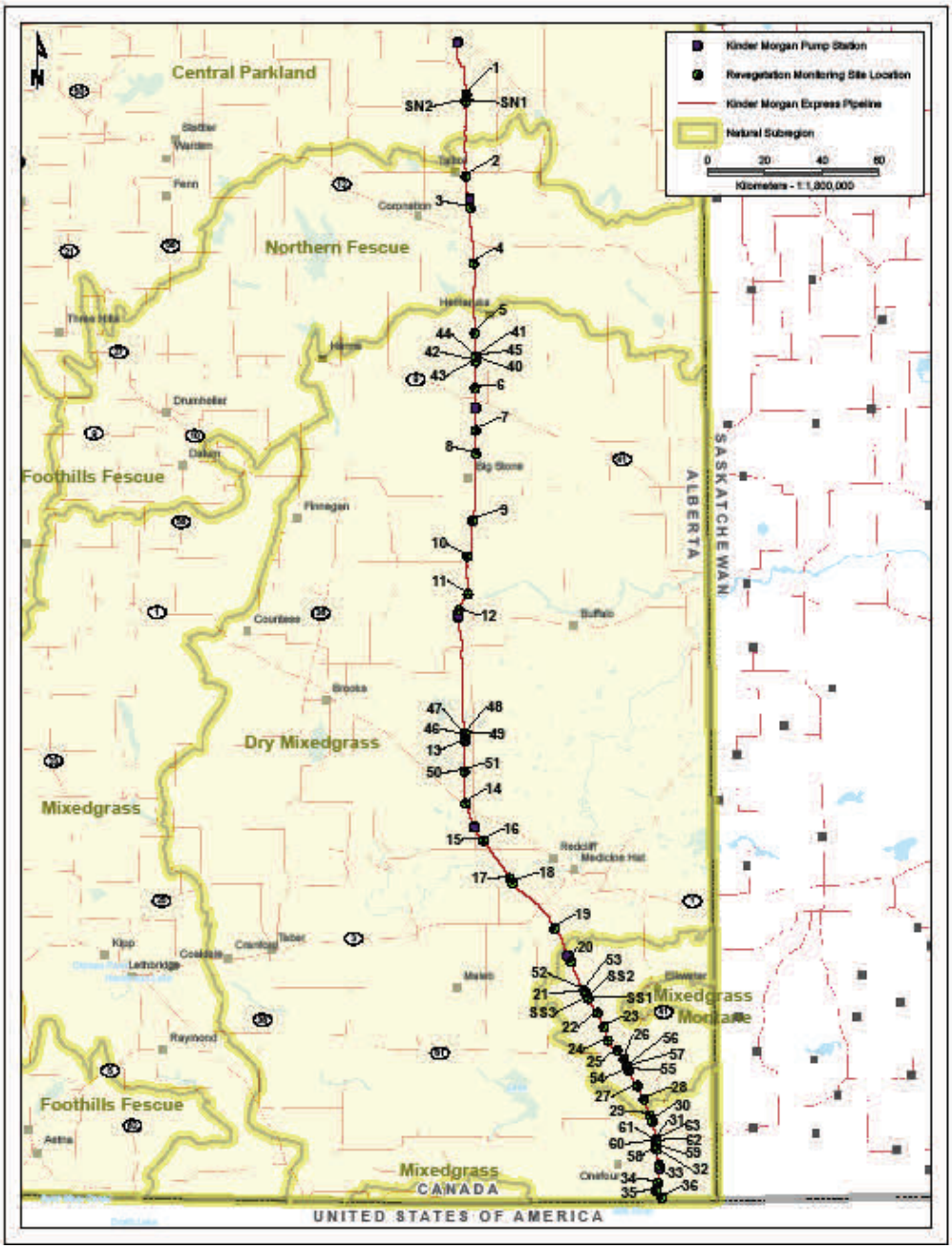
Considerable progress has been made in understanding the processes of grassland ecology and function since the mid 1990's when Express was constructed. ASRD Lands Division, Range Resource Management Branch has developed three tools (Grassland Vegetation Inventory (GVI) mapping, Range Plant Community Guides and Rangeland Health Assessment Protocols) that enable a standardized assessment of the ecological health and function of native grassland plant communities. The GVI image in Figure 2 illustrates how the Grassland Vegetation Inventory is useful in the predevelopment process and for mapping ecological range sites. These tools were applied on the long term monitoring of the Express Pipeline and in the interpretation of the results.

Figure 2 - Standardized Grassland Assessment Tools

For More Information Visit: www.srd.alberta.ca

Available resources limited the number of monitoring sites re-assessed in 2010. Priority was given to the natural recovery trial sites and the sites where soils were stripped and seeded. A total of 51 of the original 63 sites were re-evaluated in the 2010 program. Two plains rough fescue sod salvage trials assessed by Wilfred Lane Petherbridge in 1997 and 1998 as part of a Master's thesis were also evaluated in 2010.

Figure 3 - Express Pipeline Route and Revegetation Monitoring Sites



TransCanada funded monitoring of sixteen sites north of the Red Deer River. Monitoring of sites south of the Red Deer River was funded by Kinder Morgan Canada and ConocoPhillips Canada. ASRD Lands Division, Range Resource Management Branch also contributed substantially to the completion of this section by providing an additional five rangeland agrologists to the Express monitoring team and a helicopter for two days to access remote sites. This enabled monitoring of 19 of the 30 seeded monitoring sites and 15 of the original 18 natural recovery sites in 2010.

Data Collection, Processing and Analysis

Historic Data

Detailed information on construction procedures in relation to minimal width stripping, reclamation procedures including seeding rates, seeding techniques and final surface preparation is presented in the report. Details of the natural recovery reclamation procedures and the sod salvage procedures are also documented.

Monitoring data collection included; photographic records over time at fixed locations (Figure 7) and sampling for plant composition and cover in the selected zone of impact using 1/10 metre Daubenmire frames. Data was collected one, two, three, five and fourteen years post-construction.

Data and reporting from all monitoring years have been collected and archived for this project. Plot inventory data has been compiled into a composite dataset for use in the analyses. Data from monitoring sites was grouped for comparison according to several environmental variables including; Natural Subregion, ecological range site, type of disturbance and reclamation treatment.

Seasonal weather plays a significant role in the establishment and recovery of vegetation after disturbance and in the range health of grazed pastures. Of note are; the high snowfall year in the winter of 1996 after most of the line was constructed, the dry growing season of 1998 in northern portions of the line, and the extreme drought years in 2000 and 2001 in the south.

Figure 4 - Blade Width Stripping

Figure 5 - Prairie Protector Blade

Figure 6 - Sod Salvage

Analysis of Long Term Recovery using the Cumulative Data Set

The performance of each species in the seed mixes in terms of cover was tracked over time and compared to undisturbed native plant communities on the controls.

To assess whether succession towards pre-disturbance native plant communities is occurring, a time series of observations from each monitoring site collected one, two, three, five and 14 years post-construction, were analysed. Methods included cluster analysis and non-metric multi-dimensional scaling analysis. The resulting groupings of species (communities) were described using indicator species analysis.

Successional stages (or seral stages) for the reclaiming plant communities are a series of plant community conditions that develop during ecological succession from bare soils (in this case topsoil). Definitions were developed for seral stages of communities recovering from disturbance and applied to each group resulting from the plant community ordination analysis. (See Table A.)

Range health of the plant communities developing on the disturbance was also documented and compared to adjacent controls in the same pastures.

Table A - Definitions for Plant Community Seral Stages on Disturbed Topsoils

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

** Invasive non-native species that are known to replace native species and establish permanent dominance in Mixedgrass and Dry Mixedgrass communities include crested wheatgrass, smooth brome and sheep fescue. There has been a debate about whether Kentucky bluegrass should be included in the "trending to modified" category. Our feeling is that Kentucky bluegrass is a somewhat naturalized species that is relatively stable. Cover values are high in wet years but are reduced in dry years and in pastures with improved range health. It does not illustrate the same "fire front" effect on the landscape as the previously listed invasive species.*

Figure 7 - Photographic Records of Recovery over Time from Fixed Locations (Site # 4 Used for Example)

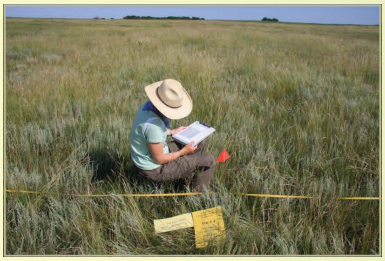
Photographic Record Excerpt - 1997

Photographic Record Excerpt - 1998

Photographic Record Excerpt - 1999

Photographic Record Excerpt - 2001

Photographic Record Excerpt - 2010



Site Used for Example - Site #4 - Blade Width Stripped - Seed Mix 2

Table B - Percent Cover of Vegetation at Site # 4: Northern Rough Fescue

Site 4 (Fescue / Mixed Grass transition)
Soil stripping: Blade width
Sample area: Ditch - disturbed topsoils

KP: 79+400 (Northern Fescue)
Seeded fall 1996 (mix #2)
Ecological Range Site: Blowouts/Solonetzic

Control (1997-99)2		On RoW (1997)		On RoW (1998)		On RoW (1999)		On RoW (2001)		On RoW (2010)		Control (2010)	
Mean % cover[1] 76.8%		Mean % cover[1] 18.1%		Mean % cover[1] 53.8%		Mean % cover[1] 103.1%		Mean % cover[1] 79.0%		Mean % cover[2] 72.1%		Mean % cover[2] 80.4%	
Species	**% Cover**	**Species**	**% Cover**	**Species**	**% Cover**	**Species**	**% Cover**	**Species**	**% Cover**	**Species**	**% Cover**	**Species**	**% Cover**
CAREPEN	11.63	AGROTRA	10.83	ARTEFRI	11.50	ARTEFRI	24.00	ARTEFRI	31.30	ARTEFRI	16.40	STIPCUR	19.50
FESTHAL	11.58	ARTEFRI	2.67	AGROTRA	9.55	MONONUT	15.75	STIPVIR	17.30	STIPCUR	15.20	CAREOBT	13.00
CAREOBT	9.80	AGROSMI	0.92	THLAARV	2.70	DESCSOP	15.30	KOELMAC	9.60	AGRODAS	7.10	SYMPOCC	7.80
STIPCUR	7.35	FESTHAL	0.67	AGRODAS	2.30	AGROSMI	10.31	ORYZHYM	7.80	KOELMAC	7.10	FESTHAL	6.50
ANEMPAT	5.18	RUMESP	0.50	KOCHSCO	1.80	AGROTRA	7.75	FESTHAL	6.60	FESTHAL	6.30	ARTELUD	5.50
AGRODAS	4.58	CAREPEN	0.42	ACHIMIL	1.50	STIPVIR	5.00	AGRODAS	2.10	AGROSMI	5.40	ARTEFRI	4.20
ACHIMIL	4.50	CHENSP	0.42	CAREOBT	0.90	STIPCUR	4.75	AGROPEC	1.80	CARESTE	5.00	AGRODAS	4.10
SYMPOCC	4.40	GRINSQU	0.42	KOELMAC	0.80	AGROREP	4.65	CAREPEN	1.00	STIPVIR	4.20	CARESTE	3.60
KOELMAC	4.13	SYMPOCC	0.42	FESTHAL	0.70	KOELMAC	3.10			DISTSTR	2.50	THERRHO	2.90
THERRHO	3.90	STIPVIR	0.33	DISTSTR	0.45	CAREPEN	2.35			AGROPEC	1.30	AGROSMI	2.20
JUNCBAL	2.35	AGRODAS	0.25	AGROSMI	0.31	AGROPEC	2.00			BROMINE	0.70	AGROTRA	1.90
GALIBOR	1.78	KOELMAC	0.25	CHENALB	0.30	CAREOBT	1.55			SOLIMIS	0.40	ANEMPAT	1.70
POAJUNC	1.65	SOLATRI	0.08	ASTEERI	0.25	AGRODAS	1.50			CAREOBT	0.30	KOELMAC	1.50
AGROSMI	1.10			SOLIMIS	0.25	RUMESP	1.50			ACHIMIL	0.20	ACHIMIL	1.00
LITHINC	1.00			STIPCOM	0.25	DISTSTR	0.75					ORTHLUT	0.90
HELIHOO	0.75			STIPVIR	0.15	FESTHAL	0.65					ANTEAPR	0.80
ASTRSTR	0.38			DESCSOP	0.10	KOCHSCO	0.65					JUNCBAL	0.80
SOLIMIS	0.25			STIPCUR	0.10	THLAARV	0.35					CERAARV	0.60
ANDRSEP	0.13			MEDISAT	0.05	BROMINE	0.25					CAREPEN	0.50
ARTEFRI	0.05			POLYARE	0.05	POLYARE	0.25					GALIBOR	0.50
BOUTGRA	0.03			SYMPOCC	0.05	CHENALB	0.05					ANDRSEP	0.30
												ASTRDAS	0.20
												SOLIMIS	0.20
												DRABNEM	0.10
												MUHLRIC	0.10

[1] Mean percent canopy cover
[2] Mean percent foliar cover

Mean % cover	Control (97-99)	On RoW (1997)	On RoW (1998)	On RoW (1999)	On RoW (2001)	On RoW (2010)	Control (2010)
Litter	80.75	1.20	6.30	19.50	26.50	n/a	n/a
Moss/Lichen	21.00	0.00	0.00	0.00	1.00	1.10	3.70
Bare Soil	1.13	93.30	52.30	50.00	17.30	1.20	0.30

Results – Dry Mixedgrass Seed Mixes

Cultivars

The expression and percent cover of seeded species over time on ten sites seeded to Solonetzic Soil Mix 4 is illustrated in Figure 9. The naturally occurring cover of these species on control sites in 2010 is also shown. Components of the seed mix are presented in Table C.

