SHIFTING MOSAICS CONSULTING

Peace-Liard Prescribed Fire Monitoring Protocol




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PURPOSE:

To quantify the effects of fire and grazing on BC Ministry of Forests, Lands, Natural Resource Operations, and Rural Development soils, vegetation, and wildlife and the subsequent implications for biodiversity, fuel loads, and interacting ecological processes (fire*grazing).

DIRECTIONS FOR USING THIS PROTOCOL:

This sampling protocol presents the field sampling in an order that matters to minimize destruction of trampling by technicians as plots are being measured because all measurements are taken from within the same permanent plot. These permanent plots are based on permanent transects that are 50 m in length. The order of sampling presented in this text document also corresponds with a data sheet. Use the text document and the data sheets together and go in the order presented during the sampling procedure. If you have questions about particular methodologies please email ShiftingMosaicsConsulting@gmail.com.

OBJECTIVES AND JUSTIFICATION:

1. Vegetation Structure and Heterogeneity: The role of fire, grazing, and fire*grazing interacting can facilitate the development of a gradient of herbaceous vegetation structure across the landscape with varying levels of low, medium, and high structures. This variance is often considered to be heterogeneity (Fuhlendorf et al. 2006) and can be important for biodiversity, especially for bird communities (Hovick et al. 2014; Hovick et al. 2015). A commonly used method for measuring vegetation structure was a pole developed by Robel (1970), which measures visual obstruction and is correlated with biomass, and has been applied in a variety of grassland types (Vermeire et al. 2002). See Figure 1 for an example from a burned and grazed grassland in the central United States.

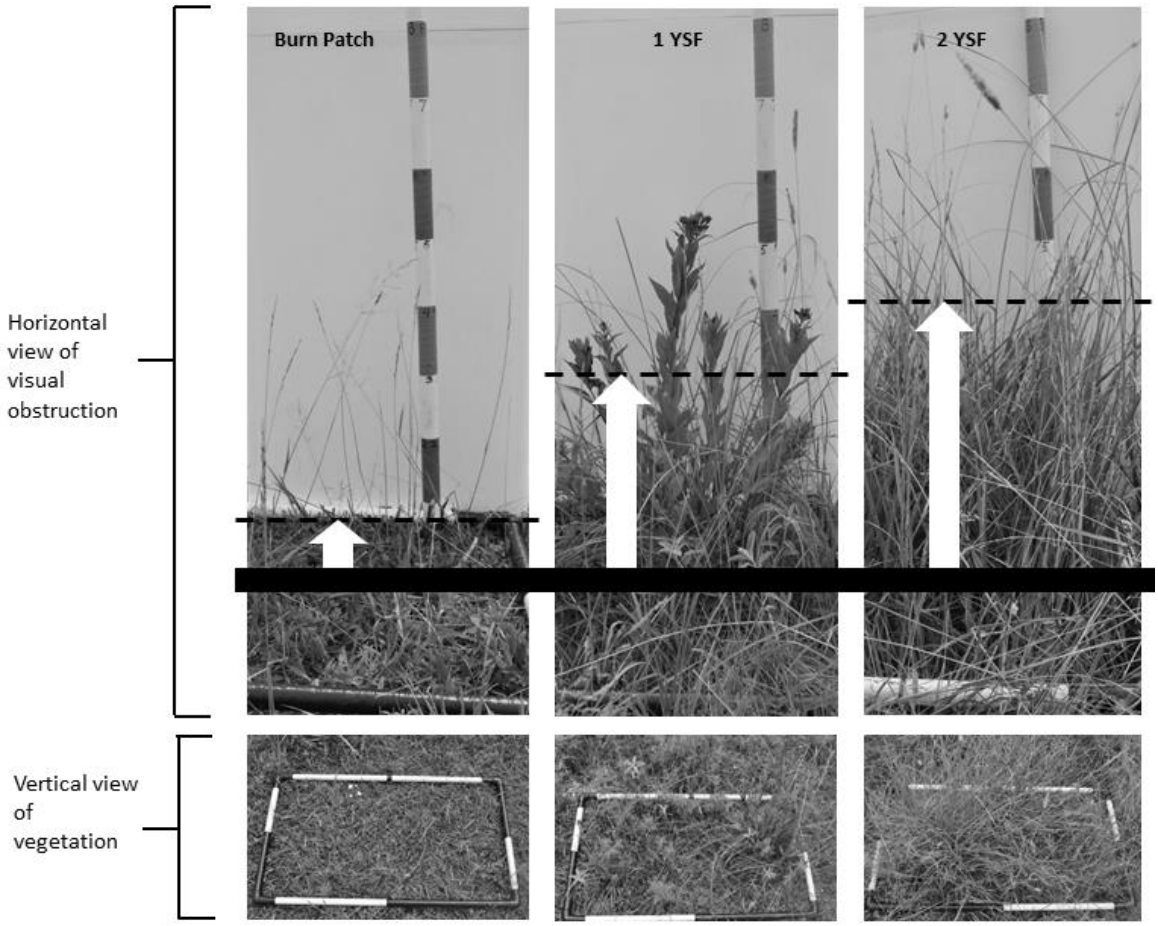

Figure 1. Demonstration of the Robel pole method of measuring visual obstruction in a burned and grazed grassland in the central United States.

