Conversion of Cultivated Lands to Native Perennials in the Dry Prairies (Framework #1)

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Executive Summary

This framework document is number one of four that provide information on sustainable practices for the conversion of cropland to native or tame forage in Alberta. This document focuses on conversion of cultivated annual cropland to native perennial cover in the Dry Prairie region, which correlates with the Brown and Dark Brown soil zones. The information is intended for all personnel involved with the Alberta Cropland Conversion Protocol (ACCP), including land managers, seed providers, policy-makers, aggregators, auditors, and professionals including agrologists or biologists. This document is designed to be all-inclusive by providing a general overview. Future documents will be designed for more specific audiences.

Information on sustainable management practices for conversion of cropland to native perennial cover in the Dry Prairie region is provided, including development of a restoration plan, preparation of the seed bed, native seed mixes, timing, seeding techniques, and pre- and post-seeding weed control and management.

Short-term and long-term verification of the success of management practices will be established by third-party professionals. Short-term verification will focus on stand establishment for a period of two to three years following seeding, and includes a grazing management plan and proof that seeding was conducted. Indicators of short-term establishment include measures of bare ground and soil erosion, plant numbers and diversity, and weed types and density. Long-term verification (to at least 15 years) focuses on range health indicators that compare range sites and plant communities to surrounding areas of native pasture. Detailed long-term grazing management plans can be adjusted based on periodic range health assessments.

Barriers and opportunities for the success of the Alberta Crop Conversion Protocol are discussed, including promotion, remuneration, seed availability, target areas, lessons learned from previous native range conservation programs, and consistency with existing programs.

Cover Photo: Native grassland planting of spring 2011 west of Orion AB, by Alberta Conservation Association and MULTISAR. Photo in June 2012 by the author.

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Introduction

Native species extend forage productivity and the growing season from late summer to winter. In addition, native grassland species contribute to biodiversity, reduce invasive species problems, enhance wildlife habitat, and increase carbon sequestration (Table 1) (Jefferson et al. 2004). The reduction in haying, baling, transport and mechanized feeding also reduces the carbon footprint.

Table 1. Native Dry Prairie framework summary. (From Janzen and Haugen-Kozyra 2012).

Estimated Net Greenhouse Gas Emission Reduction and Removal	Project Condition			
	Grass Type	Fertilizer	Grazing	Haying
High (2.0 to 2.5 t CO_2 ha^{-1} yr^{-1})	Native	No	Yes	No

Note: The conversion of t/ha to t/ac is obtained by multiplying t/ha by 0.445

Four frameworks are being developed to provide information on the conversion of cropland to native grasslands or introduced perennial grass species, in the Dry Prairie and Parkland regions of Alberta. This document is focused on native conversion in the Dry Prairie region, which encompasses the Brown and Dark Brown soil zones of Alberta (Climate Change Secretariat 2012, Figure 5). A digital copy of the boundary line is available at: http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/cl11708

This framework focuses on sustainable practices of cropland conversion for the development of farm-specific plans for land managers in the Alberta Cropland Conversion Protocol (ACCP), with guidance and reporting by third-party professionals. “Land managers” include landowners, land renters, or occupants, provided they have a signed agreement with the land manager. This framework is an initial and inclusive document that is a precursor to future specific versions directed to particular audiences. As the ACCP develops, it is expected various user documents will be prepared for land managers, seed providers, verifiers, aggregators, policy-makers, and auditors. Verifiers are professionals including rangeland agrologists or biologists, who provide planning, confirmation of conversion and establishment, and project monitoring. Aggregators take the concept to producers for participation, and potentially include multiple agreements.

The goal for land conversion in the Dry Prairies is forage stands dominated by native grasses and may or may not include native legumes. Time must be allowed for a stand to be established and healthy, as indicated by range health assessment. Contracts should be a minimum of 15 years duration as the establishment and maintenance of native stands is a long-term process.

Sustainable grazing practices maintain and promote long-term range health. Aspects of grazing that affect range health include intensity, rotational systems, and the timing and duration of grazing and rest periods. Range health assessments provide a valuable indication of grazing management and the potential need for modifications. Fertilizer is not required at any time. Fertilizer is detrimental to native stands as it promotes non-native species. Soil degradation, such as erosion, is possible during the seeding, establishment and management phases; practices must ensure minimal soil disturbance.

Potential participants in the Alberta Cropland Conversion Protocol (ACCP) are required to sign a contract to receive payments with aggregators. The following are recommended requirements for each ACCP contract. Each requirement is described in more detail in this report.

- A simple restoration plan.
- Proof of seeding and stand establishment.
- A grazing management plan that meets short- and long-term requirements, which can be adjusted based on periodic range health assessments.
- Short-term verification records, including current and on-going cultivated acres.
- Long-term verification records, including periodic range health assessments.

This framework is divided into three key components: i) land conversion and management practices promoting sustainable establishment of native species; ii) short-term and long-term verification of successful conversion, and iii) potential barriers and opportunities. The framework provides a summary; the references at the end of the document contain more details.

Conversion and Management

This section discusses the "four P's" of native conversion: planning, preparation, planting and patience.

Develop a Restoration Plan

A simple restoration plan is a required component for participation in the native conversion protocol. Potential items for inclusion in the restoration plan are discussed below.

The restoration plan for conversion of cultivated land to native will include a prioritized list of land use goals (NPWG 2001), such as the detailed list provided by Wruck and Hammermeister (2003, Appendix B). Potential objectives are identified by Gabruch et al. (no year, pg. 3) and by NDGF and NRCS (2005). Land parcels within the property should be prioritized for conversion to native perennials (Wruck and Hammermeister 2003). The plan should recommend restoration practices that are best suited for the planned area and minimize potential offsite effects (Sinton 2004). Wruck and Hammermeister (2003, Appendix C) provide a detailed framework for timeline and budget planning. A valuable flow chart is provided (Gramineae 2012, Figure 7) for planning related to native conversion of large-sized disturbances such as cultivated fields.

Natural resource information is important for successful restoration to native prairie[1]. The area planned for restoration should be characterized including the identification of potential soil types

[1] Brad Downey, Alberta Conservation Association (ACA). Personal Communication, June 2012. MULTISAR is Multiple Species at Risk, and reflects its multiple partners: agricultural producers, ACA, Alberta Environment and Sustainable Resource Development, the Prairie Conservation Forum and others. Species at Risk (SAR) is a general term for plants and animals that may be declining or are naturally rare in Alberta.

(Wark et al. 2004), range sites, and plant community types (Wruck and Hammermeister 2003; NDGF and NRCS 2005). Range sites in Alberta are correlated to soils information in range plant community guides for the Dry Mixedgrass (Adams et al. 2005), Mixedgrass (Adams et al. 2004) and Northern Fescue (Kupsch et al. 2012) Natural Subregions. Recent work in Alberta has helped to build the knowledge base on the restoration of the main range plant communities, such as in the Dry Mixedgrass Natural Subregion (Gramineae 2012).

Field Preparation

Preparation for seeding includes weed management and preparation of a firm seed bed (NDGF and NRCS 2005; Wruck and Hammermeister 2003).

Seed Bed. Best results in the Dry Prairie are typically obtained by seeding into standing annual crop stubble, so that soil erosion and evaporation are minimized. For maximum seed-to-soil contact, soil needs to be loose to friable at the surface, firm underfoot, and without large clods or debris. The seed bed is firm if the impression left by an adult footprint does not exceed approximately 3 cm (Gabruch et al. no year). Harrowing after seeding reduces the presence of soil clods (Wruck and Hammermeister 2003) and can assist with seed-to-soil contact.

Pre-Seeding Weed Control

Pre-seeding weed control is vital for restoration success. Weed seeds can remain dormant for significant time (EC3 no year), so pre-seeding weed control will require at least one and possibly, more growing seasons (Gabruch et al. (no year). Chemical and tillage methods can be used, but tillage reduces soil moisture and increases erosion risk as well as spreading certain rhizomatous weeds.

