Offset Factors in the Dry Mixedgrass and Mixedgrass Natural Subregions

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Introduction

Industrial disturbance of land has an obvious cost, but often the temporal cost is not projected beyond early stages such as construction or site re-contouring. To determine the real cost of an industrial disturbance, recovery time must also be incorporated. Range sites do not recover equally over time in natural landscapes. Loamy sites recover the fastest following disturbance compared to more sensitive range sites such as blowouts or gravels. Conservation offset factors put a value on the expected time and associated risks for restoration success of each site type after disturbance. The conservation offset factors are designed to be additive to the Multi-Species Conservation Value (MCV) developed by Downey et al 2007 which is based on habitat suitability indices in a complex model of wildlife in the prairies of Alberta and was developed for Multiple Species at Risk (MultiSAR). The MCV provides additional weighting for species at risk depending on the level of endangerment, species distribution and habitat patch size. The MCV is used as a proxy for industrial impacts associated with development that are additional to direct impacts to vegetation and soils.

This document identifies conservation offset factors for industrial disturbances in the Dry Mixedgrass and Mixedgrass Natural Subregions of Alberta. Justifications are also included, based on applicable references and expert knowledge of resource personnel and the authors.

Assumptions

The following assumptions apply to the conservation offset factors identified in this report.

- The conservation target of this offset pilot is the conversion of marginal cropland to perennial native cover where most, or all, ecological functions are restored. The time to restore ecologic integrity of the cultivated parcel is unknown, and therefore applying ecological equivalency (discussed in Weber 2011) is impractical. Eligible cultivated lands are located in the sage grouse recovery area and are intended to increase native habitat in this area.
- Another Alberta offset proposal was based on ecosite rarity versus abundance (Croft et al 2011), but this proposed offset is based on the site type (range site) in the disturbed area. The site type is used by most grassland professionals, and forms the framework of the Alberta Grassland Vegetation Inventory (GVI) which is completed in the South Saskatchewan region.
- As agricultural production in the offset area largely occupies loamy soils, this proposed offset program will not trade like for like site types. Instead, conservation offset factors are based on relative restoration rates and restoration challenges, for each site type in the disturbance area.
- Conservation offset factors are based on the idea that restoration recovery after disturbance varies with site type. For example, a company that disturbs a given area of land on any native range site could offset this development with the purchase of a set-aside area based on the sum of the MCV and the conservation offset factor(s). Disturbance of highly sensitive sites, and/or habitats highly suitable for species at risk, require larger offset areas in the conservation area.
- Tools such as soil survey and GVI can be used to identify potential or historic range site of potential offset locations. It is recommended that third party professionals would use GVI and ground truthing to assess range site(s) and quantify the area impacted by disturbance.
- The disturbance will include the surveyed area and associated facilities, dealing with all the cumulative effects of a project. Therefore disturbance is the total construction workspace and also accounts for other associated infrastructure i.e. power lines, pipelines, service corridors, trails, or roads.
- A complementary benefit of using factors for each range site could be the additional projected costs of offsets. It is possible that companies will focus efforts towards site disturbances on less sensitive site types with a higher probability for successful restoration and to locations with a lower MCV.
- Restoration potential is dependent upon construction practices. Where minimal disturbance techniques are utilized (frozen/dry ground, minimal soil disturbance) the restoration potential and rate of restoration is generally higher.
- Offset factors are different for each Natural Subregion due to climatic and soil differences. It is expected that this model for the Dry Mixedgrass and Mixedgrass can be adapted to other Natural Subregions in the Grassland and Parkland Natural Regions of Alberta.

Methods

Conservation offset factors were initially established independently by each of SRD Lands and LandWise Inc., based on expert knowledge of the authors. The factors established by the two authors were very similar, and the authors subsequently collaborated to adjust to common values.

The initial values were then refined based on recent research (Hickman 2010), key learnings from long term monitoring projects (Kestrel and Gramineae 2011), interpretations from detailed investigations (McNeil 2008) and (Hammermeister 2001), and expert knowledge and opinion (Neville 2007; Gramineae 2009). Restoration risk ratings used in this report were identified as low, moderate, high or extreme (Table 1), based on limiting factors related to landscape, soil, degradation potential, and properties of key indicator species. Knowledge gained from several other projects was also used to refine the factors, including the use and application of the 2010 native grasslands reclamation criteria (Alberta Environment and Water 2011), range health assessment (Adams et al. 2009), plant community succession models (Adams et al. 2004), and range plant community guides (Adams et al. 2005a, 2005b). The rate of restoration has not been well-established for some site types, in which case offset factors reflect the degree of sensitivity relative to other site types.

