

## **Comparison of Field Methods**

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### **ABSTRACT**

Numerous types of field sampling protocols and procedures have been developed to estimate vegetation characteristics in semi-arid rangelands throughout the world. This study compared two methods commonly used in rangeland studies 1) ocular estimates and 2) point frame estimates. Both methods estimated percent cover of shrubs, grasses, forbs, litter, bare ground, and exposed rock. Statistical analyses were performed to compare these estimation methods which suggest that some cover type estimates tend to correlate well (e.g. shrubs) between sampling methodologies, while others (e.g. forbs) do not. Both methods appear adequate to support remote sensing based studies and additional correlative work is required to fully understand the effects, biases, and error propagation of sampling procedures (*abstract written by editor*).

**KEYWORDS:** *GIS, sampling, remote sensing*

## INTRODUCTION

Collecting field data from an entire study site is often not practical, thus sampling is often performed. Sampling takes measurements on small plots that are representative of the larger study site. Most sampling methods are quantitative and can include measures of frequency, biomass, and/or cover. The latter measure, canopy cover is a measure of percentage of all ground cover such as vegetation, litter, and bareground. Cover is a measure of abundance that is not biased by the size and distribution of individuals (Floyd and Anderson, 1987; Floyd and Anderson, 1982). A challenging aspect of cover measurements is relating percent canopy cover to remote sensing data and measurements. Cover can be measured in many ways in the field; common methods include ocular estimate (Peterson, 2005), point (Friedel and Chewings, 1988), line (Rahman and Gamon, 2004), or quadrat (Hanley, 1978), surveys. Ocular estimation is most often represented as the percentage of total cover (Carlsson et al., 2005) within a plot as opposed to point, line, and quadrat methods which are direct measurements (Hanley, 1978).

Several studies have compared cover methods in grasslands and rangelands to assess the agreement between them (Hanley, 1978; Stohlgren et al., 1998; Carlsson, 2005). Within sagebrush (*Artemisia* spp.) steppe ecosystems, Hanley (1978) and Floyd and Anderson (1987) concluded that line and point interception are more precise than visual (ocular) estimation. Kinsinger et al. (1960) determined that line interception was most accurate compared with two other canopy coverage techniques. Furthermore, Floyd and Anderson (1982) determined that point and line intercept methods provided similar results but that the line intercept required 32% more time for the same precision. Their 1987 study compared sampling time and precision between three cover estimate techniques and it revealed that point interception is the most efficient. The point frame technique is a well-accepted, accurate sampling method (Hanley, 1978; Floyd and Anderson, 1982; Floyd and Anderson, 1987; Inouye, 2002). Prior to its design, line interception was one of the most widely used cover methods in shrubby vegetation (Floyd and Anderson, 1982). Created by Floyd and Anderson (1982) in sagebrush steppe ecosystems, the point frame establishes a dot grid overlooking underlying vegetation and bare ground.

There are several types of ocular methods; each can be modified based on the users' sampling needs and experimental design. They typically involve a walk-about viewing the vegetation, soil, and other ground cover across the plot then estimating their percentages. The ocular method typically estimates the percent cover of the top canopy layer, as would be viewed by a satellite sensor. Although ocular estimates may provide a less precise and less accurate estimation of cover than other methods, their advantages include the ease and efficiency of data collection and potential for being most applicable to the spatial resolution of remote sensing images (e.g. 10-30 m). Though the ocular method is more time efficient during data collection than the point frame, it requires copious training time in order to minimize user bias. Ocular methods can involve viewing ground cover from different viewpoints such as panoramic and planimetric views. Germino et al., (2001) state that there is poor correlation between panoramic and planimetric landcover methods and that planimetric methods are better than panoramic methods for landcover studies due to perspective distortions.

We chose the point frame method for comparison to the ocular method because the near nadir view of the vegetation while sampling with a point frame emulates the view of a satellite. The point frame also provides an objective method for comparison to the ocular method. As Floyd and Anderson (1987) pointed out, absolute ground coverages are unknown, therefore it is difficult to compare coverage techniques with absolute certainty.

