Elk Impacts at Fossil Butte National Monument:
Recommendations for Aspen and Tall Shrub Habitat Monitoring

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Context:

Fossil Butte National Monument (hereafter, FOBU), located in southwest Wyoming, is an 8,198 acre (3,318 ha) federal reserve established in 1972 to preserve, "…outstanding paleontological sites and related geological phenomena…" As a unit of the National Park System, FOBU is required to, "…conserve the scenery and the natural and historic objects … in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." (NPS Organic Act 1916). There is concern that perceived harboring of Rocky Mountain elk in response to hunting pressure on adjacent lands, predominantly during winter, could result in degrading vegetation within the monument. A fenced perimeter at FOBU restricts access by domestic livestock to brief crossing periods in the spring and fall, although this low fence presents no serious impediment to elk access. An elk migration study centered on FOBU was conducted in 2005 and a preliminary report was submitted (Olexa 2010). Though this work did not directly examine habitat conditions it did focus on annual migration patterns of area elk herds. Utah State University was awarded a cooperative agreement to work with NPS to develop a comprehensive aspen habitat monitoring plan, as well as make recommendations for assessing the broader tall and short shrub landscapes at FOBU.

Objectives:

1. Report on findings of the 2015 preliminary survey of aspen conditions related to elk use at FOBU.
2. Present a scientifically defensible framework for long-term aspen and tall shrub monitoring.
3. Make recommendations for a comprehensive vegetation survey at FOBU.
4. Outline expected education outreach plans addressing broader Cooperative Ecosystem Studies Unit (CESU) program goals.

Elk Use of Aspen Regionally and Locally:

Quaking aspen (*Populus tremuloides* Michx.) is very widespread across North America, from the subarctic to central Mexico and from the Atlantic to the Pacific oceans (Preston 1976). As such, the species is highly adaptable to a variety of environmental conditions. Aspen forests are also recognized as among the most biodiverse systems, second only to riparian areas, in the Rocky Mountain West (Chong et al. 2001). A recent classification divides aspen systems by their "functional types" for the purpose of recognizing their diverse ecology to inform appropriate management (Rogers et al. 2014). Recognition of ecologically-based aspen types provides a basis for anticipating trends related to climate changes. For example, seral aspen types subject to wildfire may see increasing opportunities for expansion under prolonged drought scenarios (Yang et al. 2015). Conversely, stable aspen types (i.e., where aspen dominates long-term) subjected to intense ungulate herbivory may collapse where drought predominates (Rogers and Mittanck 2014). Initial observations at FOBU suggest that both "montane seral" and "terrain isolated" stable aspen forests (Rogers et al. 2014) are present. Thus, we should be aware of the basic ecology driving specific aspen types, as well as the key disturbance factors that affect these systems.

Throughout the Rocky Mountain West, ungulate herbivory is a primary issue of concern for sustaining aspen communities (Rogers et al. 2013, Seager et al. 2013). Within National Parks there is a rich literature, dating back nearly a century, documenting elk impacts to aspen groves (Murie 1951, Olmsted 1979, Wagner 2006, Zeigenfuss et al. 2008). In brief, relatively short-lived quaking aspen reproduce primarily via asexual root "suckering." This reproductive strategy may occur continuously, though it is often punctuated by mass sprouting events following disturbance (Schier et al. 1985; Rogers et al. 2014). Interruption of this reproductive pattern results in a loss of "next generation" stems to replace mature trees that regularly die from a large variety of pathogens, insects, and physical damages wrought by animals and weather. Continuous browsing of suckers, for years and even decades, by either domestic or wild ungulates constitutes a prime factor toward ultimate collapse of aspen ecosystems (Rogers and Mittanck 2014). As a keystone species (Campbell and Bartos 2001), aspen-dependent plants and animals are expected to decline in the wake of aspen loss (Rogers and Ryel 2008). Of particular concern pertaining to FOBU, are the combined effects of climate warming and elk herbivory where relatively dry-site, low elevation, aspen communities are most susceptible to system collapse (Rogers and Mittanck 2014). A complex of drought, insects, disease and subsequent diminished physiological capacity has been implicated in broad continental patterns of mature tree aspen decline (Worrall et al. 2013). In the absence of viable regeneration due to prolonged, unencumbered, browsing we would expect to witness additional aspen die-offs (Rogers and Mittanck 2014). Finally, on private lands and reserves where apex predators are limited and hunting is not permitted, ungulates may find safe haven and often browse aspen to a greater degree than on surrounding lands (Zeigenfuss et al. 2008, Rogers et al. 2015).

