Rocky Mountain Trench Ecosystem Restoration: Site Establishment Report for Lewis Creek Open Forest and Airport Pasture OGMA

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Executive Summary

In 2008 pre-treatment vegetation monitoring plots were established at two new sites in the East Kootenays as part of the Ecosystem Restoration Program. Permanent plots were systematically established at Lewis Creek in the open forest treatment unit and at Airport Pasture in the Old Growth Management Area (OGMA). Both sites occur in the Kootenay dry, mild Interior Douglas-fir biogeoclimatic zone (IDFdm2) and were chosen as candidates for restoration due to their high value to wildlife. The sampling protocols developed by Machmer et al (2002) were utilized to ensure consistency in monitoring. Sampling was conducted between July 10 to 24, 2008 at Airport Pasture and August 6 to 14, 2008 at Lewis Creek. This report summarizes the pre-treatment characteristics at these sites.

Acknowledgements

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1 Introduction

Fire-maintained ecosystems throughout southern British Columbia have come under pressure from various sources over the past century. These sources include urban and rural development; increased recreation, especially motorized; and fire suppression. These ecosystems evolved dependencies on frequent, low-intensity fires that thin out regenerating stands to create a mosaic of grasslands and open forests. As a result of fire suppression conifer encroachment and in-growth have altered the landscape.

The Rocky Mountain Trench in southeastern BC has experienced an annual loss of 1% (3000 ha of open forests) of Natural Disturbance Type (NDT) 4 and dry NDT3 ecosystems (Gayton 1997). This loss has resulted in declines of wildlife habitat, forage availability for wildlife and domestic ungulates and subsequently increased foraging pressure on remaining areas. Invasive and noxious plants have further degraded lands and forage opportunities. Accumulation of dense, small-diameter forest stands and abundant woody debris creates favourable conditions for more catastrophic crown fires that are far more ecologically damaging than frequent, low-intensity ground fires.

Benefits to well functioning fire-maintained ecosystems include (Rocky Mountain Trench Ecosystem Restoration Steering Committee 2006):

1. enhanced biodiversity and ecological function
2. longevity of large-diameter veteran trees that provide valuable wildlife habitat and cover;
3. habitat for a variety of species at-risk
4. increased forage value for wildlife and livestock
5. improved forest health by maintaining lower stocking densities to help reduce insect and disease outbreaks
6. increased timber value through fewer, but higher value large-diameter trees (reduction of low-value small diameter trees)
7. protection of residential and other developments by reducing fuel loads and probability of catastrophic wildfire
8. improved aesthetics of open-forest savannahs, sight-lines and biologically diverse understory

The Rocky Mountain Trench Ecosystem Restoration Program is led by the BC Ministry of Forests and Range and is committed to restoring fire-maintained ecosystems in the Rocky Mountain Trench. The overall goal is "to remove excess immature and understory trees over the next 30 years to create a complex ecologically appropriate mosaic of habitats on vacant Crown lands of the Trench" (Rocky Mountain Trench Ecosystem Restoration Steering Committee 2000). A significant component of this activity is a detailed monitoring program to track the effectiveness of restoration activities (Machmer et al. 2002). Collection of baseline information prior to treatment is necessary for meaningful comparisons to post-treatment conditions.

This report summarizes site establishment and pre-treatment baseline work conducted at two locations in the Rocky Mountain Trench in 2008, Lewis Creek Open Forest Site (east of Wasa) and the Airport Pasture Old-growth Management Area (OGMA; east of Kimberley).

2 Methods

2.1 Study Area

2.1.1 Lewis Creek

The Lewis Creek treatment area is located approximately 6 km east of Wasa, BC in the Rocky Mountain Forest District. It is within the Kootenay dry, mild Interior Douglas-fir biogeoclimatic zone (IDFdm2), site series 01 and 03. The treatment area is located along the north slopes of Lewis creek and is perched high above the canyon carved out by the creek. The aspect is south by southeast and slopes vary greatly from 10-60%. Soils are orthic eutric brunisols on a veneer of fluvioglacial material (Lacelle 1990 in Davidson 2008).

The area has been used as winter and spring range by the provincially blue-listed Rocky Mountain bighorn sheep (*Ovis canadensis*), as well as elk (Cervus Canadensis), mule deer (*Odocoileus hemionus)* and also provides year round range for white-tailed deer (*Odocoileus virginianus)*. It is covered by Ungulate Winter Range guidelines for the southern part of the Rocky Mountain Trench (Order U-4-006) and is considered Class 1 (high carrying capacity) winter range for deer and elk. The bluffs at the southern boundary of the treatment area appear to be an important area as they contain natural mineral licks which are used by bighorn sheep, elk and deer. The site was chosen for restoration as it was identified as a candidate for bighorn sheep habitat enhancement in the Rocky Mountain Bighorn Sheep Habitat Enhancement Plan: Mause Creek-Premier Lake. The objective of the project is to improve winter and spring range by reducing conifer encroachment and promoting healthy forage production by opening the canopy to allow for the growth of desirable forage species such as bluebunch wheatgrass, rough fescue, balsamroot and palatable shrubs such as Saskatoon and chokecherry. It is also expected that by reducing the conifer encroachment sight lines will be opened up, resulting in decreased predation.

This area is part of CTP pasture in the Lewis/Wolf grazing unit. The range has not been stocked for the past two years but will be stocked in 2009 by Mark Sadler of Top of the World Ranch.

The Lewis Creek restoration site consists of 4 treatment units (TU 1: open forest 22.1 ha, TU2: open range 35.8 ha, TU 3: boulder outcrops 19.3 ha, TU4: open range 12.6 ha), and is 89.8 hectares in size. The stand management plan recommends hand-slashing in TU 1, 2 and 4, while TU 3 will be left untreated. Permanent vegetation monitoring plots were established in unit 1 in 2008 to gather pre-treatment data and enable comparison of post-treatment conditions to determine the response of the vegetation community.

Table 1: Treatment unit areas at Lewis Creek Site. Source: Davidson (2008)

Treatment Area	Area (ha)
1	22.1
2	35.8
3	19.3
4	12.6
Total	89.8

As part of the stand management plan prepared by Davidson (2008), two blue-listed plant species were noted, nine-leaved desert parsley (*Lomatium triternatum*) and Montana larkspur (*Delphinium bicolour*). Flammulated Owls (*Otus flammeolus*; blue listed) were detected adjacent to the treatment unit and although Lewis's Woodpecker (*Melanerpes lewis*; red-listed) were not observed, it is thought that they may occur in the area.

