RANGELAND REFERENCE AREA PROGRAM

FOR THE

PROVINCE OF ALBERTA

ALBERTA SUSTAINABLE RESOURCE DEVELOPMENT
PUBLIC LANDS AND FORESTS DIVISION

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Prepared by

Rangeland Management Branch

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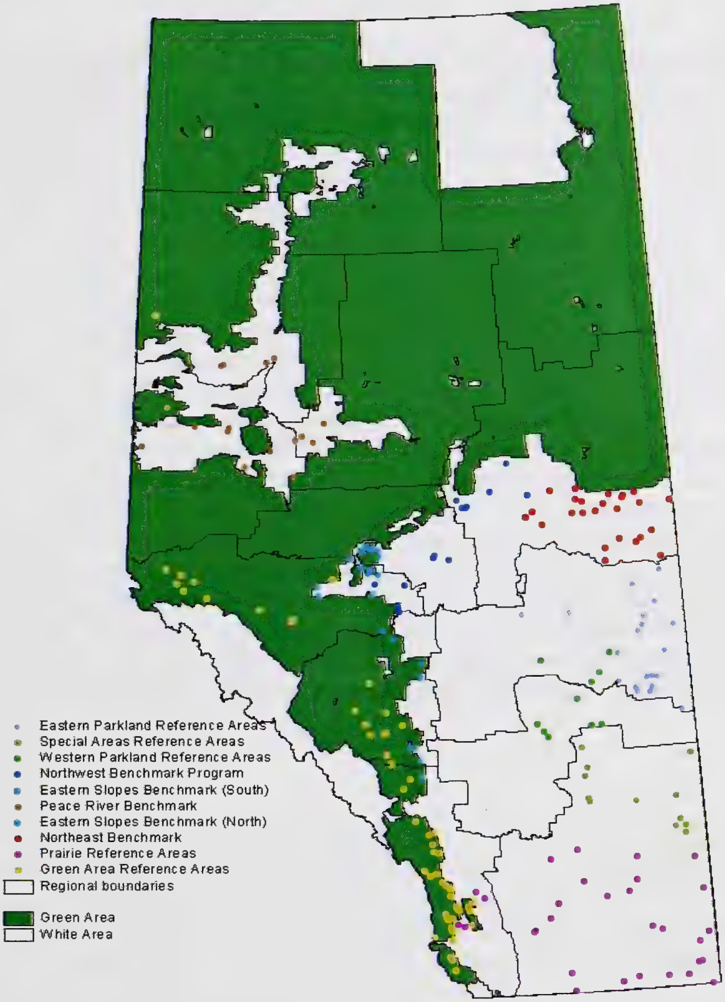
Introduction

There are over 6.6 million ha of rangeland in Alberta representing some of the most ecologically diverse areas within the province. These rangelands are important sources of timber and forage for wildlife and livestock, valued by recreationists and critical for protecting watersheds. These lands are increasingly appreciated for their biodiversity values. The Alberta Government has a mandate to manage Alberta's natural resources to ensure a perpetual supply of benefits and products while maintaining a high quality environment. The primary goal of public land range management in the province is to deliver an integrated strategy involving range and land management that achieves and maintains the public land base under acceptable or greater standard of stewardship based on range and riparian health. To determine effectiveness of this goal, long-term monitoring of the rangeland resource is required. Monitoring allows us to detect changes in rangeland diversity that exceeds the range of natural variation. It also warns us of changes to rangelands which maybe irreversible and it provides reports to the public on the status of rangeland diversity in a timely and accessible manner.

Historically rangeland management has largely occurred at the regional level, within different agencies. This has led to a number of different approaches to monitoring the rangeland resource. These approaches include the Eastern Slopes Benchmark Program (ESBM), the Northeast Benchmark Program (NEBM), the Peace River Benchmark Program (PRBM), Northwest Benchmark Program (NWBM), the Prairie Region Rangeland Reference Area Program (PRRAP), Western and Eastern Parkland Reference Area Programs (WPRRAP, EPRRAP), Special Areas Reference Area Program (SARRAP) and the Green Area Rangeland Reference Area Program (GRRAP). Currently, there are 183 reference area sites that have been and are continuing to be monitored in the province (Map 1). The location of these sites are outlined in Permanent Sample Plot (PSP) search page located at:
http://www3.gov.ab.ca/srd/land/u_oilgas_exp.html

The purpose of this document is to harmonize all of the programs into a single provincial Rangeland Reference Area Program with the following objectives:

1. Monitoring range health and long-term range trend based on species composition and productivity.
2. Monitoring the effects of livestock and wildlife grazing on biomass production, rangeland soils and plant species composition.
3. Assist in determining the characteristics of plant community succession in the presence and absence of disturbance for each ecological site.
4. Provide outdoor classrooms and demonstration sites for range managers, ranchers, students and the public.
5. Rangeland reference areas also provide benchmarks on other aspects of rangeland health including, litter, bare ground, community structure and noxious weeds.
6. Reference areas have been a valuable source of data for estimating drought impacts and will help to better understand the effects of global warming in the future.
7. Reference sites have had considerable value to the research community by providing a historical record of plant community dynamics and forage productivity.



Map 1. Rangeland Reference Area and Benchmark locations in the Province of Alberta.