Anecdotal observations from FOBU staff (Arvid Aase, email 11/27/15) indicate that, a.) elk use of FOBU was much lower, perhaps nonexistent, prior to the 1990s; b.) visual estimates of winter elk herds since 2003 have ranged in size from 300-500 animals, with more recent observations of > 500 at FOBU; and c.) observations suggest that winter elk use fluctuates greatly on an annual basis, but also diurnally with many elk leaving the monument at night and returning by day as a refuge from hunting or other human encounters. Staff also cautioned that observations were conducted mainly from the visitor center and therefore do not necessarily represent elk movements and use in large portions of FOBU obstructed by the central butte ridgeline. The Olexa (2010) elk movement for FOBU report is quite brief and a more comprehensive report based on Olexa's datasets is expected from Dr. Tabitha Graves (USGS, West Glacier, MT) in the coming months. Within this context, we wished to further understand patterns of elk impacts on plant communities at FOBU.

Preliminary Surveys – 2015

Description

We made four visits to FOBU during the spring and summer of 2015. Upon each visit we contacted monument staff; on three of four visits we conducted field tours. Discussions regarding project objectives and aspen/elk conditions were held with each of the three Superintendents during this period: Nancy Skinner (Retired), Brad Shattuck (Acting), and Angela Wetz (current). Field activities consisted of observations at 12 separate aspen locations using three levels of survey intensity: (a) visual inspection and field notes – 6 stands; (b) inspection, field notes, and GPS location – 3 stands; and (c) same as b, plus transect data collection – 3 stands. At the most intensive sites (type c) we tested several procedures anticipated for a FOBU-wide aspen survey (i.e. stem counts, pellet surveys, qualitative assessments). The map shown here provides locations of the preliminary survey points (Fig. 1).

In addition to survey locations within FOBU, we visited an aspen grove 0.5 km north of the monument near a spring converted to a cattle water trough. This small linear grove (~0.5 ha) showed intense localized impacts adjacent to the water source, but the remainder (~75%) of the grove displayed ample aspen recruitment. A summary of all locations is presented in Table 1.

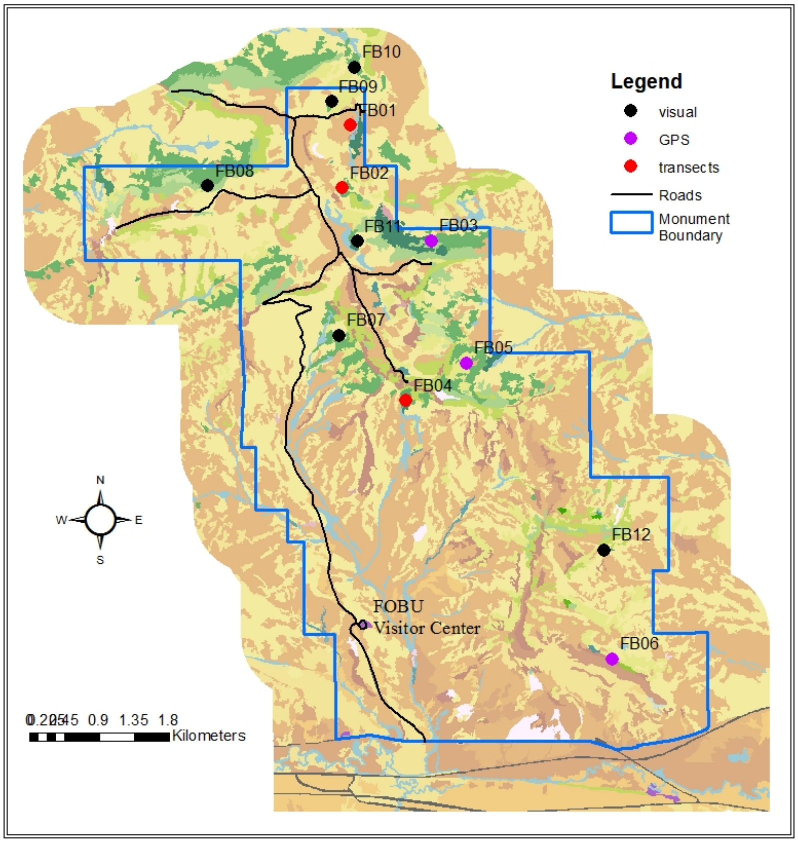

Figure 1: Preliminary aspen survey points projected onto vegetation map of Fossil Butte National Monument, Wyoming. Green shades represent forest (predominantly aspen) and tall shrub communities. Symbols correspond to plot numbers shown in Table 1. Red = transects, data collection, GPS, field notes; Magenta = GPS, field notes; Black = visual, field notes.

Table 1: Locations and conditions of prelimary aspen survey points, Fossil Butte NM, Wyoming.