Before undertaking weed control, weeds need to be identified and their distribution must be characterized. Weeds may be problematic along former structures, including fence lines, corrals, and storage locations. For cases where weed control is required, herbicide companies employ professionals who can offer free advice regarding the most effective weed control plan, including products, timing and techniques.

Herbicides are usually the most effective solution to deal with weeds for cropland to native conversion, because weeds typically out-compete native seedlings. Herbicide control is extremely important before seeding of native species, but herbicides can also be used occasionally after seeding (Wruck and Hammermeister 2003). Herbicide application can be done by back-pack sprayers, ATV-mounted sprayers, and agricultural field sprayers (Wruck and Hammermeister 2003). Seeding should be within four days of glyphosate use to optimize competition for weeds remaining in the seedbed (Iwaasa and Schellenberg 2005). MultiSAR applied glyphosate in April before seeding in May[2].

[2] Brad Downey, Alberta Conservation Association (ACA). Personal Communication, June 2012.

Removal of standing crop through silage or greenfeed harvest can be used effectively to remove introduced plants and weeds, and reduce or eliminate weed seeds before native seeding (Iwaasa and Schellenberg 2005; Grilz 2011).

Nurse or Cover Crops

Cover or nurse crops are usually agronomic cereal crops that are planted on a restoration site to protect emerging native seedlings from excessive heat and wind. Cover crops improve the potential for snow-trapping in the winter and they can out-compete weeds, but this often hinders the success of native seedlings. For this reason, the best results in the Dry Prairie region typically do not include the use of a nurse or cover crop. Cover crops can be useful during times of drought or at locations where the potential for soil erosion is high to extreme (Wruck and Hammermeister 2003), such as in areas dominated by coarse textured soils (E.g., Sands range sites).

Native Seed Mixes

General Considerations

Cool-season grasses in the Dry Prairie are best suited to cooler temperatures and shorter day lengths. They include needle and thread, western wheatgrass, June grass, green-needle grass, and porcupine grass. Warm-season grasses require warmer temperatures and longer days (NDGF and NRCS 2005, Gramineae 2007), and include blue grama, little bluestem, and sedges. Schellenberg et al. (2012) indicate native cool-season grasses may be more productive than a mix of warm and cool grasses, but warm-season grasses extend the grazing season and provide increased protein in late summer. In addition, blue grama is well adapted to drought. Grilz (2012) had success with seedings of warm-season grasses at locations in Saskatchewan including Key West, Kettlehut Lake, Old Man On His Back and Big Valley.

Stands of converted native prairie are expected to remain for the long term (≥15 years) and require a seed mix that is similar to nearby native holdings; stands that are planned for less than 15 years can use seed mixes that are more suited for ease or rapid growth (Wark et al. 2004).

Simple and diverse species mixes commonly recommended for the Dry Prairie regions of Saskatchewan and Alberta are listed in Table 2, based on data from Gabruch et al. (no year), Grilz (2011), and Iwaasa et al. (2012). These seed mixes are dominated by grasses, but also include purple prairie clover, which is a palatable, drought-resistant, warm-season, nitrogen-fixing legume (Klabi et al. 2010). It is a prolific seed producer and it can inhibit the growth of various strains of E coli (Jin et al. 2011; Schellenberg et al. 2012).

Seeding rates for the combined seed mix are about 7.9 kg/ha (Gabruch et al. no year; Wruck and Hammermeister 2003), although a higher rate of 9.5 kg/ha was used by Iwaasa and Schellenberg (2005). Schellenberg et al. (2012) found that a diverse seed mix was higher in crude protein in August and September, compared to a simple seed mix (Table 2). White prairie clover is another legume that provides high forage quality and is a useful inclusion in a seed mix (Li et al. 2012a; Li et al. 2012b). Other potential native legumes for inclusion in a native Dry Prairie seed mix include Canadian milk vetch and ground plum, although there is currently a limited seed supply for these legumes.

Table 2. Species for simple and diverse seed mixes.

Simple Seed Mix		**Diverse Seed Mix**	
Species	***Seeding Rate (PLS kg/ha)**	**Species**	**Seeding Rate (PLS kg/ha)**
Western wheatgrass	2.3	Western wheatgrass	1.2
Northern wheatgrass	1.2	Northern wheatgrass	0.9
Green needlegrass	2.3	Green needlegrass	1.8
Awned wheatgrass	1.5	Awned wheatgrass	0.6
June grass	0.1	Canada wildrye	0.1
Slender wheatgrass	0.3	Little bluestem	1.2
Purple prairie clover	0.1	Needle and thread grass	0.9
Total	7.9	June grass	0.1
		Blue grama (Grilz 2011 and Gabruch no year only)	0.4
		Prairie sandreed	0.4
		Purple prairie clover	0.2
		Slender wheatgrass	0.1
		Total	7.8

Notes: PLS indicates pure live seed, which is equal to % purity multiplied by % total germination. The conversion of kg/ha to lb/ac is obtained by multiplying kg/ha by 0.8921.

For this conversion protocol it is recommended that the standard mix to be composed of at least four native grasses, with at least two long-living species and one native legume. A diverse seed mix will allow native range to be more functional. The benefits include a longer grazing season and a higher resistance to stress such as drought. Monocultures provide lesser ecosystem benefits. Monocultures that are dominated by short-lived species such as short and awned wheatgrass will decline in the short and medium term.

Long-lived species suitable for the Dry Prairie include blue grama, June grass, western wheatgrass and northern wheatgrass. Northern wheatgrass establishes early following seeding and provides significant cover in initial years, gradually declining in subsequent years to cover levels typical of adjacent native prairie (Kestrel and Gramineae 2011). Additional native species will add diversity and increase the potential for success, because species vary in their adaptation to environmental conditions. June grass is highly tolerant of drought and has an excellent rooting system that promotes carbon sequestration[3]. June grass can be excluded from the seed mix if it is present in areas adjacent to the seeded area, because it has a high level of recruitment.

[3] Alan Iwaasa. Personal Communication. Agriculture and Agri-Food Canada in Swift Current, SK. November 2012.

A reduced seeding rate, such as 4 to 5 lb/ac (4.5 to 5.6 kg/ha), can promote the infill of non-seeded native species from adjacent parcels. Western wheatgrass can also be excluded from the mix, because it can be successfully broadcast in specific locations, such as lowlands, Solonetzic landscapes, or areas that have been prone to spreading foxtail barley[4].

In addition to the diverse-mix species shown, Iwaasa and Schellenberg (2005) used late-fall broadcasting of winterfat and saltbush to add a shrub component to their previously seeded diverse seed mix. The addition of winterfat and/or silver sagebrush to a native seed mix can enhance yield, extend the grazing season, and provide diversified forage (Schellenberg and Banerjee 2002). MultiSAR has successfully established Silver Sagebrush (plugs) and purple prairie clover (broadcast) into native stands that were one year old and four years old in the Manyberries area of Alberta[1]. Forbs do not generally need to be included in Dry Prairie seed mixes because they are readily recruited from adjacent native areas. Forbs such as non-woody sage species (E.g., pasture sage) transfer nutrients from subsoil horizons to the topsoil, resulting in an increase in native shallow-rooted grasses.

Seed Mixes Matched for Range Sites

Generic seed mix recommendations such as those provided in Table 2 can be improved for many Dry Prairie locations by adjusting the mixes to be more similar to the plant communities in adjacent native parcels, and to be more suitable to the local soil and landscape conditions.

Range sites in Alberta are correlated to soils information in range plant community guides for the Dry Mixedgrass (Adams et al. 2005), Mixedgrass (Adams et al. 2004) and Northern Fescue (Kupsch et al. 2012) Natural Subregions. Aggregators and third-party professionals involved with the ACCP are recommended to use information on soils, range sites and adjacent native plant communities associated with parcels intended for conversion, so that seed mixes can be designed for soil and landscape variability. Some Dry Prairie species are not compatible with certain range sites, and the ideal species proportions in seed mixes vary with range site. Gramineae (2012) provide an itemization of seed mixes that are recommended for common range sites in the Dry Mixedgrass Natural Subregion (Table 3). An earlier version of suggested seeding rates and the percent composition of seed mixes for loamy, sandy, Solonetzic and saline soils is provided by the Special Areas Board (2009). Seed mixes that are tailored for specific range sites improve the chances for successful establishment. Third-party professionals need to use information such as shown in Table 3 to identify the most appropriate seed mixes for specific range sites.