Table 1. Restoration risk ratings. Adapted from McNeil (2008) and Gramineae (2009).

Restoration Risk Rating	Limitations	Interpretation
Low	No significant limiting factors	Resilient
Moderate	One limiting factor	Needs extra care and attention
High	Two limiting factors	Difficult to restore
Extreme	Numerous limiting factors	No known way to restore

Limiting factors include the following.

- **Landscape** factors usually relate to topography and slope. Example site types with landscape limitations include Badlands, Thin Breaks and Choppy Sandhills.
- **Soil** factors relate to soil structure, texture, and chemical properties. Example site types with soil limitations include Blowouts, Limy, Saline Lowlands and Sands.
- **Degradation**-related factors indicate a susceptibility to increased any of soil salinity, wind erosion, water erosion, and groundwater contamination. Degradation can relate to severity, aerial extent, or both. Degradation issues can potentially occur in any site type.
- **Properties of key indicator species**: Certain plants are difficult to restore after disturbance. The bunchgrass rooting system of Rough fescue greatly affected by mechanical disturbance.

Results

Conservation offset factors developed and presented in this report are summarized in Table 2, with justifications provided for each site type in the following paragraphs. Justifications for the Dry Mixedgrass Natural Subregion (NSR) precede the justifications for the Mixedgrass NSR.

Table 2. Conservation factors for disturbances in Dry Mixedgrass and Mixedgrass NSRs.

Range Site/Upland GVI Site Type	RS Symbol	Dry Mixedgrass Natural Subregion		Mixedgrass Natural Subregion	
		Offset factor	% Mid or Late Seral from Kestrel and Gramineae	Offset factor	% Late Seral from Kestrel and Gramineae
Loamy	Lo	1	Most mid-seral at year 3	2	67% late seral at year 13
Overflow	Ov	2		2	
Sandy	Sy	2		2	
Clayey	Cy	2		2	
Limy	Li	2		2	40% late seral at year 13
Sands	Sa	2	71% mid-seral at year 5	2	
Shallow to Gravel	SwG	2		2	
Sub-irrigated	Sb	2		2	
Blowouts / Solonetzic	BlO	4	73% mid-seral or later after 13 years	4	
Choppy Sandhills	CS	4		4	
Gravel	Gr	4		4	
Saline Lowland	SL	4		4	
Thin Breaks	TB	4		4	
Badlands / Bedrock	BdL	6		6	

Justification for Site Types in the Dry Mixedgrass Natural Subregion

Loamy -Lo (Conservation Offset Factor -1). Gramineae (2009) indicates that most undulating and level Loamy soils do not have restoration limitations; for example, the Loamy 3 ecological site associated with the Wildhorse Plain has a low restoration risk. Thirteen Loamy plant communities were assessed as part of the Express Pipeline Study (Kestrel and Gramineae 2011). In the 13 years since disturbance, seven sites (54%) were in either mid-seral or late seral stages of succession. The average range health of the disturbed sites (56%) was not yet comparable to average range health on adjacent controls (81%) (Kestrel and Gramineae 2011, Appendix C-195). Kestrel and Gramineae (2011) state that the majority of Loamy sites in the Dry Mixedgrass attain mid-seral status within three years.

Overflow - Ov (Conservation Offset Factor -2). Gramineae (2009) indicates that undulating, level and slightly inclined Overflow site types do not typically have restoration limitations; for example, the Overflow 2 ecological site associated with the Wildhorse Plain has a low restoration risk. Overflow sites are relatively resilient following disturbance, with the exception that disturbed sites tend to contain less Sandberg's bluegrass than their control counterparts. The Overflow sites studied in the Manyberries region of Alberta indicate the disturbed sites typically have lower species richness, less total moss and lichen, and slightly reduced ecological status and community structure compared with adjacent controls (Hickman 2010) (Table 3).

Table 3. Component Scores for range health in Overflow Sites. From Hickman (2010).

Property or Component Score of Range Health	Disturbed Site	Control Site
Species Richness	13.9	16.9
Total moss and lichen cover	2.1	17.3
Community structure	4.5	5.8
Ecological status	14.0	20.6
Combined range health less litter	71.9	89.8

Kestrel and Gramineae (2011) report that 13 years after reclamation, the range health scores on disturbed Overflow sites (average 57) exceeded those of the controls (average 52) (Appendix B-130).