Methods

A detailed methodology for establishing new rangeland reference area sites is attached in Appendix 1. In general, historic reference areas were built with treated wooden posts generally spaced at 3.3 m with three or four strands of barbed wire. The standard shape is rectangular, but some sites have circular exclosures. The size of the reference areas are generally from 0.05 to 0.2 ha . Dimensions of 13.8 m by 39.5 m are quite common (Figure 1). In the grassland natural region, slightly larger exclosures tend to be constructed averaging 0.4 to 0.6 ha depending on variability of the site . An adjoining grazed area is also identified for monitoring in conjunction with the area within the exclosure. It is important that this area be comparable in terms of vegetation and soils to the exclosure. A number of different objectives have been considered in terms of the grazing regime on the rangeland area adjoining the exclosure. Sites with heavy grazing pressure will allow more opportunities to explore changes to the plant community with grazing and rest. A regime of light to moderate grazing will allow the expression of a plant community that is more broadly representative of local grazing conditions.

Generally, reference areas are selected from within grazing dispositions on areas that either represent primary range and broadly representative of major plant communities and site conditions. Originally sites thought to be in poor range condition were selected but late seral sites may also be selected because of their quality in representing key plant communities. These sites are usually represented by open grasslands on south-facing slopes, benchlands and terraces and by deciduous forests and shrublands. The reference sites are not located near salt or within 30 m of a fence. The preferred distance from a water source is greater than 300 m but less than 1.6 km. In recent years a number of reference areas are only represented by a transect. These reference areas are being monitored to examine shrub encroachment onto a number of foothills grasslands.

Foliar coverage

The existing reference area transects are used to obtain species composition by the foliar coverage method. The long side of a 20 cm by 50cm plot frame is placed against the right side of the transect tape. Species area analysis of each reference area indicated that 5-15 frames were suitable for detecting 80% of the species. It was decided that 15 plot frames would be placed on all transects at each reference area. The plot frame is placed at 2 m intervals starting at 2 m along the transect. Within each plot frame the foliar cover of each species is recorded. Initially Daubenmire cover classes were used to estimate canopy cover, but in more recent years foliar cover has been estimated to the nearest 1% between 1 and 5% and to the nearest 5% above 5% cover. It was found that Daubenmire cover classes tended to over-estimate the cover of many species. Currently, the foliar cover of each transect at each reference area is being recorded every 3rd year.

Forage Production

Long-term forage productivity and how it is influenced by climate, natural succession and livestock grazing is needed in order to determine carrying capacity for rangelands within the province. The specific objectives of this study are:

1. To monitor the effect of annual climate fluctuations on primary forage productivity
2. To monitor the effect of forest succession on primary forage productivity in grazed and ungrazed situations.
3. To determine if there are any differences in long-term forage productivity between different plant community types.

Currently, rangeland reference area sites are being clipped annually.

Enough plots were established to obtain a desired level of measurement. For this program an 80% confidence level and 20% sampling error was adopted (Ehlert and Downing 1992). Using the formula:

$$n=t^2\ CV^2/SE\%^2$$

where n= required sample size
t= t value for 80% confidence (2 tailed t-test)= 1.28 for infinite degrees of freedom
SE%= desired standard error (expressed as %)
CV= coefficient of variation (standard deviation of sample divided by mean of sample) expressed as a percentage

(Avery 1975)

The results indicated that 5 plots (0.5 m^2) or 10 (0.25 m^2) was the minimal sample that should be taken for statistical purposes.

Ten 0.5 m^2 or 20 (0.25 m^2) quadrats are being clipped to a 1.5 cm stubble height, five to ten inside the exclosure and five to ten outside, annually. In the grassland natural region, Smoliak (personal comm.) recommended 10 plots of 0.25m^2 inside and outside the exclosure be harvested and the sample number and frame size has been preserved through time for the sake of consistency. Smoliak et. al (1985) observed that productivity data collected on ungrazed areas only, did not provide an accurate estimate of forage yields for grazed sites due to the build of litter that would buffer the impacts of climate resulting in an overestimate of forage productivity. Therefore after 1989, between 5 to 10 agronomy cages have been located outside each exclosure site to permit forage productivity monitoring on grazed sites along with the ungrazed exclosure area.

Figure 1. Typical Rangeland Reference Area in the Foothills of Southwestern Alberta

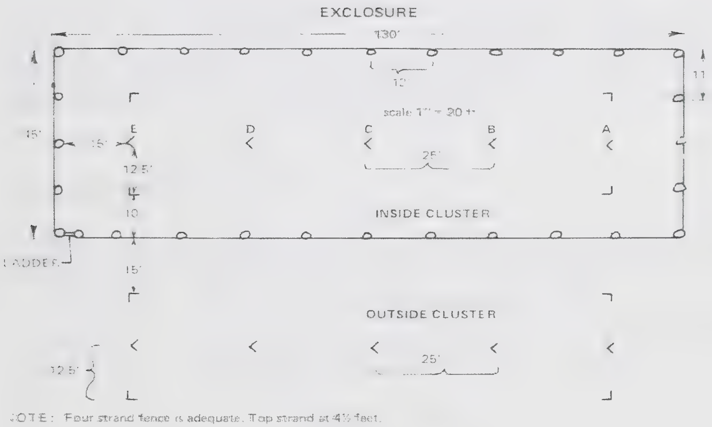


Figure 2. General dimensions and layout of a typical Rangeland Reference Area.

Forage production cages are used to protect the forage plots on the outside of the exclosure. Different areas inside and outside the exclosure are clipped every year. All plots are clipped at the end of the growing season, which is generally the 2nd and 3rd week of August. Each clipped plot is separated into forbs, grass, shrubs, trees and litter, oven dried for 24 to 48 hours at 55°C and weighed. Monthly precipitation (mm) and daily temperature (°C) are taken from the nearest recording station for each site during the growing season.