[4] Lorne Cole, Personal Communication. Alberta Environment and Sustainable Resource Development, Land Use. October, 2012.

Table 3. Native seed mixes for range sites in the Dry Mixedgrass Natural Subregion.

Species	Proportion of Seed Mix (% PLS by Weight)				
	Loamy	Blowout / Solonetzic	Sand, Sandy and Choppy Sandhills	Thin Breaks and Limy	Overflow (Non-Saline)
Needle & Thread Grass	40	20	25	40	15
Blue Grama Grass	25	8	10	15	
June Grass	15	20	15	15	10
Slender Wheatgrass	10	11	10	10	10
Northern Wheatgrass	10	11		10	10
Western Wheatgrass		18	5	10	5
Sandberg's Bluegrass		12			
Western Porcupine Grass			30		50
Sandgrass			5		

Notes: PLS indicates pure live seed, which is equal to % purity multiplied by % total germination.

Timing

Gabruch et al. (no year) and NDGF and NRCS (2005) recommend the following. i) Cool-season grass mixes can be planted between late April and June 1 or "dormant-seeded" after October 20. Late summer plantings are not recommended. ii) Warm-season grasses should be planted between mid-May and mid-June (extending to early July when soil moisture is ample), because germination requires soil temperatures of at least 10^{o}C. Grilz (2011) found that seeding in southwestern Saskatchewan was most successful in May and June, but that seeding in October to December can occur if soil moisture conditions are favourable. Late-fall seeding is not suitable in Dry Prairie regions that experience frequent chinooks, because the frequency of freeze-thaw will hinder native seedlings. Wruck and Hammermeister (2003) discuss seeding considerations for each of the four seasons.

Equipment, Techniques and Fertilizer

Row Seeding

It is essential to minimize equipment operations to prevent soil pulverization and reduce the potential for erosion. Row seeding requirements include consistent and accurate seed flow rate, accurate and uniform seed placement, and adequate packing for seed to soil contact (Gabruch et al. no year). Seeding can be done with specialized grass seed drills, air drills, and some conventional drills. Grilz (2011) successfully used a Truax press drill and some of the land was also seeded with an air drill. Scientists in the Swift Current region successfully established native grasses and legumes with a Borgault double-disc air seeder into i) standing stubble (Iwaasa and Schellenberg 2005), and ii) a harrowed packed cultivated field (Iwaasa et al. 2008).

Recommended row spacing is 15 to 25 cm (Gabruch et al. no year; Iwaasa and Schellenberg 2005). Wruck and Hammermeister (2003) recommend seeding in two passes perpendicular or diagonally to reduce row prominence, with each pass seeded at half the required rate.

Capability for depth banding is recommended (NDGF and NRCS 2005). Gabruch et al. (no year) recommend seed depths of 0.6 to 1.3 cm in medium and fine-textured soils, and 1.3 to 2 cm in sandy soils. Iwaasa and Schellenberg (2005) used seed depths of 0.6 cm at Swift Current. As a rule of thumb, about 5 to 10% of seed should be visible on the surface; otherwise the seeding is too deep.

Native seeding is commonly successful with two seed boxes (one for grasses and one for legumes). NDGF and NRCS (2005) recommend equipment with three seed boxes so that species can be separated into i) large smooth seeds, ii) awned seeds, and iii) small smooth seeds, including wildflowers and a carrier product.

Optimal seed flow to prevent bridging in tanks can be maintained by using an agitation system (NDGF and NRCS 2005). Gabruch et al. (no year) state that seed flow can be improved by adding a carrier such as cracked wheat, at a ratio of up to eight parts carrier to one part seed. Phosphate fertilizer (never nitrogen fertilizer) can also be used as a carrier to improve seedflow, but these amendments must be at low rates, such as 5.6 kg/ha. Seed will be damaged by moderate to high rates of fertilizer, so seed mixed with fertilizer should be used on the same day, and not stored for future use. Manure is also not an acceptable amendment. Not only does it contain weed seeds, but in addition, the nutrients generally cause a dynamic shift in the dominant plant species, which can promote undesirable species (McKenzie et al. 2003). Properly prepared compost does not contain weed seeds. Compost can potentially be used under specific circumstances, such as application to eroded crests and upper slopes within fields that are planned for conversion to native rangelands (Bremer 2009). In general, the only recommended amendment is native thatch crimped into the seedbed.

Broadcast Seeding

Broadcast seeding is beneficial because once established it provides more cover than row seeding, thus reducing bare soil and providing a closer approximation to natural conditions. However, required seeding rates are about 50% higher than for row seeding. Wruck and Hammermeister (2003) recommend broadcasting at higher rates to account for seed losses to desiccation, insects, birds, rodents and wind. They also note that broadcast seeds should be shallowly harrowed or raked, which can be followed by a packer.

The most common broadcasting equipment is a spin-spreader. In rough terrain, such as moderate to high-relief hummocky landscapes, broadcast equipment such as spreaders or tow-behind broadcasters are recommended (Wruck and Hammermeister 2003). MultiSAR[5] had success using broadcasting followed by shallow harrowing on undulating to gently hummocky glacial till soils in each of 2008 and 2011 (visible in cover photo).

Special Considerations for Saline Conditions

Establishment of native vegetation in saline areas will lower the water table and increase the potential for successful restoration. Saline areas can be seeded with salt tolerant native species

[5] Brad Downey, Alberta Conservation Association (ACA). Personal Communication, June 2012.

such as wheatgrass. A seed mix that is suitable for the dominant range site can then be seeded in the remaining field areas. Sprigging can also be used to establish native plants in areas with localized or extensive salinity (Sheley et al. 2011). Sprigging involves planting rhizomes at a depth of 7 to 10 cm. Rhizomes are more salt tolerant than seeds, and are placed below the highest salt concentration in the soil profile. The method requires a rhizome source location and specialized equipment.

Post-Seeding Management

Herbicides must be used carefully after seeding to prevent adverse effects on desirable species Gramineae (2007). Glyphosate application in early spring after seeding of native species will reduce weeds and cool-season grass invaders, including smooth brome and Kentucky bluegrass. However, the cool-season native component may be compromised (NDGF and NRCS 2005). Iwaasa and Schellenberg (2005) successfully used Bromoxynil and MCPA in the establishment year to control broad-leafed weeds, including flixweed. Weed control professionals can assist with recommendations on the most effective weed control plan.

Hand-held or mechanical wick applicators can be used for selective weed control, and high mowing can be used to control taller weeds. Mowing also curtails weed seeds (Gabruch et al. no year), but careful timing is critical as some weed species can become major problems if mowed at or near maturity (Sheley et al 2011).

Excessive biomass can sometimes accumulate a few years after native seeding, and this can hinder more sensitive native species, resulting in less complete plant community restoration. Litter quantity could be measured to provide an indication of the need for biomass reduction. For example, a litter quantity that is two times higher than average for that particular ecological range site may indicate the need for litter reduction[6]. Average litter values for selected ecological range sites in various Natural Subregions are provided by Alberta Environment (2010).

Haying, grazing, or burning can be used to remove excessive biomass and reduce weed species. Burning is not socially acceptable in most Dry Prairie areas, due to safety concerns. NDGF and NRCS (2005) discuss careful burning with a well-documented safety plan, and adequate equipment and resources. If burning is conducted, it may need to be followed by weed-wicking in a later season (Wruck and Hammermeister 2003). A burn in mid spring two or three years after native seeding can enhance native plantings, especially those with warm-season grasses (Gabruch et al. no year).