The expression and percent cover of seeded species over time on five sites seeded to Sandy Soil Mix 3 are illustrated in Figure 10. The naturally occurring cover of these species on control sites is also shown. Components of the seed mix are presented in Table D.

- In the Dry Mixedgrass, slender wheatgrass and northern wheatgrass behaved as transition species, establishing in the early years and providing initial cover to stabilize soils, build litter and shelter other seedlings. Both species are diminishing with time to near natural cover levels.
- Western wheatgrass established early but cover has slowly increased over the 14 years. Western wheatgrass persists at greater cover than on the controls.
- Seeded June grass developed a persistent but low cover in the earlier years which has not changed much over time. This species is beneficial for rebuilding diversity and the mid structural layer and is resilient to grazing.
- Green needle grass cover increased steadily over five years in both the Sandy and Solonetzic seed mixes. By year 14, cover levels have declined on Solonetzic sites. However, on Sandy soils, green needle grass cultivars persist at cover levels that are significantly higher than on control sites resulting in higher structure than found on the controls.
- Sand grass (sand reed grass) cultivars developed average cover levels comparable to controls, but their large size creates a persistent increase in structure on the reclaiming RoW relative to the controls.
- Non-native sheep fescue is invasive, increasing in cover slowly but steadily on both healthy and unhealthy rangeland. Sheep fescue may contribute to plant community modification over time.
- A few seeded species did not contribute much cover to the resulting pioneer or successional plant communities. They are alkali bluegrass, Indian rice grass and the non-native species Canada bluegrass.
- After 14 years, persistent cultivars that are still expanding or maintaining relative cover beyond control levels are influencing the trajectory of plant community succession. For instance, a Northern Wheatgrass - Green Needle Grass - Western Wheatgrass community on Dry Mixedgrass Loamy sites and trending to modified communities dominated by sheep fescue.

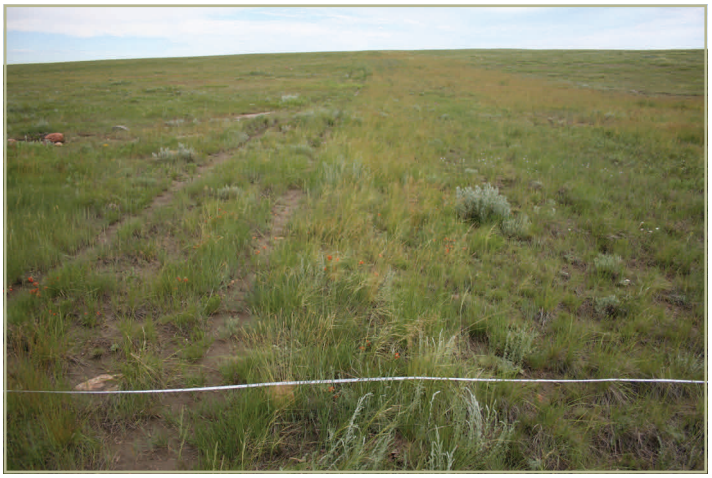


Figure 8 - Site # 29: RoW Seeded with Seed Mix 4 for Dry Mixedgrass Solonetzic Soils after 14 Years Recovery

Table C - Express Seed Mix 4 Dry Mixedgrass Prairie Solonetzic Soils

Species	seeds/g	PLS	est%	PLS/m2	plt/m2	kg/ha	%/wt	total kg
Western wheatgrass	242	92	25	20	5	0.9	7.8	737
Slender wheatgrass *Revenue*	353	83	25	18	5	0.6	5.4	515
Slender wheatgrass *Adanac*	353	86	25	25	6	0.8	7.1	676
Streambank wheatgrass	344	92	25	61	15	1.9	16.7	1589
Northern wheatgrass	345	92	25	24	6	0.8	6.5	620
Green needle grass *(MB)*	398	88	10	40	4	1.1	9.9	937
Green needle grass *(AB)*	398	81	10	40	4	1.2	10.7	1017
Sheep fescue	1498	88	5	200	10	1.5	13.1	1244
June grass *Prairie Seeds*	3300	80	5	200	10	0.8	6.5	621
Alkali bluegrass	2022	53	5	200	10	1.9	16.1	1530
Totals				**829**	**75**	**12**	**100**	**9486**

Figure 9 - Dry Mixedgrass Solonetzic Soil Seed Mix 4 - Species Cover Over Time

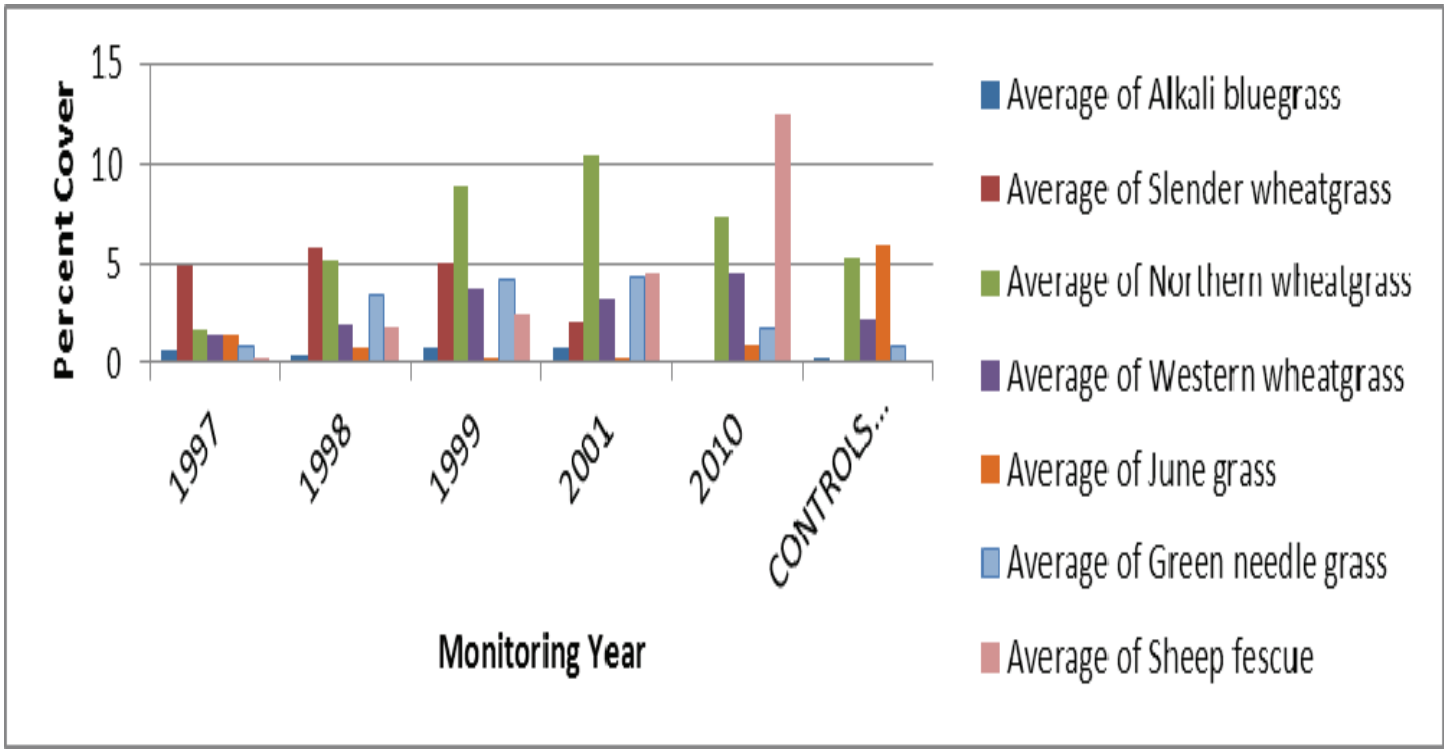
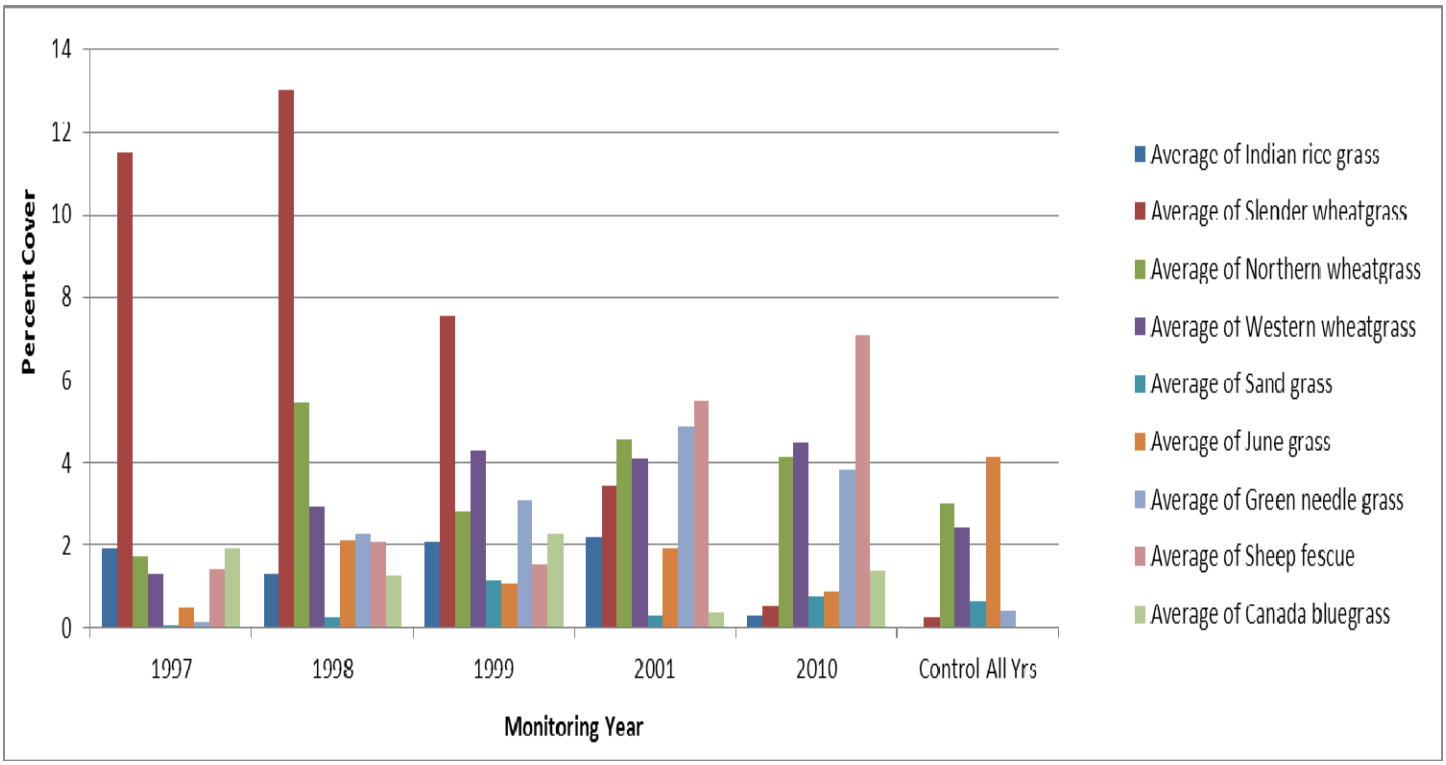


Table D - Express Seed Mix 3 Dry Mixedgrass Prairie Sandy Soils

Species	seeds/g	PLS	est%	PLS/m2	plt/m2	kg/ha	%/wt	total kg
Streambank wheatgrass	344	92	25	26	6	0.8	5.4	324
Northern wheatgrass	345	92	25	24	6	0.8	5.1	302
Western wheatgrass	242	92	25	24	6	1.1	7.2	431
Slender wheatgrass *Revenue*	353	83	25	16	4	0.5	3.7	218
Slender wheatgrass *Adanac*	353	85	25	24	6	0.8	5.3	316
Prairie sand reed *ND95*	603	61	10	42	4	1.1	7.6	455
Prairie sand reed *Goshen*	603	82	10	34	3	0.7	4.6	277
Green needle grass *Blight*	398	88	10	40	4	1.1	7.7	457
Indian rice grass	518	86	10	200	20	4.5	30.1	1796
Sheep fescue	1498	88	5	200	10	1.5	10.2	607
Canada bluegrass	5555	80	2	500	10	1.1	7.5	450
June grass *Prairie Seeds*	3300	80	5	221	11	0.8	5.6	335
Totals				**1351**	**91**	**15**	**100**	**5,968**

Figure 10 - Dry Mixedgrass Sandy Soil Seed Mix 3 - Species Cover Over Time



Mixedgrass Seed Mixes

Wild Harvested Seed

The expression and percent cover of seeded species over time on sites seeded to the Mixedgrass seed mix is illustrated in Figure 12. The cover values are averages of multiple observations from five sites during 1997 to 2001 and seven sites in 2010. The naturally occurring cover of these species on control sites is also shown. Components of the seed mix are presented in Table E.