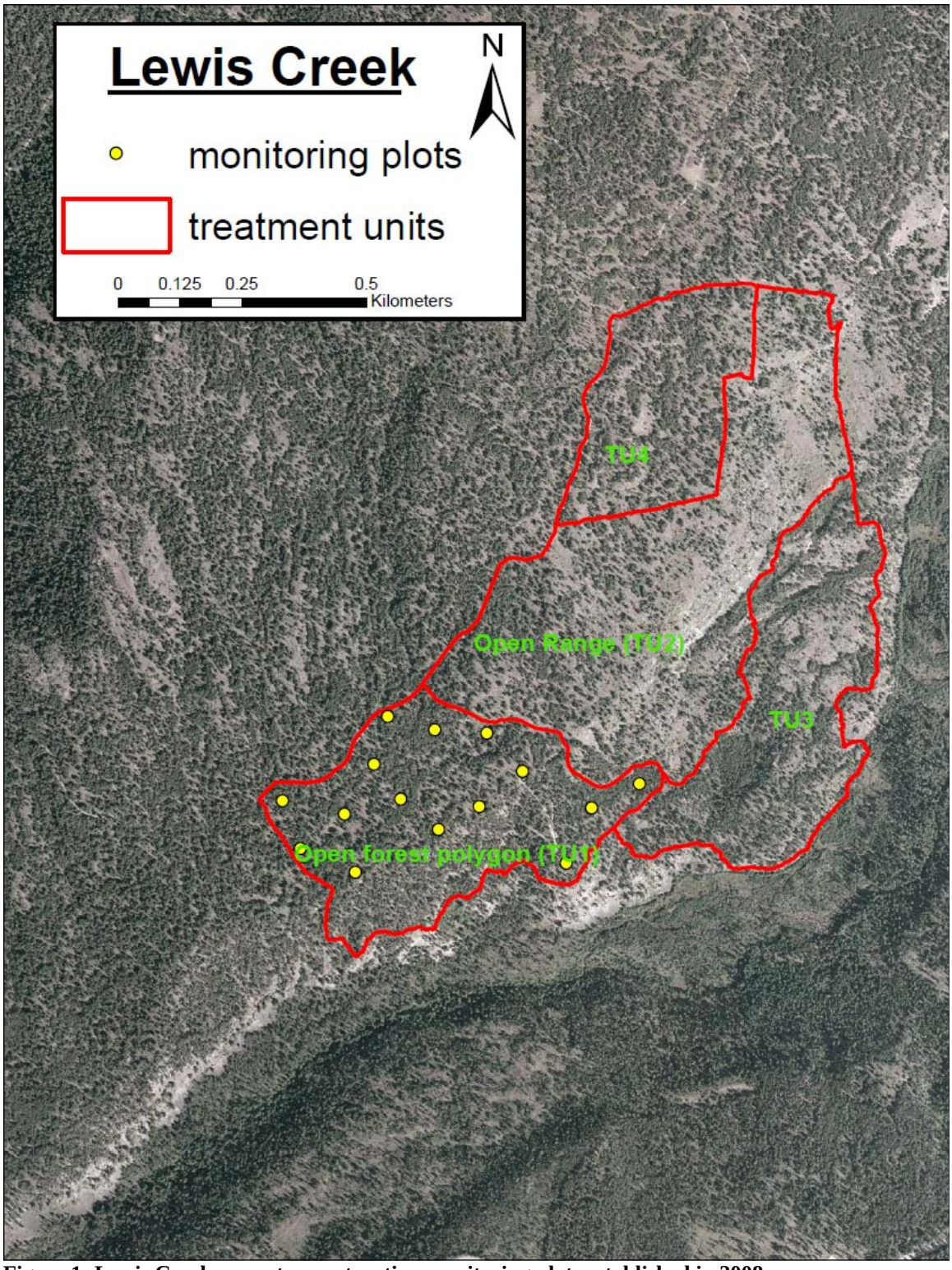

Figure 1: Lewis Creek ecosystem restoration monitoring plots established in 2008

2.1.2 Airport Pasture Old Growth Management Area

The Airport Pasture Old Growth Management Area (OGMA) restoration site is located approximately 17 km ENE of Kimberley, BC, adjacent to the old airport. It is 70 hectares and occurs in the Kootenay dry, mild Interior Douglas-fir biogeoclimatic zone (IDFdm2). The area is managed as an OGMA and is well-used by badgers (*Taxidea taxus jeffersonii*) which are federally endangered and provincially red-listed. Three Wildlife Habitat Areas (4-088, 4-089 and 4-090) are close to the site and were established under the Identified Wildlife Management Strategy to protect badger habitat. Flammulated Owls have been detected near the site and the last recorded occurrence of sharp-tailed grouse was in 1983 at the adjacent old airport. Management objectives are to open the overstory, recruit wildlife trees and increase forage production. The target is to achieve 20 stems per hectare by slashing all trees less than 20 cm dbh, and protect larger trees through fuel management and water stress reduction. Pre-treatment monitoring plots were established in 2008 to monitor the post treatment response in the vegetation community.

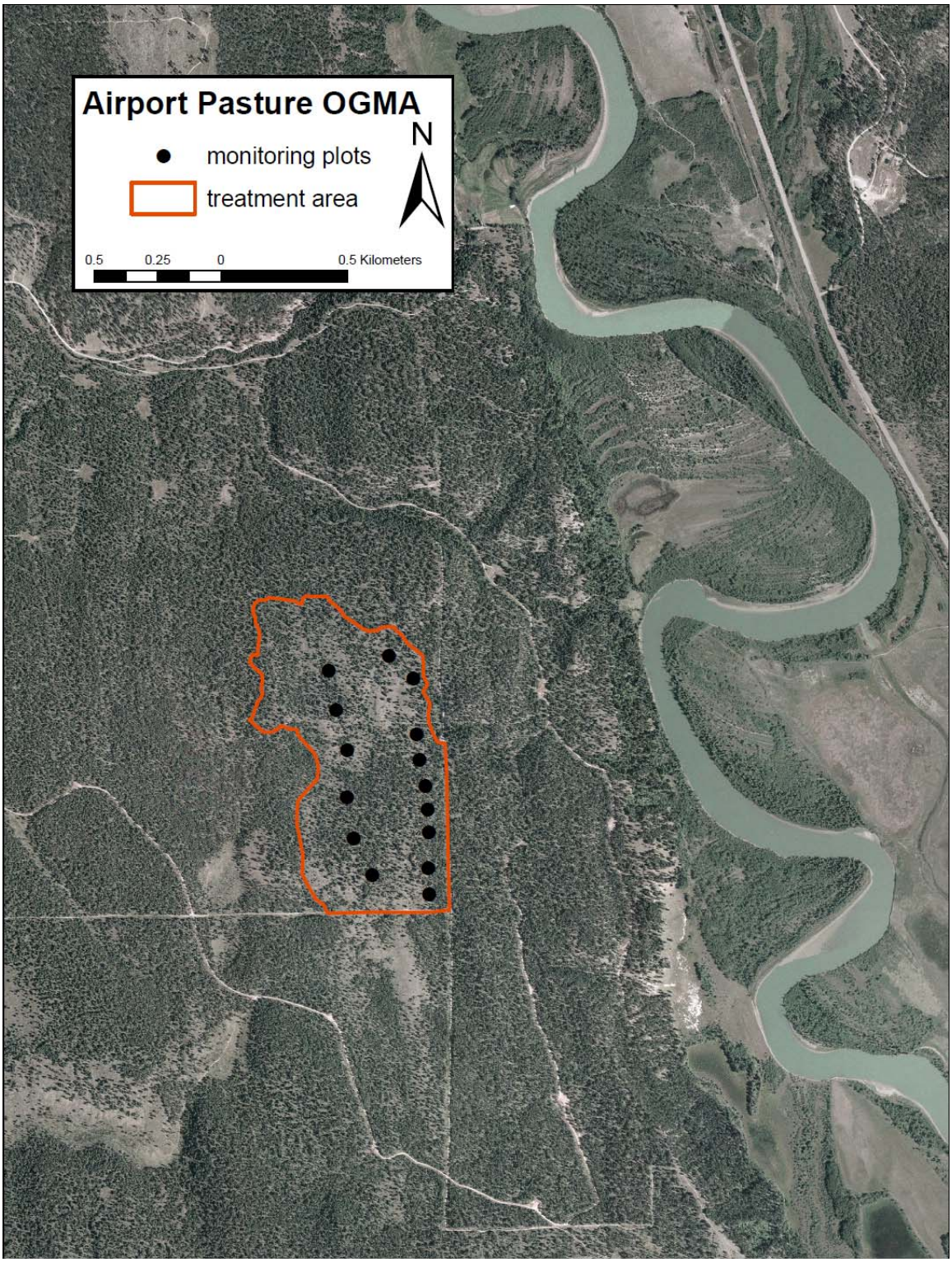

Figure 2: Airport Pasture OGMA ecosystem restoration monitoring plots established in 2008

2.2 Overstory Monitoring

Objectives:

- reduce tree density (stems per ha) to stand prescription objectives
- increase individual tree size
- achieve a stand species composition within historic range of variability
- retain wildlife trees

Response Variables:

- tree species composition
- diameter at breast height (dbh)
- tree density (stems per ha)
- percent crown closure
- number of dead trees and decay class distribution

At each site, fifteen plots were systematically established, avoiding areas such as roads and steep cliffs. Plot locations were geospatially located using a Garmin 60CSX GPS unit. Plot centres were permanently marked with a 12" spike and 2 washers, flagging tape and a metal tag. Plot specific location and orientation data for each site are provided in Appendix 1. Overstory sampling was completed between July 10 to 24, 2008 for Airport Pasture and August 6 to 14, 2008 for Lewis Creek.

Overstory plot layout and sampling methods followed methods developed Machmer et al (2002). Nested radius plots were established at each plot centre (Figure 3a). Species, diameter at breast height (dbh, in cm), decay class and evidence of disease, insects and wildlife use were recorded for each tree. Trees were also classified as one of five size / age classes (Table 2). A spherical densiometer was used to estimate canopy cover; four readings were taken in the cardinal directions from each plot centre. Photos were taken systematically at each plot center, one in each of the four cardinal directions focused at 8 metres from plot center using a 1 metre photo plot stake.

Table 2: Measurements and descriptions for sampling plots and size / age class categories

Radius	Area (m^2)	Conversion factor to ha	Size / age class	height and/or dbh range
1.78	10	x 1000	Germinants	Seedlings <2 years old
3.99	50	x 200	Regeneration	<1.3 m
			Sapling	>1.3 m height, <7.5 cm dbh
			Pole	7.5 - 12.5 cm dbh
11.28	400	x 25	Mature	12.5 - 30 cm dbh
25	~ 2000	x 5	Dominant	>30 cm dbh