This study compares a point sighting frame method with an ocular estimation method using two data sets in the same area (+/- 5 m) before and after a prescribed burn (pre-fire n = 44, post-fire n = 42). We aim to determine the correlations between the two methods as well as their applicability for application to 10-30 m remote sensing imagery in rangeland ecosystems. Ground reference data (e.g. cover measurements) are often applied to remote sensing data to 1) aid in the analysis/interpretation of remotely sensed data, 2)

calibrate a sensor, and or 3) verify information extracted from remote sensing data (accuracy assessment) (Lillesand, 2004). Although Landsat data have been correlated to ground data for decades, there are few studies that relate precise ground truth data with remote sensing data. While many remote sensing studies use ground-truth data, no well accepted and published guide is available detailing how to routinely collect vegetation cover in rangeland environments to relate to remote sensing imagery. We compared the results of these two cover methods in order to determine which one would be favorable in future rangeland applications. It was hypothesized that the point frame method would be more accurate in estimating ground cover based on the discussion above. The proportion of intercepted points averages the cover of that cover type and thus provides a better measurement for remote sensing accuracy assessment. There is flexibility in adjusting both point frame and ocular plot sizes to the scale of the imagery, yet the precision of the point frame is higher than that of an ocular estimate of ground cover.

## METHODS

The study area is the Hitching Post pasture, a 3.24 km<sup>2</sup> fenced parcel within the U.S. Sheep Experiment Station (USSES) located in Clark County, Idaho (Fig. 1). The pasture is a sagebrush steppe ecosystem characterized by extreme seasonal variability and a co-dominance of *Artemisia* with several grass species (West and Young, 2000). This semiarid area has an elevation of 1463 m, an average annual precipitation of 250-530 mm, and average annual temperatures of 5°-6°C, with a 70 to 90 day frost-free season. The majority of the study area has gradual slopes (0%-1.5%). Soils are mixed, fine-loamy, frigid Calcic Argixerolls derived from residuum, alluvium, or windblown loess (Seefeldt, 2005; Natural Resources Conservation Service, 1995). Cattle and horses have grazed this pasture for the last decade, but it has been rested for the past two and a half years. No fires have occurred in the study area for the past 10 years and most of the area has moderate fuel load ( $\approx$  6722 kg·hectare). The study area was stratified for sampling based on fuel load because vegetation biomass was unaffected by slope, soil type, grazing, or fire history. The pasture is within a sagebrush steppe ecosystem and has two primary subspecies of sagebrush (*Artemisia* ssp.), mountain big (*A. tridentata* ssp. *vaseyana*) and threetip sagebrush (*A. tripartita* ssp. *tripartita*); other shrub species include antelope bitterbrush (*Purshia tridentata*), green rabbitbrush (*Chrysothamnus viscidiflorus*), and horsebrush (*Tetradymia canescens*). There are a few small patches of the exotic forbs leafy spurge (*Euphorbia esula*) and spotted knapweed (*Centaurea maculosa*); the exotic annual, cheatgrass (*Bromus tectorum*), occurred as a small component (<1%) of the overall plant cover. Lupine (*Lupinus argenteus*) is the most plentiful forb in the pasture, ranging in height from 20 cm to 1 m. During field sampling in summer 2005, sparse bareground was observed, and live vegetation cover (sagebrush, forbs, and grass) was high. This study area was chosen because of the opportunity to participate in a prescribed burn (September 23 and 24, 2005), allowing a high degree of control for pre- and post-fire field sampling.

Though there is not a standard point frame plot size, we determined our plot size to be 20 x 40 m according to the smallest satellite imagery pixel size used in a related study (10-20 m resolution, SPOT 5). This plot size directly relates to at least two (ideally eight with precise georegistration) pixels and therefore provides more accurate comparisons between field data and remote sensing data. Vegetation and/or soil in point frames were assigned to six categories: shrub, grass, forb, litter, rock, and bareground. Shrubs, forbs, and grasses were recorded if photosynthetic tissue fell under a point; shrub stem, dead or alive, and downed combustible debris were recorded as litter if it fell under a point; and rock or bareground were recorded if they were under a point. The necessary number of frames per plot were determined using sample effort curves (Fig. 2), sufficient to capture the variability within the cover types in the study area consisted of 15 frames within each plot. The 15 frames collected within each 20 x 40 m plot used a point frame (0.5 x 1 m with 36 points at 0.1 m intervals) placed  $\approx$ 1 m aboveground, totaling 540 point observations per plot (Fig. 3). Forty-nine random point frame plots were collected with the following criteria: 1) >20m from all bulldozer-created black-lines (for enclosure of the prescribed burn), and 2) >20m from all roads to mitigate road effects. Before the fire we sampled the 49 random plots, and

post-fire we sampled 42 of the same random plots (within +/- 5 m). Plot boundaries were recorded with a Trimble GeoXT GPS receiver (+/- 0.7m @ 95% CI) (Serr et al 2006).