- Establishment of wild harvested rough fescue from two sources (plains rough fescue *Roes* from the Hand Hills and likely foothills rough fescue *Petherbridge* from the Milk River Ridge) was very slow initially, but the average cover has increased slowly and steadily on ecological range sites with potential to support rough fescue. 14 years after seeding, average cover values of rough fescue on the seeded RoW are more than 50% of the average cover values on the controls.
- Wild harvested June grass performed well, 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.

Figure 11 - Site # 54: Native Seed Mix 2 with Wild Harvested Rough Fescue after 14 Years Recovery

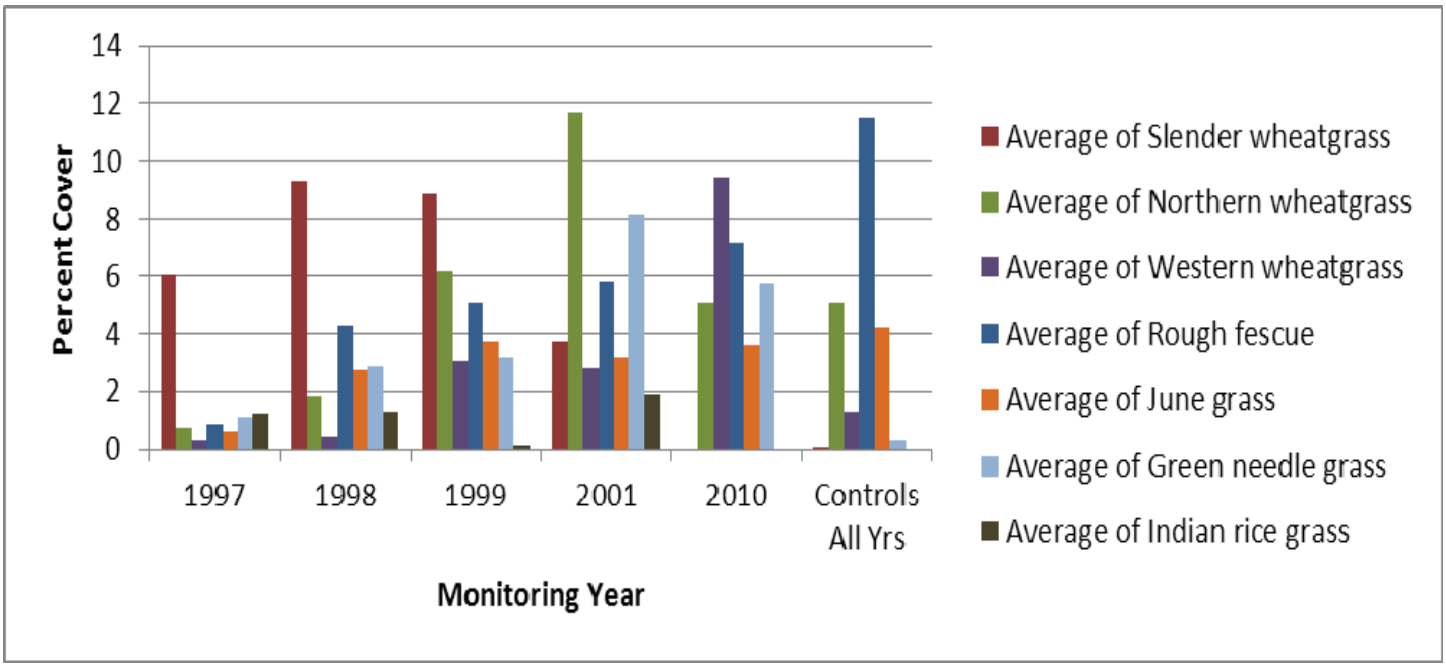
Cultivars

- Similarly to the Dry Mixedgrass seed mixes, the two slender wheatgrass cultivars, *Revenue* and *Adanac*, provided good pioneer and early seral cover and disappeared from the plant community after 14 years.
- Northern wheatgrass and streambank wheatgrass provided good cover during the first five years and have since declined to comparable average cover values to the controls. The seeded cultivars are more robust and taller than their natural counterparts.
- Western wheatgrass established early but has slowly increased over the 14 years and persists at seven fold higher cover than on the controls.
- Green needle grass is only present at low cover levels on a limited number of the native rangeland controls. The seeded cultivar provided good cover during the first five years, but is persisting well beyond natural cover levels (19 fold more) after 14 years. This grass cultivar is significantly taller and more robust than the surrounding native vegetation, creating persistent taller structure and differences in composition in the successional plant community.
- After 14 years, persistent cultivars which are still expanding or maintaining relative cover beyond levels on the controls are influencing the trajectory of plant community succession.

Table E - Express Seed Mix 2 Rough Fescue - Mixedgrass Transition Prairie

Species	seeds/g	PLS	est%	PLS/m2	plt/m2	kg/ha	%/wt	total kg
Streambank wheatgrass	344	92	25	60	15	1.9	16.3	664
Northern wheatgrass	345	92	25	24	6	0.8	6.5	265
Western wheatgrass	242	92	25	24	6	1.1	9.3	377
Slender wheatgrass *Revenue*	353	83	25	20	5	0.7	5.9	239
Slender wheatgrass *Adanac*	353	86	25	28	7	0.9	7.9	323
Green needle grass *Blight*	398	88	10	43	4	1.2	10.4	425
Indian rice grass	518	86	10	50	5	1.1	9.7	393
June grass *Gillespie*	3300	84	10	71	7	0.3	2.2	89
Plains rough fescue *Roes*	386	77	10	25	3	0.8	7.3	296
Rough fescue *Petherbridge*	386	77	10	85	8	2.9	24.6	1000
Totals				**429**	**66**	**12**	**100**	**4,069**

Figure 12 - Mixedgrass Seed Mix 2 - Species Cover Over Time



Results - Natural Recovery

Natural recovery trials were established at four upland locations on the pipeline RoW; two on Solonetzic soils in the Dry Mixedgrass, one on Sandy soils in the Dry Mixedgrass and one on Loamy soils in the Mixedgrass. Sites were selected on relatively level terrain where site stability due to slopes was not an issue and soil exposure to wind erosion was minimized.

Over 14 years, native plant communities re-established on all the natural recovery sites. Cultivars are absent from the reclaiming plant communities, which results in better potential to match off RoW communities in terms of composition and the structural characteristics of local plants. On all Dry Mixedgrass sites there was significant establishment of needle grasses and wheatgrasses that are dominant in the reference plant community state.

Natural recovery was problematic on the Mixedgrass plains rough fescue site. Exposed topsoil remained relatively bare for the first three years, lacking the flush of colonizing annuals typical of Dry Mixedgrass sites. After 14 years, plains rough fescue is notably absent from the plant community. Although diverse, the plant community does not reflect the proportional cover of species in the reference plant community or the controls. This result highlights the additional challenge of re-establishing rough fescue on disturbed topsoils .

Timing of topsoil replacement is an important factor in the outcome of the natural recovery trials. The best results in terms of reflecting the composition and cover levels of the surrounding undisturbed prairie were on Dry Mixedgrass sites where soils were replaced before the following growing season. The cover of key species for the Dry Mixedgrass, blue grama and needle-and-thread, were greatly reduced on the Rainy Hills sites where topsoils were stored through the winter and re-handled once conditions were dry enough in late spring.

There was an increase of undesirable non-native Kentucky bluegrass at the two sites where it was present on the controls. This species is able to capitalize on disturbances and moisture to expand cover when it is present in adjacent undisturbed grasslands.

The timing and duration of livestock grazing can also affect the success of natural recovery, particularly in plains rough fescue plant communities.

Figure 13 - Site # 41: Natural Recovery Site, Sounding Creek Plain

Mixedgrass Seed Trial 100% Rough Fescue

Three trial sites in the Cypress Hills were seeded to 100% wild harvested rough fescue; a combination of the Roes seed and the Petherbridge seed. Figure 14 illustrates the establishment of rough fescue on the disturbed soils of the RoW. The contributions of seven other species providing the most cover on the control sites are also illustrated. Two of the trial sites (sites 53 and 57) are situated in a reference rangeland community, Plains Rough Fescue – Western Porcupine Grass (MGA1) (Adams et al. 2004). One site (site 56) is situated in an early to mid-seral Needle-and-thread – June grass community (MGA3) influenced by grazing. This plant community is successional to the MGA1 community and so has the potential to support plains rough fescue naturally.

Rough fescue was not observed on the disturbed soils in the first growing season. It was observed at 1.0% average cover in the second and third year and 2.0% average cover the fifth year. By the 14th year, cover of rough fescue expanded significantly to 12.5% average cover (varying between 8.0% and 19.5% cover on individual sites). Cover on the controls averaged 22.9%.

Figure 14 - Seed Trial – 100% Rough Fescue - Species Cover Over Time

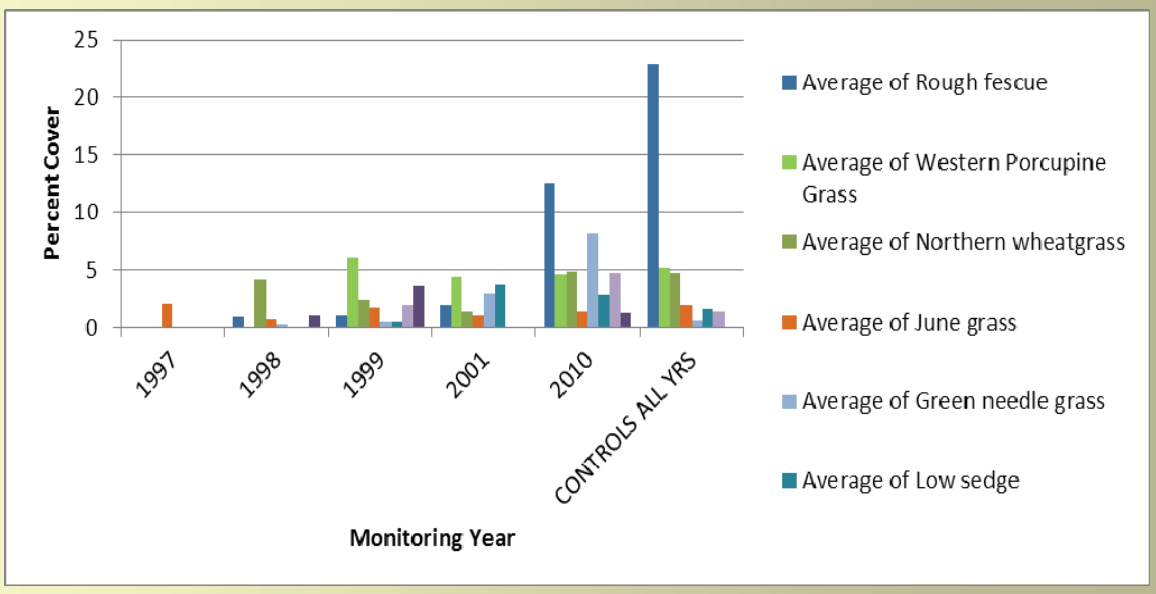
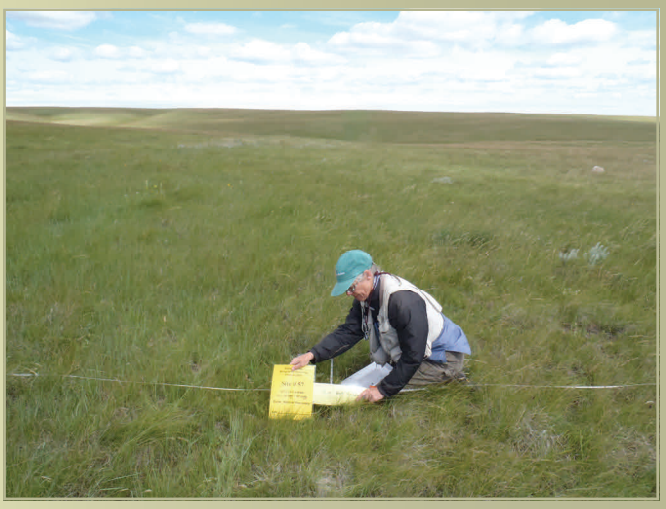