Litter production

In the grassland natural region, litter has been harvested as a component of biomass since about 1970 (Smoliak et.al 1985). Litter is the organic mulch that develops from the decomposition of carryover. Carry over is the current years growth that is left ungrazed. Over time, this material breaks down and becomes litter, the organic mulch that can be standing, freshly fallen or partially decomposed. With the advent of the range health assessment protocol (Adams et. al 2003), consistency in litter monitoring is important. Litter monitoring will help to characterize the amounts of litter (kg/ha or lb./ac.) that would be expected on a plant community under light to moderate stocking rates. Litter sampling is accomplished by carefully hand raking the litter from the plot frame, only harvesting materials that grew prior to the current year. Experience will allow you to distinguish currents season material from litter by color and degree of oxidation. Carryover will be pale green or yellow. Litter tends to be more grey in color and oxidized. Litter will often include standing leaves and seed heads. Effort should be made to separate current season materials from prior years growth based on degree of color change and oxidation. Avoid collecting manure and sticks which will bias the weight estimate. Also avoid collecting lichen, feather mosses or little-club moss which are normally living layers of vegetation.

Soils/Site Information

Brierley (1992) has described the soils and site characteristics of each reference area site including the following attributes: elevation, aspect, slope, drainage, Lat/Long, described each soil profile and classified the profile as to soil order and subgroup as well as dominant soil series. Chemical and physical lab analysis were also carried out for all sites defining soil particle size distribution, pH, total N, C, exchangeable cations and electroconductivity.

Analysis of Data

Species composition

Foliar cover data for each species is averaged for all 15 microplots within the transect. The transects in each year in the presence (i) and absence (o) of grazing is analyzed using ordination (DECORANA) and cluster analysis (SAS) techniques (Gauch 1982). These techniques combine the transects together based on the similarity of species composition (Figure 3). The groupings outlined in the ordination are called community types and represent the

successional changes occurring on the site in the presence and absence of disturbance. The change in species composition over-time in the presence and absence of disturbance provides insights into the successional pathways of the various plant communities that can occupy an ecological site.

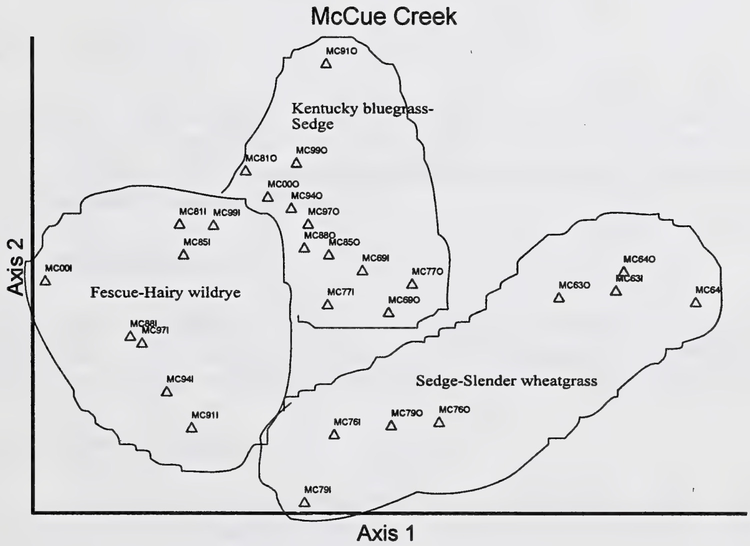


Figure 3. Ordination of the McCue Creek Rangeland Reference Area (number refers to the year the transect was recorded, I=Inside and O=Outside).

Forage Production

Data will be analyzed at yearly intervals using analysis of variance. Relationships between forage production, precipitation and temperature are explored using multiple regression.

Special Rangeland Reference Area Sites

Antelope Creek Ranch

This project is examining a four field deferred rotation on 5500 acres of Dry Mixed grass prairie. There are four reference areas on site, one in each of four native pastures. Continuous monitoring of production, species composition and livestock production has occurred since 1987 (Adams et al 1993, Dormaar et al 1993).

Picture Butte Exclosure

An exclosure established in 1978 centered on a plow line with native grassland versus abandoned cultivation. This has become an intensive monitoring site for Scientists with Agriculture and Agri-Food Canada studying carbon sequestration. (Dormaar et. al 1996).

Silver Sagebrush Exclosures

Silver sagebrush is the most important shrub species providing structural diversity in prairie grasslands in the Dry Mixedgrass subregion. Two exclosures have been constructed near Wildhorse to permit long-term monitoring of Silver Sagebrush to better understand the current status, vigor and trend of sagebrush stands. These sites will be monitored according to the standard reference area protocol and also be made available as research venues for graduate research.

Stavely and One-Four Exclosures

These research sites are long-term rangeland research site maintained by AAFC. Carrying capacity studies define the long-term carrying capacity for normal soils in the foothills fescue and dry-mixed grass prairie (Willms et. al 1985)

Westman exclosures

Six exclosure sites were established in recently harvested aspen cutblocks in 1995 to examine the effect of livestock grazing on aspen regeneration. Three exclosures were established in a June-July grazed treatment and 3 exclosures were established in a August-September grazed treatment. Yearly species composition changes continued to be monitored in the presence and absence of grazing.