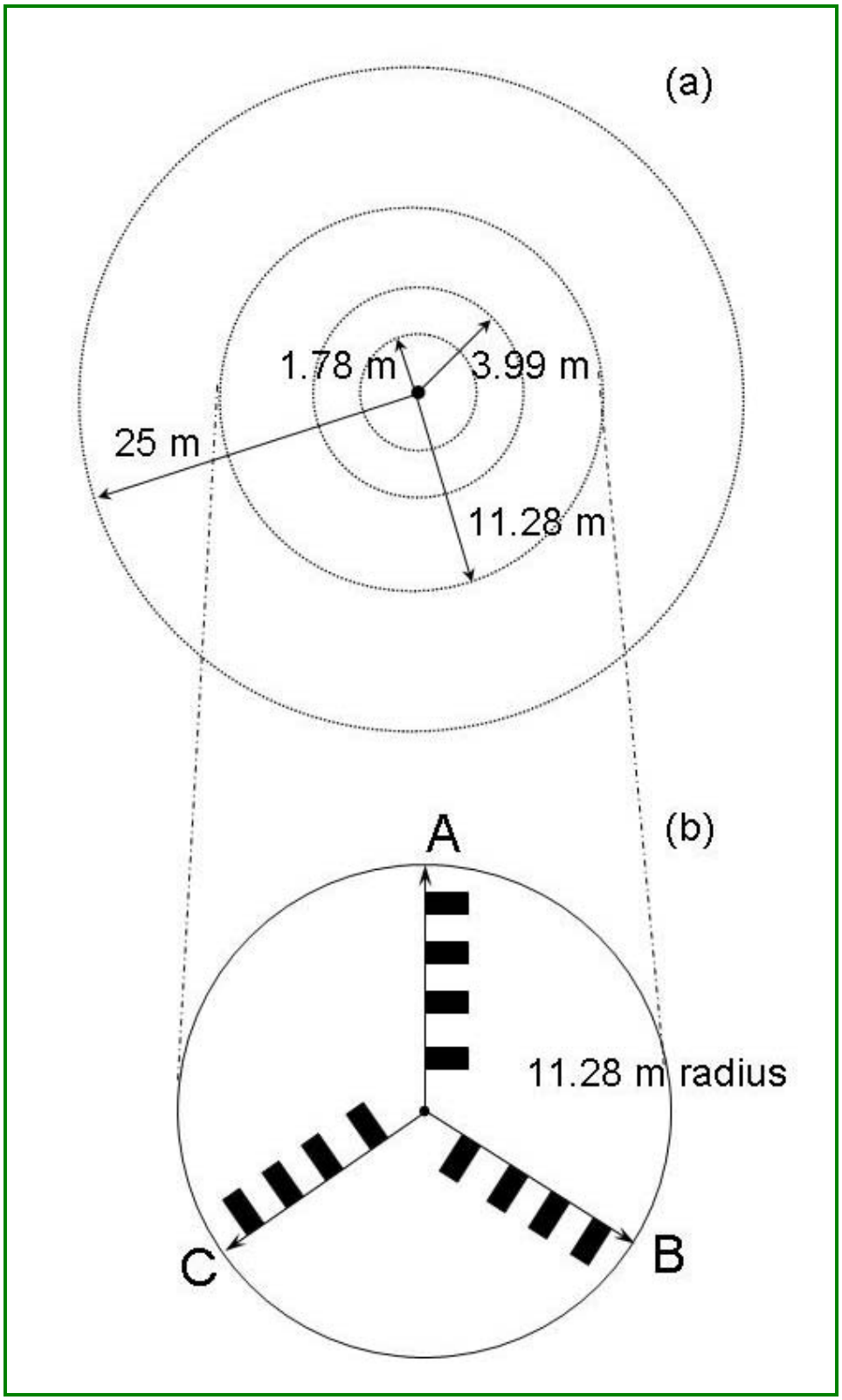

Figure 3: Schematic diagram of sampling plot layout for overstory (a) and understory (b). Adapted from DeLong et al. (2001).

2.3 Understory Monitoring

Objective:

- maintain or increase fire-adapted native grasses, forbs and shrubs

Response Variables:

- grass, herb and shrub cover
- species richness
- species composition

Overstory plot layout and sampling methods followed methods developed Machmer et al (2002).. Three 11.28m transects were established from each plot centre at 120° intervals (Figure 3b). The direction of the initial transect was randomized using a compass. Four Daubenmire frame locations were permanently marked on each transect with 10" spikes at intervals of 3, 5, 7 and 9 m along the transect. At each frame location, a daubenmire frame was placed on the right hand side of the transect to estimate percent cover of forbs, grasses and sedges. Daubenmire data was also collected on depth of duff layer, percent cover of rock, bare soil, bryophytes, dead wood, live wood, litter, cryptogrammic crust, and feces. Shrub cover was estimated as percent cover in a 5.64m radius plot. Shrubs were also classified by height. B1 shrubs were defined to be >2m in height; B2 shrubs were <2m in height. Understory sampling was completed July 10 to 24, 2008 for Airport Pasture and August 6 to 14, 2008 for Lewis Creek.

2.4 Forage Production

Objective:

- maintain or increase forage production in treated areas

Response Variable:

- dry mass (kg/ha) of clipped understory vegetation

Forage production sampling followed methods developed by Machmer et al (2002). Fifteen un-caged clip plots were established at each site (one per plot) to estimate forage production. A 70.7 cm square (0.5 m^2) quadrat was placed on the left side of transect one at the three-meter mark. These plots should be rotated in future work to avoid possible negative effects of destructive sampling. Within each 0.5m^2 quadrat, herbaceous material was clipped to the ground and current annual growth of shrubs collected. Kinnikinnick (*Arctostaphylos uva-ursi*) was not collected because it is not typically used as forage and has limited interest to restoration activities. Samples were divided into functional groups: forbs, bunchgrasses, pinegrass (*Calamagrostis rubescens*), other grasses, sedge, shrub, conifer and exotic. Samples were collected in paper bags, air-dried, then oven-dried for 24 hours. Clip plot sampling was completed 24 Sept, 2008 for both Airport Pasture and Lewis Creek sites.

2.5 Data Analyses

Data were entered into Microsoft Excel© spreadsheets for summary analyses. Overstory trees were divided into the following dbh classes based on size / age classes (Table 2) all in cm: <2.5, 2.5 to 7.5 , 7.5 to 12.5 (lower limit for mature), 12.5 to 17.5 , 17.5 to 25 , 25 to 30 (lower limit of dominant); 30 to 35, 35 to 40, 40 to 45, 45 to 50 and >50. For density, measured by stems per hectare (sph), trees were also divided into the size / age class categories. The absolute number counted in each quadrat was multiplied by the corresponding conversion factor in Table 2 to obtain an estimate of stems per hectare. Trees were also classified as live and dead for density.

3 Results and Discussion

3.1 Lewis Creek

3.1.1 Overstory

3.1.1.1 Species composition and Individual Tree size

Douglas-fir formed the majority of the overstory tree composition at Lewis Creek (Table 3). The remainder of the overstory was ponderosa pine (9%); no other overstory tree species were recorded.

Roughly one-quarter (26.3%) of all Douglas-fir trees were <12.5cm dbh, the upper limit for 'pole'. Just over half (53.3%) of the Douglas-fir trees were classified as 'mature', the remaining 20.4% were 'dominants' >30cm dbh. However, 139 of the 245 'mature' Douglas-fir were clumped at the lower end of that classification's distribution, <17.5 cm dbh (Figure 4). Similarly for 'dominants', 65 of 94 trees (69.1%) were <40cm dbh. Whereas over half (56.5%) of Douglas-fir trees were <17.5cm dbh, most (60.5%) of the ponderosa pine trees were greater >35 cm dbh (Figure 4). All ponderosa pine trees, except one, were classified as 'mature' or 'dominant'. In summary, although most Douglas-fir trees were classified as 'mature' and 'dominant' (73.7% combined), the diameter classes tended to be most numerous at the lower end of each age/size class.

Table 3: Number of individual trees by species and age/size class for all plots pooled at Lewis Creek restoration site.

Species	Total	Germ.	Regen.	Sapling	Pole	Mature	Dominant
Douglas-fir	460	9	48	42	22	245	94
Ponderosa pine	43	0	1	0	0	16	26
total	503	9	49	42	22	261	120

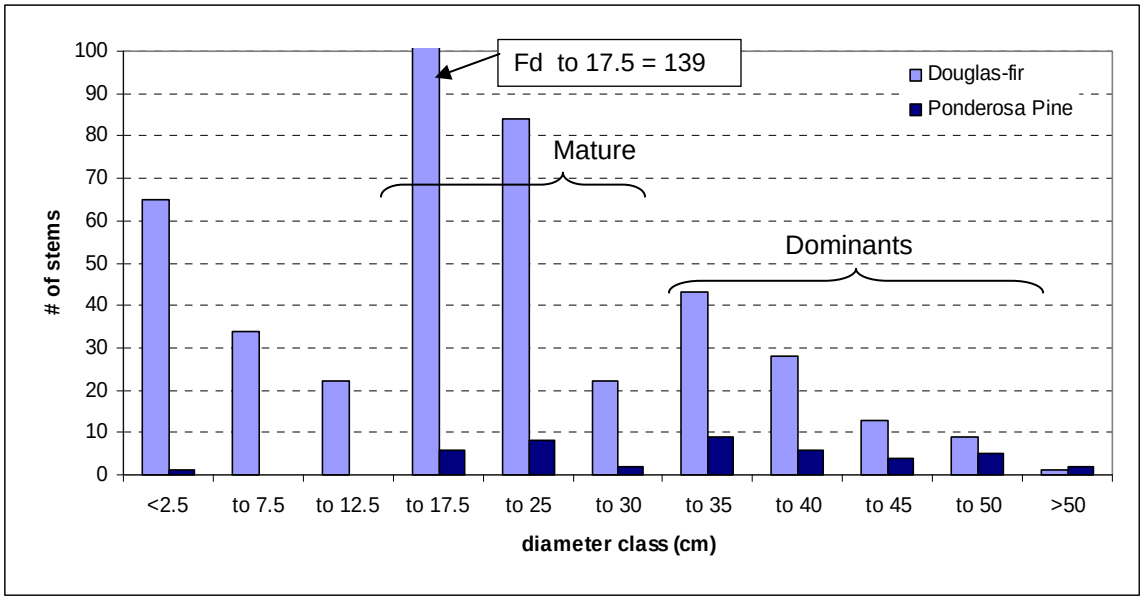

Figure 4: Diameter class distribution for all trees found at Lewis Creek restoration site.

3.1.1.2 Tree density

Density of overstory was highly variable both among and within the 15 plots (Table 4), particularly as size / age class decreased. (Plot-wise means are provided in Appendix 2.) Germinants and regeneration classes

were particularly divergent, with stems per hectare values either very high (>1000) or zero. Standard deviations for the overall site mean values for germinants and regeneration were both more than double the mean. Pole and sapling classes were also divergent, but not to the extent of regeneration and germinants. The high density situations indicated by these values is typical of ingrown Douglas-fir forests in the Rocky Mountain Trench and represents the condition that restoration activities are seeking to reduce. Large size / age classes (mature and dominant) were more consistent across the site. This variability may be a result of the factors used to convert recorded values to 'stems per hectare'. If 1 germinant is recorded, the conversion factor multiplies this to 1000 stems per hectare. There is no opportunity for values between 0 and 1000. Conversion factors for 'mature' and 'dominant' trees were much lower (25 and 5, respectively).

Table 4: Number of live and dead stems per hectare by varying age/size class at Lewis Creek restoration site. Mean and standard deviation are pooled across 15 plots.