Plot#	Type	GPS x	GPS y	*Browse %	**Recruit. / ha	Condition Description
1	visual/data	518937	4638139	59	2333	moderate; dying overstory, ample recruitment
2	visual/data	518763	4637330	87	667	moderate; cattle and elk damage
3	Visual/GPS	519683	4636514			poor; heavy shrub cover, little recruitment
4	visual/data	519526	4634496	100	0	poor; trees scarred, very heavy elk scat count
5	Visual/GPS	520178	4624864			poor; leaf blight, elk scat, little recruitment
6	Visual/GPS	521721	4631852			moderate; narrow strip, mostly 1-2 m stems
7	Visual					good; scat abundant, recruitment good
8	Visual					moderate; heavy shrub cover, recruitment
9	Visual					poor; small stand, little recruitment
10	Visual	outside FOBU fence				moderate; heavy cattle trampling localized
11	Visual					moderate; heavy browse, still recruiting
12	Visual					poor; near spring, little regen./recruit.

* Browse % = the percentage of regeneration (< 2 m ht.) with terminal buds browsed.

** Recruit./ ha = aspen stems > 2 m ht., but < 8 cm dbh and < ht. of canopy stems.

Preliminary Results and Observations

Most sample locations displayed moderate-to-poor conditions, overall, though aspen stem recruitment—a critical variable of long-term browse sustainability—was highly variable. Visual and actual pellet counts suggest that elk presence is moderately high to very high. We only conducted an actual area-based pellet count at one location (#4), however this is the highest recorded density of elk by the principle investigator ever (4667 distinct pellet groups/ ha). (This site was specifically "targeted" for sampling based on FOBU Supervisor (Skinner) observation that elk congregated in this area.) Figure 2 displays tally of regeneration (aspen stems < 2 m ht.) and recruitment (stems > 2 m ht.) on three survey locations in comparison to browse rates at FOBU. While these data are inadequate for conclusive landscape characterization, they do illustrate two important points. First, in situations where browsing is moderate-to-heavy there may be ample regeneration (Fig. 2a) but few aspen stems achieve recruitment status (Fig 2b). If this persists, when mature aspen begin to die there will be a decrease in root system carbohydrate reserves, decreasing suckering ability, and an eventual thinning and dying of entire clones and stands. Secondly, these initial surveys show high browse rates (60-100%); previous research has established that persistent annual browse rates of greater than 30% will cause long-term aspen decline (Olmsted 1979). More recently work from California recommends maintaining aspen on the landscape by adhering to a 20% annual browse limit (Jones et al. 2005). On average, our three browse samples easily exceeded recommended levels, yet we observed ample evidence of adequate recruitment on many sites, too. Resolution of this apparent inconsistency begs for a more thorough tracking of aspen conditions across the FOBU landscape. The most probable explanation is that there are habitat conditions that attract elk in to some locales more than other, or perhaps alternative forage that is superior to aspen suckers. One hypothesis that we are toying with is that serviceberry, which is highly abundant at FOBU, may be an alternative food source for elk. Certainly our casual observations suggested that abundantly "pruned" serviceberry were quite evident.

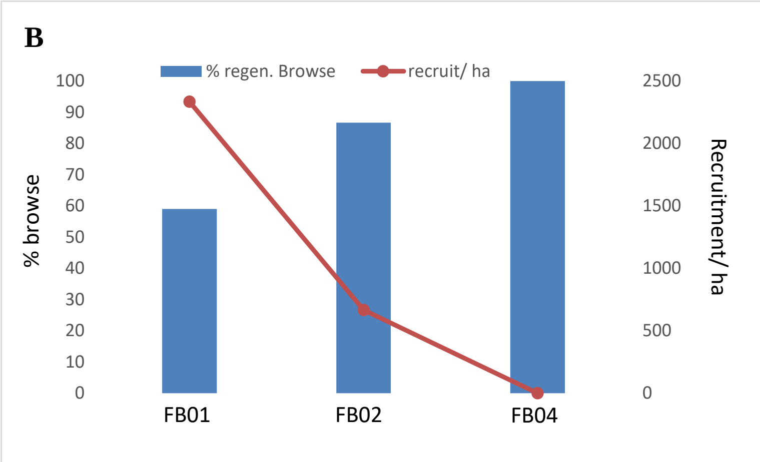

Figure 2: Results from preliminary survey of juvenile aspen conditions at three locations at Fossil Butte National Monument, Wyoming. Site numbers correspond to those in Fig. 1 and Table 1. A) regeneration (stems < 2 m ht.) of aspen is positively related to browse level, and B) recruitment (stems > 2 m ht.) is negatively related to browse level.

Proposed Methods for Landscape-wide Aspen/Tall Shrub Monitoring

Because there is concern that elk may be depleting vegetation including aspen communities, our central objective is to present a framework for statistically defensible monitoring of this habitat component at FOBU. Secondarily, via suggestion of NPS staff and personal observations, a hypothesis has arisen that tall shrubs—woody species adjacent to and within aspen stands (e.g., serviceberry, willow, etc.)—play an import part in elk diets and may dissipate or exacerbate potential impacts to aspen communities. Below we outline key components of a systematic landscape monitoring program with these objectives in mind. To be clear, the framework proposed defers many details of monitoring implementation to the discretion of the research team that eventually implements the baseline survey (i.e., likely a master's research committee, graduate student, and undergraduate technicians). Whatever methods are ultimately selected will be vetted on the basis of their ability to be accurately repeated by future monument staff (assuming budgets for periodic monitoring are available) with a basic level of training and quality control. Earlier we reviewed several approaches to aspen and tall shrub monitoring (Rogers, 2015), but favored a basic elk impact/use method that would be most repeatable by agency personnel, economical (i.e. avoiding expensive lab time), and scientifically credible.