Stitt exclosures

Three exclosures were established in recently harvested lodgepole pine cutblocks in 1995 to examine the effect of livestock, and wildlife grazing on lodgepole pine regeneration. Species composition changes and forage production continue to be monitored in two harvesting treatments (slash return, limbed in block) and three grazing treatments (ungrazed, ungrazed by livestock, and grazed by wildlife and livestock).

Porcupine Hills exclosures

Six exclosures were established in 4 and 5 year old Douglas fir harvested cutblocks in the Porcupine Hills. The purpose of the exclosures is to examine the effect of livestock grazing on regenerating lodgepole pine and douglas fir trees. Three exclosures were built on northern aspects and 3 exclosures were built on Westerly and Southerly aspects.

Future Direction

Range Health and Trend

The range science community, has moved to define rangeland health on a broader list of functions, not just plant species integrity. These functions include site stability (erosion), hydrologic integrity and nutrient cycling and energy flow. The term proper functioning condition (PFC), is now applied to both rangeland and riparian health (Alberta Rangeland Health Task Group 1999). In order to determine the PFC of a particular site the ecological site must be characterized. An ecological site as defined for rangeland, is a distinctive kind of land with specific physical characteristics that differs from other kinds of land in it's ability to produce a distinctive kind and amount of vegetation (Task Group on Unity and Concepts 1995). An ecological site is the product of all the environmental factors responsible for it development, and it has a set of key characteristics that are included in the ecological site description. Ecological sites have characteristic soils, hydrology, plant communities, herbivory and fire regimes.

In order to develop ecological site descriptions the Reference Plant Community (RPC) must be known. Reference plant community (RPC) is the term we use for the potential natural community since we use it as the "reference" for comparison. Both primary and secondary succession occur on the climax community in response to interactions with climate, soil development, plant growth and disturbances. These

interactions lead the RPC to a different "state", or plant community that develops in response to that interaction. The processes that cause shifts from one state to another are called transition pathways. Before a ecological site can be completely described a state and transition model must be developed. Figure 4 outlines a state and transition model for a grass dominated reference area site.

Long-term data from rangeland reference areas are valuable in developing state and transition (successional) models for various ecological sites. The change in species composition over-time in the presence and absence of disturbance provides insights into the successional pathways of the various plant communities that can occupy an ecological site. The Alberta Rangeland Health Task Group is committed to the development of ecological site descriptions across the province (Alberta Rangeland Health Task Group 1999) and continued monitoring of species composition and forage production in the presence and absence of disturbance on all rangeland ecological sites is essential.

Gaps in the Rangeland Reference Area Program

Six gaps in the rangeland reference area program have been identified.

1. Overlaying the various rangeland reference area sites onto the provincial subregions map (Map 2), shows a good representation of reference areas in all subregions of the province that are extensively utilized by livestock. However, species composition and forage production data needs to be collected and analyzed so that all rangeland reference area programs are consistent across the province.

2. Reference sites in the northern boreal forest need to be expanded to include long-term species composition and forage production data in the presence and absence of disturbance. This long-term data is needed in order to develop Ecological Site Descriptions for Boreal rangelands.

3. Further information on long-term forage and litter production is needed for foothills grass dominated rangelands. Currently, forage production is only being collected at only a handful of sites. A protocol for assessing long-term forage production is attached in Appendix 1.

4. We lack adequate information about the status and biology of Silver Sagebrush (*Artemisia cana*) a species with significant value for many species-at-risk.. Two long-term monitoring exclosure sites are planned for southeastern Alberta to monitor shrub vigor and to document forage productivity on overflow range sites.

5. In order to complete the ecological site descriptions for various range sites forage growth data over the growing season is required. To date only a handful of sites have had forage growth studies completed. A methodology for assessing forage growth is attached (Appendix 2).

6. There is a need to ensure that the technical methods of theRangeland Reference Area Program are consistent with the developing Alberta Biodiversity Monitoring Program (2004,

http://www.abmp.arc.ab.ca/) and the long-term objectives of the Reference area program are consistent with the developing Alberta Biodiversity Strategy (2004, http://internal.gov.ab.ca/srd/biodiversity/)