	Mean live trees ± SD	mean dead trees ± SD
Germ.	600 ± 1242.1	0
Regen.	586.7 ± 1535.2	66.7 ± 123.4
Sapling	546.7 ± 573.0	13.3 ± 51.6
Pole	280 ± 476.9	13.3 ± 51.6
Mature	428.3 ± 345.4	6.7 ± 11.4
Dominant	36 ±17.0	3.7 ± 3.5
Total	412.9 ± 872.2	17.3 ± 61.4

3.1.1.3 Crown Closure

Mean crown closure was 65.0% (SD = 32.8, n = 60 readings). Readings ranged from 0.2 – 97.9%, with a median value of 79.2%. There was substantial variation between and often within plots (Figure 5), indicating highly uneven canopy closure across the Lewis Creek open forest site.

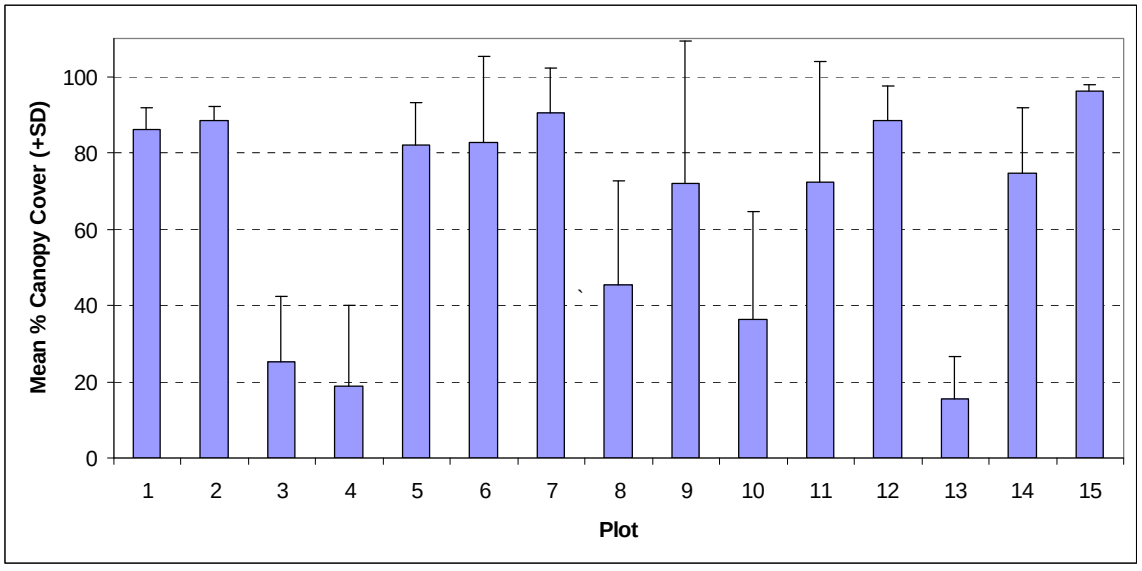

Figure 5: Mean percent crown closure values (plus standard deviation) for each plot at Lewis Creek. n = 4 readings per plot.

3.1.1.4 Decay Class

The majority of both Douglas-fir and Ponderosa Pine were live, class 1 trees (434 and 36, respectively, pooled across the entire site). Classes with some degree of visible decay were fairly evenly split across the

remaining classes (Figure 6). Decaying trees provide high value as wildlife habitat for cavity nesting species (e.g. Flammulated Owl) and should be maintained and recruited during the ecosystem restoration process. Davidson (2008) provided a detailed summary of all wildlife trees on the Lewis Creek Site in the SMP. He noted 125 wildlife trees on the entire block and 112 within the 3 sub-units slated for treatment. The SMP describes characteristics; classification, tree flaws and planned action are described for each tree.

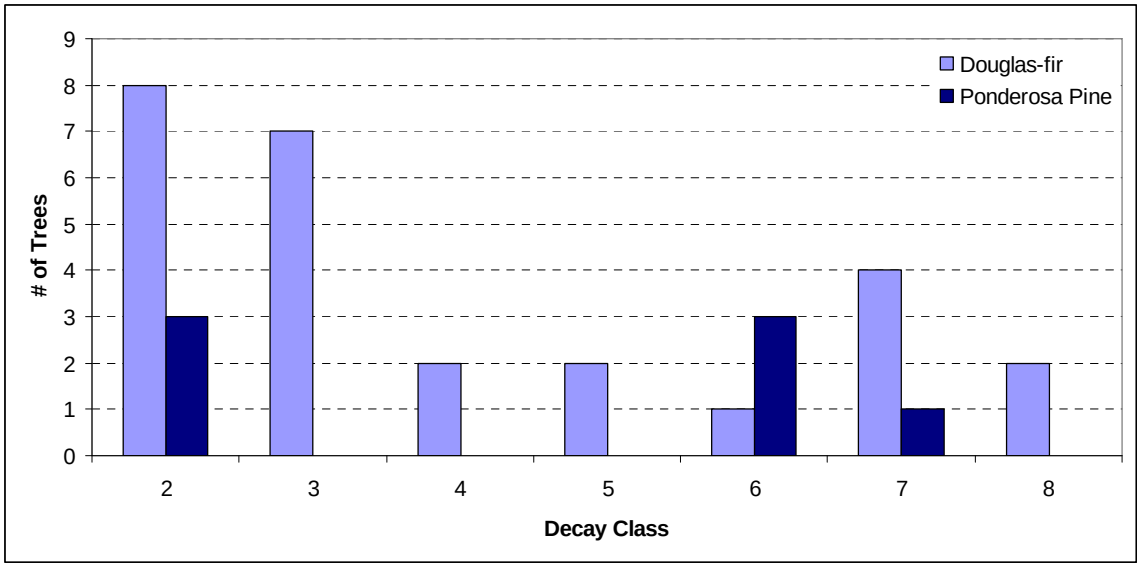

Figure 6: Distribution of decay classes 2 – 8 at Lewis Creek.

3.1.2 Understory

3.1.2.1 Percent Cover of Functional Groups

Understory species were combined into functional / descriptive groups. Forbs comprised the greatest portion of the herbaceous cover, followed by bunchgrasses, pinegrass (*Calamagrostis rubescens*) and sedges, respectively (Table 5). An exotic forb, black medic (*Medicago lupulina*) was observed on one quadrat (plot 8, quadrat 6). Shrubs formed the majority of the cover of understory at Lewis Creek. There was often substantial variation both within and among plots (see Appendix 3), especially for shrub cover which ranged between mean values of 1.3 and 21.6 %. Pinegrass and sedge were more evenly distributed among the plots. Where present, bunchgrasses were typically in relatively low percent cover. Quadrat 1 on Plot 3 was an exception, where bunchgrasses were very abundant at 38%. Most shrubs were classified as B2 (<2m in height; Table 6). Common juniper was the only shrub observed at Lewis Creek (once each at plot 8 and 12) to be greater than 2 metres high. Wildlife feces detected within the plots included black bear, deer, elk, rabbit and bighorn sheep.

Table 5: Plotwise means (± SD; n = 12 quadrats per plot) for percent cover of functional / descriptive species groupings at Lewis Creek.

	Mean percent cover (±SD)
Forb	2.9 (± 4.9)
Bunchgrass	1.0 (± 3.4)
Pinegrass	0.7 (± 1.3)
Sedge	0.3 (± 1.0)
Shrub	8.1 (± 16.3)

Table 6: Plotwise means (± SD; n = 12 quadrats per plot) for shrub classes B1 (>2m high) and B2 (<2m high) at Lewis Creek.

	Mean percent cover (±SD)
B1 (tall shrubs)	0.13 (± 0.35)
B2 (short shrubs)	27.4 (± 15.4)

3.1.2.2 Species Composition

Individual species within each functional group were ranked by both overall mean percent cover (Table 7) and by occurence in the greatest number of quadrats (Table 8). Arrowleaf balsamroot was the most common forb at Lewis Creek in terms of overall mean percent cover. However its presence was limited to seven of the 180 quadrats. The species is a large flowering plant that occurs in dense clusters on open ground and individuals can cover large areas. The forb more representative of the entire site was moss phlox which had effectively the same mean percent cover as balsamroot and was the most common forb at Lewis Creek site in terms of number of quadrats in which it occurred.

Two blue-listed forbs known to occur within the Lewis Creek treatment area, nine-leaved desert parsley and Montana larkspur were not recorded in any of the daubenmires in Treatment Unit 1, where vegetation monitoring occurred. Davidson (2008) noted that "desert parsley is widespread on dry open grassland slopes of Treatment Unit 2", while "Montana larkspur is also common near the rock outcrops in Treatment unit 1".

Bluebunch wheatgrass and rough fescue were the most common bunchgrasses, respectively, in terms of both overall mean percent cover and number of quadrats. Kinnikinnick was the most common shrub in mean percent cover and tied with birch-leaf spirea in number of quadrats. One sedge was present, northwestern sedge. There was only one recorded exotic species (black medic).

Table 7: Top species, by functional group with greatest overall mean percent cover, by quadrat, at Lewis Creek

Group	Species	Common Name	Mean (SD, n)
Forb	*Balsamorhiza sagittata*	Arrowleaf balsamroot	0.6 (±3.5, n= 7)
	Phlox hoodii	Moss Phlox	0.6 (±1.5, n = 30)
Bunchgrass	*Pseudoroegneria spicata*	Bluebunch wheatgrass	0.5 (±3.1, n = 26)
	Festuca campestris	Rough fescue	0.2 (±0.6, n = 11)
Shrub	*Arctostaphylos uva-ursi*	Kinnikinnick	3.5 (±8.4, n = 55)
	Juniperus communis	Common juniper	2.4 (±13.6, n = 10)

Table 8: Top three species, by functional group, found in the most number of quadrats at Lewis Creek (total quadrats = 180).