Figure 15 - Example RoW (Site 57) 100% Rough Fescue Seed Trial After 14 Years Recovery



Natural Recovery Dry Mixedgrass Blowout – Solonetzic Soils (Rainy Hills)

Figure 16 illustrates the cover of the 10 most common plant species on the controls and the reclaiming RoW in 2010, 13 years after construction. The data is comprised of four monitoring sites on Solonetzic soils in the Rainy Hills (sites 46-49). Final clean-up occurred in June after fall construction the previous year. There are some notable differences in cover. Blue grama provides three times more cover on the controls compared to the disturbed soils. Needle-and-thread cover on the controls is more than double the cover on the disturbed soils. The disturbance forb pasture sagewort is present on the RoW at four times the cover levels of the controls. The moss-lichen-selaginella groundcover provides double the cover on the controls, but is notably present on the RoW. The other species represented have comparable cover levels between controls and disturbed soils after 13 years recovery.

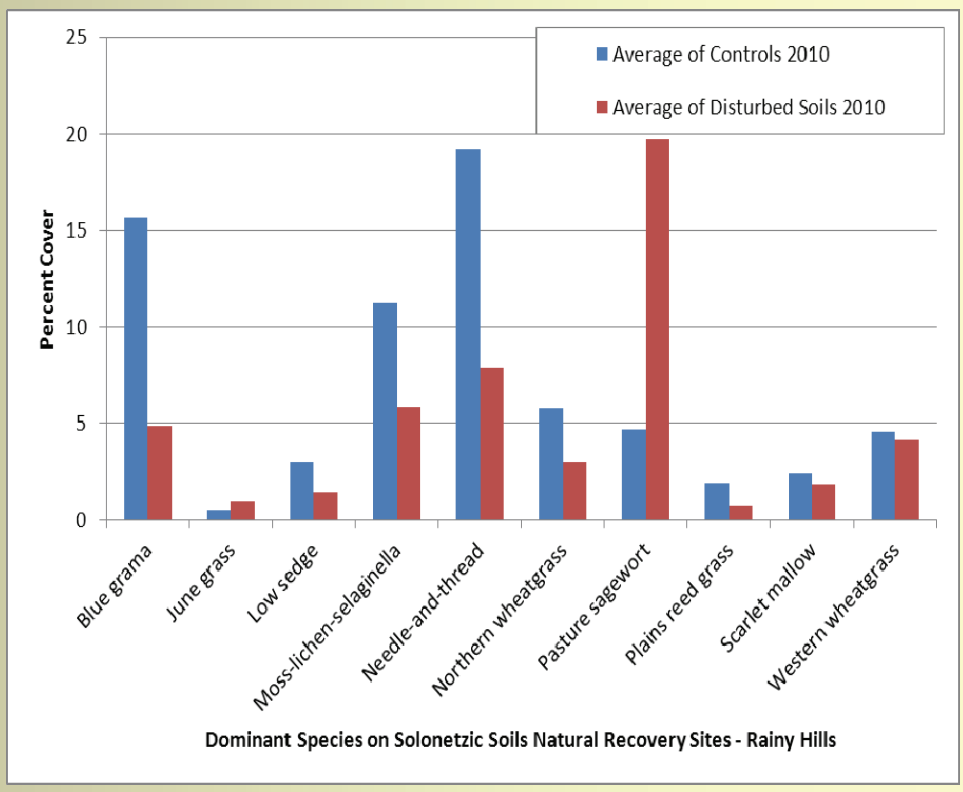


Figure 16 - Species Cover on a Solonetzic Soils Natural Recovery Site after 13 Years – Late Spring Clean-up

Natural Recovery Dry Mixedgrass Blowout – Solonetzic Soils (Sage Creek)

Figure 17 illustrates the cover of the 10 most common plant species on the controls and the reclaiming RoW in 2010, 14 years after construction. The data is comprised of five monitoring sites on Solonetzic soils in Sage Creek (sites 58-62). Final clean-up occurred in fall of 1996, after construction in September of the same year. The dominant species have comparable levels of cover between the controls and the disturbed soils of the RoW. The exception is the groundcover layer of moss, lichen and prairie selaginella, which is much lower on the disturbance.

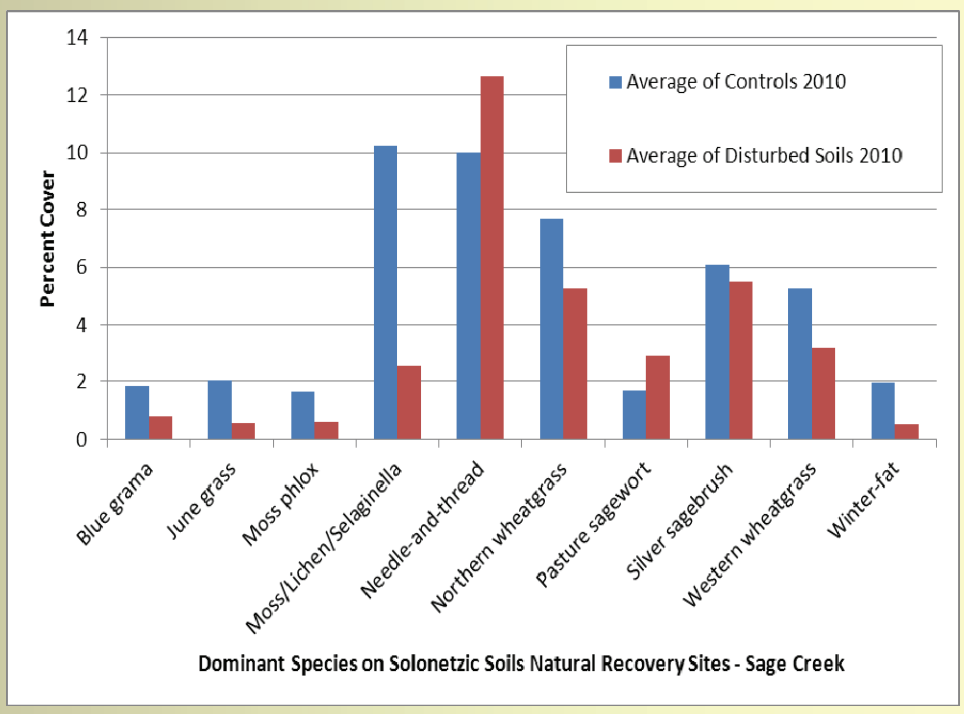


Figure 17- Species Cover on a Solonetzic Soils Natural Recovery Site after 14 Years – Fall Clean-up

Natural Recovery Dry

Mixedgrass Sandy Soils (Hemaruka Dunes)

Figure 18 illustrates the cover of the 11 most common plant species on the controls and the reclaiming RoW in 2010. The data is comprised of six monitoring sites in the Hemaruka Dunes (sites 40-45). Composition and cover are very similar between disturbed and undisturbed soils with the exception of two grazing increaser species. Blunt sedge (*Carex obtusata*) is dominant on the controls and Kentucky bluegrass (*Poa pratensis*) is dominant on the disturbed soils.

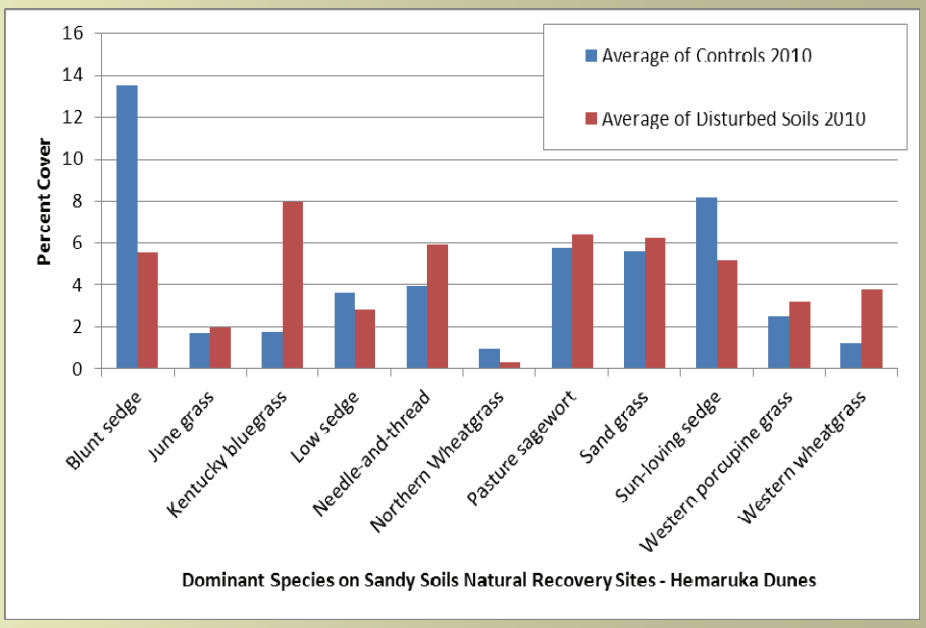


Figure 18 - Species Cover on a Sandy Soils Natural Recovery Site after 14 Years

Natural Recovery Mixedgrass Loamy Soils (Cypress Hills)

Due to concerns about the ability of desirable colonizing species to establish quickly enough to control erosion and the risk of invasive non-native species establishing on Loamy Mixedgrass soils in the Cypress Hills, only one site was left to recover naturally (site 57). The site was straw crimped in the fall of 1996. The following figure illustrates the cover of the most common species on the controls and on the recovering RoW in 2010, 14 years later. Figure 19 illustrates the composition of the control and the revegetating RoW. The relative cover of species on and off the disturbance is different for many species. The biggest differences are the lack of rough fescue cover on the RoW compared to 48.5% cover off RoW and the presence of Kentucky bluegrass at 32% cover on the disturbed soils compared to 2.2% cover on the controls. Other prominent increasers on the RoW are low sedge and pasture sagewort.

This site is summer grazed and is close to a cattle trail across the top of a butte. Cows camped on the RoW in the first few years after construction and grazing pressure on the reclaiming RoW was heavy during the summers.