Sandy - Sy (Conservation Offset Factor -2). Gramineae (2009) indicates that undulating Sandy site types do not usually have restoration limitations; for example, the Sandy 2 ecological site associated with the Wildhorse Plain has a low restoration risk.

Subirrigated - Sb (Conservation Offset Factor -2). McNeil (2008) identifies a moderate risk for disturbed plant communities such as wild licorice and wire rush, with each having the potential for an increase in invasive species and impaired hydrologic flow. Gramineae (2009) indicate that Subirrigated site types have a high restoration risk, which typically means two or more limiting factors. The limiting factors are considered as the proximity to groundwater, the

potential for groundwater contamination, in addition to the potential impairment to natural water flow.

Clayey - Cy (Conservation Offset Factor -2). Gramineae (2009) indicates that Clayey site types have a moderate restoration risk. Soil tilth describes structure and consistence, and if soil tilth is poor, there may be reduced seed germination. Clayey site types must be handled carefully to prevent impaired soil tilth.

Limy - Li (Conservation Offset Factor -2). Gramineae (2009) indicates that Limy site types have a moderate restoration risk. When Limy sites are disturbed there is a potential for increased soil carbonates and higher soil pH, and these factors can reduce seed germination success, particularly for species that are sensitive to a more alkaline soil reaction.

Sands - Sa (Conservation Offset Factor -2). Gramineae (2009) indicates that undulating Sands site types have a moderate restoration risk. The most significant risk factor is typically the potential for wind erosion.

For Sands locations monitored by Kestrel and Gramineae (2011), disturbed sites and controls generally showed similarity in range health scores 14 years after reclamation (average 57 on disturbed vs. 65% on control) (pg. B139 and C215). Kestrel and Gramineae (2011) monitored seven Sands sites that are located north of Youngstown (sites #5 and 40-45, pgs. C224 to C227) and noted that five of the seven (71%) attained mid-seral status by year 5 and late seral succession 13 years after reclamation. In the same study, Sands disturbed sites and controls generally showed good similarity (p 7-59), with the exception of an increase in Kentucky Bluegrass, an undesirable species, (8% on disturbed vs. 2% on control), and less Blunt Sedge, (5.5% on disturbed sites vs. 13.5% on controls). *(Note: these sites were identified as the Sandy site type, but soils information indicates they are the Sands site type).*

Shallow to Gravel - SwG (Conservation Offset Factor -2). Gramineae (2009) indicates that undulating, level and terraced Shallow to Gravel site types have a moderate restoration risk. The low water-holding capacity of this site type presents a limitation for restoration, particularly if the coarse fragments from deeper depths are mixed in the topsoil and upper subsoil.

Blowouts / Solonetzic Order - BlO (Conservation Offset Factor -4). Gramineae (2009) indicates that undulating, Blowout site types have a high restoration risk. Restoration limitations include high sodium content, low organic matter, and the potential for salinization. Blowout sites are subject to an increase in introduced grasses and an increase in Northern Wheatgrass when disturbed (Hickman 2010, pg. 139). In addition, the natural small-scale patchy variability of Solonetzic landscapes is currently very difficult to replicate during restoration.

The Blowout sites studied in the Manyberries region of Alberta indicate the disturbed sites typically have reduced species richness, ecological status and community structure, and much reduced total moss and lichen, compared with adjacent controls (Hickman 2010, pg. 144) (Table 4). Disturbed Blowout sites (Table 4) have lower resilience compared to disturbed Overflow sites (Table 3), because the recovery pathway is more complicated (Hickman 2010, pg. 230).

Table 4. Component Scores for Range Health in Blowout Sites. From Hickman (2010).

Property or Component Score of Range Health	Disturbed Site	Control Site
Species Richness	15.3	18.4
Total moss and lichen cover	4.6	63.0
Community structure	4.0	6.0
Ecological status	16.2	24.0
Combined range health less litter	76.6	99.6

Fourteen Blowout sites were assessed as part of the Express Pipeline Study (Kestrel and Gramineae 2011). Thirteen years after disturbance, four sites remain in early seral (29%), six were late-mid seral (43%), and 4 of the 14 sites (28%) have attained a late seral succession stage (pg. C195). Data from Kestrel and Gramineae (2011) may suggest Blowout Sites in the Wildhorse Plain Ecoregion restore faster than Blowout sites in the Rainy Hills district (Table 5).