Grasshoppers can quickly destroy emerged native seedlings, and control may be required if they reach infestation levels. Grasshopper control using insecticides may be required when grasshoppers reach densities of 8 to 14 per m^2, and control is important at higher densities (Gabruch et al. no year). Grasshoppers may be deterred from invading newly seeded fields by

[6] Barry Adams. Alberta Environment and Sustainable Resource Development. Personal Communication, February 2013.

planting a non-preferred crop (E.g., oats) in strips of 30 m wide around the field perimeter; in contrast, rye should be avoided (Wark et al. 2004). Iwaasa and Schellenberg (2005) used insecticide bait to control grasshoppers during the establishment year. Agriculture and Agri-Food Canada is researching grasshopper control, including grasshopper preference for different types of forage species, and the development of biological methods to control grasshoppers.

Verification

Verification is an essential component of the Alberta Cropland Conversion Protocol (ACCP), and includes short-term and long-term indicators. Short-term verification focuses on stand establishment and success, and is conducted in the seeding year and up to two to three years following seeding. Long-term verification focuses on sustainable management practices indicative of range health, and is conducted periodically following successful establishment. Verification of stand establishment, sustainable management, and range health will be conducted by qualified professionals including agrologists or biologists.

Short Term Verification (Establishment)

Third-party professionals will assess the success of seeding and stand establishment using short-term indicators, including verification of the seed mix used, an introductory grazing management plan, and periodic assessments of stand establishment. Short-term verification must account for variations in the time required for stand establishment, and patience is critical. Establishment of native plantings require longer time-frames than do tame plantings.

Seeding and Stand Establishment

Seeding success will be promoted by high seed purity that originates from the general area where it will be used. Gramineae (2012) provide guidelines on procuring native seed and wild-harvested native plant materials (pp. 52-54), and information on calculating seeding rates and interpretation of seed analysis reports (Appendix D). Items that prove seeding was conducted include receipts indicating seed purchase, seed tag labels showing quality and quantity at levels adequate for the indicated area, photographs, and third-party confirmation. Seed certificates should indicate percent ratings for Pure Live Seed, inert component, germination, dormant seed, other crop seed, hard seed, and types and amounts of weed seeds (Wark et al 2004; NRCS 2009a; NRCS 2009b). Copies can be sent to verifiers prior to seeding to confirm that the mix and quality is appropriate.

Verification requirements used in the Conservation Cropping Protocol (Climate Change Secretariat 2012) can be modified slightly for the Native Conversion Protocol. Short-term verification records required for this project include: 1) land title certificate for legal locations being claimed, 2) an agreement between the aggregator and the land manager, 3) GPS track file for seeding operations, or measurement of the field size, 4) detailed records of the native seeding, including the seed labels and supporting records, 5) evidence of re-seeding events if applicable, and 6) records of current and on-going cultivated acres.

The program will not allow the breaking of other native holdings while being eligible for cropland conversion to natives on other owned lands. Seeded acres of native prairie must not be countered with conversion of existing owned or rented native range to cultivated land. An increase in cultivated annual acres is allowed only if the participant purchases or rents additional cultivated land. Verification tools are required to ensure that participants do not convert native to cultivated, such as an on-going record of cultivated acres, crop insurance records, and/or remote sensing imagery. Remote sensing imagery can also be used to assess stand establishment. Analysts skilled in imagery interpretation for the Grassland Vegetation Inventory can assist with the assessment of stand establishment in young native range.

Hecker and Neufeld (2006) identify several parameters that can be used to indicate the success of prairie restoration. Five indicators that are deemed to be most useful as indicators of short-term establishment to this project are listed in Table 4, based on selected items modified from Hecker and Neufeld 2006). The indicators will be assessed at representative field locations using counts or measurements within a 50 x 50 cm frame. For fields with multiple management units (different range sites or topography) each of the management units will be assessed separately.

Table 4. Five recommended indicators of the success of short-term establishment.

Indicator	Typical Assessment Method at Representative Field Locations	Assessment Guidelines
Bare Ground	At representative field locations, and compared to nearby native controls.	Guidelines are contained in Adams et al. (2009, pp 42-44). Bare ground will be high at establishment, but decreases significantly as the native plants in-fill.
Soil erosion	Representative of a field management unit, and compared to nearby native controls.	Guidelines are contained in Adams et al. (2009, pp 39-41). Useful to combine with weather and site history since seeding.
Plant count	Each individual plant is counted.	A plant count of at least 9 plants per ¼ m^2 indicates success[7]. A lower count requires patience and monitoring, and re-seeding will be required if counts remain low for the first few years following seeding.
Plant community similarity	Calculated as the number of established species in the restoration divided by number of species seeded, multiplied by 100.	It is expected that most seeded species will be evident a few years after seeding, even if only in low numbers. It is recommended that a score of ≥50% represents establishment success, as used by the 2010 Native Grasslands Criteria used by Alberta Environment (2010).
Weed types and density	Rate the density distribution of weeds of each type (problem, noxious, and prohibited noxious). Weed designations are explained in the Weed Control Act (Province of Alberta 2010). Density class information is provided in Fig. 17 (Adams et al. 2009).	The number of allowed weeds is specific for each weed type. There is zero tolerance for prohibited noxious weeds. Noxious weeds must not be present at a class higher than in adjacent control areas, and require control. For problem weeds, any total weed count less than 3 per ¼ m^2 is generally acceptable and more than 14 per ¼ m^2 requires control. Municipal weed designations over-ride provincial designations.

[7] Agriculture and Agri-Food Canada in Swift Current, SK, also uses this indicator. Alan Iwaasa, Personal Communication, November 2012.

Soil erosion is an example of a parameter that is recommended to be reported on a management unit basis within fields. Third party professionals may not have all the skills required for field assessment, and therefore, training is required to ensure a consistent approach among assessors. The root system of the seeded stand can also be assessed. The presence of secondary and tertiary tillers (root systems) is an indicator of successful establishment because they are crucial for survival.

Grazing Management Plan

A grazing management plan is required for the duration of each ACCP agreement. Grazing must not occur in the establishment year, and in the year following establishment, grazing must be at sustainable levels. The goal of Alberta's Grazing Lease Stewardship Code of Practice is careful stewardship that maintains healthy functional rangeland ecosystems on public lands for present and future generations. The key management variables that leaseholders must apply to achieve range health goals are stocking rate, stocking density, timing and frequency and duration of grazing (ASRD 2007). Light to moderate grazing, adequate animal distribution, and the use of an effective grazing management system contribute to high forage productivity, high habitat values, and sustainable health for the ecosystems and the forage resource (Bailey et al. 2010). This reference also provides a useful discussion on grazing management, including effective management during drought.

MultiSAR and the Alberta Conservation Association[8] use the principles noted in the ASRD (2007) Grazing Code of Practice, in addition to the following guidelines regarding sustainable grazing management. After establishment of native conversion, grazing is allowed at up to 75% of animal unit months (AUM) for the identified plant community published in the relevant range plant community guide (Adams et al. 2004; Adams et al. 2005). The allowable grazing rate is increased to 100% of AUM as the plant community matures.

[8] Brad Downey, Alberta Conservation Association (ACA). Personal Communication, November 2012.

Long-Term Verification (Health)

The goal of native prairie conversion is to increase the viability of grassland-dependent species, and to move to a plant community that is similar to the surrounding area (Helzer 2011). Exact replication of the adjoining prairie community is not expected. The long-term success of native restoration can be efficiently evaluated using range health indicators after successful establishment. Range health indicators are used to ensure that grazing practices are not degrading the long-term potential or carrying capacity of the pasture (Moen 1998). Range health assessments are used to make a rapid determination of the ecological status of rangeland (RRMP 2004).

Range health is assessed in different ways by different organizations. Indicators used in range health assessment for areas applicable to the Dry Prairies are shown in Table 5. The indicators used by Adams et al. (2009) (Table 5) are the components recommended for use by third-party professionals for long-term verification of range health within the ACCP. These indicators are listed in the right-hand column of Table 5, with reasons for excluding indicators used by other jurisdictions. The native grassland range health assessment score sheet (Adams et al. 2009, Appendix 1) is to be used in the ACCP by third-party professionals to assess all indicators at a similar time; a score is determined by following the detailed instructions in Adams et al. (2009). Professionals require training and practice to become familiar and experienced with range health assessment. They will then be able to perform more rapid visual assessments that fulfill assessment requirements.