2. <u>Community Composition:</u> Fire and grazing can also influence the abundance of plant functional groups and ground covers that fluctuates relative to time-since-fire (Fuhlendorf et al. 2006). Measure plant functional groups and ground cover presence/absence and canopy cover abundance at multiple scales in a nested and hierarchical design. Plant functional groups include: forbs, exotic grass, native C3 perennial grass, native C4 perennial grass, sedge/rush, shrub, tree, and ground covers include rock, bare soil, litter, moss, and lichen. This will use a 50 meter long transect with visual cover estimates and then the determination of presence/absence at one larger 500 m^2 scale along the same transect. We are recommending the visual estimation of canopy cover method over the Line Point Intercept (LPI and related methods) because (1) line intercept type of methods are documented to over-estimate plant cover (Kercher et al. 2003; Korb et al. 2003; Rochefort et al. 2013; Thacker et al. 2015), (2) visual canopy cover estimates are more efficient for technicians to accomplish (almost half the time was required in Rochefort et al. 2013) and thus less expensive in terms of time and money, (3) key plant functional groups and ground cover classes are well suited for visual cover estimates whereas rare plant detection is more ideal for line

intercept methods. The primary issue with visual canopy cover estimation is the potential for observer bias, thus, calibrating technicians prior to starting sampling is critical.

3. Herbaceous Biomass: Measure herbaceous plant biomass to quantify the herbaceous plant materials before fire, after fire, after grazing, or after fire*grazing. This has implications for net primary productivity (NPP), fuel loading, future fire activity, and herbivore demand and nutritional requirements (Busso et al. 2016).

4. Wildlife: All trophic levels of wildlife respond to fire with different preferences relative to time-since-fire. The primary objective for wildlife will be to determine wildlife presence/absence (and occupancy) and use to quantify species responses to fire management, specifically the variability of time-since-fire across the landscape. Use 3 techniques to determine direct evidence of occupancy, indirect evidence of occupancy and abundance, and evidence of use. (1) Direct evidence of presence/absence and occupancy will be accomplished by noting visual confirmation of animals in treated areas (note that this method will be conducted at a broader scale than the next 2 methods described below). This approach, while opportunistic in nature which limits detectability, still will provide an idea of wildlife occupancy as it will require repeated observations at each site over time (Huth et al. 2015). The primary covariate will be time-since-fire and technicians will note observations of wildlife species of interest as they travel to, through, and from treated and untreated areas. This will allow for the modeling of occupancy probabilities relative to fire management including the application of prescribed fire, use of wildfire, or exclusion of fire, all relative to the time-since-fire covariate (MacKenzie et al. 2006). (2) Indirect evidence of presence/absence and occupancy will be accomplished by noting the presence and density of dung identified to wildlife species. The use of line transect surveys of wildlife dung has become an internationally used methodology that is adaptable to a wide spectrum of vertebrate species and can aid management and conservation (Marques et al. 2001). Dung transects have been used to quantify a large guild of wildlife species (> 10) at the species level (Sensenig et al. 2010) and separate groups of species combined with groups of species lumped together (Zavala and Holdo 2005) in Africa and the subsequent response to fires of varying times and sizes. (3) Evidence of wildlife use will be accomplished by documenting herbivory by noting observations of grazing (on graminoids) and browsing (on shrubs). The method will be based on directly observable effects using standardized descriptive classes of field indicators (Albon et al. 2007). Field indicators will have 5 classes and will relate to level of grazing/browsing (None, Light, Moderate, Heavy, and Very Heavy) and will be rated separately for (a) graminoids and (b) shrubs.

5. Soils: Measure the effects on soils, specifically soil organic matter consumption, hydrophobicity, erosion, and texture. This approach is largely based on the "Field Guide for Mapping Post-Fire Soil Burn Severity" a United States Forest Service protocol (RMRS-GTR-243) (https://www.fs.fed.us/rm/pubs/rmrs_gtr243.pdf). This will include the use of

standardized descriptive classes of field indicators for severity ratings for soil surface ground cover, ash color and depth, soil structure, roots, and soil water repellency (aka, hydrophobicity). Guidelines from both technical references have been modified for this customized monitoring protocol. For the soil water repellency test (aka, soil hydrophobicity) we use the NSW Australian standardized test (http://www.www.environment.nsw.gov.au/resources/soils/testmethods/rep.pdf) with one modification of specifying 1 mL of water rather than "1 drop". Measurements of soil erosion are largely based on the rangeland health indicators that pertain to soil erosion as outlined by the US Bureau of Land Management "Interpreting Indicators of Rangeland Health" Technical Reference 1734-6 (https://www.blm.gov/nstc/library/pdf/1734-6rev05.pdf). Finally, it is also possible to use 'erosion pegs' as described in the Australian Northern Rivers Catchment Management Authority's "Fact Sheet 3: Monitoring Erosion" (http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/255156/fact-sheet-3-monitoring-erosion.pdf) if pre-treatment or baseline data is taken and pegs can be established.