Group	Species	Common Name	n Quadrats
Forb	*Phlox hoodii*	Moss Phlox	30
	Achillea millefolium	Yarrow	16
	Antennaria umbrinella	Umber pussytoes	12
Bunchgrass	*Pseudoroegneria spicata*	Bluebunch wheatgrass	26
	Festuca campestris Koeleria	Rough fescue	21
	macrantha	Junegrass	11
Shrub	*Spiraea betulifolia*	Birch-leaved spirea	55
	Arctostaphylos uva-ursi	Kinnikinnick	55
	Juniperus communis	Common juniper	10

3.1.2.3 Species Richness

Overall richness for Lewis Creek was 48 species. Richness on individual plots was relatively variable, with a mean for the 15 plots of 13.1 species (SD = 5.8), ranging from 3 on plot 15 to 22 on plot 6 (Figure 7).

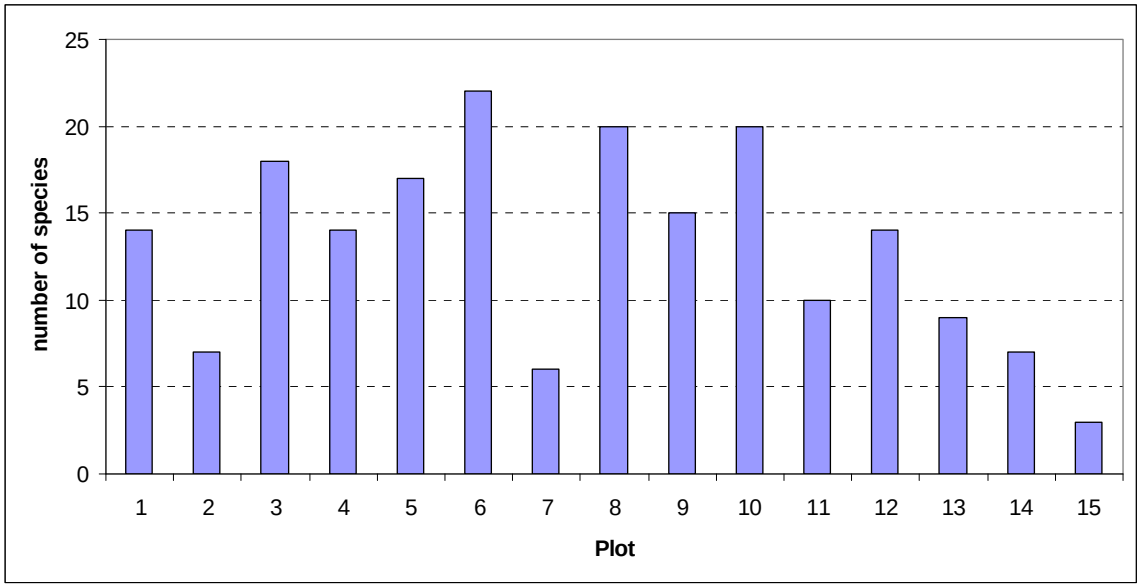

Figure 7: Species richness (including shrubs and trees) at each of 15 plots at Lewis Creek.

3.1.3 Forage Production

Bunchgrasses and pinegrass contributed similar biomass to forage production, followed by forbs (Table 9). Sedges and shrubs provided minimal contributions, except for plot 12, where sedges had one of the highest contributions of the entire site. There was significant variation among plots within functional groups, particularly for forbs, bunchgrasses and pinegrass.

Table 9: Mean forage production (kg / ha, dry mass; ± SD, n = 12 plots) at Lewis Creek open forest restoration site.

	Mean forage production (± SD)
Forb	41.5 (± 52.4)
Bunchgrass	55.2 (± 107.6)
Pinegrass	52.5 (± 70.6)
Sedge	18.4 (± 58.4)
Shrub	6.5 (± 9.7)
Total	174.1 (± 157.2)

3.2 Airport Pasture

3.2.1 Overstory

3.2.1.1 Species composition and Individual Tree Size

Douglas-fir was the most common overstory species (71.8%) found at Airport Pasture restoration site (Table 10). Other species were ponderosa pine (26.0%) and lodgepole pine (2.1%). The one unknown tree was a decay class 7 snag. The Douglas-fir diameter distribution was divided. Half (50.9%) of the Douglas-fir trees were classed as 'regeneration', while 23.1 % were 'dominants'. Ponderosa pine trees were mostly 'mature' (50.0%) and 'dominant' (32.8%) with numerous 'regeneration' (10.9%). There was a large cohort of Douglas-fir <2.5 cm dbh (Figure 8), most of these were classified as regeneration (Table 10). There were few trees of any species between 2.5 cm and 12.5 cm dbh (mostly sapling and pole classifications). Mature and dominant Douglas-fir and ponderosa pine classifications were biased toward the lower diameter range for both classifications. There were too few lodgepole pine trees present to make any biologically meaningful conclusions.

Table 10: Number of individual trees by species and age/size class for all plots pooled at Airport Pasture restoration site.

Spp.	Total	Germ.	Regen	Sapling	Pole	Mature	Dominant
Douglas-fir	481	21	245	26	3	75	111
Ponderosa pine	174	4	19	7	0	87	57
Lodgepole pine	14	0	5	0	0	6	3
unknown	1						1
total	670	25	269	33	3	168	172

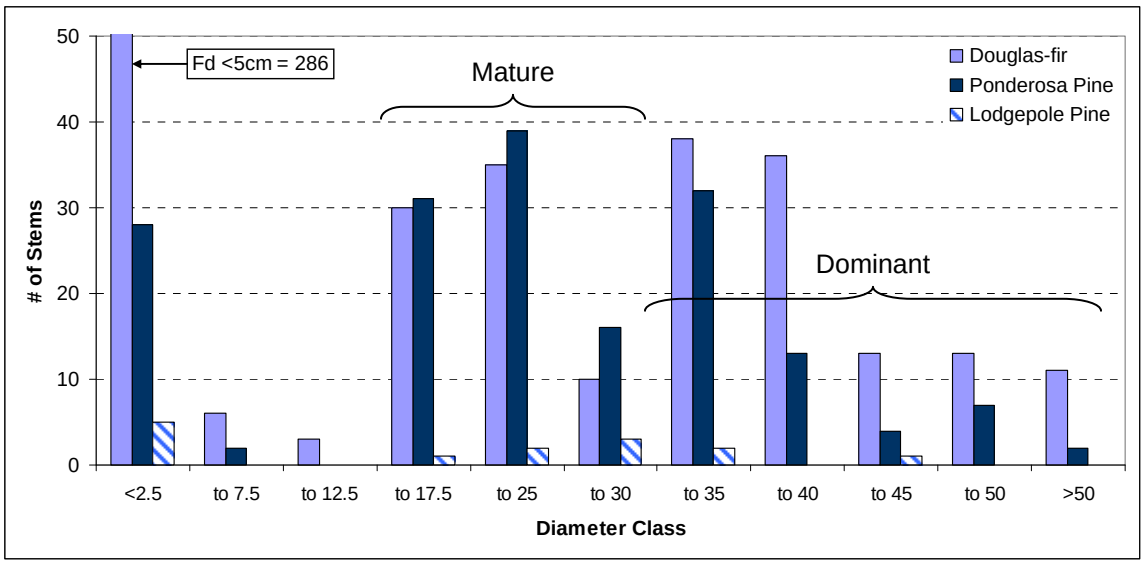

Figure 8: Diameter class distribution for all trees found at Airport Pasture restoration site. One unknown tree is removed. Total number of Douglas-fir stems <5cm dbh is noted separately; dependent axis was split to retain detail for the remaining classes.

3.2.1.2 Tree density

Tree density for the younger / smaller diameter age classes (germinants – pole) was highly variable across the plots (Table 11). Density was much more evenly distributed for 'mature' and 'dominant' age / size classes. Standard deviations for pooled means were more than twice their associated mean value for 'germinants', and 'pole' classes and well above the mean for both 'regeneration' and 'saplings' (Table 11). Conversely, standard deviations were a fraction of their associated mean for 'mature' and 'dominant'. Part of the skewed values may be a result of the methodology. This variability may be a result of the factors used used to convert recorded values to 'stems per hectare'. One recorded germinant became 1000 stems per hectare; there was no opportunity for values between 0 and 1000. Conversion factors for 'mature' and 'dominant' trees was much lower (25 and 5, respectively).

Table 11: Number of live and dead stems per hectare by varying age/size class at Airport Pasture restoration site. Mean and standard deviation are pooled across 15 plots.

	Mean live trees ± SD	mean dead trees ± SD
Germ.	1666.7 ± 3921.9	
Regen.	3493.3 ± 4519.1	13.3 ± 51.6
Sapling	386.7 ± 634.6	40 ± 154.9)
Pole	40 ± 112.1	
Mature	265 ± 152	
Dominant	60.3 ± 30.4	
Total	985.3 ± 2698.5	8.9 ± 66.4

3.2.1.3 Crown Closure

Mean crown closure was 43.1% (SD = 27.2, n = 60 readings). Readings ranged from 2.2 – 96.9%, with a median value of 34.5%. There was moderate variation between plots (Figure 9) indicating uneven canopy closure across the Airport Pasture site.