Table 5. Comparision of Blowout Restoraton at two Ecodistricts. From Hickman (2010).

Property and Percent	Rainy Hills Ecodistrict		Wildhorse Plain Ecodistrict	
	Disturbed	Control	Disturbed	Control
	(Four Sites)		(Five Sites)	
Blue grama	5	16	1	2
Needle and Thread	7.5	19	13	10
Moss, lichen, *Selaginella densa*	6	12	2.5	10
Low sedge	2	3.5	------	------
Pasture sage wort	20	4	3	1.5

Choppy Sandhills - CS (Conservation Offset Factor -4). Gramineae (2009) indicates that Choppy Sandhills site types have a high restoration risk, due to adverse topography and a high potential for wind erosion. Nielsen (2011) found that Choppy Sandhills sites in the Dry Mixedgrass have a high degree of vulnerability when disturbed, and that there is a low potential for replacement of all topographic elements. Avoidance is recommended.

Gravels - Gr (Conservation Offset Factor -4). Gramineae (2009) indicates that Gravels site types have a high restoration risk, due to thin topsoil and high coarse fragment content. The low water-holding capacity of this associated soil presents a significant limitation for restoration, particularly if the coarse fragments from the subsoil are mixed in the topsoil.

Saline Lowland - SL (Conservation Offset Factor -4). McNeil (2008) identifies a moderate to high risk to natural plant communities such as salt grass and Nuttall's salt meadow grass, which both have the potential for increased foxtail barley because the latter typically out-competes more desirable native species. Gramineae (2009) indicates that Saline Lowland site types have a high restoration risk. Salinity is the major limiting factor, with the potential for increases in both the degree and aerial extent of salinity.

Thin Breaks - TB (Conservation Offset Factor -4). Gramineae (2009) indicates that Thin Breaks site types have a high restoration risk, due to thin topsoil, adverse topography, and water erosion potential. Bedrock materials must be carefully handled to avoid potential issues with soil chemistry or textural limitations.

Badlands / Bedrock – BdL (Conservation Offset Factor -6). Gramineae (2009) indicates that Badlands / Bedrock site types have a high to severe restoration risk due to multiple limiting factors, including non-existent to thin topsoil, severe slope limitations, and extreme water erosion potential. Developments should be avoided on this site type in order to prevent the necessity for costly and laborious restoration.

Justification for Site Types in the Mixedgrass Natural Subregion

Loamy -Lo (Conservation Offset Factor -2). Gramineae (2009) indicates that most undulating and level Loamy soils have low to moderate restoration limitations. The main limitation is the moderate difficulty of recovery for some plant species, such as Idaho fescue. In addition, data suggest that it takes longer to attain comparable range health scores on Loamy sites in the Mixedgrass compared to in the Dry Mixedgrass and that the risk of invasive species is higher in the Mixedgrass. Therefore, we recommend a factor of 2 in the Mixedgrass versus a factor of 1 for Loamy in the Dry Mixedgrass. The average range health of the disturbed sites (56%) was not yet comparable to average range health on adjacent controls (72%) (Kestrel and Gramineae 2011, Appendix C-244*).* Four of the six sites (67%) were in late seral stages of succession 13 years after restoration.

Overflow - Ov (Conservation Offset Factor -2). Neville (2007) and Gramineae (2009) indicates that there is a moderate risk for restoration of Overflow site types, due to the potential for the introduction of, or increase in, invasive species. Kestrel and Gramineae (2011) report good restoration success 13 years after disturbance. Range health scores on disturbed Overflow sites (average 60) were similar to those of the controls (average 62); bare soil was 2.8% on the right-of-way and 2.1% on the control (pg. F-289).

Sandy - Sy (Conservation Offset Factor -2). Gramineae (2009) indicates that undulating Sandy site types do not usually have restoration limitations.

Subirrigated - Sb (Conservation Offset Factor -2). McNeil (2008) identifies a moderate risk with disturbed plant communities such as wild licorice and wire rush, as each have the potential for an increase in invasive species and impaired hydrology flow, if the site is disturbed.

Clayey - Cy (Conservation Offset Factor -2). Neville (2007) and Gramineae (2009) indicate that Clayey site types have a moderate restoration risk. Soil tilth describes structure and consistence, and if soil tilth is poor there is a major reduction in seed germination success. Clayey site types must be handled carefully to prevent impairment to soil tilth. Due to the limited aerial extent of Clayey sites, there is scant information on experience and techniques used by reclamation service providers in this site type.