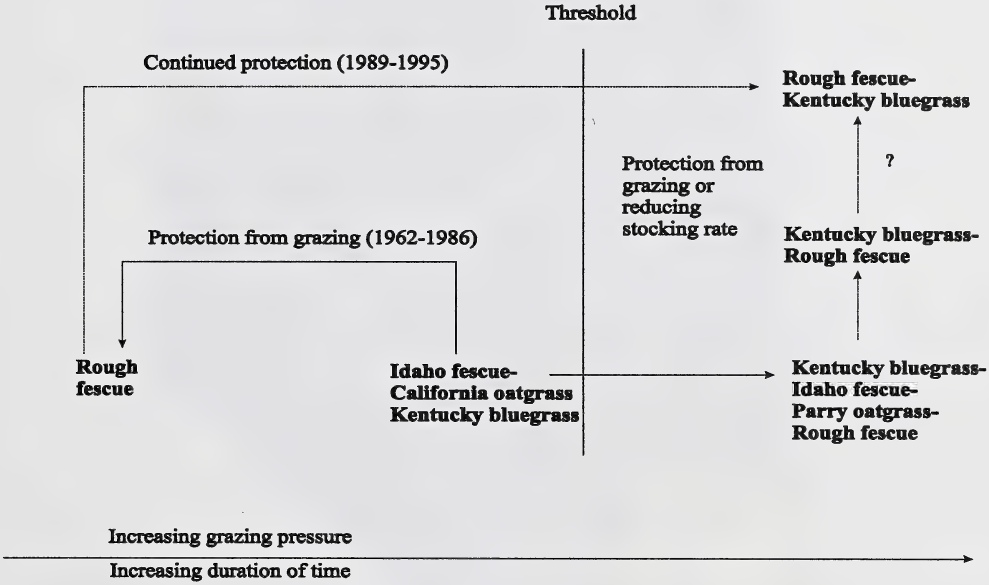
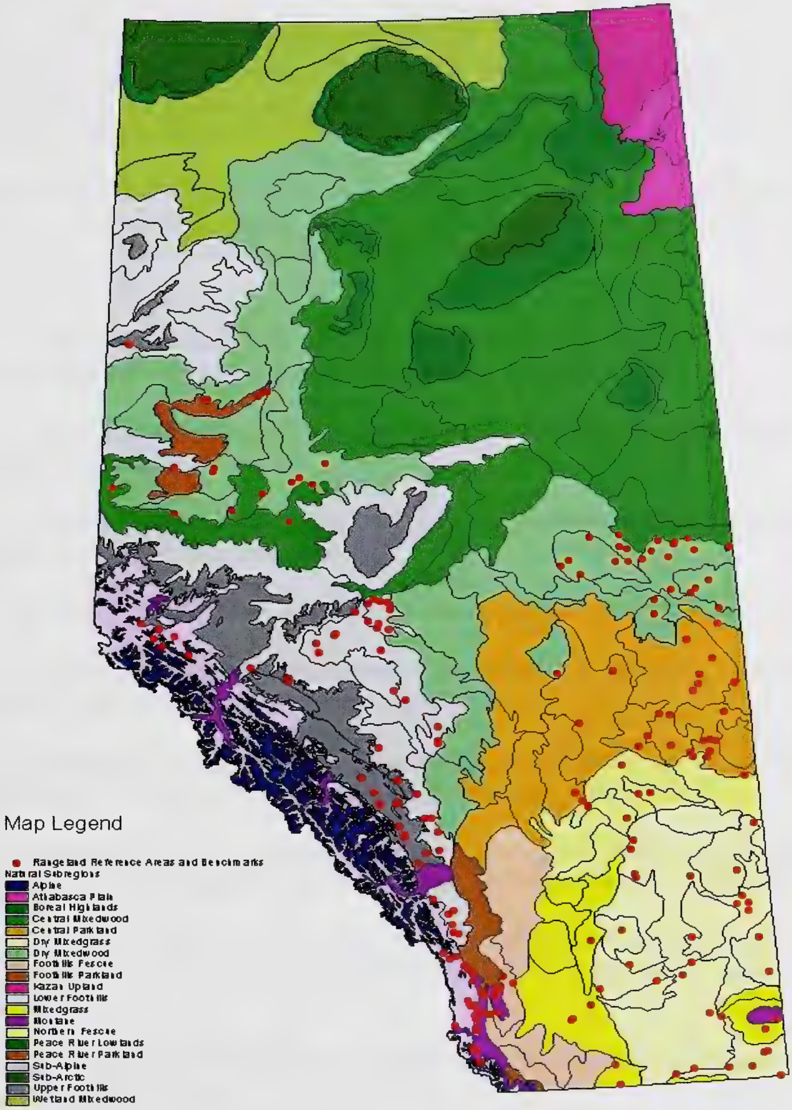


Figure 4. State and transition diagram developed from data at the Castle River Rangeland Reference Area.



Map 2. Rangeland Reference Area Locations and Natural Subregions of Alberta.

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Appendix one:

Methodology for monitoring species composition and forage productivity on native rangelands in Alberta

Objectives

The purpose of collecting vegetation data is to determine if there is a difference in plant species composition and forage production between grazed and ungrazed sites and to examine the successional changes between the two treatments. The specific objectives include:

1. Monitoring range health and long-term range trend based on species composition and productivity.
2. Monitoring the effects of livestock and wildlife grazing on biomass production, rangeland soils and plant species composition.
3. Assist in determining the characteristics of plant community succession in the presence and absence of disturbance for each ecological site.
4. Provide outdoor classrooms and demonstration sites for range managers, ranchers, students and the public.
5. Rangeland reference areas also provide benchmarks on other aspects of rangeland health including, litter, bare ground, community structure and noxious weeds.
6. Reference areas have been a valuable source of data for estimating drought impacts and will help to better understand the effects of global warming in the future.
7. Reference sites have considerable value for the research community by providing a historical record of plant community dynamics and forage productivity.

Methods

Exclosure size

Exclosure should be built with treated wooden posts generally spaced at 3.3 m with three or four strands of barbed wire. The standard shape of existing reference areas is generally rectangular, but some sites have circular exclosures. The minimum size of each new reference area should be no smaller than 20 x 40 m.

Reference areas should be selected from within grazing dispositions on areas that represent plant communities that occupy significant portions of the range landscape, based on gap analysis or identified as of special interest.. The reference sites should not be located near salt or within 30 m of a fence. The preferred distance from a water source should be greater than 300 m but less than 1.6 km.

Location and Plot size

Vegetation transects must be placed in a representative part of the site. For example transects located on slopes must be established parallel to slope contours to ensure similar moisture and nutrient regimes across the transect. Transects should be placed both inside and outside the exclosure. A transect must be 30 meters long with 15 microplots placed every 2 m along the transect. The microplots should be located on the right hand side of the transect

starting at 2 m (Figure 1).