The long-term grazing management plan required for this project will include timing and type of grazing (E.g., rotational or deferred grazing), and must show sustainable practices including light to moderate grazing regimes. Plan factors such as livestock numbers, grazing season and grazing duration can be adjusted based on periodic range health assessments. A documented grazing plan may be provided to the third-party evaluator, or it may be developed and reviewed by the third-party evaluator with the land owner/manager (Grilz 2011; NDGF and NRCS 2005; Gabruch et al. no year). Long-term verification relies on indicators of restoration success and biodiversity. Indicators of rangeland health and the seral stage of plant communities are compared to similar range sites in the surrounding area or in published data.

Table 5. Range health indicators applicable to the Dry Prairie region.

Indicator	**SK** **Hecker and Neufeld (2006)**	**SK** **SK PCAP (2008)**	**AB** **Adams et al. (2009)**	**AB** **Alberta Env. (2010)**	**BC** **BC MAFF (2005)**	**U.S.A.** **Pellant et al (2005); Herrick et al. (2009a; 2009b)**	**Recommendations for Long-Term Verification (This Paper)**
Similarity to Reference Plant Community	√	√	√	√		√	√
Structural Layers	√	√	√	√		√	√
Invasive/noxious species present	√	√	√	√		√	√
Invasive/noxious species cover	√	√	√	√		√	√
Invasive/noxious species distribution		√	√	√		√	√
Soil erosion	√	√	√	√	√	√	√
Soil movement or loss				√	√		Included in erosion
Bare soil/ground	√	√	√			√	√
Soil compaction				√	√	√	Optional if required
Litter (for hydrologic function; protect soil)	√	√	√	√	√	√	√
Desirable species >50% of total				√	√		Included with Ref. Plant Comm.
Representive age and size of desirable species					√		Included with Structural Layers
Desirable species indicate vigour					√		Difficult to assess for graminoids
Plants per ¼ m^2	√						In plant community similarity
Reproductive capability of perennials						√	Optional if required
Annual production						√	Existing data can be extrapolated to sites
Plant mortality/ decadence						√	Could be used in ungrazed holdings
Browse/hedge overuse on shrubs or trees					√		Could be used in ungrazed holdings

Range Plant Community Guides classify rangeland as non-native when there is 30% or less native species (Adams et al. 2004; Adams et al. 2005). If verifiers determine that native seeded parcels or portions within fields have regressed to non-native conditions (>70% non-native), these areas will no longer be eligible as native range. These fields, or portions, may qualify for ACCP credits as tame pasture.

In addition to the requirements in Table 5, some records used in the Conservation Cropping Protocol (Climate Change Secretariat 2012) are also required for long-term verification, including:

- Land title certificate for legal locations being claimed,
- An agreement between the aggregator and the farm operator, and
- Records of current and on-going cultivated acres, to ensure that program applicants do not counter seeded acres of native prairie with conversion of other native prairie stands to cultivated annual acres.

Contract renewals must be tied to long-term verification requirements. Alberta Environment suggests contract renewals at six year intervals (Climate Change Central 2011). Claims for offset credits are contingent on verification. Long-term monitoring for the ACCP is recommended to be conducted every three years. The Alberta Conservation Association monitors rangeland health and assesses wildlife at three-year intervals[9].

Barriers and Opportunities for Adoption

Published information relating to barriers and opportunities for native conversion is limited. This section focuses on factors that will promote the success of the Alberta Cropland Conversion Protocol, including knowledge gained from previous conversion programs.

Lessons Learned from Previous Conversion Programs

This section provides a brief background regarding completed or on-going conservation programs for native range or pasture in western Canada and the United States. A more detailed analysis of these programs is required so that useful aspects can potentially be used in the Alberta Cropland Conversion Protocol.

Permanent Cover Canada Program

The Agriculture Canada Permanent Cover program (1989 to 1992) provided one-time payments to western Canadian producers for the conversion of annual cropland to pasture land. Remuneration under the Permanent Cover program began at $20 per acre in 1989, and was increased in 1990 to $30 for ten year contracts and to $65 per acre for 21 year contracts.

The Permanent Cover program successfully promoted the conversion of cultivated land to pasture systems in western Canada. More than 585,000 acres (230,000 ha) were converted to pasture under this program (Hilliard et al. 2009). This represented an increase of only about 1% of the previous 55,854,000 acres (21,757,000 ha) of combined natural and hay land in the Prairie

[9] Brad Downey, Alberta Conservation Association (ACA). Personal Communication, November 2012.

Provinces in 1992 (Statistics Canada 2012). The vast majority (90%) of respondents indicated the Permanent Cover program helped their farm operations, according to a survey conducted by Hilliard and Fomradas (2009). Most conversion in the Dry Prairie region of western Canada was to pasture, (as opposed to hay or a combination of hay and pasture). Pasture accounted for 75% of the total converted lands in the Brown soil zone and 68% in the Dark Brown soil zone.

Only 4% of the overall total lands enrolled in the program were converted back to annual cropping by 2009. Of the total contracts in Alberta, only 3.9% were liquidated prior to their expiration at 10 or 21 years.

Greencover Canada Program

One component of the Agriculture Canada Greencover program (2003 to 2008) was to provide payments to western Canadian producers for the conversion of annual cropland to pasture land and native cover. Greencover administered ten-year land use agreements, and the youngest contracts expire in 2018 (Climate Change Central 2011). The Land Conversion component of Greencover accounted for approximately 59% of overall program expenditures (AAFC 2008).

Greencover conversion contracts required at least 40 contiguous acres on the same quarter section. At least 75% of the seed mix had to be composed of long-lived perennial species such as native and non-native forages and shrubs. Greencover payments were higher for conversion to native than to non-native cover. Two one-time payments were as follows (AAFC 2008):

- $20 per acre for tame forage or trees; $75 per acre for native species.
- $25 per acre after establishment and inspection of perennial cover, contingent upon signing a ten-year land-use agreement.

An audit of the Greencover program (AAFC 2008, Table 6) found no fiscal issues, and recommended a simplification of the contribution agreements within the Land Conversion component.

Table 6. Audit of Greencover Contracts.

Greencover Land Conversion Program	Number	Total Value	Percentage of Total	Average Value
Contracts Audited	73	$392,100	2.4%	$5,371.23
Total Contracts	3130	$16,181,400	100%	$5,169.78

Other Conservation Cover Programs in Western Canada

Ducks Unlimited Canada currently funds a Rangeland Grazing Incentive Program at $10 per acre.

One goal of the Alberta component of the North American Waterfowl Management Plan (NAWMP) is to convert 1500 acres (607 ha) to upland native cover by 2012, with a total of 7700 acres (3116 ha) converted by 2032 (ANPMC 2008). Some of the targeted areas are located in the Sullivan Lake Plain in the northern portion of the Dry Prairies, although the main target areas are in the Parkland region, specifically the Pine Lake and Bashaw Uplands.

More than 11,000 producers converted more than 200,000 hectares to perennial cover under Saskatchewan's Conservation Cover Program in 2001. This represented an increase of less than 1% of the 25,728,000 acres of combined natural land and hay in Saskatchewan in 2001 (Statistics Canada 2012). Program applicants also planted perennial forages on an additional 60,000 hectares above those acres eligible under the program.

International Programs

Russillo and Pinter (2009) provide guidance on the design of farm-level programs that provide ecosystem services through producer practices. They recommend that program design should be practical, compensate the farmer for data collection, include simple databases, provide knowledge transfer, and provide threshold values and numerical scoring wherever possible.

Ruto and Garrod (2009) indicate that most farmers prefer short contracts because they increase flexibility. A review of the conservation reserve program in the U.S.A. provided two key findings: i) restoration support should be tied to ecosystem services using science-based models, and ii) agricultural producers favour having varying contract lengths, and this reduces potential liquidation (Khanna and Ando 2009).