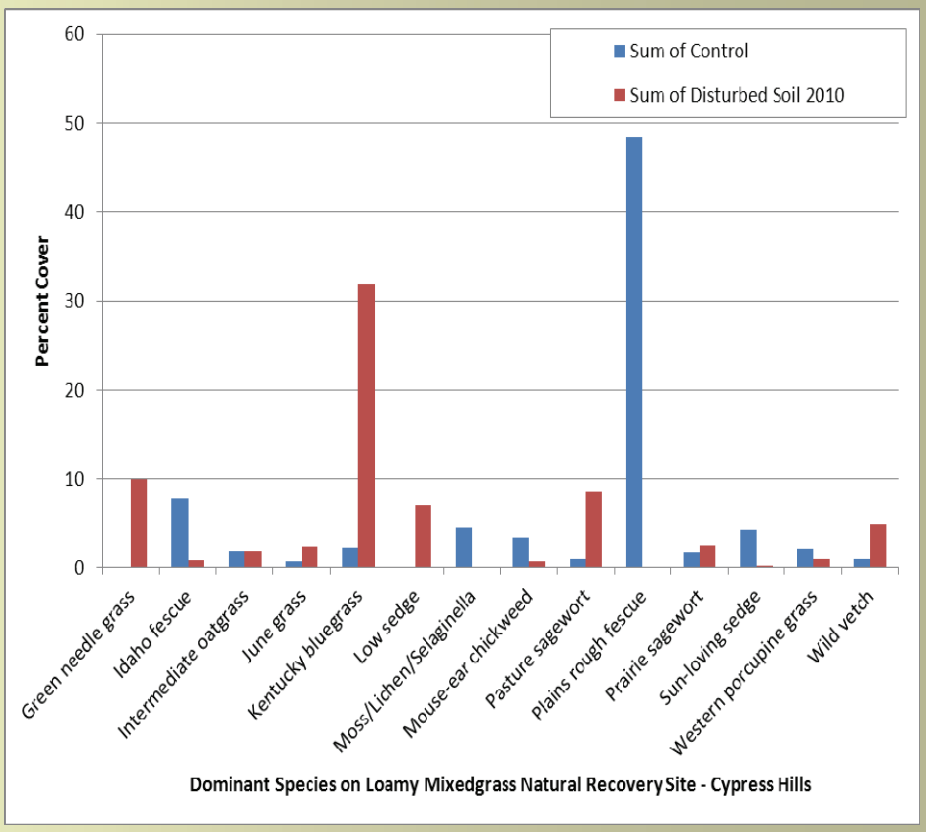


Figure 19 - Species Cover on a Loamy Mixedgrass Natural Recovery Site after 14 Years

Results – Plant Community Succession

For the analysis of succession, sites were grouped by Natural Subregion (NSR) and Ecological Range Site (ERS) and compared within these similar climate / physiography / soils units. Dry Mixedgrass Loamy and Blowout-Solonetzic ERS groups and the Mixedgrass Limy and Loamy ERS groups are included in the analysis. A number of successional plant communities were differentiated within each group. (See Table A for definitions of seral stages.)

The accompanying figures illustrate the observations that clustered together based on similarities in species composition (an observation is the data from one site in a particular year (e.g. site 6 in 1999)). The plant community was named based on the species that were present most frequently and provided the most cover. The "Group Number" associated with each plant community references a more detailed description of the community found in Appendix C of the full report.

Reclaiming sites are generally progressing from early to late seral communities with successional progress variously influenced by range health, non-native perennial species and climate. The plant community ordination analysis indicates that positive successional change is occurring on most seeded and unseeded disturbed soils in the long term. Forty percent of all sites where soils were disturbed developed into a late seral plant community after 14 years. Almost none of the monitored sites are equivalent in composition, structure or range health to undisturbed control areas or to reference sites described in the Range Plant Community Guides (Adams et al. 2004, Adams et al. 2005), although many are trending in this direction.

Dry Mixedgrass – Blowouts/Solonetzic Ecological Range Sites

Figure 20 shows the plant communities that developed over time on both seeded and unseeded Solonetzic range sites in the Dry Mixedgrass. There are four pioneer communities, three dominated by annual weeds and one by seeded slender wheatgrass. Seeded sites remained in a pioneer stage for one to three years, unseeded sites one to four years. Two early seral plant communities were identified on Solonetzic Dry Mixedgrass range sites dominated by the native perennial disturbance forb, pasture sagewort, and the colonizing native perennial grass, needle-and-thread. Most of the reclaiming plant communities remained in an early successional state for two to five years after disturbance. Late seral plant communities are characterized by a dominance of decreaser grasses, the presence of infill species and no more than one structural layer missing. Two late seral communities were identified; one linked to seeded sites and a second found primarily on unseeded sites in later years.

Dry Mixedgrass – Loamy Ecological Range Sites

Figure 21 shows the plant communities that developed over time on seeded and unseeded Loamy range sites in the Dry Mixedgrass. Two pioneer communities, dominated by seeded slender wheatgrass or an unseeded annual forb are prevalent on seeded sites in the first years post-disturbance. All the natural recovery sites on Loamy soils, including unstripped spoil storage areas and disturbed soils, begin their recovery at the early seral stage.

On seeded sites, the cluster analysis indicates two mid-seral plant communities. One community is comprised primarily of seeded species, the other of colonizing grass species from the seed bank, pasture sagewort and seeded green needle grass. These mid-seral communities are prevalent between two and three years after disturbance, but linger in some cases for five to 14 years.

Most unseeded sites progressed directly from early seral to late mid-seral plant communities and did so in five years after disturbance.

Figure 20 - Plant Community Succession on Dry Mixedgrass Solonetzic Ecological Range Sites

		Pioneer			→	Early Seral	→	Mid-seral	Late Mid-seral	Late Seral	→	Trending to Modified	
**	Site # *	*Group 8: Slender Wheatgrass-Northern Wheatgrass-Pasture Sagewort*	*Group 9: Common Knotweed - Pasture Sagewort - Slender Wheatgrass*	*Group 10: Nuttall's Atriplex / Knotweed sp.- Pasture Sagewort*	*Group 11: Summer Cypress-Lamb's quarters-Slender Wheatgrass*	*Group 12: Pasture Sagewort-Needle-and-Thread Grass*	*Group 3: Pasture Sagewort-Needle-and-Thread Grass - June Grass*	*Group 4: Northern Wheatgrass-Pasture Sagewort-Western Wheatgrass*	*Group 5: Needle-and-Thread Grass - Pasture Sagewort-Northern Wheatgrass*	*Group 1: Western Porcupine Grass - Western Wheatgrass - Pasture Sagewort*	*Group 2: Western Wheatgrass -Pasture Sagewort*	*Group 7: Sheep Fescue - Northern Wheatgrass –Pasture Sagewort /Moss and Lichens*	*Group 6 - Sheep Fescue-Pasture Sagewort-Northern Wheatgrass*
Seeded Sites (yr)	6D	97, 98								99, '01			10
	7D		97		98, 99	10					01		
	8D	97, 99				98				10		01	
	28D	97										98, 10	99, '01
	29D	97				98		99, 01					10
	34D					98, 99			97, 01				10
Unseeded Sites (yr)	30N		01	97, 98		99					10		
	9S				97			98	99, 01, 10				
	27S						97, 98, 99, 01						
	32T						99, '01	97, 98					
	46N					98, 99, '01, 10							
	47N					98, 99, '01					10		
	48N					99, '01	98, 10						
	49N					98, 99, '01					10		
Diversity Index		2.07	1.88	1.09	1.92	1.62	2.19	1.79	1.85	2.53	2.11	2.07	1.94
Average Richness		16.0	14.0	9.5	16.3	12.4	14.2	12.6	11.6	21.0	15.5	18.0	14.8

* Site Number Modifiers: D=disturbed topsoil, N=natural recovery site, S=unstripped spoil storage area, T=unstripped travel lane
** The observation year is recorded for the plant community at each site

Figure 21 - Plant Community Succession on Dry Mixedgrass Loamy Ecological Range Sites

		Pioneer →		Early Seral →			Mid-seral →		Late Mid-seral →		Late Seral	Trending to Modified
***	Site # **	Group 5: Summer Cypress-Slender Wheatgrass	Group 3: Slender Wheatgrass - Western Wheatgrass - Northern Wheatgrass	Group 4: Low Sedge - Pasture Sagewort	Group 6: Pasture Sagewort - Northern Wheatgrass	Group 8: Narrow-lved Goosefoot - Pasture Sagewort - Northern Wheatgrass	Group 2: Northern Wheatgrass - Green Needle grass - Western Wheatgrass	Group 11: Needle-and-Thread Grass - Green Needle Grass - Pasture Sagewort	Group 7: June Grass - Pasture Sagewort - Northern Wheatgrass	Group 9: Needle-and-Thread grass - Pasture Sagewort	Group 10: Needle-and-Thread grass - Northern Wheatgrass	Group 1: Sheep Fescue - Northern Wheatgrass
Seeded Sites (yr)	10D											10
	11D			97	98, 99			10*		01		
	12D		97		10*		98, 99, 01					
	13D		97, 99				98, 10					01
	14D	97, 98					99, 01, 10					
	15D		97					98, 99			01	10*
	35D		97					98, 99		10		01
Unseeded Sites (yr)	10S			97, 98, 99						01, 10		
	31S								97		98, 99, 01	
	36S								97, 98	99, 01		
	60N					98		99		01, 10		
	61N					98, 99					01, 10	
	63N				97, 99	98				01		
Diversity Index		0.72	1.43	1.67	1.98	1.99	1.87	2.07	2.14	1.75	1.68	1.55
Average Richness		4.5	9.4	13.2	14.2	11.5	12.2	15.5	14.3	13.0	10.5	9.5

* Reseeded in 2004
** Site Number Modifiers: D=disturbed soil, N=natural recovery site, S=unstripped spoil storage area
*** The observation year is recorded for the plant community at each site

Dry Mixedgrass – Sandy Ecological Range Sites

Figure 22 shows the plant communities that developed over time on six unseeded natural recovery sites on disturbed topsoils (sites 40N – 45N) and an unstripped travel lane (site 5T) in Sandy range sites as identified by GVI. The first two years of data collection on four of the six natural recovery sites was not used.

The unstripped travel lane site is a heavily grazed pasture and the plant community (Buckbrush – Sun-Loving Sedge - Pasture Sagewort) remains as a mid-seral plant community dominated by increaser species during all of the monitoring years.

The six natural recovery sites of the Hemaruka Dunes progress from pioneer plant communities in the first year or two to early seral and late seral communities in the third year.

The pioneer community is dominated by an exotic annual weed, lamb's quarters, and rhizomatous native perennials.

The early seral community is dominated by an introduced annual mustard. The native perennial grass western porcupine grass and pasture sagewort are establishing on the RoW. The late seral plant communities are characterized by the dominance of species that characterize the reference plant communities for Sandy ecological range sites, including western porcupine grass, needle-and-thread and sand grass.

By year five all of the sites have developed to late seral plant communities dominated by needle-and-thread or western porcupine grass. One site (40) is clustering with a mid-seral plant community, but this is likely due to the high cover of buckbrush on this site.

Figure 22 - Plant Community Succession on Dry Mixedgrass Sandy Ecological Range Sites

		Pioneer	Early Seral	Mid-seral	Late Seral →		
***	Site# *	Group 4: Prairie Rose - Lamb's Quarters - Prairie Sagewort	Group 6: Tansy Mustard - Western Porcupine Grass - Pasture Sagewort	Group 1: Buckbrush - Sun-Loving Sedge - Pasture Sagewort	Group 5: Western Porcupine Grass - Pasture Sagewort - Sand Grass	Group 2: Needle-and-Thread - Pasture Sagewort - Kentucky Bluegrass	Group 3: Needle-and-Thread - Blunt Sedge - Sand Grass
Unseeded Sites (yr) **	5T			97, 98, 99, 01, 10			
	40N			10	98, 99, 01		
	41N				98, 99, 01	10	
	42N				01		98, 99, 10
	43N				01		98, 99, 10
	44N	97	99		01	98, 10	
	45N	97, 98	99		01	10	
Diversity Index		1.14	2.06	1.98	1.95	2.36	2.37
Avg. Richness		11.0	17.0	18.2	16.0	18.5	22.7

* Site Number Modifiers: N=natural recovery site, T=unstripped travel lane
** The observation year is recorded for the plant community at each site

Mixedgrass – Limy Ecological Range Sites

Figure 23 illustrates the progress of revegetation on four seeded sites and one unstripped spoil storage area on Limy range sites in the Cypress Hills. All the seed mixes included at least 31.9% by weight rough fescue (Seed Mix 2). The seed mix for site 23 was Seed Mix 2; the mix for site 54 included 50% of Seed Mix 2 plus 25% needle-and-thread and 25% wild harvested rough fescue. The seed mix for site 57 was 100% wild harvested rough fescue. There is some uncertainty about the treatment at site 56.

The pioneer plant community was only distinguished by the common presence of June grass, with a few other species present and less than 10% green cover.

Rough fescue is establishing in one of the two early seral communities characterized by the prominence of pasture sagewort or knotweed. Seeded grasses, western porcupine grass and other infill colonizers are establishing from the seedbank.

A mid-seral community comprised primarily of species present in Seed Mix 2 developed between the third and 14th year of growth.

An unstripped spoil storage area maintained a late seral state as a plains rough fescue community from the first year after disturbance. The site where disturbed soils on healthy rangeland were seeded to 100% rough fescue transitioned to this state by 14 years post-construction.