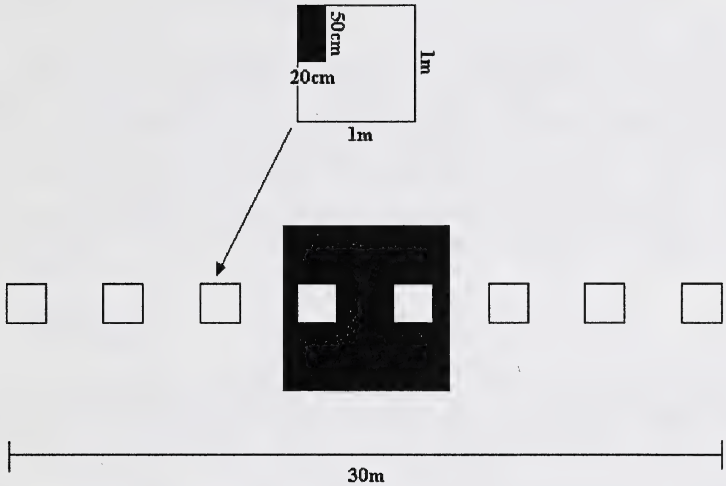


Figure 1. General transect layout for a typical grassland dominated reference area site (Note: 15 quadrats will be measured in each transect).

Forested sites

In forested sites a 1 x 1 m microplot will be used to record the canopy cover of shrubs (<2.5 m in height) and a nested 0.25 m^2 microplot will be used to assess the canopy cover of forbs and graminoids. One 40 x 40 m macroplot located at the centre of the 30 m transect will be used to estimate the canopy cover of trees and tall shrubs (> 2.5 m in height). Trees and tall shrubs will only have to be recorded once in the average % cover column to the nearest 5%.

Grassland and Shrubland Sites

In grassland and shrubland sites a 1 x 1 m microplot will be used to record the canopy cover of shrubs (<2.5 m in height) and a nested 20 x50 cm microplot will be used to assess the canopy cover of forbs, graminoids, moss/lichen and litter cover.

Establishment Procedure

Drive a brightly coloured 1 m metal post well below the frost zone at the ends and middle of each transect. In Aspen dominated types it is preferable to use 2 m steel posts for easy location. The post should be labelled with sub unit (grazed/ungrazed). A sign should be attached to the exclosure with contact information. All reference area sites should be registered

on LSAS with a protected notation (PNT or CNT).

Microplot Measurement

Foliar cover estimates for all other species will be recorded to the nearest 5%; those between 0 and 5%, to the nearest 1%. Foliar cover estimates will be recorded at each microplot on the MF5 or PLD020 form. The plant species (trees, shrubs, graminoids and forbs) will be recorded using a seven letter code composed of the first four letters of the genus and the first three letters of the species (per Moss, E. H. 1983 Flora of Alberta.). If the species is unknown it will be marked on the plot sheet, collected and later identified. If possible all plants should have a species name. The species will be listed on the plot sheet in the following order: graminoids, forbs, shrubs and trees.

Photographs

Photographs should be taken on both the grazed and ungrazed transects every time they are recorded. One closeup of the first quadrat frame and one overall picture should be taken for each transect. Site location and date should be recorded for each picture.

Timing and Frequency of Monitoring

Transects should be recorded when plants are fully grown. This usually occurs from the last week in June to the first week in August. Sites should be monitored a minimum of every three years.

Soils/Site Information

The soils and site characteristics of each reference area should be described. This information should include the following attributes: elevation, aspect, slope, drainage, Lat/Long, description of each soil profile and a classification of each profile to range site, soil series, soil order and subgroup.

Forage Production

Long-term forage productivity and how it is influenced by climate, forest succession and livestock grazing is needed in order to determine carrying capacity for rangelands within the province. The specific objectives for collecting long-term forage production are:

1. To monitor the effect of annual climate fluctuations on primary forage productivity
2. To monitor the effect of forest succession on primary forage productivity in grazed and ungrazed situations.

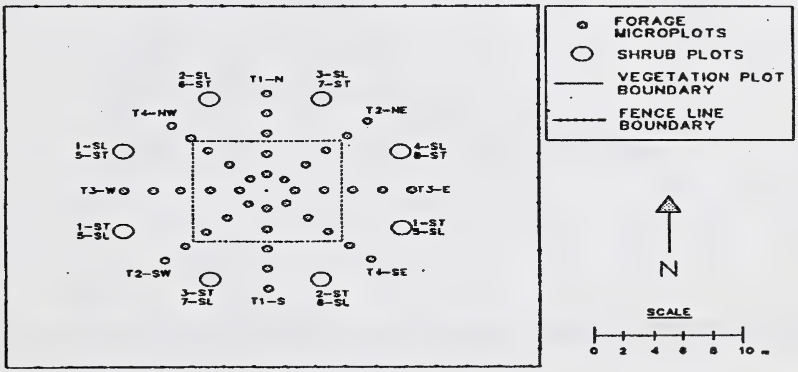
3. To determine if there are any differences in long-term forage productivity between different plant community types.

If time and budget constraints are not limiting clipping forage production by species can be considered. However collecting forage production by life form layer is the most common method.

Forage production by species

This procedure is outlined in detail in Ehlert and Downing (1992). Listed here is a brief description. The 100 x 100 foot sampling area is arranged in a circular arrangement (Figure 2).

Figure 2. Plot layout for obtaining forage production by species.



