2010 FIELD SPECTROMETRY COLLECTION OF SAGEBRUSH AT THE O'NEAL ECOLOGICAL RESERVE, IDAHO

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ABSTRACT

The spectral reflectance of a ground target can be greatly influenced by atmospheric conditions and airborne particles before reaching a satellite-based sensor. For this reason, compiling a spectral library characterizing target spectra can be useful in later classification of remotely sensed imagery. Spectral data were collected for five ground target classes (basalt, bare ground, grass, dead-shrub, and live-sagebrush) during July, 2010 (n = 2,565). Data were collected using an Analytical Spectral Devices, Inc. (ASD) FieldSpec® Pro Spectroradiometer and imported into Microsoft Excel for further processing. Spectra were sorted by target type and wavelength. Descriptive statistics were calculated, and mean spectral reflectance values for each target were used to calculate a pairwise single-factor Analysis of Variance (ANOVA) comparing the spectra of dead shrubs to each of the other four targets types to determine if dead woody shrubs could be differentiate from the matrix of other rangeland features (e.g., basalt, bare ground, grass, and live-sagebrush). In each case a statistical difference was observed ($P < 0.001$) between pairwise samples suggesting further differentiation with satellite sensors may be possible. Calculated variability of spectra within each target type is narrow providing additional supporting evidence that differentiation is possible.

KEYWORDS: Sagebrush, sampling, GIS, remote sensing, field spectroscopy, shrub die-off, spectroradiometer

INTRODUCTION

Sage Grouse (*Centrocercus urophasianus*) are a sagebrush-obligate species requiring large, contiguous expanses of habitat. While the quantity or area of available habitat is important, so too is the quality of the available habitat. Recent land cover maps typically describe sagebrush dominated areas and treat all these areas as viable Sage Grouse habitat. However, large areas of dead sagebrush sometimes occur which may lead to an overestimation of total habitat available to the Sage Grouse. Sagebrush (shrub) die-off in semiarid rangelands was a widespread phenomenon in the salt-desert region of Utah between 1983 and 1988 due to extremely wet seasons (Wallace et al., 1989). Though this phenomenon is known to occur throughout the semiarid sagebrush-steppe, published reports pertaining to this phenomenon in southeast Idaho is limited. Shrub die-off affects the quality of Sage Grouse habitat as it impacts their primary food source and a source of shelter. The ability to differentiate dead shrubs from other ground cover targets with remotely sensed satellite imagery would allow land managers to better assess the quality of Sage Grouse habitat across their range.

Aside from monitoring Sage Grouse habitat however, positive identification of dead shrub during image classification would provide new insight into the capabilities of remote sensing technologies. This study determined whether stands of dead shrubs can be accurately delineated using geospatial technologies beginning with the characterization of target spectra in the field.

Field spectrometry is the quantitative measurement of radiance, irradiance, reflectance or transmission in the field (Curtiss and Goetz, 1994). Field spectroradiometers have a wide range of useful applications from aiding understanding of how an object of interest (i.e., target) might be detected using remote sensing, to collecting data that will serve as a spectral library for more precise image analysis and interpretation.

Atmospheric scattering and the signal to noise ratio (SNR) of a sensor can interrupt or alter spectral reflectance of a target. Scattering occurs when reflected light strikes other particles in the atmosphere before reaching the satellite sensor. The type of scattering (Rayleigh, Mie, or Nonselective) is dependent upon the size of particles in the atmosphere, their abundance, the wavelength of the reflected light, and the depth of the atmosphere through which the energy is traveling (Campbell, 2008). Rayleigh scattering is attributed to atmospheric gas molecules and cause visible effects such as a blue sky. Mie scattering occurs when particles have diameters that are roughly equivalent to the wavelength of the scattered radiation, and is experienced primarily in the lower atmosphere through larger particles such as dust or pollen. Nonselective scattering accounts for what we observe as a whitish haze in the atmosphere, and refers to scattering that occurs from particles larger than the wavelength of the scattered light (Campbell, 2008). The SNR of a particular sensor can also influence the ability to discriminate field targets. The signal refers to differences in image brightness caused by actual variations in scene brightness whereas noise refers to variations unrelated to scene brightness, and more with errors inherent in the sensor itself. If the magnitude of noise is large relative to the signal, resulting imagery image will not provide a reliable representation of the target of interest (Campbell, 2008). For this study, *in situ* spectra were collected from five target types (basalt, bare ground, grass, dead shrub, and live sagebrush) to produce a spectral reference library of ground cover types throughout the O'Neal study area in southeast Idaho. These data were analyzed to determine feasibility of target differentiation between dead shrubs and the matrix of other sagebrush-steppe plants and landscape features present at the study area.