Figure 23 - Plant Community Succession on Mixedgrass Limy Ecological Range Sites

		Pioneer	Early Seral →		Mid-seral	Late Seral
**	Site # *	Group 3: June Grass	Group 2: Pasture Sagewort - Plains Rough Fescue - Northern Wheatgrass	Group 4: Common Knotweed - Pasture Sagewort - Western Porcupine Grass	Group 1: Green Needle Grass - Northern Wheatgrass - June Grass	Group 5: Plains Rough Fescue - Western Wheatgrass - Northern Wheatgrass
Seeded Sites (yr)	23D		97, 98, 10		99, 01	
	54D				98, 99, 01, 10	
	56D	97, 98		99, 01	10	
	57D	97	98	99, 01		10
Unseeded Sites (yr)	26S					97, 98, 99, 01, 10
Diversity Index		1.56	2.17	2.19	2.24	1.98
Avg. Richness		9.3	17.5	20.2	16.6	16.2

* Site Number Modifiers: D=disturbed topsoil, S=unstripped spoil storage area
** The observation year is recorded for the plant community at each site

Mixedgrass – Loamy Ecological Range Sites

Six seeded sites and three unseeded sites are included in the cluster analysis for Mixedgrass Loamy soils. Figure 24 illustrates the five plant communities differentiated, their successional status on reclaiming sites and the progression of each site over time.

An early seral community on Loamy sites is characterized by the dominance of the disturbance forb pasture sagewort, the persistence of the colonizing seed mix grass species slender wheatgrass and the low cover of other establishing long-lived native grasses. This plant community persisted for five years on a site subjected to heavy summer grazing on the RoW. It was also found in years two and three on other seeded sites. Plains rough fescue is present at 3.4% cover with a constancy of 71.4%. Western porcupine grass is colonizing from the seedbank.

Two mid-seral plant communities developed; one dominated by wheatgrasses and desirable decreasers on seeded sites and sites where Kentucky bluegrass is dominant. This invasive exotic grass is present on the undisturbed but should not take over as long as the range stays in healthy condition.

By year 14, four seeded sites are at a late seral stage, characterized by prominence of the slow to establish decreaser species rough fescue. This group includes observations from three sites seeded to Seed Mix 2, one site seeded to pure rough fescue, and one natural recovery site.

The unstripped spoil storage area did not revert to a pioneer community after disturbance but remained as a mid-seral plant community for five years thereafter. Similarly, an unstripped travel lane remained as a late mid-seral plant community for five years after disturbance. These two sites were not monitored in 2010.

Figure 24 - Plant Community Succession on Mixedgrass Loamy Ecological Range Sites

		Early Seral	Mid-seral	→	Late Mid-seral	Late Seral
**	Site #*	Group 3: Pasture Sagewort - June Grass - Wild Vetch	Group 1: Northern Wheatgrass - Western Wheatgrass – Needle-and-Thread	Group 5: Kentucky Bluegrass - Low Sedge - Pasture Sagewort	Group 2: Western Porcupine Grass - Northern Wheatgrass - Wild Vetch	Group 4: Plains Rough Fescue - Northern Wheatgrass - Pasture Sagewort
Seeded Sites (yr)	20D		10			
	21D	97, 98, 99, 01				10
	24D					10
	25D	98			01	97, 99, 10
	53D	99		01		98, 10
	55D	98	99, 01, 10			
Unseeded Sites (yr)	20S		97, 98, 99, 01			
	24T				97, 98, 99, 01	
	52N			01, 10		98, 99
Diversity Index		2.18	2.04	1.44	2.08	2.16
Avg. Richness		14.9	13.2	11.8	22.7	18.1

* Site Number Modifiers: D=disturbed topsoil, N=natural recovery site, S=unstripped spoil storage area, T=unstripped travel lane
** The observation year is recorded for the plant community at each site

Summary of Succession on Seeded Disturbed Topsoils

- Unfortunately the use of sheep fescue in the Dry Mixedgrass seed mixes has resulted in 50% of these sites trending to modified plant communities over 14 years. The communities are still primarily native plant communities but non-native sheep fescue cover is increasing over time and occupying > 5% of the total live cover.
- On Loamy Mixedgrass soils in the Cypress Hills, where no non-native species were present in the seed mixes, four of the six seeded sites developed into a late seral plant community dominated by plains rough fescue and trending towards the MGA1 reference community for these sites. None of the seeded species are present beyond natural levels. Part of the reason for the success of these sites is likely their location in very large pastures with little presence of invasive species, little fragmentation and few routine sources for introducing invasive species. Two sites remain as mid-seral communities in 2010, with seeded northern and western wheatgrass dominant, and characteristic off RoW species such as the needle grasses and plains rough fescue still at very low cover.
- For seeded sites that remain as early or mid-seral plant communities after 14 years (both in the Mixedgrass and the Dry Mixedgrass), pasture sagewort (a persistent native disturbance forb) or seeded cultivars (including green needle grass, northern wheatgrass or western wheatgrass) are still dominant, often beyond natural levels.

Unseeded Disturbed Topsoils

On Dry Mixedgrass soils, 78% of the natural recovery sites support late mid-seral to late seral communities after 14 years.

- Dry Mixedgrass Solonetzic Soils: Three of five natural recovery sites support a late seral plant community dominated by western wheatgrass and pasture sagewort. Two remain as early seral communities with pasture sagewort still dominant.
- Dry Mixedgrass Loamy Soils: Of the two sites, one is a late mid-seral Needle-and-Thread – Pasture Sagewort community and the other is a late seral Needle-and-thread – Northern Wheatgrass community.
- Dry Mixedgrass Sandy Soils: The six sites all re-established to a late seral Western Porcupine Grass – Pasture Sagewort community by the fifth year. By year 14, five of the sites shifted to two different late seral needle-and-thread communities. One site shifted to a mid-seral stage Buckbrush – Sun-loving Sedge community.

Mixedgrass Loamy Soils

There was only one unseeded trial site in the Mixedgrass due to concerns about the ability of these sites to revegetate to desirable species and the vulnerability of sites in the Cypress Hills to erosion. This site had very little cover for the first three years and was subject to summer grazing. The bare RoW attracted cattle. Although in the analysis the developing plant community clustered with a late seral community in years two and three, it has shifted into a community dominated by Kentucky bluegrass (an invasive exotic species) in years five and 14.

Unstripped Spoil Storage Areas and Travel Lanes

Native vegetation at monitoring sites where spoil was stored directly on the grass or where vehicles drove directly on the grass did not revert to a pioneer stage. Native vegetation re-established quickly from underground propagules to provide partial cover and early to mid-seral plant communities. However, many of these sites do not appear to have progressed towards more mature seral stages. Most maintained the same plant community cover over five years. Some sites have maintained the same plant community over the 14 year recovery period.

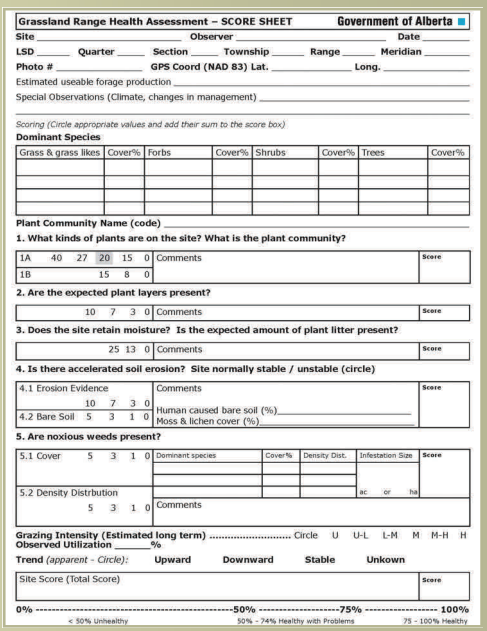
Table F - Seral Stage on Unstripped Spoil and Travel Lane Sites after 14 Years

Unstripped Construction Areas *	Site # **	Seral Stage on Revegetating Unstripped Soils in 2010					
		Pioneer	Early Seral	Mid-seral	Late	Mid-seral	Late Seral
DMG - Solonetzic: Spoil	9S	97		98	99, 01		
DMG - Solonetzic: Spoil	27S		97, 98, 99, 01				
DMG - Solonetzic: Travel Lane	32T		99, 01	97, 98			
DMG - Loamy: Spoil	10S		97, 98, 99		01, 10		
DMG - Loamy: Spoil	31S				97		98, 99, 01
DMG - Loamy: Spoil	36S				97, 98, 99, 01		
DMG - Sandy: Travel Lane	5T			97,98,99,01,10			
MG - Limy: Spoil	26S						97,98,99,01,10
MG - Loamy: Spoil	20S			97, 98, 99, 01			
MG - Loamy: Travel Lane	24T				97, 98, 99, 01		

* DMG = Dry Mixedgrass; MG = Mixedgrass
** Site Number Modifiers: S=unstripped spoil storage area, T=unstripped travel lane

Results – Range Health

Range health was measured both on the disturbance and the associated controls in 2010. Health assessments included measures of ecological status (as indicated by the community of plants present on the site), plant community structure, litter, site stability, soil exposure and the presence of noxious weeds (Adams et al. 2009). The health of the range before disturbance affects the ability of a disturbed area to respond and can affect the outcome of restoration. Ultimately, impacts to plant community integrity will impact the provision of ecological services.



Grassland Range Health Assessment – SCORE SHEET **Government of Alberta**

Site _____ **Observer** _____ **Date** _____
LSD _____ **Quarter** _____ **Section** _____ **Township** _____ **Range** _____ **Meridian** _____
Photo # _____ **GPS Coord (NAD 83) Lat.** _____ **Long.** _____
Estimated useable forage production _____
Special Observations (Climate, changes in management) _____

Scoring (Circle appropriate values and add their sum to the score box)

Dominant Species

Grass & grass likes	Cover%	Forbs	Cover%	Shrubs	Cover%	Trees	Cover%

Plant Community Name (code) _____

1. What kinds of plants are on the site? What is the plant community?

1A	40	27	20	15	0	Comments / Score
1B			15	8	0	

2. Are the expected plant layers present?

10	7	3	0	Comments	Score

3. Does the site retain moisture? Is the expected amount of plant litter present?

25	13	0		Comments	Score

4. Is there accelerated soil erosion? Site normally stable / unstable (circle)

4.1 Erosion Evidence	10	7	3	0	Comments / Score
4.2 Bare Soil	5	3	1	0	Human caused bare soil (%)_____ Moss & lichen cover (%)_____

5. Are noxious weeds present?

5.1 Cover	5	3	1	0	Dominant species	Cover%	Density Dist.	Infestation Size	Score
								ac or ha	
5.2 Density Distrbution	5	3	1	0	Comments				

Grazing Intensity (Estimated long term) ..... Circle U U-L L-M M M-H H
Observed Utilization _____%
Trend *(apparent - Circle):* **Upward** **Downward** **Stable** **Unkown**

Site Score (Total Score) | Score

0% ----------50% ----------75% ---------- 100%
< 50% Unhealthy 50% - 74% Healthy with Problems 75 - 100% Healthy

Range Health Assessment

Field Worksheet for Grasslands

What is Rangeland Health?

Range health refers to the ability of rangelands to perform certain important natural functions like:

- produce plant biomass including forage for livestock and wildlife,
- maintain the soil and protect the site from erosion
- capture and beneficially release water,
- cycle nutrients and energy, and
- maintain biological diversity.

Healthy rangelands will provide a long list of goods and services for society. For livestock producers this means sustainable grazing opportunities along with watershed and soil protection.

Why Should I Consider Range Health?

The range health score is a cumulative measure of the 5 factors that you will rate for the representative area of grassland you have selected to monitor. A range health assessment provides a snapshot in time of management impacts on a particular site. Range health monitoring can alert livestock producers to management issues and problems on their rangelands so that management changes can be made.

A Tool for Ranchers and Other Resource Managers

The range health protocol is very similar to the riparian health assessment system that has been developed by the Alberta Cows and Fish Program. Range health builds on the traditional range concept, but like the riparian health assessment, adds additional indicators of important natural processes and functions – things that producers can observe and that are easier to measure than plant community alone. Ranchers, wildlife managers, researchers, the oil and gas industry and other users, are all able to use this tool to successfully judge the health of rangelands.

How Do I Assess My Rangeland?

Assessing the health of rangelands involves comparing the ecological functions being performed on a grazed site to a corresponding lightly grazed potential natural plant community or reference plant community (RPC). The RPC shows which native plants are expected to be growing on that kind of site for that particular successional stage. Information on RPC can be derived from a lightly grazed site nearby or in range plant community guides available at www.srd.alberta.ca.

Get a look at as much of the site as possible to ensure that the answers to the questions represent the entire area being represented. You may need to consider subdividing the site into smaller sample areas to provide improved assessment. Alternatively you may decide to only assess a smaller area to represent the site.

Health Categories

Healthy: A health score of 75 or greater.
All of the key functions of health rangeland are being performed.