METHODS:

1. Vegetation Structure and Heterogeneity: Along each 50 meter long transect, the Robel pole will be used to measure vegetation visual obstruction readings (often referred to as VOR) at 5 regular intervals. The pole will be placed at 5m, 15m, 25m, 35m, and 45m. At each position, a VOR reading will be taken from each of the four cardinal directions (Figure 2). We are proposing to use the original Robel pole design that has 1 decimeter demarcations with observers visually assessing vegetation obstruction from a distance of 4 meters at a visual observation height of 1 meter (Figure 3). These can be built using PVC pipe or wooden rods and a 3.4 cm wide size is suggested. We propose they have alternating white and red bands. The red bands can be marked with red electrical tape and then each band marked with a black permanent marker. The bottom can be secured with hose clamps and large nails so the pole can be fastened to the soil surface for a single observer or, if two observers are available, then one person can hold the pole up while the other person takes the measurements. VOR readings are an indication of the lowest band or interval not completely obscured by vegetation (Figure 4). For example, if bands 1, 2, 3, and 4 are mostly obscured but band 5 is more than 50% visible then we would record a 5 (Figure 3). It should also be noted that we can and do expect to have readings of 0 if the bottom of the pole is visible and the majority (> 95%) of band 1 is visible (see Figure 4 for example). It is also important to not bias the readings by avoiding the placing of the pole in areas of bare ground. The Robel pole is designed to capture the feature of the landscape so observers should place the pole as close to the transect intervals as possible.

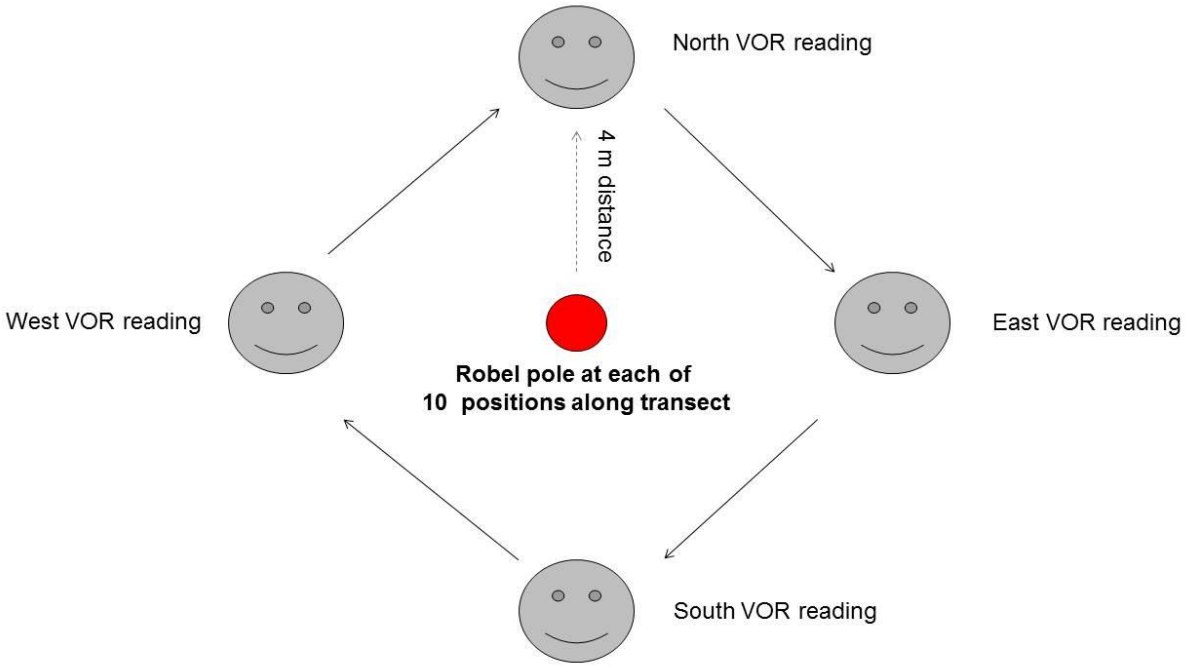

Figure 2. Robel pole readings at each point along the 50 meter transect should include readings from each of the four cardinal directions (North, East, South, and West). This corresponds to the entries in the data sheet.