Limy - Li (Conservation Offset Factor -2). Gramineae (2009) indicate that Limy site types have a moderate restoration risk. When Limy sites are disturbed there is a potential for increased soil carbonates and higher soil pH, and these factors can reduce seed germination success, particularly for species that are sensitive to a more alkaline soil reaction. Kestrel and Gramineae (2011), found that 13 years after restoration on Limy site types, the average range health of the disturbed sites (51%) was comparable to average range health on adjacent controls (55%) Appendix C-233*).* Two of the five sites (40%) were in late seral stages of succession and two other sites (40%) were in the mid seral stage. These data suggest that in the Mixedgrass Natural Subregion, it takes slightly longer to attain late seral stages of succession on Limy sites than on Loamy sites (see above); however the factors remain the same at 2 for simplicity.

Sands - Sa (Conservation Offset Factor -2). Neville (2007) and Gramineae (2009) indicate that undulating Sands site types have a low restoration risk, with the risk factor being wind erosion.

Shallow to Gravel - SwG (Conservation Offset Factor -2). Gramineae (2009) indicate that undulating, level and terraced Shallow to Gravel site types have a moderate to high restoration risk. The low water-holding capacity of this site type presents a limitation for restoration, particularly if the coarse fragments from deeper depths are mixed in the topsoil and upper subsoil.

Blowouts / Solonetzic Order - BlO (Conservation Offset Factor -4). Neville (2007) indicate that undulating Blowout site types have a high restoration risk. Restoration limitations include high sodium content, low organic matter, the potential for salinization, and the difficulty in restoring the natural small-scale patchy variability of Solonetzic landscapes. Research has found that it is difficult to restore the plant community due to the potential for invasive species and/or native increasers. Kestrel and Gramineae (2011) monitored a site that indicates the difficulty of site restoration after 13 years, where bare soil remains high on the right-of-way, and native species are markedly different between the right-of-way and control (pg. F-293).

Choppy Sandhills - CS (Conservation Offset Factor -4). Gramineae (2009) indicate that Choppy Sandhills site types have a high restoration risk, due to adverse topography and a high potential for wind erosion.

Gravels - Gr (Conservation Offset Factor -4). Neville (2007) and Gramineae (2009) indicate that Gravels site types have a high restoration risk. Limitations include thin topsoil and high coarse fragment content. The low water-holding capacity of this site type presents a significant limitation for restoration, particularly if the coarse fragments from the subsoil are mixed in the topsoil.

Saline Lowland - SL (Conservation Offset Factor -4). McNeil (2008) identifies a moderate to high risk to natural plant communities such as salt grass and Nuttall's salt meadow grass, with both having the potential for increased foxtail barley as the latter typically out-competes more desirable native species. Neville (2007) indicates that Saline Lowland site types have a moderate restoration risk. Salinity is the major limiting factor, with the potential for increases in both the degree and aerial extent of salinity.

Thin Breaks - TB (Conservation Offset Factor -4). Thin Breaks site types have a high restoration risk (Neville 2007) or a moderate to high restoration risk (Gramineae 2009). It is inferred that the moderate risk applies to landscapes with slopes less than 15%, while landscapes with slopes steeper than 15% have a high restoration risk. The limitations include thin topsoil, adverse topography, and high water erosion potential. If disturbed, bedrock materials must be carefully handled to avoid potential issues with soil chemistry or textural limitations. Kestrel and Gramineae (2011) monitored a site (page F-315) that is transitional between Thin Breaks and Limy, and is inferred to be on slopes less than 15%. Thirteen years after restoration, range health was comparable between the right-of-way (45%) and the control (43%), but the species mix remained different, and bare ground on the right-of-way (18%) was significantly larger than on the control (1%). The results for Thin Breaks are similar to results for the Blowout site type (above), but they show more bare ground than for disturbed Limy site types. The comparison to other site types indicates an offset factor that is higher than Limy (2) and similar to Blowouts (4).

Badlands / Bedrock – BdL (Conservation Offset Factor -6). Gramineae (2009) indicate that Badlands / Bedrock site types have a high to severe restoration risk due to multiple limiting factors, including non-existent to thin topsoil, severe slope limitations, and extreme water erosion potential. Developments should be avoided on this site type in order to prevent the necessity for costly and laborious restoration.

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