Broadly, implementation of a vegetation monitoring program has two basic components: a landscape design which is statistically representative of the entire target community and a standardized set of plot-level measures recognized by published studies for characterizing sample units (e.g., 1 acre, 1 hectare, a forest stand). The combination of these components provides a credible, flexible, mechanism for landscape description and mapping, statistical analysis, comparison between survey points or stratified groups, and extrapolation of data to total area of, for example, aspen coverage.

Study Design

The study design details an objective sample location method. In the case of large-scale vegetation surveys, a framework for plot selection strives to represent a diversity of conditions by implementing a selection process using GIS or maps in the office setting. Selection of sample locations while in the field carries the high potential of inserting bias into the monitoring process. Given the relatively small area of aspen forest in relation to the total FOBU area, we believe we can sample a very high percentage (50-75%) of all aspen polygons on the landscape. This level of target sample representation will yield very high statistical confidence in the ultimate findings. Subsampling larger contiguous aspen stands would likely be based on a selection process that is area based (e.g., if aspen stand > 10 ha, then randomly select additional sample location per each 10 ha increment). Previous aspen monitoring programs using both systematic and polygon-based sampling, and yielding peer-reviewed publications, form the basis of the framework proposed here (Rogers and Ryel 2008, Rogers et al. 2010, Rogers and Mittanck 2014, Rogers et al. 2015). Additionally, previous works by Rogers and others are designed for implementation with modest training, thus technical knowledge is not necessarily a prerequisite to follow-up monitoring.

Plot-level Sampling Components

For clarity, a sample unit is normally subsampled using a preselected plot design assumed to be representative of that area (e.g. 1 ha). After all data are collected, each data element will be expanded to represent the entire sample unit (e.g. basal area of dead aspen/ ha, visual conditions across the entire ha, or percent cover of species X/ ha). We expect to collect between 20-30 data elements at each aspen survey plot. As final variable selection is expected to be made as part of a master's degree thesis project, exact data items are not specified here. The list below presents likely data components by indicator categories. A sample tally sheet for standard aspen habitat surveys is shown in Appendix A. Site Description and Tall Shrub data are expected to be collected across an entire sample unit, while the remaining sample categories will likely be recorded within strictly defined subsample areas, such as belt transects or fixed-radius circular plots. For sampling purposes, we define tall shrubs as those species occurring under aspen cover and commonly having the capacity to grow at least 2 m in height (e.g., serviceberry, chokecherry, mountain ash, woods' rose, Scouler's willow, red osier dogwood). Finally, a special survey technique will be developed for sampling species and browse level of tall shrubs outside, but nearby, target sample locations. (Our preliminary survey noted many instances of high cover of serviceberry in adjacent non-forest openings that appeared intensively browsed.)

<u>Site Description</u>—Elevation, Slope, Aspect, Visual Condition Rating, Number of Aspen Layers, Total Shrub Cover, Percent Aspen Canopy Cover, Percent Other Tree Species Cover, Dominant Understory Plant Form, Distance to Water Source, Distance to Road

<u>Forest Mensuration</u>—Mature Tree DBH, Tree Status (live/dead), Tree Species, Tree Damage (mortality inducing insects, disease, physical/animal damage)

<u>Live Regeneration & Recruitment</u>—Regeneration Count (stems) by height category, Recruitment Count (stems)

<u>Browse Level</u>—Number of Regeneration (stems) Browsed, where terminal buds are removed due to browse (other mechanisms may cause terminal bud loss, such as disease or frost damage which can be distinguished with minimal training).

<u>Ungulate Presence</u>—Pellet Group Counts following established procedures (Bunnefeld et al. 2006).

<u>Tall Shrubs</u>—Shrub Cover by Species, Browse Level of Shrubs by Species, Shrub Species Outside Aspen Stand, Browse Level of Outside-stand Species. (We anticipate using elements of Wyoming Game & Fish's "Browse Production and Utilization Measurement Protocol" to assess tall shrubs outside, but adjacent to, aspen habitat. See Appendix B.)