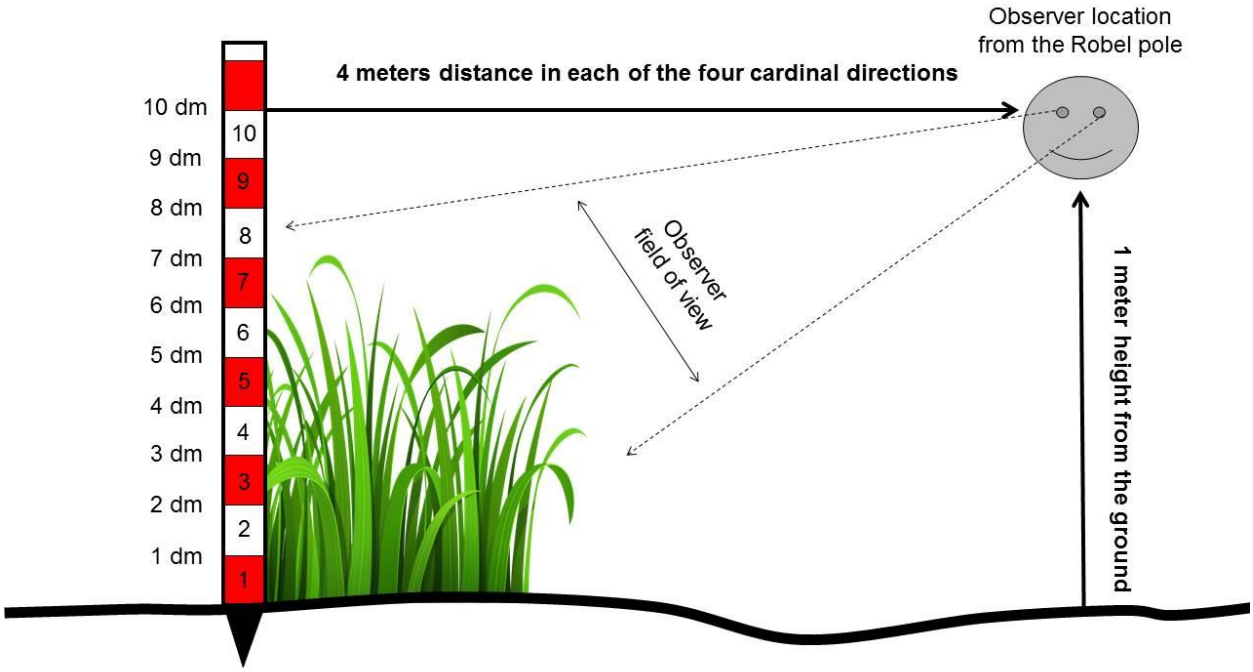

Figure 3. Robel pole with 1 decimeter demarcations and observer position relative to the pole.

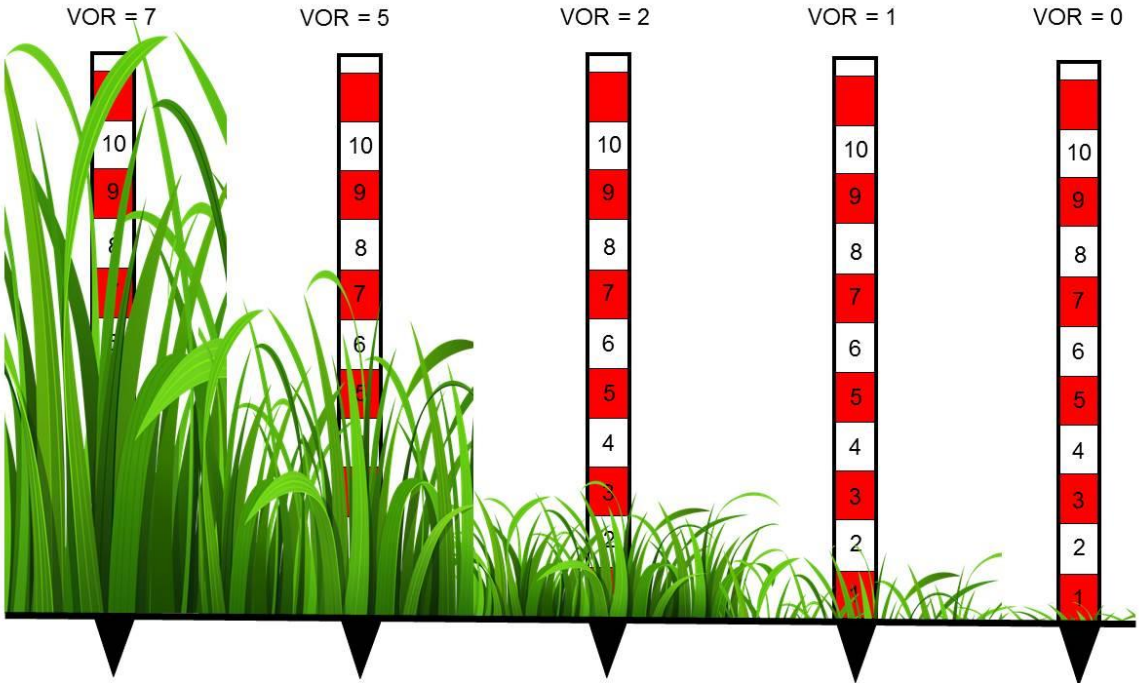

Figure 4. Robel pole examples for determining visual obstruction readings. Note that 0 can and is expected to be a value.