NRCS (2011) provide a short list of criteria required to meet native conversion program obligations with the United States Dept. of Agriculture: i) the seeded plant community will consist of at least four native grasses and at least four native forbs; ii) seeding must be done in a properly prepared seed bed as determined by NRCS; iii) fungal and microbial inoculants will be used where appropriate; additional planting conditions may be specified if an ecological site description has been developed; iv) weeds shall be controlled during the establishment phase; v) after establishment, the site will not be grazed or disturbed during the primary nesting or fawning season; and will be deferred from use for up to three years; vi) a grazing plan will be developed and implemented.

Promoting Program Success in the Alberta Dry Prairie Region

Training of Third-Party Professionals

Agrologists or biologists will assist with the design and review of plans for cropland conversion and grazing management, and verify stand establishment and range health. ACCP efficiency will be promoted by providing professional training programs in topics including the choice of representative sampling locations and controls, understanding range site variability, understanding weed designations, recommending seed mixes for parcels, the use of density distribution charts and range plant community guides, imagery interpretation, plant identification, and plant community similarity. Similar training programs have been conducted to improve the professional practice of agrologists and biologists working with the Alberta Reclamation Criteria (Alberta Environment 2010). These programs have been implemented as user pay programs, and training for the ACCP can follow the same model. Training will allow professionals to improve their skill set and therefore be more qualified than competitors who do not take the training.

Turning Barriers into Opportunities

Luciak et al. (no year) identify three barriers for ranching in western Canada. These barriers can potentially be reduced by conversion of cropland to native prairie (Table 7).

Table 7. Ranching barriers and related opportunities related to native prairie conversion.

Barriers for Ranching in Western Canada (From Luciak et al. no year).	Opportunities for Native Prairie Conversion
High winter feeding costs	An increase in native acres may reduce winter feeding costs because native lands have an extended grazing period through the fall and winter, provided protein levels are adequate and snow cover is minimal.
Drought frequency causes a high risk for grazing production, and this sometimes leads to herd downsizing.	Native pastures are less sensitive to drought than tame pastures because native species are adapted to a wider range of conditions.
Cattle inventories are subject to reduction when feed grain prices surge (also in Vaisey et al. 1996).	A payment structure that encourages conversion to native vegetation can offset the risk of high feeding costs.

Promoting Awareness

Once they are established, native stands are a low cost and low maintenance land use with tremendous societal and ecosystem benefits. Promoting awareness of the long-term benefits of converting to native stands will enhance the potential success of the program.

The perception of some in the agricultural community is that seeded introduced species are superior. Institutional changes can promote a wider awareness of the benefits of native range. For example, the term “unimproved land”, which is used by organizations such as the Census of

Canada, should be replaced with the term “native rangeland”.[2] Ranchers will be more amenable to a program promoting the ecosystem benefits of native range than to a program that is solely promoted as greenhouse gas mitigation.

Native prairie is more drought-tolerant than tame forages; crop insurance contracts should apply different risk ratings to account for reference plant communities, modified native plant communities, and tame forage plant communities.[10]

Remuneration for Conversion Costs

Producers require economic incentive for native conversion, because establishment of native range is expensive. The cost in 2008 was calculated as $164.30 per acre (Jones 2011), based on seed and seeding costs. Fencing, including supplies and labour for a four-strand barb wire fence, was estimated to be $3720 per mile (approximately $23.25 per acre if fenced on all four sides) (Saskatchewan Ministry of Agriculture 2009). The conversion to native pasture may also require the cost of water development.

Contracts will require periodic review so that potential adjustments can be made as required, to ensure that program participation does not markedly decline.

Consistency with Existing Programs

This potential program must mesh constructively with other programs currently being discussed, such as payments for ecosystem services. The ACCP should be a “stackable” program as long as the standards of all potential programs are made compatible. A detailed analysis is required to investigate how the currently proposed ACCP may stack with other programs, including the existing Ducks Unlimited program that pays for conversion to native species. Potential remuneration associated with native conversion in the Dry Prairies also requires a modeling analysis, possibly with the expertise of Agriculture and Rural Development (ARD) and Agriculture Financial Services Corporation (AFSC), with input data including conversion costs, price ranges for crops such as canola and wheat, and the valuation of native and tame forage.

Promoting Seed Availability

The native seed industry is currently challenged to supply native seed, ecovars, and native plant materials. The current challenge to supply native seed will increase due to the current growth in industrial reclamation. Furthermore, this potential native conversion program could create strong demand that might push native seed prices even higher over the short term. The program provides a potential opportunity for additional producers to be involved in native seed production. Neufeld (2010) reports that some seed buyers have experienced issues with germination and dormancy, and he recommends research to investigate the issues and increase reliability and confidence in seed production and/or seed establishment. Efforts should be synchronized with existing native seed producers, and establishment of a native seed producer

[10] Duane McCartney, retired from Agriculture and Agri-Food Canada, Research Branch. Personal Communication, June 2012, at State & Trends of Canadian Grasslands Workshop, Saskatoon, SK

organization should be considered. There is a need for communication of the potential native seed demands; the Alberta Native Plant Council (ANPC), the Association of Alberta Co-op Seed Cleaning Plants, and the Association of Alberta Agricultural Fieldmen can all assist in this role.

Selection of Potential Target Areas

An effective program will target locations most amenable to native conversion. Alberta Environment estimated that the proposed perennial conversion protocol would be applicable to only 0.1 to 0.2 M ha (0.25 to 0.50 M ac) of annual cropland per year in Alberta, with a target period of 18 years (Climate Change Central 2011). Ruto and Garrod (2009) found that areas with limited rural development efforts, such as lower growth areas, are target areas for focusing programs on the provision of ecosystem services.

In Alberta, eastern municipalities from the County of Forty Mile and Cypress in the south, through the Special Areas to the County of Paintearth in the north, encompass the low growth regions of the Dry Prairies in Alberta. This region is characterized by high transport costs for annual crops and a relatively high drought risk for annual crop production. Livestock density is higher in the northern portion of southeastern Alberta.

The relatively high risk for soil degradation, including erosion and/or salinity, in eastern Alberta also makes this area ideal for native conversion. Land managers who participated in the Permanent Cover program conducted by Agriculture and Agri-Food Canada from 1989 to 1992 were surveyed. Almost 80% of survey respondents identified soil degradation issues (erosion or salinity), or poor crop production (Hilliard and Fomradas 2009) as their reason for enrollment.

Uncertainties Posed by Climate Change

Climate change and unpredictable weather patterns pose a challenge for the conversion to native lands. Most climate change models predict an increase in warm season grasses and a decline in cool season grasses in the Dry Prairie region, and they do not account for the carbon fertilization effect associated with climate change. It is speculated that the CO_2 fertilization effect will somewhat offset the effect of a drier climate[11]. Some climate change models also predict an increase in shrubs. Shrubs will have ecosystem benefits but they may not contribute significantly to forage production in the Dry Prairie region. Most climate change models predict an increased risk of prolonged drought (Bailey et al. 2010).

Climate change models indicate the potential for the Dry Prairies area to expand to the north and west. However, it may be difficult to convert to the Dry Prairie seed mixes identified in Table 2, because Black soils that occur to the north and west have a higher fertility, and the soil conditions promote non-native invasive grasses such as Kentucky blue grass and smooth brome.

[11] Jeff Thorpe, Saskatchewan Research Council, Personal Communication, June 2012, at State & Trends of Canadian Grasslands Workshop, Saskatoon, SK.

References

Adams, B.W., G. Ehlert, C. Stone, M. Alexander, D. Lawrence, M. Willoughby, D. Moisey, C. Hincz, A. Burkinshaw, J. Carlson, and K. France. 2009. Range health assessment for grassland, forest and tame pasture. Public Lands and Forests Division, Alberta Sustainable Resource Development. Pub. No. T/044. ISBN No. 0-7785-2848-0. 128 pp.

Adams, B.W., L. Klein, D. Moisey and R. 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/039. 92 pp.