Recommendations for Assessment of Non-forest Shrubs and Grasslands

Should funding become available for comprehensive vegetation monitoring across the FOBU landscape, sagebrush (*Artemisia spp.*) and grassland communities are the logical next step for implementation. We favor stratifying areas of interest according to ecological site types (https://esis.sc.egov.usda.gov/About.aspx) which are determined by soil type and potential vegetation. With such an approach, the first stage of monitoring would provide an initial overall assessment of departure of these areas from ecological-site-specific reference conditions. This would occur via systematic, qualitative assessments of land health (Pellant et al. 2005). In the second stage of monitoring, we would likely couple repeated assessments of ungulate use and vegetation condition to infer ungulate activity as a potential driver of vegetation condition. Annual monitoring would occur at randomly or systematically (i.e. grid intersections) located permanent points, stratified by ecological site. At each point, three 50- or 100-m transects would be established for conducting field measurements. Vegetation measures would include: belt transects to assess densities of shrubs by species and size class; belt transects to assess densities of perennial bunchgrasses by species; line-point intercept to measure plant and ground cover; gap-intercept to assess erosion potential; visual estimates of plant production; and soil impact penetrometer to assess soil compaction (Herrick et al. 2009). Assays of herbivore presence would include fecal pellet counts identified to species and/or camera trapping. Indicators of herbivore utilization would include grass stubble height measurements and assessment of herbivory intensity on key plant species. This monitoring could be further supported by the use of small (1m x 1m) utilization cages and/or larger ungulate exclosures that could be used to infer directional effects of ungulate herbivory (or lack thereof) on plant community trajectories. The specific methodologies selected will ultimately depend on available time and resources and development of more specific monitoring questions and objective.

Broader Context Monitoring

Upon consultation with NPS staff at FOBU, CESU, and the regional NPS office, consideration should be toward localized expansion of proposed monitoring protocols to adjacent lands surrounding FOBU. Given that the monument is entirely fenced, restricting domestic livestock (but allowing elk and deer) use for most of the year, there is an *in situ* experimental design in place that may be advantageous (although FOBU staff have raised the issue that cattle trespass is taking place, which may confound this design). In other words, we could determine whether wild ungulates alone are impacting aspen to a greater/lesser extent than communities exposed to domestic and wild browsers. This information may be very useful to monument staff when working with area partners, livestock owners, local and regional policymakers, and FOBU visitors. Consideration of domestic livestock affects may also inform impacts of current brief uses of FOBU for seasonal livestock pass-through.

Proposed Education and Outreach

We anticipate dissemination of knowledge gained from aspen habitat monitoring to benefit FOBU, USU students, local K-12 science/discovery programs, and the public at-large with the following targeted programs:

- **FOBU Interpretive Programs:** Animal-vegetation interactions are not the primary attraction at FOBU. However, monument programs could incorporate ecological concepts and findings expected from this work. Additionally, NPS and investigators here could partner to produce a brochure or booklet summarizing aspen ecology, elk habitat, and key plant-animal interactions for distribution at the visitor center.

- **USU Graduate Student(s):** Depending on available budgets, we anticipate one or two master's level projects to result from the proposed monitoring work. Graduate students, in addition to required coursework, would be expected to design a credible and comprehensive program for aspen habitat assessment. Results of this project would be published in a report to NPS, as well as 1-3 technical publications. Graduate work would be supervised by principle investigators.
- **Undergraduate Students:** Given the proximity of FOBU to the USU campus we hope to bring classes to FOBU for field-based learning. We may consider honor students and/or general science classes to take advantage of combined earth-, biological-, and social-based curricula. (Such a program may be expanded to include Wyoming state or regional technical/vocational schools.) Also, we anticipate employment of undergraduate students at field technicians upon project implementation.
- **Local K-12 Programs:** Kemmerer grade schools, middle school, and high school classes should benefit from local basic science findings. Many such rural schools have limited resources for field excursions. We will develop a 45-minute learning module on aspen-wildlife science that university students can bring to these schools. Advertising for such programs may result in expanding our area of presentation. A current partnership with the Teton Science School in Jackson, Wyoming will allow for more in-depth programs for K-12 students interested in a hands-on field learning course.
- **Public Education:** Incorporation of vegetation, aspen, and wildlife findings into interpretive programs and written materials at FOBU will directly benefit monument visitors. Additionally, USU students and faculty involved would certainly be amenable to special presentations at FOBU for targeted audiences (e.g. an advertised aspen program). Published works resulting from this project will be available publicly and will contribute to the wider mission of advancing research and education under the CESU program.