2. Community Composition: We recommend the use of a five - 0.5 m x 1.0 m quadrats placed at equal distances along a 50 meter length tape (Caratti 2006 suggests a minimum of five transects for herbaceous plants). This quadrat size is equivalent to a 0.5 m^2 sampling area per quadrat. This sampling size is ideal for productive grasslands and parks and allows for the detection of shrubs and herbaceous species simultaneously. We recommend estimating 7 plant functional groups and 5 ground cover classes. We suggest the Daubenmire cover class scale with 6 cover classes that are based on the mid-point of each and are designed to collect rapid (and a 0 class for absence) and spatially robust data (Table 2) (Daubenmire 1959). Due to the overlapping plant and ground layers, the sum of the Daubenmire cover classes can and will exceed 100%. From the 50 meter length tape, we also suggest doing a presence/absence inventory from a distance of 5 meters on both sides of the 50 meter tape measure to quantify if any of the other plant functional groups occur at a larger 500 m^2 scale. This nested approach is robust for the detection of less abundant plant species, plant functional groups, or trees in the overstory. On the data sheet, we also suggest that staff determine if there are any problematic plant species that they want to itemize out. These can be placed in the 5 empty fields below the plant functional groups and ground covers list that is in the first column. Examples of such species might include Canada thistle (*Cirsium arvense* (L.) Scop.), yellow toadflax (*Linaria vulgaris* Mill.), or spotted knapweed (*Centaurea stoebe* L.).

Table 1. Plant functional groups and ground covers.

Plant Functional Groups	Ground Covers
Forbs	Rock
Exotic grass	Bare soil
Native C3 (cool-season) perennial grass	Litter
Native C4 (warm-season) perennial grass	Moss
Sedge/Rush	Lichen
Shrub	
Tree	

Table 2. Daubenmire canopy cover classes

Cover Class	Range	Midpoint
0	Not present	None
1	>0 to 5%	2.5%
2	5 to 25%	15.0%
3	25 to 50%	37.5%
4	50 to 75%	62.5%
5	75 to 95%	85.0%
6	95 to 100%	97.5%

3. Herbaceous Biomass: Four randomly selected plots will be clipped, weighed in the field, dried, and weighed in the lab. We recommend weighing in the field (aka a "green weight") just in case something happens to the samples so the data can be preserved and potentially still informative. We recommend using a 0.5 m by 0.5 m quadrat which is equivalent to a 0.25 m^2 sampling area per quadrat. To determine random plots, the vegetation sampling quadrat will be thrown from the starting pin and the ending pin along the permanent monitoring transect to both sides of the transect. Because we are concerned with both forage and fuel, we suggest clipping all standing herbaceous biomass (both living and dead) and not clipping any shrubs or cacti. All herbaceous plants that are clipped should be identified to plant functional group if possible and noted. Clipped plant material should be placed in a paper bag. Dry plant material in an oven for 24 hours at 60 °C. If a drying oven is not available, air dry for at least 48 hours. Once biomass has been dried, it should be re-weighed and converted to kg per hectare.

   Conversion to kg/ha example: Consider a clipped dry weight from a 0.25 m^2 quadrat was 90 g. Divide 90 g by 0.25 m^2 to determine g/m^2. This equals 360 g/m^2. Then divide by 1000 g to convert to kg/m^2. This equals 0.36 kg/m^2. Then multiply by 10,000 m^2 to convert to kg/ha. This equals 3,600 kg/ha. To simplify this conversion, simply divide by 0.25 and multiply by 10.

4. Wildlife
    a. *Visual Occupancy:* Technicians will note the number of key wildlife species that are noted within a treated area as they travel to, through, and from plots in portion 4a of the data sheet. Similarly, if species are noted outside of a treated area then that should also be noted along with pre-treated areas. This sampling method relative to the permanent plots for which all sampling is based is demonstrated in Figure 5. If additional space on the data sheet is needed due to a lot of wildlife sightings, please use the back of the data sheet.