Adams, B.W., L. Klein, D. Moisey, and R. McNeil. 2005. Rangeland plant communities and range health assessment guidelines for the Dry Mixedgrass Natural Subregion of Alberta. Rangeland Management Branch, Public Lands Division, Alberta Sustainable Resource Development, Lethbridge, Pub. No. T/040. 90 pp.

Agriculture and Agri-Food Canada (AAFC). 2008. Audit Report - Greencover Canada Program. Office of Audit and Evaluation. Ottawa, Ontario. Available at: http://www4.agr.gc.ca/AAFC-AAC/display-afficher.do?id=1234817744362&lang=eng

Alberta Agriculture and Rural Development (ARD). 2011. Intent to Develop Alberta Offset System Quantification Protocol: Conversion of Annual Cropland to Perennials. Edmonton, Alberta. 13 pp.

Alberta Environment 2010. 2010 reclamation criteria for wellsites and associated facilities for cultivated lands *(includes tame pasture)*. Alberta Environment, Edmonton, AB. 77 pp.

Alberta Environment and Sustainable Resource Development (AESRD). 2012. Quantification protocol for conservation cropping. Version 1.0. Specified Gas Emitters Regulation. Edmonton, Alberta. 98 pp. ISBN: 978-0-7785-9627-1 (Printed). ISBN: 978-0-7785-9628-8 (On-line). Available at: http://environment.gov.ab.ca/info/library/8561.pdf

Alberta NAWMP Partnership Management Committee (ANPMC). 2008. Alberta NAWMP Implementation Plan, 2007-2012. 56 pp.

Alberta Sustainable Resource Development (ASRD). 2007. Grazing lease stewardship code of practice. Edmonton, Alberta. 14 pp.

Bailey, A.W., D. McCartney, and M.P. Schellenberg. 2010. Management of Canadian prairie rangeland. AAFC No. 10144. 58 pp. Available at: www.agr.gc.ca/scienceandinnovation

B.C. Ministry of Agriculture, Food and Fisheries (BCMAFF). 2005. Assessing native range. Pasture and Range Health Factsheet No. 3 in series.. 10 pp.

Bremer, E. 2009. Potential for reductions in greenhouse gas emissions from native rangelands in Alberta. Technical scoping document. Symbio Ag Consulting for Alberta Agriculture and Rural Development. 24 pp.

Environmental Consulting Group Inc (EC3). no year. Prairie restoration guidelines. Available at: www.ec3grp.com/prairie-restorationguidelines.htm

Gabruch, L.K., D.B. Wark, C.G. Penner, and J. Giles. no year. Rebuilding your land with native grasses: a producer's guide. Agriculture and Agri-Food Canada, Ducks Unlimited Canada, Fisheries and Oceans Canada, Proven Seeds, and Native Plant Solutions. 10 pp.

Gramineae 2007. Revegetation strategies for public lands: a gap analysis. Prepared by Gramineae Services Ltd for Land Management and Rangeland Management Branches, Alberta Sustainable Resource Development. 92 pp.

Gramineae 2012. Recovery strategies for industrial development in native prairie: the Dry Mixedgrass Natural Subregion of Alberta. Prepared for Range Resource Management Program, Lands Division, Alberta Environment and Sustainable Resource Development. 132 pp.

Grilz, R. 2011. Case Study: Old Man on His Back. Powerpoint by Nature Conservancy of Canada – Saskatchewan Region, presented at Native Prairie Restoration/ Reclamation Workshop, Saskatchewan Prairie Conservation Action Plan, Regina, SK., Feb. 16-17, 2011.

Grilz, R. 2012. Putting it all together in the prairie. Video and audio presentation by Nature Conservancy of Canada – Saskatchewan Region, presented at Native Prairie Restoration/ Reclamation Workshop, Saskatchewan Prairie Conservation Action Plan, Saskatoon, SK., Feb. 8-9, 2012.

Hecker, K., and C. Neufeld. 2006. Guide: Restoration Assessment Form and Sheets. Prepared by Last Mountain Lake National Wildlife Area and Migratory Bird Sanctuary, Environment Canada – Canadian Wildlife Service. 5 pp.

Helzer, C. 2011. When is a prairie restoration (reconstruction) project successful? In: The Prairie Ecologist. Available at: www.prairieecologist.com/2011/02/08/when-is-a-prairie-restoration-reconstruction-project-successful/

Herrick, J.E., J.W. Van Zee, K.M. Havstad, L.M. Burkett, and W.G. Whitford. 2009a. Monitoring manual for grassland, shrubland and savanna ecosystems. Vol. 1: Quickstart. Published by USDA – ARS Jornada Experimental Range, Las Cruces, New Mexico. 36 pp.

Herrick, J.E., J.W. Van Zee, K.M. Havstad, L.M. Burkett, and W.G. Whitford. 2009b. Monitoring manual for grassland, shrubland and savanna ecosystems. Vol. II: Design, supplementary methods and interpretation. Published by USDA – ARS Jornada Experimental Range, Las Cruces, New Mexico. 200 pp.

Hilliard, C., and K. Fomradas. 2009. Permanent forage cover programs, 1989-1992. An evaluation of medium-term environmental outcomes and program participation. Agriculture and Agri-Food Canada- Agri-Environmental Services Branch. Part 11: Interview study of program participants. Regina, SK. 11 pp.

Hilliard, C., C. Kenny, and K. Fomradas. 2009. Permanent forage cover programs, 1989-1992. An evaluation of medium-term environmental outcomes. Agriculture and Agri-Food Canada- Agri-Environmental Services Branch. Regina, SK. 34 pp.

Iwaasa, A.D., Lennox, T. and Jensen, R. 2008. Management techniques required for establishing native grass stands in combination with various tame and native legumes. Greencover Canada TAC Project Fair in Regina, SK., Feb. 27-28, 2008.

Iwaasa, A.L, and M. Schellenberg. 2005. Re-establishment of a mixed native grassland in southwest Saskatchewan. Agriculture and Agri-Food Canada, Swift Current, SK., 135 pp.

Iwaasa, A.D., M.P. Schellenberg, and B. McConkey. 2012. Re-establishment of native mixed grassland species into annual cropping land: a long-term research study 2001 to 2012. Agriculture and Agri-Food Canada – Semiarid Prairie Agricultural Research Centre, Swift Current, Saskatchewan.

Janzen, R., and K. Haugen-Kozyra. 2012. Science discussion document for proposed conversion to perennials protocol. Submitted to Alberta Agriculture and Rural Development. Edmonton, Alberta. 42 pp.

Jefferson, P.G., A.D. Iwaasa, M.P. Schellenberg, and J.G. McLeod. 2004. Re-evaluation of native plant species for seeding and grazing by livestock on the semiarid prairie of western Canada. Semiarid Prairie Agricultural Research Centre, Agriculture and Agri-Food Canada, Swift Current, SK. 48 pp.

Jin, L., Zhang, Y.G., Iwaasa, A.D., Xu, Z., Schellenberg, M.P. McAllister, T.A., and Wang, Y. 2011. Fecal shedding of Escherichia coli of cattle grazing pastures with and without purple prairie clover (Petalostemon purpureum). Canadian Society of Animal Science Annual General Meeting, Halifax, N.S. May 4-5, 2011.

Jones, P.F. 2011. The right mix – native seeds bring promise to the prairies. In: Conservation Magazine of the Alberta Conservation Association, pg. 24-25.

Kestrel and Gramineae. 2011. Long term recovery of native prairie from industrial disturbance. Express pipeline revegetation monitoring project 2010. Kestrel Research Inc. and Gramineae Services Ltd. 349 pp.

Khanna, M., and A.W. Ando. 2009. Science, economics and the design of agricultural conservation programmes in the US. J. Environmental Planning and Management 52(5):575-592.

Klabi, R., Hamel, C. Iwaasa, A. and Raies, A. 2010. Nitrogen fixation of native and tame forage stands. Soils and Crops Conference, Saskatoon, SK., Feb. 25, 2010.