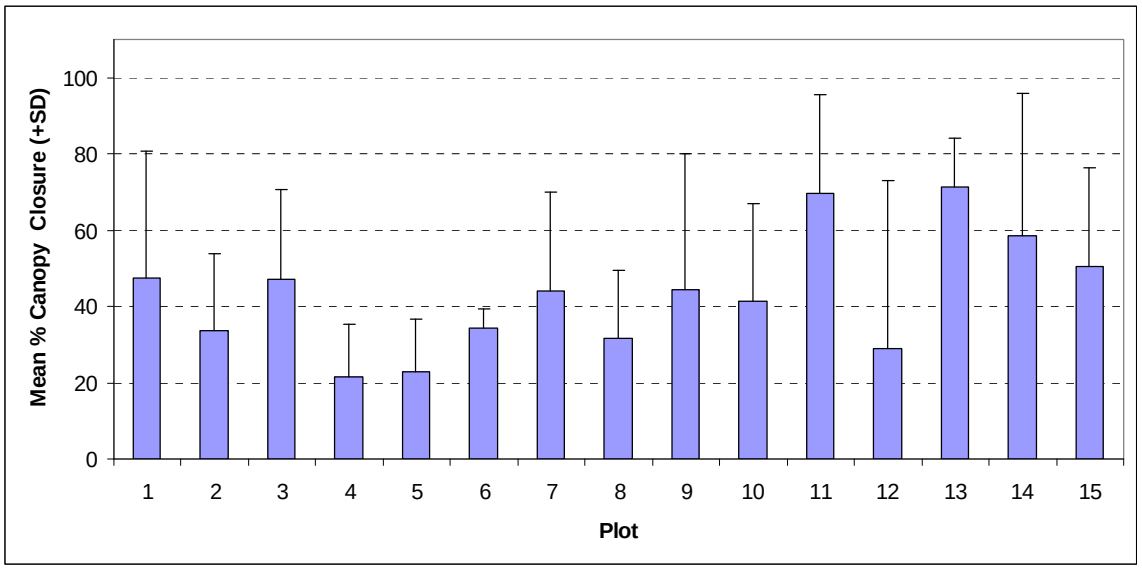

Figure 9: Mean percent crown closure values (plus standard deviation) for each plot at Airport Pasture. n = 4 readings per plot.

3.2.1.4 Decay Class

The majority of trees recorded at the Airport Pasture site were Class 1 (live). There were very few trees recorded with more advanced signs of decay. Across the entire site, only four Douglas-fir, eight ponderosa pines, one lodgepole pine and one unknown species (unidentifiable at decay class 7) were recorded (Figure 10). This low number of potential wildlife trees could limit available habitat for cavity nesters. However, Figure 8 indicates that there are a number of Douglas-fir and ponderosa pine trees between 20 and 40 cm dbh that may provide wildlife tree options in the future. A number of mature to dominant sized trees should be retained to be recruited as potential future wildlife trees. Some of these current live trees may be candidates for heart-rot inoculation to accelerate the natural process of decay (see Manning 2007).

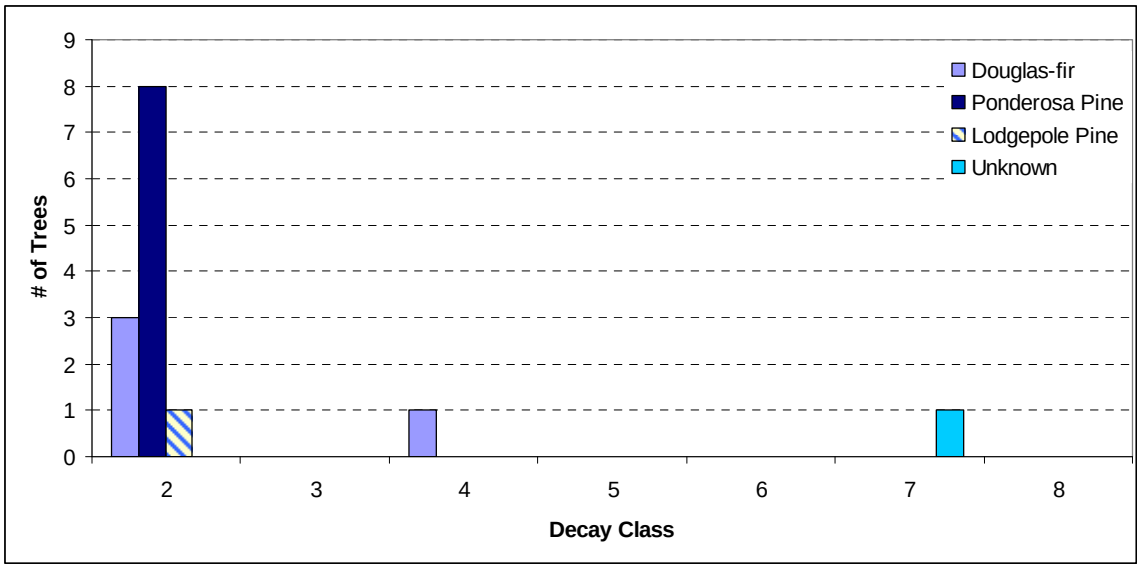

Figure 10: Distribution of decay classes 2 – 8 at Airport Pasture.

3.2.2 Understory

3.2.2.1 Percent Cover of Functional Groups

Shrubs formed the majority of the cover of understory at Airport Pasture, followed in order by forbs, bunchgrasses, pinegrass and sedge (

Table 12). Between plots, there was often substantial variation, especially for shrub cover which ranged between mean values of 0.1 and 27.6 %. Bunchgrasses were relatively evenly distributed, occurring on all plots, and just over half of all quadrats (52.3%), at a fairly consistent percent cover (range = 0 – 8 % cover). Pinegrass was similarly evenly distributed, occurring on all plots (58.9% of quadrats, range = 0 – 5 % cover). See Appendix 3 for details. Shrub class was dominated by short shrubs; no shrubs >2 metres in height were recorded (Table 13). There were no wildlife feces detected within any of the plots at Airport pasture.

Table 12: Plotwise means (± SD; n = 12 quadrats per plot) for percent cover of functional / descriptive species groupings at Airport Pasture OGMA.

	Mean live trees ± SD
Forb	3.7 (±3.9)
Bunchgrass	1.2 (±1.6)
Pinegrass	1.1 (±1.3)
Other Grass	0.01 (±0.1)
Sedge	0.4 (±1.2)
Exotic Forb	0.02 (±0.2)
Exotic Grass	0.2 (±0.6)
Shrub	11.0 (±14.6)

Table 13: Plotwise means (± SD; n = 12 quadrats per plot) for shrub classes B1 (>2m high) and B2 (<2m high) at Aiport Pasture OGMA.

	Mean percent cover (SD)
B1 (tall shrubs)	0
B2 (short shrubs)	41.4 (±20.8)

3.2.2.2 Species Composition

Understory species were combined into functional / descriptive groups and ranked by both overall mean percent cover (Table 14) and by the most number of quadrats (Table 15). Most common forbs included umber pussytoes and yellow penstemon in both categories. Bunchgrasses were dominated by rough fescue and bluebunch wheatgrass, respectively. Kinnikinnick was by far the most common shrub, with lesser amounts of snowberry and saskatoon.

Other grasses present included slender wheatgrass (*Elymus trachycaulus*) and mat muhly (*Muhlenbergia richardsonis*). One sedge was present, northwestern sedge.

Few exotic species were recorded. Black medic was recorded on 3 quadrats; grasses quackgrass (*Elymus repens*) and common timothy (*Phleum pretense*) occurred on 22 quadrats and one quadrat, respectively.

Table 14: Top species, by functional group with greatest overall mean percent cover, by quadrat, at Aiport Pasture

Group	Species	Common Name	Mean* (SD, n)
Forb	*Antennaria umbrinella*	Umber pussytoes	0.84 (±2.3, n = 43)
	Penstemon confertus	Yellow penstemon	0.78 (±1.2, n = 72)
Bunchgrass	*Festuca campestris*	Rough fescue	0.6 (±1.4, n = 47)
	Pseudoroegneria spicata	Bluebunch wheatgrass	0.2 (±0.5, n = 28)
Shrub	*Arctostaphylos uva-ursi*	Kinnikinnick	8.8 (±13.7, n = 109)

Table 15: Top three species, by functional group, found in the most number of quadrats at Airport Pasture (total quadrats = 180).

Group	Species	Common Name	n Quadrats
Forb	*Penstemon confertus*	Yellow penstemon	72
	Antennaria umbrinella	Umber pussytoes	43
	Achillea millefolium	Yarrow	31
Bunchgrass	*Festuca campestris*	Rough fescue	47

	Pseudoroegneria spicata	Bluebunch wheatgrass	28
	Koeleria macrantha	Junegrass	18
Shrub	*Arctostaphylos uva-ursi*	Kinnikinnick	109
	Symphoricarpos albus	Snowberry	28
	Amelanchier alnifolia	Saskatoon	26

3.2.2.3 Species Richness

Overall richness for Airport Pasture was 43 species. Richness was relatively evenly distributed across the 15 plots. Mean richness was 17.4 (SD = 5.8) and ranged from 10 species on plot 15 to 22 species on plot 4.

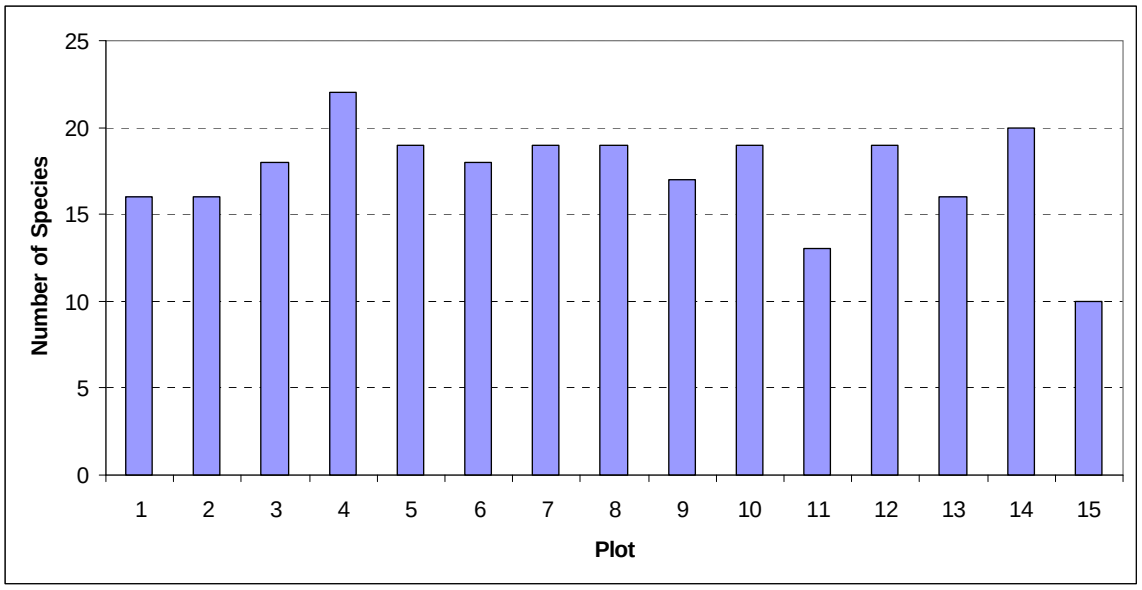

Figure 11: Species richness (including trees) at each of 15 plots at Airport Pasture.