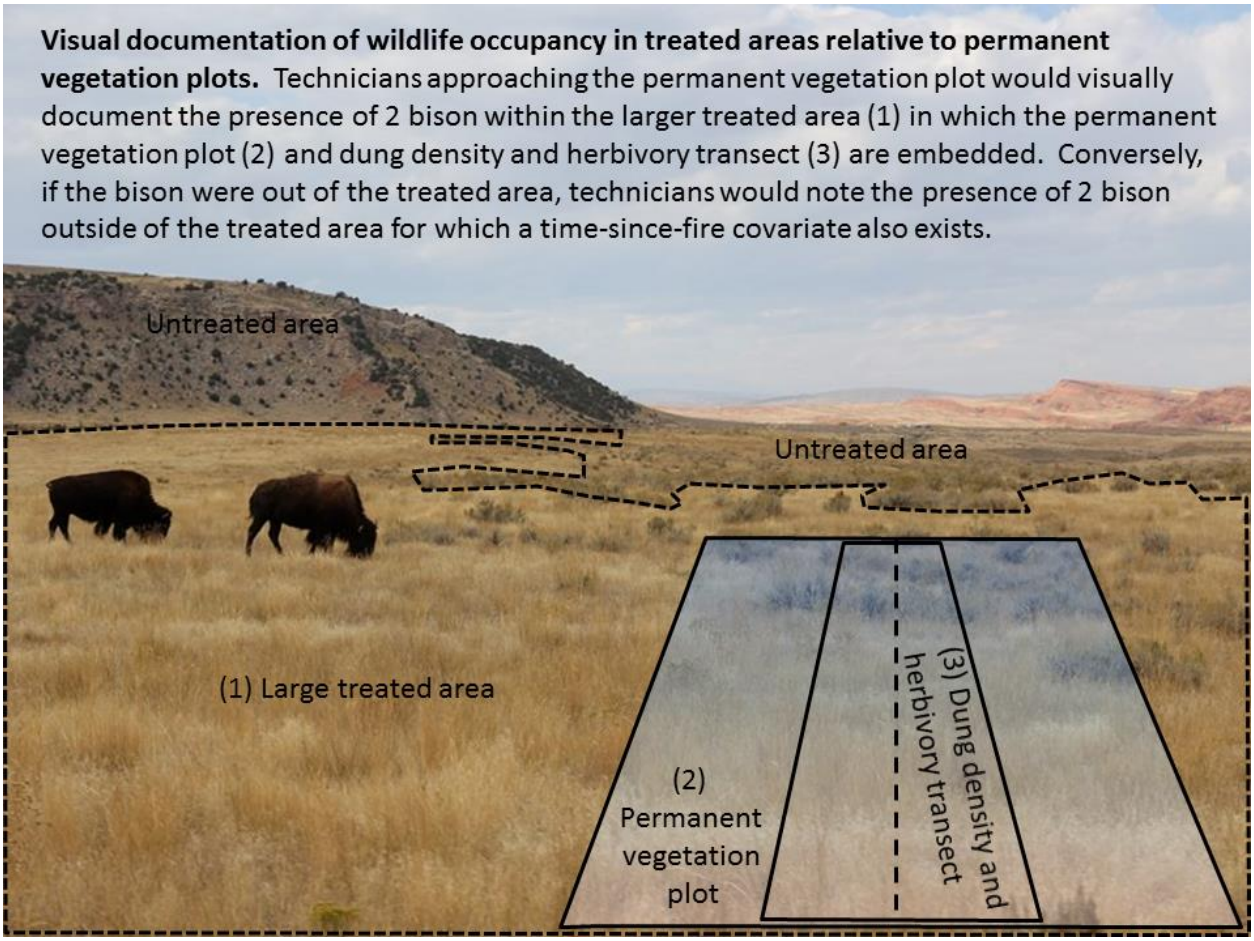

Figure 5. Wildlife sampling protocol relative to landscape scales at which treatments are applied and animal occupancy/presence is noted and plot scales at which dung density and herbivory are noted.

    b. *Dung Transect:* Technicians will begin on the left side of the tape and will walk a belt transect 2m wide down the length of the 50m transect. While walking, mark each individual dung pile for each wildlife species of interest in portion 4b of the data sheet. Once the left side of the transect is complete, do the same method on the right side of the transect. Note that in portion 4b of the data sheet, 4 blank rows are available to note wildlife species other than deer, elk, and moose.

You may also consider small animals such as rabbits and domestic livestock such as cattle.

c. *Herbivory:* Using the 4c portion of the data sheet, technicians will use visual field indicators to rate herbivory at 3 portions along the 50m transect at 0m, 25m, and 50m. At each point, herbivory will be separately rated for graminoids (all grasses, sedges, and rushes combined) and for shrubs. The rating index has 5 classes including None, Light, Moderate, Heavy, and Very Heavy. Descriptions for each are provided in Table 3.

Table 3. Descriptions of visual field indicators of grazing/browsing to be used for separate assessments of graminoids then shrubs in each permanent plot.

None	Light	Moderate	Heavy	Very Heavy
No noticeable removal of graminoid or shrub vegetation.	Some individual plants lightly browsed or grazed. Individuals that were not browsed or grazed are abundant. Browsing is limited to new leader tips and grazing is limited to palatable species.	For graminoids, approximately 50% of the available biomass is removed. For shrubs, new leader tips have been largely removed.	All accessible plant material has evidence of browsing/grazing. No unbrowsed individuals. More than 75% of available graminoid biomass removed.	All accessible plant material has evidence of browsing/grazing. No unbrowsed individuals. More than 90% of available graminoid biomass removed.