Kupsch, T., K. France, J. Richman, and R. McNeil. 2012. Range Plant Communities and Range Health Assessment Guidelines for the Northern Fescue Natural Subregion of Alberta: First Approximation. Alberta Environment and Sustainable Resource Development, Edmonton, Alberta. Pub. No. T/ 265. 70 pp. Available on-line at:

http://esrd.alberta.ca/LandsForests/GrazingRangeManagement/RangePlantCommunityGuidesStockingRates.aspx

Li., Y., Iwaasa, A.D., Birkedal, E. and Han, G. 2012a. Forage quality constituents of purple prairie clover (Dalea purpurea) and white prairie clover (Dalea candida) harvested at different phonological stages in southwest Saskatchewan. Soils and Crops Conference, Saskatoon, SK., Feb. 2012.

Li., Y., Iwaasa, A.D. Wang, Y, Jin, L, and Han, G. 2012b. Condense tannins concentrations of prairie legume forages at different phonological stages. ASAS/ADSA/CSAS/AMPA Conference, Phoenix, AZ., July 15-19, 2012.Luciak, G.M., B. Kirychuk, and B.L. Ward. no year. Economic viability and environmental considerations on the rangeland dependent livestock sector in Canada. 10 pp.

McKenzie, R.H., J.F. Dormaar, B. Adams, and W. Willms. 2003. Manure application and nutrient balance on rangeland. Agri-Facts. Agdex 538-1. Alberta Agriculture, Food and Rural Development, Edmonton, Alberta.

Moen, J. 1998. Managing your native prairie parcels. Your guide to caring for native prairie in Saskatchewan. Saskatchewan Wetland Conservation Corporation. Regina, AK. ISBN 1-896-793-19-3. 49 pp.

North Dakota Game and Fish Dept. and Natural Resources Conservation Service (NDGF and NRCS). 2005. Getting started in prairie revegetation – a recipe for success. 7 pp.

Neufeld, C. 2010. Assessment of the native plant materials industry in western Canada and the northern United States – Results from the providers and users of native plant materials. Native Plant Society of Saskatchewan. Saskatoon, SK. 96 pp.

Native Plant Working Group (NPWG). 2001. Native plant revegetation guidelines for Alberta. H. Sinton Gerling (Editor). Alberta Agriculture and Rural Development and Alberta Environment. Edmonton, AB. 58 pp.

Natural Resources Conservation Service (NRCS) of the United States Dept. of Agriculture (USDA). 2009a. Understanding seed certification and seed labels. Plant Materials Technical Note No. 10. 6 pp.

Natural Resources Conservation Service of USDA (NRCS). 2009b. Understanding seeding rates, recommended planting rates, and pure live seed (PLS). Plant Materials Technical Note No. 11. 4 pp.

Natural Resources Conservation Service (NRCS) of USDA. 2011. Animal enhancement activity: Prairie restoration for grazing and wildlife habitat. Fact Sheet ANM21. 4 pp.

Pellant, M., D.A. Pyke, P. Shaver, and J.E. Herrick. 2005. Interpreting indicators of rangeland health. Version 4. Prepared for the Bureau of Land Management of the United States Dept. of the Interior. Technical Reference #1734-6. Denver, CO. 122 pp.

Province of Alberta. 2010. Alberta Regulation 19/2010. Weed Control Act. Weed Control Regulation. Alberta Queen's Printer. http://www.qp.alberta.ca/documents/Regs/2010_019.pdf

Rangeland Resource Management Program (RRMP). 2004. Methodology for calculating carrying and grazing capacity on public rangelands. Rangeland Resource Management Program of Alberta Sustainable Resource Development, Public Lands and Forests. 25 pp.

Russillo, A., and L. Pinter. 2009. Linking farm-level measurement systems to environmental sustainability outcomes: Challenges and ways forward. Prepared for Agriculture and Agri-Food Canada by the International Institute for Sustainable Development. 66 pp.

Ruto, E., and G. Garrod. 2009. Investigating farmers' preferences for the design of agri-environment schemes: a choice experiment approach. J. Environmental Planning and Management, 52(5):631-647.

Saskatchewan Ministry of Agriculture. 2009. Fencing costs. Fact Sheet. Available at: http://www.agriculture.gov.sk.ca/default.aspx?dn=c339823b-d410-4b8e-8987-46957c437d5a

Saskatchewan Prairie Conservation Action Plan (PCAP) Greencover Committee. 2008. Rangeland health assessment for native grassland and forest. Regina, SK. 82 pp.

Schellenberg, M.P. and M.R. Banerjee. 2002. The potential of legume – shrub mixtures for optimum forage production in southwestern Saskatchewan: a greenhouse study. Can. J. Plant Sci. 82:357-363.

Schellenberg, M.P., B. Bilegetu, and A.D. Iwaasa. 2012. Species dynamic, forage yield, and nutritive value of seeded native plant mixtures following grazing. Can. J. Plant Sci. 92:699-706.

Schellenberg, M.P., A.D. Iwaasa, B. Bilegetu, and R. Muri. 2012. Native and tame forage research at the Semi-Arid Prairie Agriculture Research Centre (SPARC) – Agriculture and Agri-Food Canada (AAFC) contributing to grassland sustainability. Poster presented at: State & Trends of Canadian Grasslands Workshop, June 27-28, 2012, Saskatoon, SK.

Sheley, R., J. Mangold, K. Goodwin, and J. Marks. 2011. Revegetation guidelines for the Great Basin: Considering invasive weeds. ARS #168. USDA Agricultural Research Service. 52 pp.

Sinton, H.M. 2004. Native prairie reclamation. 6 pp.

Special Areas Board. 2009. Recommended native grass seed mixes for sites located in areas of native grass. Available at: www.SpecialAreas.ab.ca/assets/PDF/NativeGrassSeedRecommendation.pdf

Vaisey, J.S., T.W. Weins, and R.J. Wettlaufer. 1996. The permanent cover program – is twice enough? Paper presented at the conference: Soil and Water Conservation Policies: Success and Failures. Prague, Czech Republic, Sept. 17-20, 1996. Available at: www.agri.gc.ca/AAFC-AAC/display-afficher.do?id=1187267959357@lang=eng

Wark, D.B., L.K. Gabruch, C. Penner, R.J. Hamilton, and T.G. Koblun. 2004. Revegetating with native grasses in the Northern Great Plains: Professional's Manual. Agriculture and

Agri-Food Canada, Ducks Unlimited Canada, Fisheries and Oceans Canada, Proven Seeds, and Native Plant Solutions. 60 pp.

Wruck, G.W., and A.M. Hammermeister. 2003. Prairie roots: a handbook for native prairie restoration. Native Plant Society of Saskatchewan Inc., Saskatoon, SK. Funded by Agriculture and Agri-Food Canada. 35 pp.

Appendix 1

Native Grassland Range Health Assessment - SCORE SHEET

(From Adams et al. 2009)

Site ____________________ Observer ________________ Date _________________

LSD ___ Quarter ___ Section ___ Township ___ Range ___ Meridian ___ Photo#______

GPS Coord (NAD 83) Lat. ________ Long. _______

Estimated usable forage production ________________

Special Observations (climate, changes in management) __________________________

SCORING (circle appropriate values and add their sum to the Score box)

Dominant Species

Grasses & Grasslikes	Cover %	Forbs	Cover %	Shrubs	Cover %	Trees	Cover %

Plant Community Name (code)____

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

						Comments	Score
1a	40	27	20	15	0		
1b			15	8	0		

2. Are the expected plant layers present?

				Comments	Score
10	7	3	0		

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

			Comments	Score
25	13	0		

4. Is there accelerated soil erosion? Site normally (circle): Stable / Unstable

					Comments	Score
4.1 Erosion Evidence	5	3	1	0		
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
5.2 Density Distribution	5	3	1	0

Dominant Species	% Cover	Density Dist.	Infestation Size (ac or ha)
Comments			

Score

Grazing Intensity Est. long Term (circle): U U-L L-M M M-H H Observed Utilization _________________% Trend (apparent – circle): Upward Downward Stable Unknown	**Site Score (total score)**

0---50-------------------------------75---------------------------100

<50% (Unhealthy) 50 – 74% (Healthy with problems) 75 – 100% (Healthy)