3.2.3 Forage Production

Bunchgrasses contributed the greatest biomass to forage production, more than double the greatest biomass of the next highest functional group, pinegrass (Table 16). Forbs also made a contribution of forage biomass, while the remaining groups provided very scattered contributions. There was significant variation among plots within functional groups, particularly for bunchgrasses and pinegrass. See Appendix 4 for details.

Table 16: Mean forage production (kg / ha, dry mass; ± SD, n = 12 plots) at Airport Pasture OGMA restoration site.

	Mean forage production (± SD)
Forb	23.6 (±31.5)
Bunchgrass	76.1 (±91.9)
Pinegrass	35.2 (± 71.1)
Other grass	1.2 (± 4.6)
Sedge	7.9 (±23.0)
Shrub	4.5 (± 10.5)
Conifer	5.2 (± 17.0)
Exotic	5.1 (± 19.6)
Total	158.8 (± 91.5)

Other Notes

Substantial recent and historical badger and Columbian ground squirrel (*Spermophilus columbianus*) activity was noted throughout the block (Table 17). Recent (new) diggings had fresh dirt on top of this year's vegetation; burrows classified as historical (old) did not. Extensive badger use of the area is well documented and nearby Wildlife Habitat Areas (WHA) have been established to help maintain key badger habitat features. Badger burrows serve various functions including denning, foraging (primarily for ground squirrels) and natal den sites. Many of the badger burrows observed here may have been badgers expanding existing ground squirrel burrows while foraging. The number of badger burrows is not related to local badger population size.

Table 17: New and old ground squirrel and badger burrows noted on Airport Pasture site between plots.

	Ground Squirrels		Badger	
Between plots	**New**	**Old**	**New**	**Old**
1 - 2	0	24	0	6
2 - 3	0	35	11	2
3 - 4	3	20	2	4
4 - 5	4	12	8	5
5 - 6	3	10	6	5
6 - 7	2	8	2	4
7 - 8	17	7	0	8
8 - 9	10	9	7	5
9 - 10	8	10	20	16
10 - 11	12	24	10	35
11 - 12	16	23	9	15
12 - 13	21	17	13	3
13 - 14	0	9	0	10
14 - 15	0	4	0	0

4 Recommendations

Post treatment vegetation monitoring should be completed using the same methodology that was used in the pre-treatment. It should be done in years 1, 3, 5 and 10 post-treatment to determine the response of the vegetation community. Special attention should be given to any invasive species detected, so that a maintenance program can be employed to ensure they do not become established. Forage production should also be assessed in year 1, 3, 5 and 10 post-treatment and compared to other sites to determine the available forage at these sites.

5 References

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Appendix 1.

Lewis Creek: Plot information

	Measurement	UTM[1]		Elevation	Transect bearing						Tran or	Clipped		
Plot	Date	Easting	Northing	(m)	1	2	3	Slope	Aspect	Photos	N/S/E/W	Date	Cage	comments
LC01	6-Aug-2008	596102	5517145	1004	206	326	86	12	150	yes	N/S/E/W	24-Sep-2008	no	Mid-open on ridge
LC02	7-Aug-2008	596224	5517214	1007	36	156	276	24	215	yes	N/S/E/W	24-Sep-2008	no	slight gully north of road
LC03	8-Aug-2008	596400	5517131	989	88	208	328	28	100	yes	N/S/E/W	24-Sep-2008	no	open plot near road on slope
LC04	11-Aug-2008	596313	5517060	987	294	54	174	2	132	yes	n/S/E/W	24-Sep-2008	no	open plot near steep ridge (moved plot to avoid steep slope)
LC05	7-Aug-2008	596064	5516928	986	8	128	248	0	0	yes	N/S/E/W	24-Sep-2008	no	
LC06	12-Aug-2008	595954	5516975	987	46	166	286	13	102	yes	N/S/E/W	24-Sep-2008	no	mid closed plot inn SW corner
LC07	12-Aug-2008	595918	5517071	1008	83	203	323	15	136	yes	N/S/E/W	24-Sep-2008	no	closed Fd plot in SW corner
LC08	12-Aug-2008	596042	5517045	992	204	324	84	7	168	yes	n/S/E/W	24-Sep-2008	no	mid open
LC09	13-Aug-2008	596129	5517241	1008	46	166	286	15	141	yes	N/S/E/W	24-Sep-2008	no	
LC10	13-Aug-2008	596155	5517075	992	76	196	316	22	152	yes	N/S/E/W	24-Sep-2008	no	open plot of west facing slope
LC11	13-Aug-2008	596231	5517014	987	92	212	332	6	230	yes	N/S/E/W	24-Sep-2008	no	plot on ridge in slight gully in SW corner
LC12	15-Aug-2008	596328	5517208	1003	270	30	150	13	156	yes	n/S/E/W	24-Sep-2008	no	NE corner
LC13	14-Aug-2008	596488	5516946	963	250	10	130	23	203	yes	N/S/E/W	24-Sep-2008	no	open plot near view point
LC14	14-Aug-2008	596539	5517057	951	28	148	268	31	50	yes	N/S/E/W	24-Sep-2008	no	closed plot on west ridge
LC15	14-Aug-2008	596635	5517106	934	256	16	136	19	112	yes	N/S/E/W	24-Sep-2008	no	closed plot in NE corner

[1] all UTMs are NAD83, Zone 11

Airport Pasture: Plot information

Plot	measurement date	UTM[1] Easting	UTM[1] Northing	Elevation (m)	Transect bearing 1	Transect bearing 2	Transect bearing 3	Slope	Aspect	photo	Tran or N/S/E/W	Clipped Date	cage	comments
AP01	July 10, 2008	590754	5507336	869	354	114	234	14	100	yes	N/S/E/W	24-Sep-2008	no	Slight slope, mid-open plot in SE corner
AP02	July 11, 2008	590751	5507440	866	76	196	316	14	80	yes	N/S/E/W	24-Sep-2008	no	Mid-open plot in SE corner
AP03	July 15, 2008	590753	5507584	881	146	266	26	22	111	yes	N/S/E/W	24-Sep-2008	no	SE facing slope W of Road
AP04	July 15, 2008	590748	5507674	870	62	182	302	13	113	yes	N/S/E/W	24-Sep-2008	no	flat mid-open plot W of road
AP05	July 16, 2008	590739	5507766	872	228	348	108	5	45	yes	N/S/E/W	24-Sep-2008	no	open plot next to dense stand
AP06	July 17, 2008	590716	5507870	872	92	212	332	0	0	yes	N/S/E/W	24-Sep-2008	no	mid-open and flat near old road
AP07	July 17, 2008	590705	5507969	871	164	284	44	6	268	yes	N/S/E/W	24-Sep-2008	no	closed plot near old road
AP08	July 18, 2008	590692	5508191	862	285	45	165	6	132	yes	N/S/E/W	24-Sep-2008	no	open plot near gully and old landing
AP09	July 21, 2008	590595	5508282	866	160	280	40	1	90	yes	N/S/E/W	24-Sep-2008	no	mid-open plot near gully
AP10	July 22, 2008	590357	5508221	881	22	142	262	-8	270	yes	N/S/E/W	24-Sep-2008	no	Mid-open NW corner
AP11	July 22, 2008	590385	5508066	880	94	214	308	6	124	yes	N/S/E/W	24-Sep-2008	no	closed plot in SW corner
AP12	July 23, 2008	590430	5507907	880	190	310	70	-9	310	yes	N/S/E/W	24-Sep-2008	no	Open flat plot
AP13	July 23, 2008	590428	5507722	884	262	22	202	1	122	yes	N/S/E/W	24-Sep-2008	no	Closed site on W side of ridge
AP14	July 24, 2008	590454	5507560	891	358	118	238	-2	178	yes	N/S/E/W	24-Sep-2008	no	Mid-open plot on ridge next to stand of Fd regen
AP15	July 24, 2008	590528	5507416	876	100	220	340	7	180	yes	N/S/E/W	24-Sep-2008	no	mid-open plot at SE edge of plot

[1] all UTMs are NAD83, Zone 11

Appendix 2.

Lewis Creek: Plot-wise mean information for tree density (see Table 4).