5. Soils

A scale of Low, Moderate, and High soil burn severity will be used for ground cover condition, ash color/depth, soil structure, and roots (Table 4). For pictures of each soil burn severity rating, we suggest referring to the "Field Guide for Mapping Post-Fire Soil Burn Severity" a United States Forest Service protocol (RMRS-GTR-243) (https://www.fs.fed.us/rm/pubs/rmrs_gtr243.pdf). For soil water repellency, use a standard water dropper that can load 1 mL of distilled water at a time. In a level spot, gently scrape away any ash to expose the soil surface. Drop 1 mL of distilled water from the water dropper to the soil surface form a height of 1.5cm. If the drop forms a beaded and spherical shape that is sitting on top of the soil surface without penetrating the soil and disappearing, this is an indication of soil water repellency (hydrophobicity). From the time the water is dropped, record the length of time to disappearance using the 5 categories in Table 5. Finally, note the presence of rills, gullies, or pedestals. All soils estimates will be conducted at 0m, 25m, and 50m along the permanent transect.

Table 4. Soil burn severity ratings for 4 soil features.

Feature	Low	Moderate	High
Ground Cover Condition	No change to < 50% litter consumption relative to pre-fire conditions	50 to 80% litter consumption with recognizable leaves/needles	Little litter to no litter remaining; generally no recognizable leaves/needles
Ash Color/Depth	Black ground surface but ash not measureable	Thin layer of black/ gray ash (0.5cm to <3cm depth)	Thick layer (3 to 6cm) of powdery gray to white ash
Soil Structure	No change, no consumption of organic matter in top 1cm of soil	Structure slightly altered with some organic matter in top 1cm	Aggregate stability destroyed. Loose and single grained soil dominates. Organic matter consumption in the top 5cm of soil.
Roots	Fine roots (<0.25cm diameter) intact and unchanged	Fine roots (<0.25cm diameter) charred/scorched. Large roots (0.25 to 0.5cm diameter) intact.	Most fine roots consumed/charred with some charring on very large roots (0.5 to 8cm diameter)

Table 5. Time to water disappearance and soil water repellency rating.

Time to disappearance	Repellency
<1 second	None
1 to 10 seconds	Very Low
10 to 50 seconds	Low
50 to 260 seconds	Moderate
>260 seconds	Severe

Field Sampling Protocol: All of the methods are arranged in a single permanent plot design as shown in Figure 5. All sampling will be conducted in the same permanent transect.

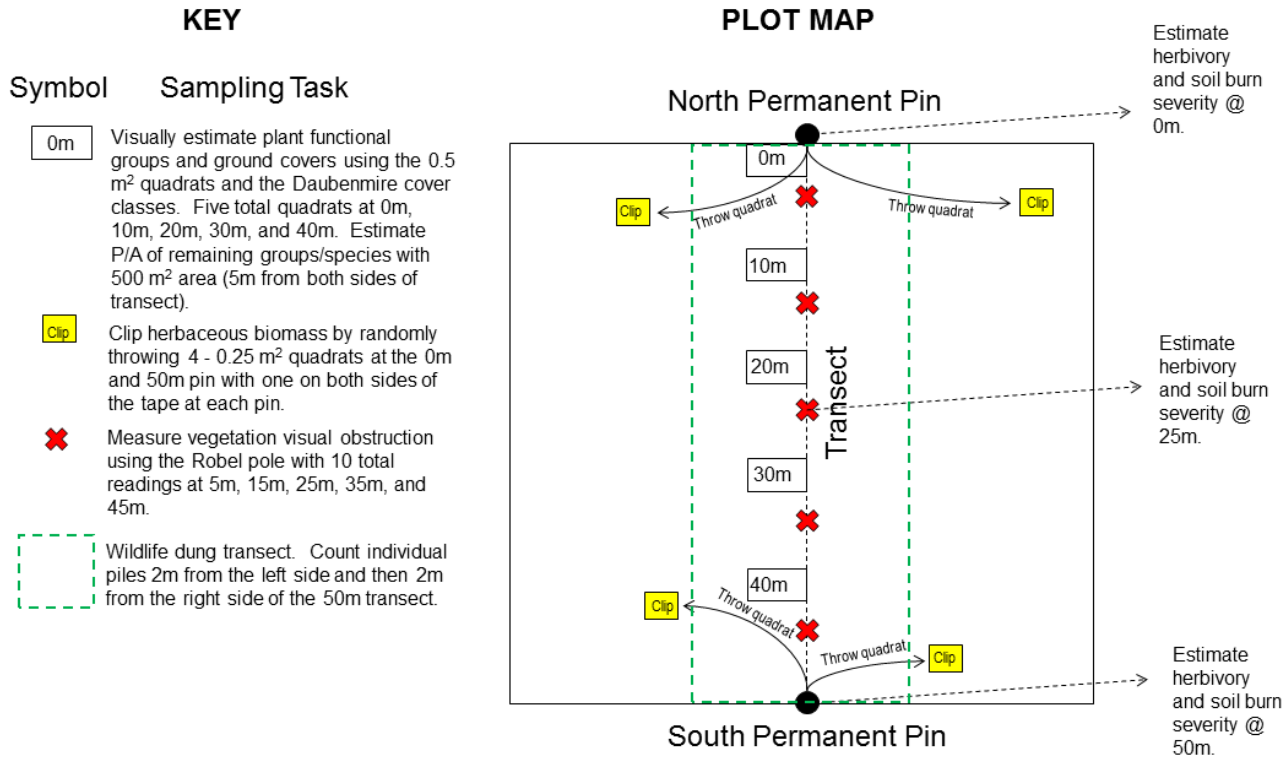

Figure 6. Sampling plot design.