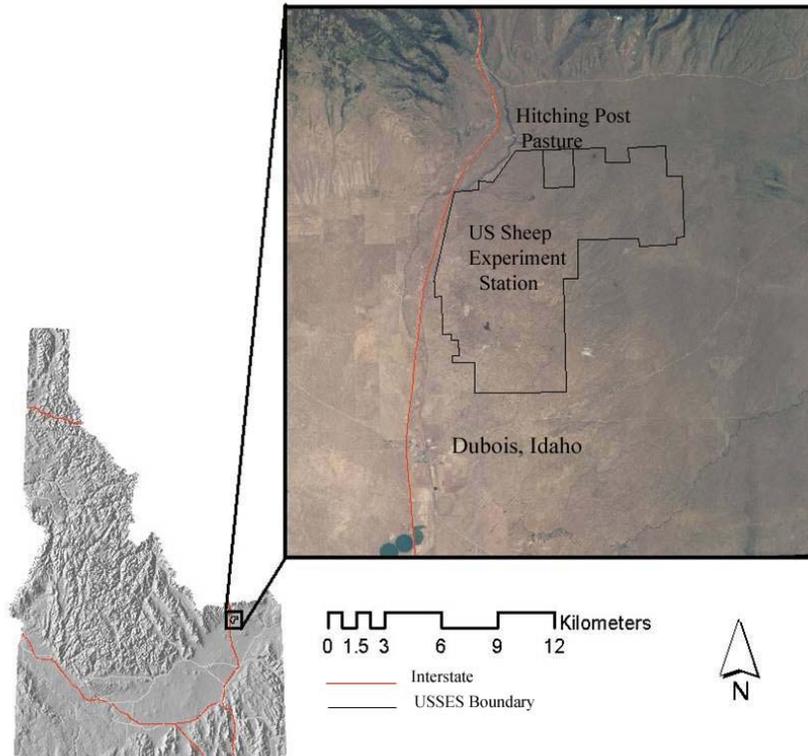


Figure 1. Location of the Hitching Post pasture study area in southeastern Idaho.

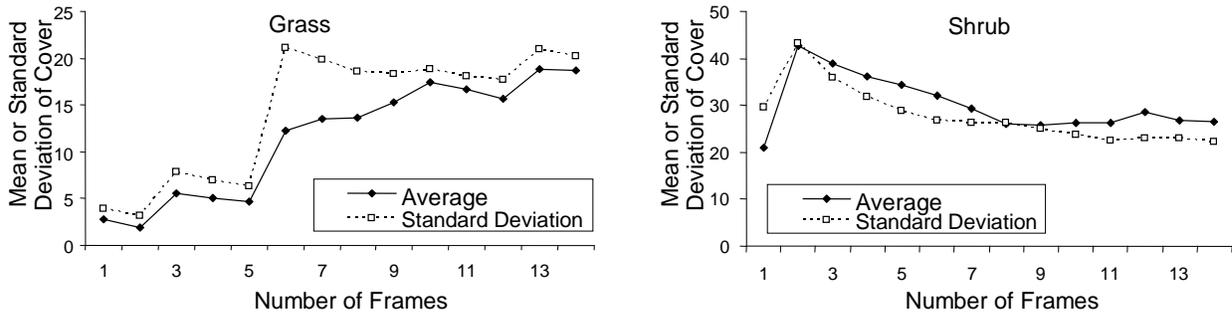
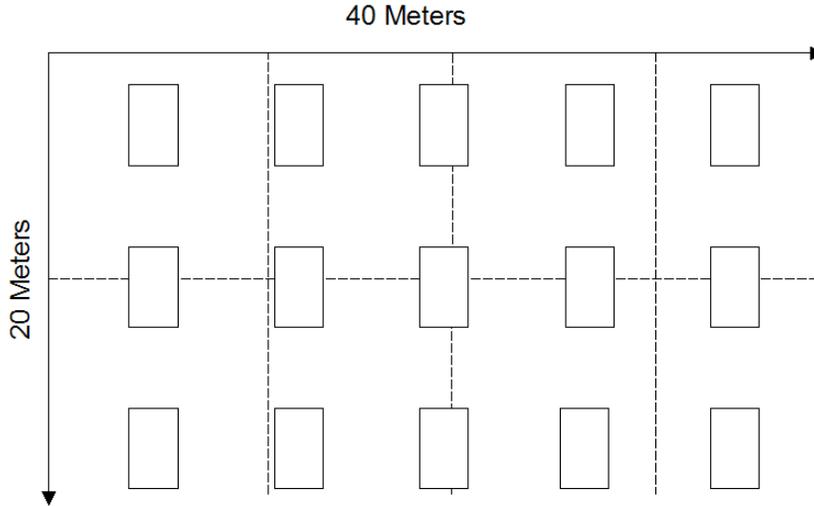