Plot	Germinants	Regeneration	Sapling	Pole	Mature	Dominant	Total
1	1000	0	400	0	475	15	1890
2	3000	0 (400)	400 (200)	600	1100	45 (5)	5145 606)
3	0	6000	0	0	225	50	6275 (2)
4	0	0	0	0	100 (25)	45	145 (28)
5	0	0	400	600	250	40	1290 (4)
6	0	200	1000	400 (200)	475	20	2095 205)
7	0	0	1000	0	1125	30	2155 (6)
8	0	0	0	0	400	55 (10)	455 (17)
9	0	600 (200)	1400	200	375 (25)	25 (5)	2600 (238)
10	0	0	0	0	275	5 (5)	280 (14)
11	4000	0 (200)	0	0	350	25 (5)	4375 (215)
12	1000	1200	800	400	225	50 (5)	3675 (16)
13	0	400	0	0	100	60 (10)	560 (22)
14	0	400 (200)	1600	200	50 (25)	55 (5)	2305 (243)
15	0	0	1200	1800	900 (25)	20 (5)	3920 (44)
Mean	600	586.7 (66.7)	546.7 (13.3)	280 (13.3)	428.3 (6.7)	36 (3.7)	412.9 (17.3)
SD	1242.1	1535.2 (123.4)	573.0 (51.6)	476.9 (51.6)	345.4 (11.4)	17.0 (3.5)	872.2 (61.4)

Note substantial inter-plot variation within age-classes, particularly for lower diameter classes.

Airport Pasture: Plot-wise mean information for tree density (see Table 11).

Plot	Germinants	Regeneration	Sapling	Pole	Mature	Dominant	Total
1	0	4200	2400	400	425	35	7460
2	0	2200	800	0	300	75	3375
3	5000	3200	200	0	500	35	8935
4	0	200	0	0	0	40	240
5	0	0	200	200	325	40	765
6	0	3200	200	0	300	75	3775
7	0	1000	0	0	425	45	1470
8	1000	1800	0	0	400	55	3255
9	1000	600	800	0	250	35	2685
10	2000	5200 (200)	0 (600)	0	175	35	7410 (800)
11	1000	200	0	0	350	75	1625
12	0	400	0	0	25	30	455
13	0	3600	600	0	150	105	4455
14	15000	17000	0	0	75	100	32175
15	0	9600	600	0	275	125	10600
mean	1666.7	3493.3 (13.3)	386.7 (40)	40	265	60.3	985.3 (8.9)
SD	3921.9	4519.1 (51.6)	634.6 (154.9)	112.1	152	30.4	2698.5 (66.4)

Note substantial inter-plot variation within age-classes, particularly for lower diameter classes.

Appendix 3.

Lewis Creek: Plot-wise means (± SD; n = 12 quadrats per plot) for percent cover of functional groups

Plot	Forb	Bunchgrass	Pinegrass	Sedge	Exotic forb	Shrub
1	2.3 (± 2.9)	1.7 (± 1.6)	0.4 (± 0.5)	0.2 (± 0.6)	-	4.7 (± 5.6)
2	0.6 (± 1.0)	-	-	0.3 (± 0.9)	-	1.5 (± 2.7)
3	6.8 (± 8.4)	4.3 (± 10.7)	0.7 (± 0.5)	-	-	19.6 (± 20.6)
4	1.7 (± 2.2)	3.1 (± 4.9)	-	0.3 (± 0.9)	-	21.6 (± 32.1)
5	3.7 (± 3.4)	0.3 (± 0.6)	1.2 (± 1.5)	0.9 (± 1.2)	-	10.2 (± 11)
6	3.8 (± 3.4)	0.9 (± 1.2)	0.9 (± 1.8)	0.3 (± 0.8)	-	1.3 (± 1.4)
7	1.1 (± 2.6)	-	2.7 (± 2.1)	-	-	4.6 (± 5.2)
8	5.5 (± 6.6)	0.9 (± 1.2)	0.7 (± 1.2)	0.4 (± 0.9)	0.1 (± 0.3)	8.8 (± 9.7)
9	3.3 (± 5.9)	-	0.4 (± 0.8)	0.6 (± 2)	-	1.3 (± 1.8)
10	7.6 (± 9.5)	2 (± 4.2)	0.8 (± 1.4)	0.3 (± 1.2)	-	15 (± 26.7)
11	2.6 (± 3.1)	-	1.0 (± 1.5)	0.1 (± 0.3)	-	1.7 (± 3)
12	1.9 (± 3.0)	0.3 (± 0.5)	0.5 (± 0.5)	0.2 (± 0.6)	-	14.9 (± 28.9)
13	1.0 (± 2.0)	1.0 (± 1)	0.4 (± 1.2)	0.6 (± 2)	-	9.7 (± 16.9)
14	0.4 (± 1.0)	-	1.4 (± 1.6)	0.0 (± 0)	-	3.0 (± 3.1)
15	0.8 (± 1.6)	-	-	-	-	4.2 (± 3.3)
mean	2.9 (± 4.9)	1.0 (± 3.4)	0.7 (± 1.3)	0.3 (± 1.0)	0.01 (± 0.1)	8.1 (± 16.3)

Empty cells indicate no species of that group were observed on the plot.
Summary mean and SD values represent all quadrats pooled for entire site (n = 180).

Airport Pasture: Plot-wise means (± SD; n = 12 quadrats per plot) for percent cover of functional groups

Plot	Forb	Bunchgrass	Pinegrass	Other Grass	Sedge	Exotic Forb	Exotic Grass	Shrub

1	3.6 (±3.6)	1.3 (±2.1)	0.7 (±1.4)	-	0.4 (±0.8)	-	0.1 (±0.3)	6.8 (±6.9)
2	2.3 (±2.7)	0.7 (±1.1)	2.9 (±1.7)	-	0.5 (±1.2)	-	0.3 (±0.9)	6.1 (±7.6)
3	3.0 (±3)	1.4 (±2.7)	0.8 (±1)	-	0.2 (±0.6)	-	-	5.2 (±4)
4	7.1 (±6.4)	1.3 (±1.4)	1.2 (±1.4)	0.1 (±0.3)	0.8 (±1)	-	-	27.6 (±23.4)
5	3.8 (±2.5)	1.5 (±2)	1.0 (±0.7)	-	1.5 (±3.1)	-	0.2 (±0.4)	23.3 (±16.6)
6	4.3 (±4.2)	1.8 (±2.1)	1.3 (±1.3)	-	1.0 (±2)	-	0.1 (±0.3)	11.2 (±13.9)
7	6.3 (±6.2)	1.2 (±1.3)	0.8 (±1.2)	-	0.3 (±0.6)	-	-	0.8 (±1.2)
8	4.2 (±2.4)	1.5 (±1.4)	0.9 (±1.2)	-	0.3 (±0.9)	-	0.4 (±0.7)	20.0 (±11.7)
9	2.8 (±2.6)	1.0 (±1)	1.4 (±1.1)	-	0.7 (±1.3)	-	0.3 (±0.7)	12.4 (±17.5)
10	1.8 (±2)	1.3 (±1.2)	0.8 (±0.8)	-	0.2 (±0.6)	0.3 (±0.7)	0.1 (±0.3)	20.5 (±14.8)
11	2.2 (±2.1)	1.1 (±1.9)	1.5 (±0.9)	-	0.3 (±0.6)	-	0.3 (±0.5)	9.4 (±19.1)
12	5.0 (±6)	1.2 (±1.9)	0.7 (±1)	0.1 (±0.3)	0.3 (±0.6)	-	0.8 (±1.7)	9.2 (±9.6)
13	2.2 (±2.1)	0.2 (±0.4)	1.0 (±0.7)	-	-	-	-	7.3 (±10.7)
14	4.7 (±4.1)	1.0 (±1)	1.1 (±1.4)	-	0.3 (±0.9)	-	0.1 (±0.3)	5.5 (±7.2)
15	2.0 (±1.5)	1.1 (±1.2)	0.8 (±1.3)	-	-	-	-	0.1 (±0.3)
mean	3.7 (±3.9)	1.2 (±1.6)	1.1 (±1.3)	0.01 (±0.1)	0.4 (±1.2)	0.02 (±0.2)	0.2 (±0.6)	11.0 (±14.6)

Empty cells indicate no species of that group were observed on the plot.
Summary mean and SD values represent all quadrats pooled for entire site (n = 180).

Appendix 4.

Lewis Creek: Plot-wise (and overall mean, ± SD) forage production (kg / ha, dry mass)

Plot	Forbs	Bunchgrass	Pinegrass	Sedge	Shrubs	Total
1	70	84	0	0	0	154
2	14	0	2	0	14	30
3	24	2	22	18	2	68
4	0	386	0	0	0	386
5	0	0	144	0	2	146
6	28	0	14	22	4	68
7	0	48	66	0	16	130
8	66	0	106	0	0	172
9	2	0	0	0	0	2
10	138	190	168	0	0	496
11	158	0	0	8	0	166
12	30	2	208	228	8	476
13	92	116	0	0	0	208
14	0	0	52	0	20	72
15	0	0	6	0	32	38
mean	41.5	55.2	52.5	18.4	6.5	174.1
SD	52.4	107.6	70.6	58.4	9.7	157.2

Airport Pasture: Plot-wise (and overall mean, ± SD) forage production (kg / ha, dry mass)

Plot	Forb	Bunchgrass	Pinegrass	Other Grass	Sedge	Shrub	Conifer	Exotic	Total
1	0	0	0	0	0	8	0	0	8
2	2	0	228	0	4	0	0	0	234
3	2	0	156	0	0	2	10	0	170
4	16	194	0	0	10	0	0	0	220
5	0	274	0	0	0	0	0	0	274
6	76	20	0	18	2	0	0	0	116
7	36	42	0	0	0	0	0	0	78
8	94	52	0	0	90	40	0	0	276
9	20	96	0	0	0	0	0	0	116
10	2	98	0	0	0	0	0	76	176
11	18	0	36	0	2	0	2	0	58
12	4	250	0	0	10	12	0	0	276
13	2	8	0	0	0	0	0	0	10
14	72	42	0	0	0	6	66	0	186
15	10	66	108	0	0	0	0	0	184
mean	23.6	76.1	35.2	1.2	7.9	4.5	5.2	5.1	158.8
SD	31.5	91.9	71.1	4.6	23.0	10.5	17.0	19.6	91.5