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Appendix A

Page 1

Data Sheet: Aspen Habitat Monitoring

plot#: _____ date ________ GPS X __________ GPS Y ____________ Elev. __________ Stable (1) or Seral (2)_____

Stand (aspen) layers ________ 1st Disturbance ______ 2nd Disturbance ______ Stand condition_______ Percent polygon aspen _______

Cover: Tr #1 A___ C___ S___ A___ C___ S___ A___ C___ S___ A___ C___ S___ A___ C___ S___ A___ C___ S___ A___ C___ S___ Aspen stand age _____

Cover: Tr #2 A___ C___ S___ A___ C___ S___ A___ C___ S___ A___ C___ S___ A___ C___ S___ A___ C___ S___ A___ C___ S___ Understory cover_____

Plot-level comments:

Fecal Count (transect):	1	2
Cattle		
Sheep		
Elk		
Deer		

Tree Tally (classes = 1 Regeneration; 2 Recruitment; 3 Mature):

Line	transect #	class	species	count	browse	dead	dbh class	comments
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
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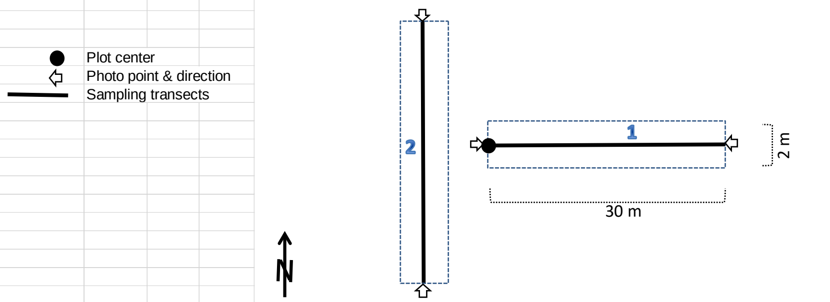
Page 2

Line	transect #	class	species	count	browse	dead	dbh class	comments
27								
28								
29								
30								
31								
32								
33								
34								
35								
36								
37								
38								
39								
40								

Plot layout: Aspen Habitat Monitoring



Appendix B

Browse Production and Utilization Measurement Protocol, Tally Sheet

Wyoming Game & Fish, Pinedale Field Office

Establishing Transects

Browse production and utilization shrub transects are meant to be established and used for management guidance on important wildlife habitats. Therefore, selection of *representative* sites is critically important. Selecting the best or worst condition shrubs does not likely represent a landscape-scale and may not directly answer management questions. Depending on time availability, several transects may be installed to capture a variety of conditions within a landscape, or if less time is available selecting a site with conditions that are not the extreme is important. Aspect, slope and soil type play a critical role in site potential and vegetation response to annual precipitation. Sites should occur within one vegetation community and not fall on an ecotone or edge. If two communities are in question, two separate sites should be established. Multiple species can be measured along the same transect.

1. Establish the permanent location by marking the start with rebar and use a GPS to capture a UTM location for return monitoring events.
2. From the start point, choose an appropriate azimuth to be used for transect direction on every monitoring event.
3. A repeatable photo point should be taken on each monitoring event in the direction of the transect. A ground photo may or may not be useful based on location and objectives. Make sure the horizon, whiteboard and depictive patch type is captured in the photograph.
4. Exclosure cages may be established near each transect for ocular comparison.

Browse Production

Each fall, between early September and mid October, when annual growth has ended and before mule deer have returned to winter ranges, measure the average annual leader growth of your shrubs as a proxy for shrub production for each transect. Use the following procedures:

1. Each shrub to be measured will be chosen using a 4 step transect method. Starting from the start point, take 4 steps along the permanently established direction of the transect. Choose the closest shrub from where your foot lands. Any age class shrub that has more than 10 leaders should be used for measurements.
2. For each shrub document age class of the nearest shrub: Young, Mature, Decadent or Dead. Young plants have a stem diameter of less than ¼ inch and typically do not have evidence of seed head production. Decadent plants have 50% or greater death of the canopy. Dead plants should be documented for age class and then the next closest shrub will be used for the remaining measurements (hedging, production, utilization). For long-term transects age class can be measured on 5-year intervals because this does not change quickly.
3. Hedging category needs to be recorded for each shrub: Light, Moderate, or Severe. Light hedging is when two-year-old wood is relatively long and unaltered or only slightly altered from the normal growth form. Moderate hedging is indicated by moderately altered growth form and 40-70% of current year leaders extending off of two-year-old wood. Severe hedging is indicated by strongly altered growth form typically presenting a clubbed or broomed appearance due to more than 70% of current year leaders sprouting in locations other than off the terminal leader.

Appendix B (continued)

For long-term transects hedging category can be measured on 5-year intervals because this does not change quickly.

4. Measure annual leader production. Randomly grab 1 leader on the top available portion of the individual shrub and measure the length of the terminal internode (from the last growth scar to the tip of the stem) in mm. Repeat this on 4 more leaders for a total 5 leaders measured per shrub. An individual shrub is defined as a shrub that shares the same main stem leading to the root.
5. Measure summer utilization of the same shrub. Randomly choose 10 leaders on the shrub that are available for utilization and count how many of those 10 have evidence of browse from the previous summer. Use this as an estimate of incidence of use on the shrub from the previous summer.
6. If it is a management concern, document the wildlife or livestock species that were in the vicinity of the transect during the summer by identifying species of fecal pellet groups. Continue steps 1 thru 5 for a minimum of 25 shrubs along the transect.