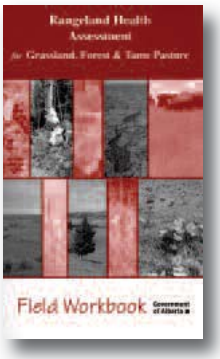
Healthy with Problems: A health score of 50 to 74%.
Most but not all of the key functions of healthy range are being performed. This score is an early warning that adjustments to management are needed. Recovery to a healthy category can normally be accomplished within a few years.

Unhealthy: A health score of less than 50%.
Few of the functions of healthy range are being performed. Management changes are essential and many years will be required to regain a healthy status..

Need More Information?

This document is an abridged version of the rangeland health assessment.

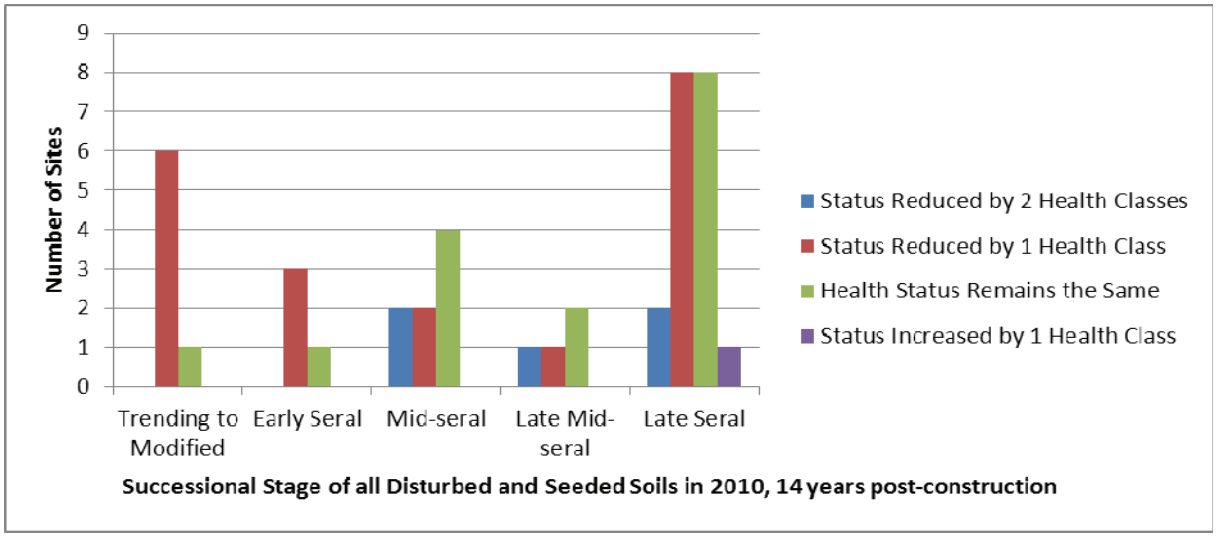
For more detailed information, please refer to the *"Rangeland Health Assessment for Grassland, Forest and Tame Pasture Field Workbook"* available at your nearest Sustainable Resource Development Lands office or at www.srd.alberta.ca.



Ecological Status

After 14 years, 45% of the sites on disturbed soils have developed into late seral plant communities of varying ecological status. Some 43% of the 42 measured sites have the same ecological status as the adjacent undisturbed pasture. Another 43% of the sites have reduced ecological status compared to the adjacent rangeland. Ecological status scores dropped by two health classes for 11% of the sites and increased by one health class at one site. There were no discernible differences in range health status between seeded and unseeded sites after 14 years.

Figure 25 - Ecological Status and Seral Stage of Reclaiming Sites on Disturbed Topsoils



Plant Community Structure

Healthy native rangeland communities include tall, mid, low and ground cover structural layers. Diversity in the canopy structure provides resilience to fluctuations in grazing pressure and climate events, promotes energy flow and nutrient cycling, and protects the ground surface from erosion (Adams et al. 2009). A consistent observation from all the reclaiming sites on disturbed soils is the continuing lack of a groundcover layer after 14 years. Bare soils were still more prevalent on the recovering RoW than on native rangeland, which contributed to reduced health scores. Typically prairie selaginella (*Selaginella densa*), and to a lesser extent mosses and lichen are the major components of this layer. Litter values were also diminished with increased grazing pressure and lower range health scores.

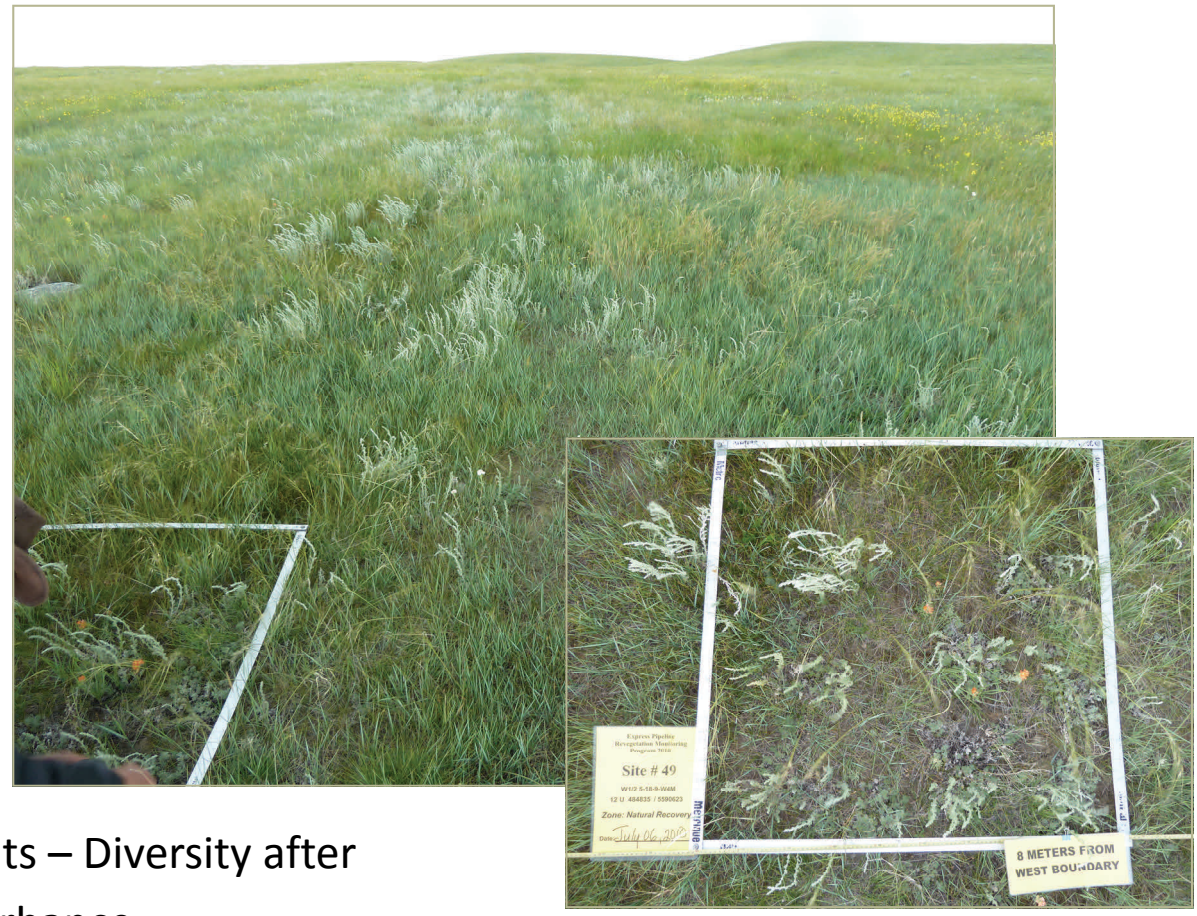
Invasive Species

Establishment of invasive species from the seedbank or through infill has only been an issue at a few monitoring sites. Kentucky bluegrass is the dominant cover at two natural recovery sites in the Mixedgrass that are used as summer pasture. Crested wheatgrass is also establishing on two southern sites in the Dry Mixedgrass where it is present off RoW. The large pastures in the expansive areas of native prairie in the southern portion of the Express Pipeline route are relatively free of introduced species. Further north, where there is increased landscape fragmentation and cultivation, introduced species are more common.

Interacting Variables

Range health was generally better in larger pastures and on Public Land. Smaller pastures and private land, particularly on more northern portions of the RoW, tended to have reduced range health scores. In smaller pastures the disturbed RoW takes up proportionally more of the available land which can put further pressure on both the undisturbed and disturbed portions of the area. The droughts experienced during recovery can also exacerbate grazing impacts on the recovering RoW, particularly in smaller pastures.

Figure 26 - Site # 49: Natural Recovery Site, Rainy Hills Upland



Results – Diversity after Disturbance

An assessment was made of the proportion over time of three growth forms of interest (annual forbs, perennial forbs, and graminoids) on reclaiming soils in the Dry Mixedgrass. The assessment compares the relationship between the diversity of species on a site (represented by Shannon's Diversity Index) and the proportion of a site occupied by each growth form. The biggest changes in proportion are the flush of annual forbs immediately after disturbance, their gradual decline over time and the slow steady increase in the diversity of graminoids (grasses and sedges) on natural recovery sites as opposed to the high cover, low diversity seed mix graminoid cover in early years.

Over time the diversity of graminoids and the proportion of the naturally reclaiming sites occupied by graminoids increases and are comparable to values on seeded areas and undisturbed controls by 2010.

Results – Plains Rough Fescue Sod Salvage Trials

Plains rough fescue plants can survive a transplant procedure in the long term where sod of sufficient depth and quality is used. Range health plays an important role in transplant success over the long term. Shallow-rooted, rhizomatous, non-native grasses such as Kentucky bluegrass or smooth brome can colonize the sod transplant areas from outside sources, competing with the recovering plains rough fescue and associated native bunch grasses. The presence of invasive non-native grasses in the stand prior to disturbance severely limits the success of the sod salvage procedure. Loamy range sites appear to be more susceptible to Kentucky bluegrass and smooth brome invasion than drier, less fertile range sites. Restoring surface contours is challenging and changes to drainage can also result in changes in the plant associations on the sod blocks over time. This technique is also very labour intensive.

Figure 27 - Dominant Species on Salvaged Sod after 14 Years Recovery – Parkland Sites

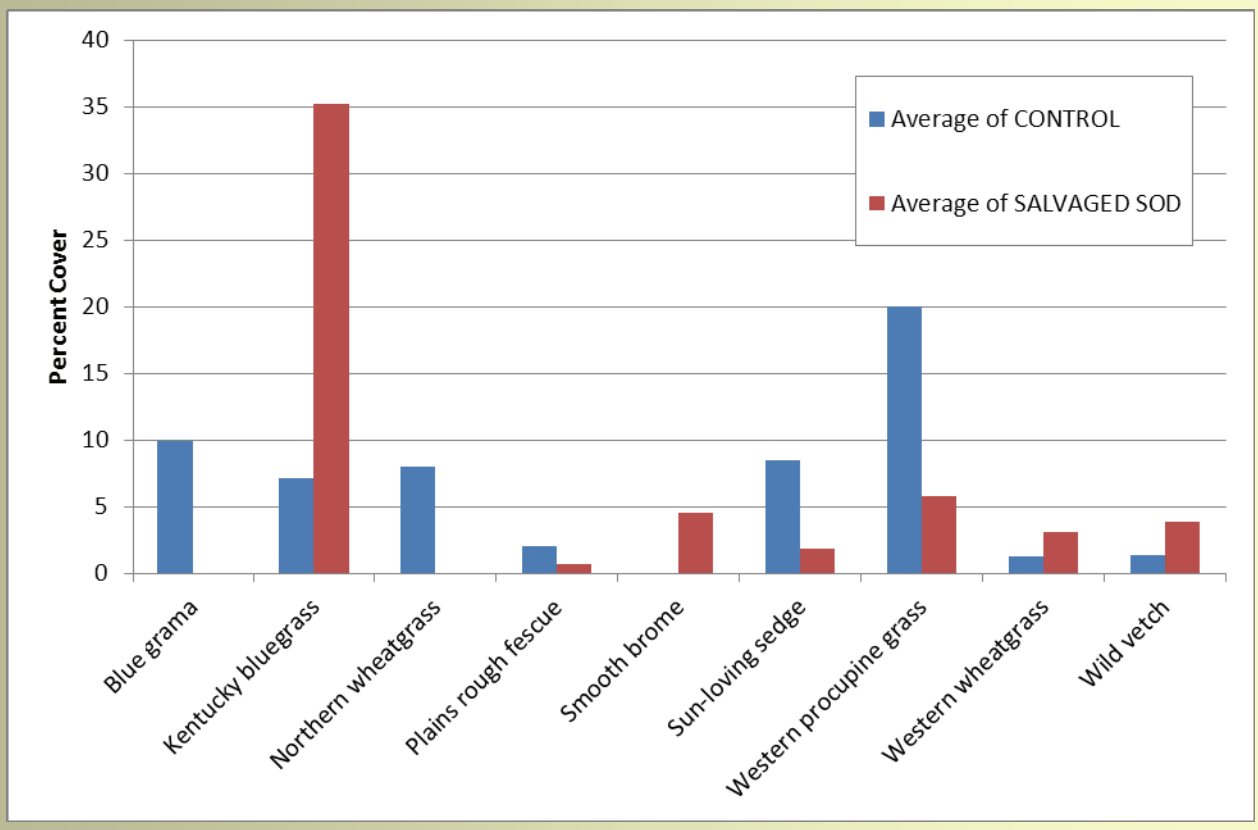


Figure 28 - Dominant Species on Salvaged Sod after 14 Years Recovery – Mixedgrass Sites