Figure 2. A sample effort curve is used to determine the necessary sampling intensity from one 20 x 40 m plot. Above, the cumulated mean (boxes) and standard deviation (diamonds) of shrub and grass cover for the plot level out around ten, indicating the need for approximately ten frames to estimate shrub and grass cover.

The ocular estimate method used mimics that developed by the ISU GIS TRc (2006) in 1999 and modified by McMahan et al. (2003) for semiarid rangelands in southeastern Idaho. In this method, six cover classes are used to visually assess percent of ground cover by two observers over a 60 m x 60 m plot which ideally covers four Landsat 30 x 30 m pixels or at least two pixels. Each person starts in the plot center and paces 30 m in opposite directions to the plot boundary. After walking the plot circumference, they proceed to walk in a spiral pattern within 3-4 m of the previous track back towards the plot center while observing plot attributes. At the center, each plot attribute is discussed until agreed upon. The six cover classes collected include shrub, grass, forb, litter, bare ground, and rock. Categorical

groups (Table 1) are used to assess percent cover for each cover class (McMahan et al., 2003). The same 42 random plots (as point frame plots) were navigated to both pre- and post-fire for this method so that cover class correlations could be fairly assessed. Each plot center location was recorded using a Trimble GeoXT GPS receiver (+/- 0.7m @ 95% CI) (Serr et al. 2006). Other attributes of the point frame method (Table 2) are compared with the ocular method attributes.



**Figure 3. Approximate location of 15 point frames within each 20 x 40 m plot. Dashed lines indicate potential SPOT pixel 10 x 10 m placement.**

Polynomial correlation was used to analyze the variability between the ocular and point frame estimates of ground cover. Before remote sensing could be performed, this was the most appropriate statistical technique for preliminary data analysis. Since both variables (point frame estimates and ocular estimates) were response variables and there was no assumption that one would predict the other, correlation was chosen over regression. Significances for ground cover were compared by applying analysis of variance (ANOVA) for each cover category in each data set (pre-fire data set n = 49; post-fire data set n = 42) using SAS (SAS Institute Inc., 2005).

**Table 1. Categorical groups of percent cover.**

Percent Cover	Cover Class
None	0
1-5%	1
6-15%	2
15-25%	3
26-35%	4
36-50%	5
51-75%	6
>75%	7

**Table 2. Point frame plot field attributes collected with Trimble GeoXT GPS receiver and ArcPad customized form.**

Attributes
Plot ID and its boundary location
Fuel load (3 categories) or Burn Severity
Plot homogeneity (as described in Field Methods)

## RESULTS

Correlation analyses between the point frame and ocular estimates were performed with the pre-fire and post-fire field collected data sets. Data show that shrub has the best correlation coefficient for both pre-fire and post-fire data sets (Figures 4 and 5). For the pre-fire data, shrub is the only cover that has fair correlation 79%; bare ground has the next best correlation, a weak 65%. However, for the post-fire data, shrub, forb, and bare ground have strong correlation, 89%, 83%, and 81% respectively. Litter and rock correlations are poor for pre-fire data (38% and 45% respectively), yet post-fire correlations improve to 74% and 53% respectively. Therefore, point frame and ocular estimate correlations improved after the prescribed burn.