PLOT DIMENSIONS

Fence dimensions : 36.5 m x 36.5 m
Fenceline length : ± 146 m
Vegetation plot : 10 m x 10 m, oriented N-S and E-W
Shrub plot : 5 m^2 (1.26 m) radius. Centre marked by steel post with aluminum tag labels.
Forage plot : 0.5 m^2 (0.4 m) radius
Forage plot transect: Length 20 m. Direction of sampling rotated @ 45° annually. Ends marked by steel posts with aluminum tag labels.

Four permanent forage sampling transects and 8 permanent 5 m^{2}shrub plots should be established (Ehlert and Downing 1992). In July within each exclosure grasses, forbs, dwarf shrubs and litter will be clipped to ground level in ten 0.5 m^2 circular plots along one transect (Figure 2). In addition leaves will be removed from all medium and tall shrubs in 5 m^2 circular shrub plots from ground level to a height of 2.5 m. The clipped plants and shrub leaf samples are then separated into species, dried for 24 to 48 hours at 55°C and weighed to the nearest 0.1 gram. This forage production should be measured in every year. In October, current annual twig growth will be clipped from all medium and tall shrubs in another 5 m^2 circular plot from ground level to a height of 2.5 m. Again these plots will be separated into species oven dried for 24 to 48 hours at 55°C and weighed to the nearest 0.1 gram. These measurements will be

repeated in every year. .
SL - refers to shrub plots from which leaf biomass samples are collected in years 1,2,3 and respectively
ST - refers to shrub plots from which current annual twig biomass samples are collected in years 1,2,3 and 4 respectively
T - Transects along which forage plots are spaced at 2 m center to center.

Forage production by life form layer

Enough plots should be established to obtain a desired level of measurement. For this project an 80% confidence level and 20% sampling error was adopted (Ehlert and Downing 1992). Using the formula:

$$n=t^2\ CV^2/SE\%^2$$

where n= required sample size
t= t value for 80% confidence (2 tailed t-test)= 1.28 for infinite degrees of freedom
SE%= desired standard error (expressed as %)
CV= coefficient of variation (standard deviation of sample divided by mean of sample) expressed as a percentage

(Avery 1975)

The results indicated that 5 plots was the minimal sample that should be taken for statistical purposes.

Ten 0.5 m^2 quadrats will be clipped to a 1.5 cm stubble height, five inside the exclosure and five outside, annually. Forage production cages are used to protect the forage plots on the outside of the exclosure. Different areas inside and outside the exclosure are clipped every year. All plots should be clipped from the 3rd week in July to the 3rd week of August. Each clipped plot is separated into forbs, grass, shrubs, trees and litter, oven dried for 24 hours and weighed. Monthly precipitation (mm) and daily temperature (°C) are taken from the nearest recording station for each site during the growing season.

Litter production

Litter sampling is accomplished by carefully hand raking the litter from the plot frame, only harvesting materials that grew prior to the current year. Experience will allow you to distinguish currents season material from litter by color and degree of oxidation. Carryover will be pale green or yellow. Litter tends to be more grey in color and oxidized. Litter will often include standing leaves and seed heads. Effort should be made to separate current season materials from prior years growth based on degree of color change and oxidation. Avoid

collecting manure and sticks which will bias the weight estimate. Also avoid collecting lichen, feather mosses or little-club moss which are normally living layers of vegetation.

Data Entry

Species composition

The mean foliar cover of each species over the 15 microplots (grazed, ungrazed) will be entered on Excel or Lotus in the format outlined below.

Spacing for Lotus or Excel file columns are: plot no=7 spaces, layer=2 spaces, species=8 spaces, cover=5 spaces, species=8 spaces, cover=5 spaces, species=8 spaces, cover=5 spaces, species=8 spaces, cover=5 spaces,

(7) **Plot no.**	(2) **layer**	(8) **Species**	(5) **Cover**	(8) **Species**	(5) **Cover**	(8) **Species**	(5) **Cover**	(8) **Species**	(5) **Cover**
lr96i	7	festrub	25.2	phlepra	26.3	poa pra	25.2	festsca	52.3
lr96i	7	dantpar	0.3						
lr96i	6	astelae	25.6	taraoff	25.2	trifrep	1.2	galibor	5.2
lr96i	6	geumtri	0.3	antelan	2.5	astecil	2.1	trifpra	2.3
lr96i	6	haledef	0.1						
lr96i	5	rosaaci	2.0						
lr96o	7	phlepra	3.0	poa pra	0.3				
lr96o	6	galibor	2.0	trifpra	25.0	taraoff	35.1	haledef	12.5

Where layer is:

1=trees
2=understory trees
3=epiphytes (tree lichens)
4=tall shrubs (alder willow)
5=understory shrubs (rose, raspberry)
6=forbs
7=grasses, graminoids
8=mosses
9=lichens

Note: do not exceed a total of 4 (species, cover combinations) per row (for example if you have 5 grass species enter 4 then start a new row for the fifth), start a new row for each layer (make sure the plot numbers are the same for the various layers).

Forage production

It is recommended that forage production be recorded in excel spreadsheets in the format outlined below. This format can be easily analyzed using PROC ANOVA in SAS.

Year	Out=1, In=2	Sample	Grass	Forb	Shrub	Tree	Total	Litter
2000	1	1	85.2	75.0	10.0	5.0	175.2	5.6
2000	1	2	0.0					
2000	1	3	75.2					
2000	1	4						
2000	1	5						
2000	2	1						
2000	2	2						
2000	2	3						
2000	2	4						
2000	2	5						

Data Analysis

Classification

The data for each site will be analyzed using the multivariate analysis techniques of classification and ordination. Classification is the assignment of samples to classes or groups based on the similarity of species. A polythetic agglomerative approach will be used to group the samples. This technique assigns each sample to a cluster which has a single measure. It then agglomerates these clusters into a hierarchy of larger and larger clusters until finally a single cluster contains all the samples (Gauch 1982). Cluster analysis will be performed in SAS and Euclidean distance will be used as the Cluster Distance Measure and Ward's method will be used in the Group Linkage Method. The groupings generated in cluster analysis with be overlain on the site ordination to determine final groupings.