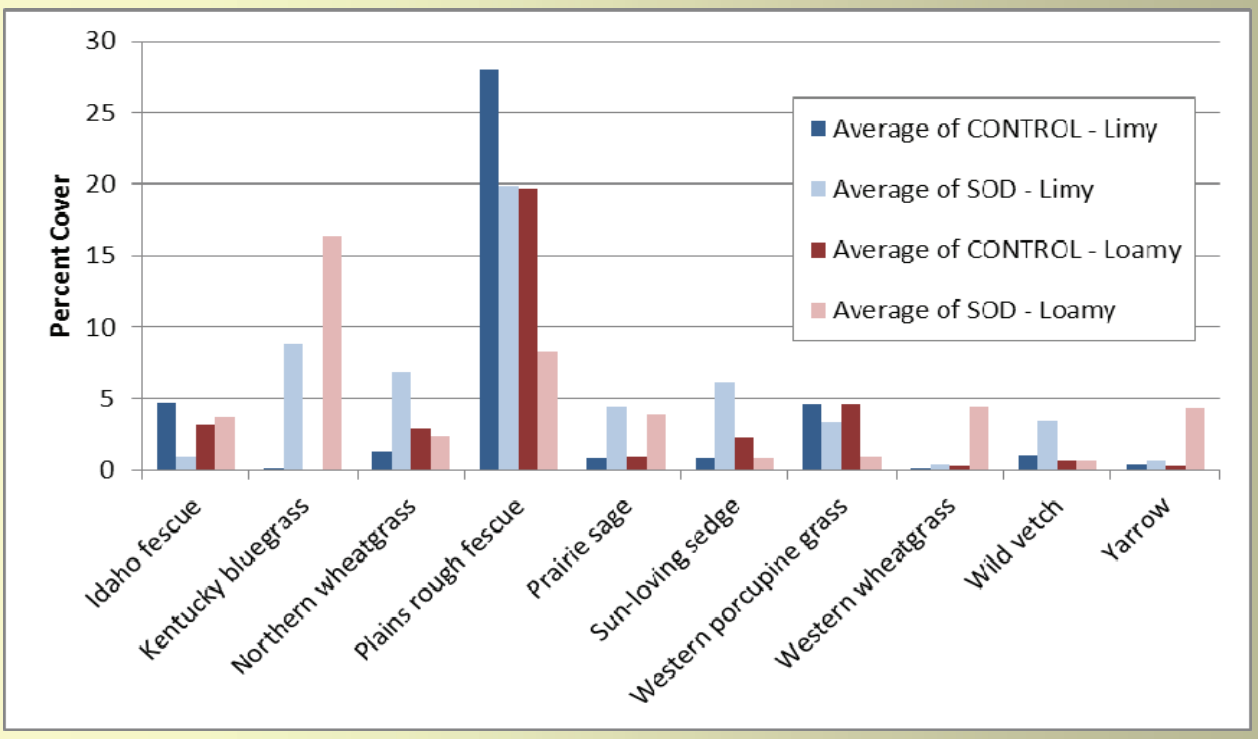
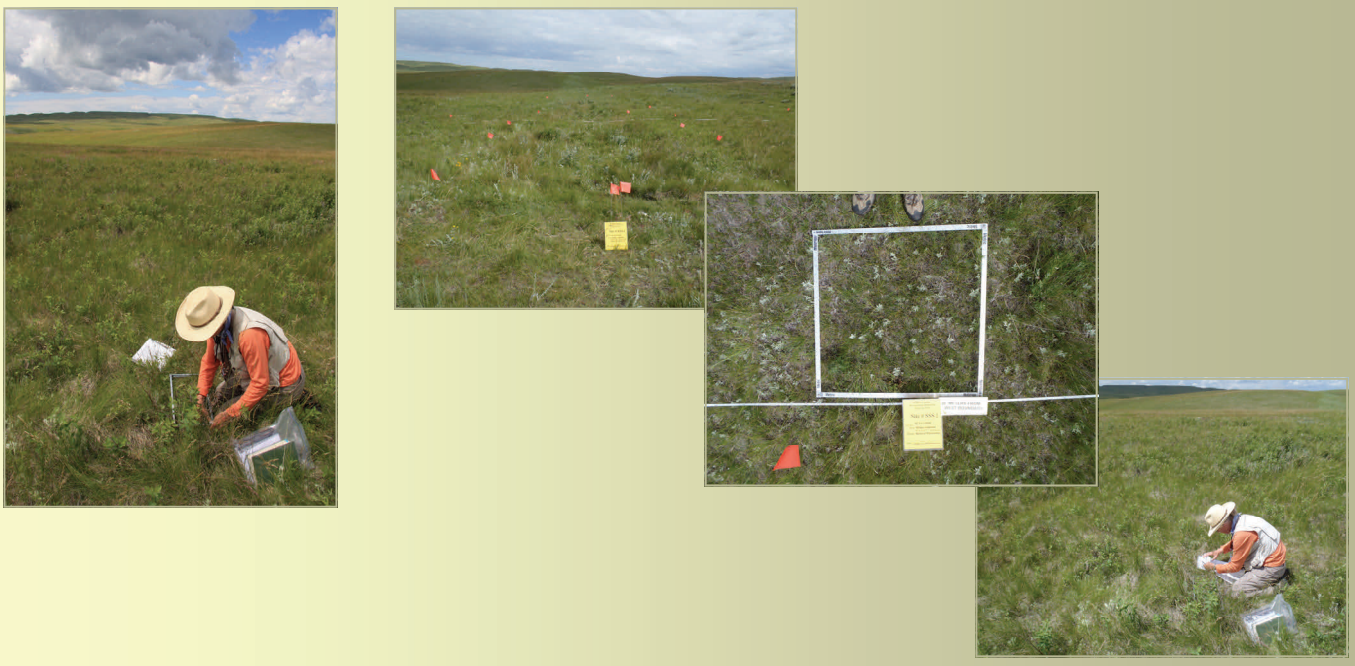


Figure 29 - Example Photos - Sod Salvage Site #1 South - Manyberries Mixedgrass



Management Recommendations

A number of recommendations based on key learnings from Express are presented in Section 11 of the main report. A few are highlighted here.

Restoration Planning

- Sites where long-lived seeded species matched those present naturally on the surrounding rangeland had the best chance of establishing and persisting over time.
- New tools for planning restoration of native prairie after disturbance will identify ecological site characteristics and target plant communities for restoration planning.
- There may be more options for restoration in healthy rangeland. Diminished range health or high grazing intensity can hinder recovery.

Figure 30 - Crew Photos

Seed Mixes

- Avoid seeding persistent species that are not present naturally on the same ecological range site (ERS).
- Non-native sheep fescue is invasive and should not be used for restoration. Sheep fescue may contribute to plant community modification over time.
- It is important to plan for different structural layers when designing a seed mix and include a variety of species with tall, mid and low structural characteristics. Diverse structure improves range health and builds ecological resilience.
- Persistent cultivars that developed taller structure on the RoW are green needle grass, sand grass (sand reed grass), northern wheatgrass and western wheatgrass.
- It is very important to use seed with genetic origin that is compatible with the area of the project. Some cultivars are much taller and more robust than local plants, creating persistent increases in plant community structure on the revegetating disturbance. The common aggressive cultivars on Express were green needle grass, western wheatgrass and northern wheatgrass.
- Slender wheatgrass in a useful short term cover crop, providing erosion control and shade for slower growing species and disappearing for the most part by year five, leaving space for infill by other species.
- Do not use non-native species for native prairie restoration unless they are annual cover crops that are guaranteed not to persist more than one year or reseed.

Figure 31 - Site # 11: Seed Mix 3 - Berry Creek Plain

Natural Recovery

- Natural recovery techniques were successful in establishing native plant communities in the Dry Mixedgrass Natural Subregion. Cultivars are absent from the reclaiming plant communities, which results in better potential to match off RoW communities in terms of composition and the structural characteristics of local plants. The result is a native plant community rather than a community of native cultivars.
- The timing of topsoil replacement is an important factor in the outcome of natural recovery as a revegetation strategy. Topsoil replacement in the fall or during dormant conditions before the first post-construction growing season is recommended.
- The presence of undesirable non-native species such as Kentucky bluegrass prior to disturbance can negatively affect the outcome of natural recovery as a revegetation strategy. Seeding may be a better option on invaded sites.
- The timing and duration of livestock grazing can also affect the success of natural recovery, particularly in plains rough fescue plant communities. Protecting sites from grazing during spring and summer in the first few years can be beneficial.
- Natural recovery is more risky on moist, Loamy sites in the Mixedgrass Natural Subregion and on sites where invasive species are present in the pre-disturbance plant community.

Figure 32 - Site # 59: Natural Recovery Site - Wildhorse Plain

Sod Salvage

- Although plains rough fescue plants can survive a transplant procedure and persist if range health is good, sods are vulnerable to invasion by undesirable rhizomatous species. Sod salvage is very labour intensive and not recommended for mitigating industrial scale disturbance.

Communication of Restoration Commitments and Strategies from Construction to Operations

- Remedial repairs and seeding may be required on projects up to 10 years after construction. It is important to communicate restoration goals, commitments and strategies agreed to for construction to the operations team. A failure to communicate reclamation commitments made at the restoration design phase is a problem experienced on Express.

Assessing Restoration Progress

- Patience is required to restore native grassland communities. The 14 year post-construction monitoring on Express indicates that succession is still on-going and range health on the disturbances is improving, but is lower than the surrounding rangeland.

The Importance of Long-term Follow-up Monitoring

If we are to conserve what remains of our native prairie for future generations then we must continue to improve our reclamation and revegetation practices in native prairie landscapes. Our focus must shift from reclamation to restoration.

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

The results of the Express monitoring 14 years after construction indicate that significant changes may occur after the first five years of reclamation both in positive and negative directions. There is very little information available on the long term efficacy of various native grassland reclamation techniques in the Natural Subregions of Alberta and on native plant community successional pathways following industrial disturbance in the long term. Long term monitoring is needed to contribute to our understanding of whether restoration of native vegetation communities is possible, and if so, in what situations and over what timeframe.

Key Messages

- This report links pre-site assessment and planning to effective selection of best practices.
- This project documents advancement towards native plant communities on disturbed sites in a time scale of five to 14 years post construction.
- Long term monitoring is essential to confirm restoration outcomes.
- Results confirm the efficacy of minimal disturbance construction procedures and practices in prairie reclamation.
- Results will enable industry to more effectively apply the new reclamation criteria for Alberta grasslands.
- The report encourages improved selection of native plant materials for more successful plant community restoration.
- Range health tools enable improved understanding of site and plant community characteristics leading to improved reclamation outcomes.
- An understanding of range sites, range plant communities and plant community succession will allow industry and government to better track restoration success in Alberta grasslands.
- Project results provide insight into the ecological character of “footprint” and the potential mitigation thereof.

It is necessary to continue to develop best management practices and appropriate revegetation strategies for industrial disturbances in native prairie to promote industry stewardship on increasingly pressured prairie landscapes.

References

Adams, B.W., L. Poulin-Klein and D. Moisey and R.L. McNeil. 2004. Rangeland Plant Communities and Range Health Assessment Guidelines for the Mixedgrass Natural Subregion of Alberta. Rangeland Management Branch, Public Lands Division, Alberta Sustainable Resource Development, Lethbridge. Pub. No. T/03940 101 pp. Online at: http://www3.gov.ab.ca/srd/land/publiclands/range.html

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