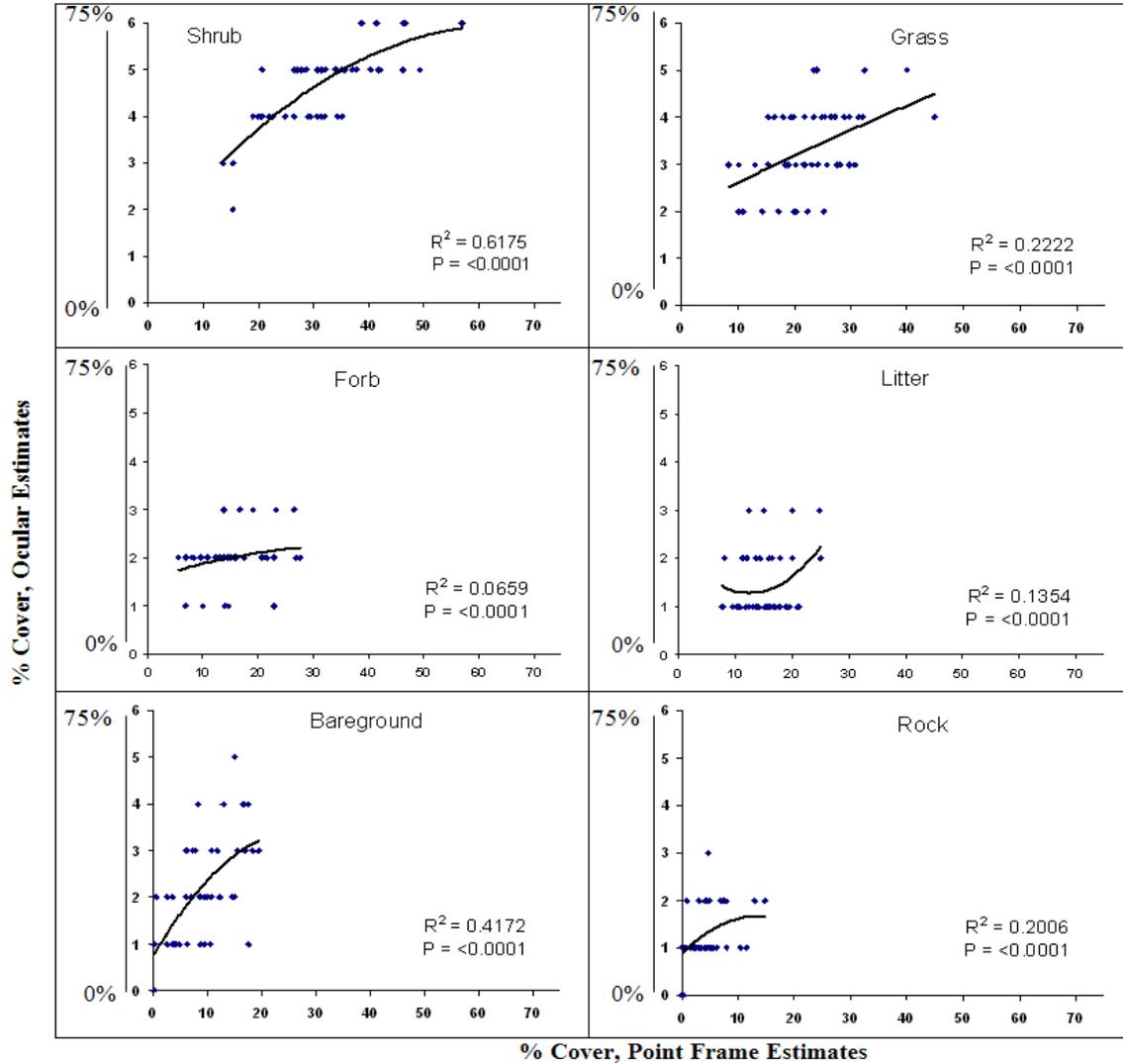


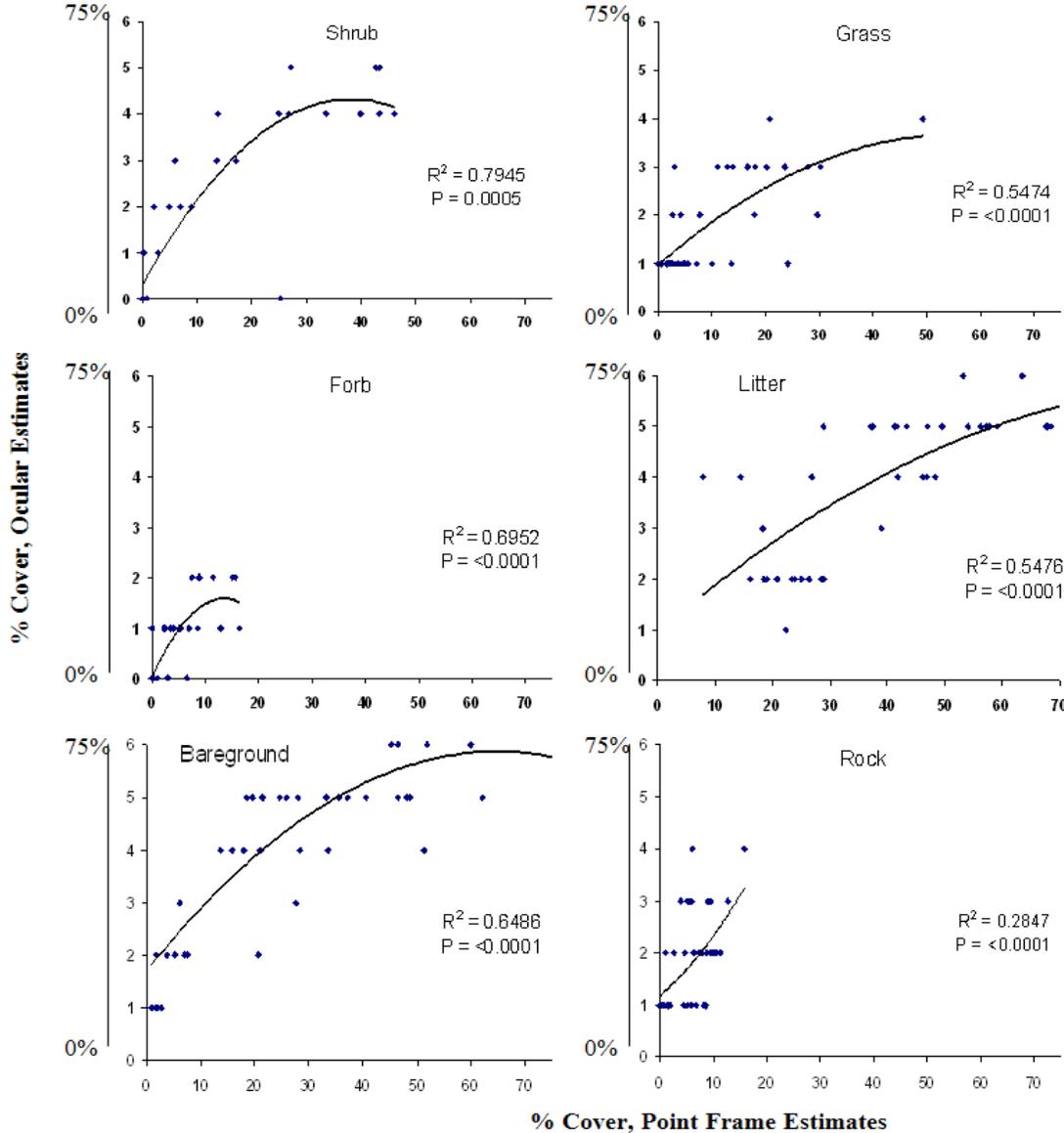
Figure 4. Using the pre-fire data set, point frame estimates are fairly correlated with ocular estimates (n = 49) in the same area for shrub and bareground.

## DISCUSSION AND CONCLUSIONS

The shrub cover had the best correlation between ocular and point frame estimates, likely because of its relatively large size (scale) and thus easy for the human eye to estimate total cover. Our lowest correlations with pre-fire data were with litter and rock, hypothesized to be due to their fine scale and thus difficulty to interpret. All post-fire correlations were higher between field methods, most likely because visually assessing cover on the same plane (i.e. burned landscapes) is easier than assessing cover with

multiple canopy levels (i.e. vegetated landscapes).