Browse Utilization

Each spring, between early May and mid June, once mule deer have departed from winter ranges, measure the average shrub utilization of shrubs for each transect. Use the following procedures:

1. Each shrub to be measured will be chosen using a 4 step transect method. Starting from the sample point, take 4 steps in the permanently established direction of the transect. Choose the closest shrub from where your foot lands. Any age class shrub that has more than 10 leaders should be used for measurements.
2. To measure utilization of the individual shrub, randomly choose 10 leaders on the shrub that are available for utilization and count how many of those 10 have evidence of browse from the previous winter. An individual shrub is defined as a shrub that shares the same main stem leading to the root. Use this as an estimate of incidence of use on the shrub from the previous winter.
3. Repeat steps 1 and 2 for a minimum of 25 shrubs along the transect.

Appendix B (continued)

Location: ____ Azimuth: ________
Date: ____________________________ Observer: ____________________________________
UTM: N __________________________ E _________________________ zone _______ NAD _____

Utilization											
Percent Utilization (10 Stems/Plant)											
Species	0	10	20	30	40	50	60	70	80	90	100
Total											
										Average Percent Utilization	

Annual Production																				Species:					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
Leader																									
(mm)																									
Total																									
	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
Leader																									
(mm)																									
Total																									
Total length of all leaders =										Number of leaders measured =										Average leader length=					

Hedging Class				Age Class			
Species	1 (Light)	2 (Moderate)	3 (Severe)	Young	Mature	Decadent	Dead
Total							

Appendix C (field notes and raw data)

Notes on FOBU field survey, Aug. 24-25

Paul Rogers & Leidy Rogers

General Issues:

1. Is elk browsing of aspen and shrubs at FOBU at a sustainable level?
2. Need method to document spp. and abund. and browse level of all tall shrubs & trees at each site
3. Key variables for aspen: regeneration count & browse %, recruitment count, stand age, mortality of mature trees, pellet counts by ungulate spp., shrub species (presence, abund., browse level), other tree species, slope/aspect, elevation, number layers, stand condition rating (subjective), distance to spring/water, remoteness (proximity to road/trail), livestock migration corridor (how to measure?? NPS map? - livestock signs: low, med., high???), **other???**

All visits: April, May, August = total of 12 sites (one outside FOBU); 6 GPSed

8/21/15 - filed research permit with online NPS system

8/24/15 - met with Marsha at FOBU visitor center a.m.; Arvid and Annette p.m. (obtained gate key and made sure permit notification came to Arvid).

<u>Sites visited:</u>

FB01: (transect data recorded: N/S 30 x 2 m)

- near spring & gate at far N end of FOBU (visited earlier in the summer with Brad Shuttuck and Kari Veblen)
- Many mature trees; lots dying, too.
- Plenty of recruitment
- not animal feces survey

FBO2: (transect data recorded: N/S 30 x 2 m)

- east of gate to Ruby Point; east of main road, across sagebrush meadow, into small basin
- mature trees nearly all scarred by elk rubbing
- cattle sign plentiful - must be on annual cattle migration route through FOBU
- moderate to heavy browse evident; few escaping to recruitment size

FB03: (no transect data taken; just GPS)

- North Canyon - through Cundick Ridge gate, take left fork toward Eagle Nest Point, park at small curve near road end, and hike down very steep slope through D-F and Limber P. to aspen stand at lower slope in bowl
- very little recruitment and lots of elk feces
- GPS: x-0519683, y-4636514. elev.-2285
- Shrub spp. plentiful: snowberry, buffaloberry, serviceberry, chokecherry, rose

Other sites visited:

- after surveying FB01, we made a brief visit to "cow area" outside of FOBU beyond far NE gate. This area had a water trough set up below a spring, so probably received plenty of cow use (season?). In the stand itself there was one particularly trampled area, but outside that spot most of the stand seemed to be recruiting without heavy browse (a.k.a., do cattle really browse aspen much? Does it depend on season?).
- small aspen stand near Cundick Ridge road gate; lots of elk droppings and notable smell with mod. - heavy browse obvious, but still recruiting; some very young Limber P. and D-F present.

Appendix C (continued)

8/25/15-(camped the previous night on BLM Point rd.) a.m. on Cundick Ridge proper; p.m. on Fossil Butte proper. Dropped off key at visitor center around noon.