Ordination

Ordination will be used to find relationships among species, communities and environmental variables. Ordination reduces the dimensionality of the data to 1-3 most important axes to which environmental gradients can be assigned. The ordination technique used in the analysis of the monitoring data will be DECORANA (Detrended Correspondence Analysis). Decorana detrends and rescales the axes thereby reducing the arching and compression of axes problems associated with other ordination techniques (Reciprocal averaging, Principle Components Analysis). Once final groupings are determined on the ordination specific environmental variables can be assigned to the variation outlined on the ordination axes.

Analysis of species cover and diversity

Once final groupings are completed foliar cover and measures of species richness and diversity can be analyzed using analysis of variance (SAS) between the various groups outlined. It is recommended that an index of species diversity be used to determine if there is a difference between the plant species diversity of the grazed and ungrazed treatments over time. Peet (1974) provides a good review of the various species diversity indices available. These indices can basically be split into 3 categories 1. Species richness 2. Species evenness and 3. Heterogeneity indices.

Species richness is an indicator of the relative wealth of species in a community (Peet 1974). The problem with measures of species richness is that they are dependent on sample sizes. The larger the sample size the greater the expected number of species.

Species evenness refers to the relative abundance of individuals over the species list. A community with uniform abundance of the species would have higher diversity. It is necessary to know the number of species in the underlying sample universe or community in order to use species evenness indices. This is often impossible to determine for most ecological applications (Peet 1974).

Heterogeneity indices combine both the evenness and richness components. There are two distinct types of heterogeneity indices. Type I indices are those that are most sensitive to changes in the rarest species and type II indices are those that are most sensitive to changes in the importance of the most abundant species (Peet 1974). Peet also recommends that heterogeneity indices be used when the underlying species-abundance relation and the number of species in the universe are unknown.

For this monitoring data it is recommended that a combination of species richness (total number of species), mean number of species/plot, and type I and II heterogeneity indices, be used to assess the plant species diversity across the various treatments over time. A combination of a number of these indices will allow one to determined the underlying species structure of the various treatments. For example if the untreated sites had a high species number and a high value for a type I index (rare species) with a dramatic decline in value of the type II index (common species) compared to the treated plots, would indicate a number of plant species are

being affected by the herbicide treatment. An example of type I and II heterogeneity indices would be Hill's N1 and N2 indices.

Analysis of Forage Production

Data will be analyzed at 5 year intervals using analysis of variance. Differences between yearly production and grazed and ungrazed production will be examined. Relationships between forage production, precipitation and temperature will be explored using multiple regression.

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Appendix two:

Methodology for determining Forage and Nutrient Growth Cycles on Native Rangelands

Background

Rangeland management is only effective if it is practiced within limitations of our knowledge about the rangeland resource. Rangelands are managed under a multiple use philosophy to provide for a full range of resource values and benefits. As the need to intensify management increases, more detailed information and an improved understanding of the range and other resources are essential.

Presently, information about the forage and nutrient growth cycles involving continuous and rotational grazing on forage productivity within Alberta's rangelands is limited. This information is important in order to determine proper turnout dates, length of grazing season, stocking rates, carrying capacities, and forage requirements for livestock nutrient needs, thereby, ensuring their sustainability for wildlife, recreation, timber and livestock.

Objectives

The overall objectives of these forage growth trials will be to:

1. Determine the forage growth and nutrient cycles of grasses, forbs, and shrubs within various rangeland community types.

2. Determine the optimal time and grazing period in order to maximize forage productivity and livestock nutrient demands on native rangelands.

Detailed Project Design

Five treatments will be clipped each year for two years. The clipping treatments are outlined in Table 1. These treatments represent: 1. May growth, 2. June growth, 3. July growth, 4. August growth and 5. September growth.

Treatment	June 1	July 1	August 1	Sept 1	October 1
T1	Clip				
T2		Clip			
T3			Clip		
T4				Clip	
T5					Clip

Each forage growth site will have ten replicates for each treatment and these will be randomized over each year (Table 2). Marked wooden stakes placed at 1 m intervals will identify each treatment by year combination within a block. Each treatment will be

clipped using a 50 x 100 cm quadrat and the components sorted into grass, forbs, shrubs, trees and litter and oven dried for 24 to 48 hours at 55°C.

Table 2. Randomized block design with treatments split by year.

1	T1Y1	T2Y2	T3Y1	T4Y1	T1Y2	T2Y1	T3Y2	T5Y1	T5Y2	T4Y2
2	T2Y2	T1Y1	T4Y1	T3Y2	T2Y1	T2Y1	T5Y1	T5Y2	T1Y2	T3Y1
3	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.
4	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.
5	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.
6	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.
7	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.
8	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.
9	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.
10	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.	etc.

Five levels of a clipping treatment and year will be randomly assigned to 10 blocks within a 40 x 20 m exclosure.

Analysis

Treatments will be analyzed as a split plot in time. Forage growth curves can determined by plotting mean monthly growth over the growing season. Nutrients (Ca, P, ADF, and crude protein) will be analyzed from combined samples for each treatment.