The shrub cover class has overwhelmingly more height and depth than the other classes. Grass and forbs also have height and depth but they are much shorter and not as broad. Litter, bareground, and rock have relatively little height or depth; these classes are at ground level (except for some litter and shrub stem) and tend to cover a more continuous area than the vegetation classes. These characteristics are pertinent to the perspective of the observer(s).



**Figure 5. Using the post-fire data set, the best correlation between point frame estimates and ocular estimates are for shrub (best overall correlation) and forb.**

Because pre-fire vegetation at our study site had a variety of height and depth characteristics, panoramic observations through the ocular method are likely poor estimates. Though our ocular estimates involved walking the plot extensively, we didn't have a completely nadir view upon the ground cover, as the point frame did. Thus the point frame results have better accuracy in the pre-fire estimates. On the other hand, the post-fire ground cover had fewer canopy levels (often just one), with less vegetation and more

exposed litter, bare ground, and rock. As our post-fire correlation results show, it was easier to ocularly estimate cover with fewer canopy levels and more continuous cover.

Field methods for determining ground cover must take into account perspective distortions such as line of sight and distance effects (Germino et al., 2001). For example, observations taken only from the plot center are error prone. Thus a nadir view of underlying vegetation is necessary to mitigate these effects. Therefore if ocular methods are used, the viewer must walk the plot in a small-scale, grid-like fashion in order to view in nadir the vegetation across the whole plot. The ocular estimations could be improved by decreasing the grid size and using a complete nadir observation stance. The point frame observations were taken at a small scale (0.5 x 1.0 m) with 15 frame estimates across the plot. More point frames may increase the accuracy and precision through observing more of the plot.

The intention of this project was to correlate two field methods for estimating ground cover in rangelands in order to determine the best method for application with 10-30 m remote sensing data. A method which correlates with remote sensing data will enhance training data and thus provide better accuracy assessments. We show that the point frame may be more accurate for dense vegetation, whereas the ocular method may be more appropriate in single canopy or extremely sparse vegetation. The only exception to this is the shrub category which had high correlation; therefore it may be applicable to estimate its cover alone for application to remote sensing imagery. The point frame method is a practical option because it provides better overall accuracy, no subjectivity/user bias is introduced, and it has good repeatability which is essential in multi-temporal studies. It takes only two to three times more sampling time (Table 3) than ocular methods, with relatively no training time. Because ocular estimates require less field time for each plot and thus more area can be covered, it is also an attractive option for ground truthing purposes. We've shown that both methods are feasible for ground truthing purposes as long as scale, number of canopy levels, and perspective distortions are taken into consideration so that ground cover units are not compromised (Tables 4 and 5). The results of this analysis are the backbone for future correlational studies between cover methods and application to remote sensing data.

**Table 3. Attributes of the ocular and point frame vegetation cover field methods.**

	Ocular	Point Frame
Time per plot	15-20 minutes	30-40 minutes
Accuracy	Low	0.5 x 1.0 m
Precision (repeatability)	Poor	High
Scale (extent)	60 m x 60 m	20 m x 40 m

**Table 4. Maximum percent cover (within each cover class) using ocular and point frame estimate data collected pre-fire.**

	Ocular Estimates					Point Frame Estimates						
	Shrub	Grass	Forb	Litter	Bare-ground	Rock	Shrub	Grass	Forb	Litter	Bare-ground	Rock
0%												
1-5%				65%	31%	71%						57%
6-15%			80%						53%	59%	49%	
16-25%		43%						53%				
26-35%							41%					
36-50%	45%											
51-75%												
> 75%												

**Table 5. Maximum percent cover (within each cover class) using ocular and point frame estimate data collected post-fire.**

	Ocular Estimates				Point Frame Estimates							
	Shrub	Grass	Forb	Litter	Bare-ground	Rock	Shrub	Grass	Forb	Litter	Bare-ground	Rock
0%	48%		57%				55%		50%			
1-5%		60%				45%		43%				
6-15%												
16-25%											21%	
26-35%												55%
36-50%				48%	36%					31%		
51-75%										31%		
> 75%												

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