Table 6. Steps to complete the monitoring protocol.

Step	Description
1	On the data sheet, note the observer, date, and site code.
2	Note the relevant fire, grazing, and fire*grazing interaction metadata.
3	Mark the North point with the GPS. Secure the 50 meter long tape to the ground with a pin and using the GPS stretch the tape completely out by walking directly to the south. Pin the end of the tape and mark the South point with the GPS.
4	Begin at the 5 m point along the transect and prepare the Robel pole. At this point, either stake the pole into the ground or have an assistant hold the pole. Record 4 visual obstruction readings (VOR) at the 5 m location by viewing the vegetation visual obstruction from the North, then the East, then the South, and finally the West. Now move to the 15 m point along the transect and repeat. Continue to repeat at 15 m, 25 m, 35 m, and 45 m. Record all VOR readings in the data sheet in Section 1 "ROBEL POLE MEASUREMENTS OF VEGETATION STRUCTURE".

5	Now you will visually estimate plant functional group and ground covers. This will require the reading of 5 quadrats. The first 0.5 m^2 quadrat is placed at the 0 m mark and the short side of the quadrat will extend to the 0.5 m mark. The second quadrat is placed at the 10 m mark and extends to the 10.5 m mark. The third, fourth, and fifth quadrats are similarly placed at the 20, 30, and 40 meter marks. In the plot map (Figure 5), these are the white boxes.
6	In each quadrat, visually estimate all of the plant functional groups and ground covers found in Table 1 by using the Daubenmire cover classes found in Table 2. These are all recorded in the data sheet in Section 2 "VISUAL COVER CLASS ESTIMATES".
7	Now, you will walk 5 m along each side of the transect to note the presence of any other functional groups that were not noted in the 0.5 m^2 quadrats above. This is also the time to note any exotic/invasive plant species and any tree species that may have not been detected in the 0.5 m^2 quadrats.
8	Return to the 0 m point on the transect and throw the 0.25 m^2 quadrat to the left. Clip all of the herbaceous biomass down to the soil surface level. Place in a paper bag and obtain a weight wet and record on the data sheet in Section 3 "CLIP HERBACEOUS BIOMASS ESTIMATES". Repeat this process by throwing the 0.25 m^2 quadrat to the right side, then go to the 50 m mark and again repeat this process by throwing the 0.25 m^2 quadrat to the left, clipping and bagging, then throwing to the right and clipping and bagging.
9	Store all herbaceous biomass samples for transport to a drying oven and re-weighing. All wet and dry weights should be noted in the corresponding data sheet.
10	Now you will go to Section 4 "WILDLIFE" on the data sheet. In Sub-section 4a of the data sheet, note any wildlife species you have seen traveling to or through the treated area. When you leave, if you see wildlife record that here.
11	In Sub-section 4b of the data sheet, you will now record data for the wildlife dung transect. Starting at the 0m mark along the transect, walk along the left side of the transect and record all individual dung piles by species until you reach the 50m mark. Now, turn around and walk down the other side of the transect and record the same thing until you reach the 0m mark again.
12	In Sub-section 4c, you will now rate grazing and browsing herbivory at the 0m, 25m, and 50m marks along the 50m transect. Use the 5 point rating index and note None, Light, Moderate, Heavy, and Very Heavy.
13	In Section 5 "SOILS", you will now rate the soil burn severity. For the first four estimates (Ground Cover Condition, Ash Color/Depth, Soil Structure, and Roots) you will use the Low, Moderate, High severity index. For Soil Water Repellency, you will conduct the water disappearance test using 1mL of distilled water dropped from 1.5cm onto exposed surface soil and will record the time it takes for the soil to disappear into the soil. For Rills, Gullies, Pedestals, you will need to note if any of these features occur. All soils features are to be estimated at the 0m, 25m, and 50m marks along the 50m transect.
14	Review the data sheet to make sure that sampling was conducted for all 5 sections.

Site Metadata:

We suggest that staff use a standardized approach to developing site codes based on metadata. While we are not intimately familiar with the study area, we do suggest that this incorporate some combination of known explanatory variables including site location, year of sample, burned/unburned, and transect #. An example might be something like the following: North Pasture, 2017 sampling, burned, transect number 1. The resulting site code would be: NP-17-B-T1. Additional covariates that could be considered would be aspect and we recommend at least 3 replications per aspect per burn unit to allow for the quantification of variance both within and across aspects.

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