FB04: (transect data taken & **elk feces count**: N/S 30 x 2 m)

- at end of Cundick Ridge rd. we hiked down/around cliffs to the south to a stand of aspen where former Superintendent Nancy Skinner had mentioned seeing a lot of elk in winter. Bowl formation just below steep cliffs/slope formed by land slumping and springs.
- site is fairly dense stand of pole-to-moderate sized mature aspen on somewhat level terrain; located just 20 m below spring/wallow that obviously sees regular elk use. Before survey began we found elk feces obvious/plentiful and little recruitment (except in dense patches)
- data collection confirmed intense browse and heavy elk feces concentrations

FB05: (no transect data taken; just GPS)

- Moose Bones Canyon; hiked below short/steep rim and into canyon through fairly large, nearly continuous aspen in bowl. Much of the area we hiked through contained a lot of downed/dead aspen stems and what appeared to be sickly/brown leafed aspen (check aspen leaf blight); again, elk sign was evident and recruitment minimal
- at stand just north spring where GPS was recorded; appeared to be on a drier aspen site; **mature trees only - no regen/recruit.**; wildlife paths and elk poop common; mature trees look healthier than upslope stands we just passed through
- GPS: x-0520178, y-4634864, elev.-2261

FB06: (no transect data taken; just GPS)

- north side of Fossil Butte proper; valley at E/SE portion of FOBU (hiked up/over Fossil Butte from Historic Quarry Trail)
- this "stand" is really only a strip (est. 10 m x 75 m) of 1-2 m tall young aspen running perpendicular to the steep slope; one older 3-4 m tall dead aspen is located in this group. It is likely that this location would **not qualify as large enough** to be surveyed as an "aspen forest."
- Other very small aspen stands, consisting mainly of standing dead trees with regeneration below, were found in this general area (i.e., near north facing slop of Fossil Butte).
- We observed via binoculars one thriving, slightly larger, aspen stand across the valley midway up the opposing south-facing slope of this bowl-shaped drainage (most of the entire valley is too dry to support aspen or other trees - scattered Limber P. present).
- GPS: x-0521721, y-4631852, elev.-2257

Other sites visited:

- we hiked to one site near the SE edge of Fossil Butte along the Historic Quarry Trail (NE corner of trail loop) just below the cliff base and confirmed that it was entirely cottonwood trees.

Appendix C (continued)

Plot Summary Data

FOBU preliminary survey - Aug. 24-25, 2015 (Paul Rogers & Leidy Rogers) based on one 30 x 2 m transect: expansion factor = * 166.66												
												Pellet count on FB04 is highest measured, compared to Book Cliffs and Wolf Creek
Plot#	date	GPSx	GPSy	elev	#layers	condition	elk scat groups	% regen. Browse	recruit/ ha	regen/ ha	scat/ ha	Notes
FB01	8/24/2015	518937	4638139	2428	3	2	NA	59	2333	3667	Na	Many mature-size trees dead/dying, but plenty of recruitment; located at far north end of FOBU near NE gate &
FB02	8/24/2015	518763	4637330	2379	2	2	NA	87	667	5000	NA	mature trees nearly all scarred by elk antler rubbing; lots of cattle sign around stand; plot east of Ruby Point rd. gate
FB04	8/25/2015	519526	4634496	2243	1	3	28	100	0	10833	4667	A fairly dense stand just 10 m below a spring/wallow. Elk visitation evident from scat and tree scarring; site located to
* FB03, FB05, FB06 - no transect data collected												
Plots marked, but not surveyed												
FB03	8/24/2015	519683	4636514	2285								
FB05	8/25/2015	520178	4624864	2261								
FB06	8/25/2015	521721	4631852	2257								

Regeneration, Recruitment, Mature Trees						LP = limber pine	
						AS = aspen	
Plot#	class	species	count	browse	%browse	status (L/D	Notes
FB01	3	as	15	6	40		
FB01	2	as	7	7	100		
FB01	7	as	1			1	
FB01	4	as	14				
FB01	6	as	2			1	
FB01	5	as	4			0	antler rubs
FB02	6	as	6			1	
FB02	2	as	9	8	89		
FB02	5	as	5			1	
FB02	4	as	4				
FB02	3	as	8	8	100		
FB02	1	as	13	10	77		
FB02	5	as	4			0	
FB04	1	as	5	5	100		
FB04	2	as	49	49	100		
FB04	6	as	2			1	
FB04	5	as	1			0	
FB04	5	as	7			1	
FB04	3	as	11	11	100		
			75				

Appendix C (continued)

Regen & recruit - analysis						LP = limber pine		
						AS = aspen		
						expansion factor = *83.33		
Plot#	class	species	count	browse	%brows	status (L	Notes	
FB01	3	as	15	6	40			
FB01	2	as	7	7	100			
FB01	7	as	1			1		
FB01	4	as	14					
FB01	6	as	2			1		
FB01	2	LP	2					
FB01	5	as	4			0	antler rubs	
					59			
FB02	6	as	6			1		
FB02	2	as	9	8	89			
FB02	5	as	5			1		
FB02	4	as	4					
FB02	3	as	8	8	100			
FB02	1	as	13	10	77			
FB02	5	as	4			0		
					87			
FB04	1	as	5	5	100			
FB04	2	as	49	49	100			
FB04	6	as	2			1		
FB04	5	as	1			0		
FB04	5	as	7			1		
FB04	3	as	11	11	100			
					100			