METHODS

STUDY AREA

The O'Neal Ecological Reserve (Figure 1) is located along the Portneuf River, approximately 30 km southeast of Pocatello, Idaho (42° 42' 25"N, 112° 13' 0" W). The O'Neal receives <0.38 m of precipitation annually with nearly 50 percent falling as snow in the winter months (October 1- March 31). An average of 0.15 m (SE = 55.4) of rainfall occurs during the growing season (April 1 – September 31). The topography is relatively flat with a mean elevation of approximately 1426 m (1400-1440 m).

The site is characterized by shallow, well drained soils over basalt flows originally formed from weathered basalt, loess, and silty alluvium that remain homogenous throughout the site (USDA NRCS 1987; Weber and Gokhale 2010). Dominant plant species include big sagebrush (*Artemesia tridentata*) with various native and non-native grasses, including Indian rice grass (*Oryzopsis hymenoides*) and needle-and-thread (*Hesperostipa comata*) (Weber et al. 2010). The O'Neal is managed by Idaho State University (ISU) while land immediately surrounding it is managed by the USDI BLM. This area has a history of rest-rotation cattle grazing (> 20 years) at low stocking rates (300 AU/ 1467 ha [6 AUD ha-1]). Prior to ISU management, no fences existed to restrict movement of cattle from the adjacent USDI BLM grazing allotment to the O'Neal study area. In 2005, the site was fenced providing areas of grazing and total rest. The last fire to occur within the O'Neal was in 1992.

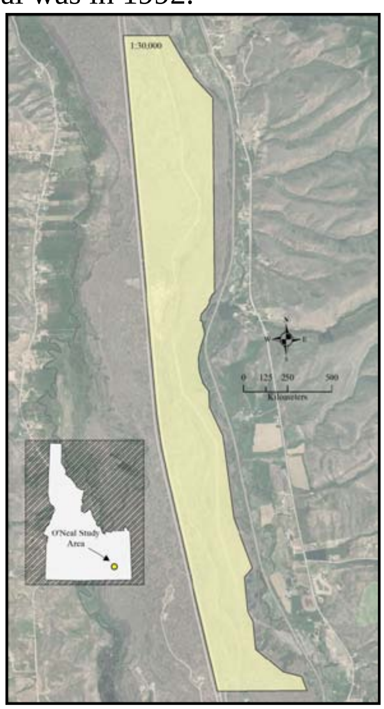

Figure 1. Research study area: The O'Neal Ecological Reserve, represented by the polygon, is located near McCammon, Idaho.

FIELD SPECTRORADIOMETER

An ASD FieldSpec® Pro Spectroradiometer was used to collect target spectra in the field. The FieldSpec Pro model was used to record relative spectral reflectance at wavelengths ranging from 350 - 2500nm. Spectral irradiance for targets was collected using a bare fiber optic sensor and then converted from raw digital number (DN) to relative reflectance values using ViewSpec®Pro software.

FIELD SAMPLING

Thirty sample sites were visited for each of five target categories (basalt, bare ground, grass, dead shrub, and live sagebrush) representing the primary ground cover types found at the O'Neal study area. Directed sampling was used to locate representative targets and capture the variability in reflectance of these targets.

All spectra were collected ± 1 hour of solar noon from 9 July 2010 to 12 July 2010. A calibrated diffuse white reference panel was used to optimize the sensor to sky/weather conditions on each day of the collection. The pistol grip fiber optic cable sensor attached to the ASD was pointed approximately at nadir above targets at a distance of approximately 60 cm. The bare fiber optic cable used represented a field of view (FOV) of 60 cm. When nadir perspective was inaccessible (such as when we approached shrubs or rock faces that exceeded our own height), the sensor was pointed toward targets at an angle, however this angle never exceeded 90° from nadir. At each site, a minimum of 15 spectra were collected consecutively resulting in a total of 2565 spectra collected (a minimum of 450 spectra per target class). Data were downloaded and processed at ISU's GIS Center using Microsoft Excel to sort reflectance data according to target type and wavelength.

ANALYSIS OF SPECTRA

Spikes in reflectance associated with atmospheric water absorption bands were removed from all further analysis of target reflectance. Absorption bands included wavelengths from 1300nm to 1550nm, 1750nm to 2080nm, and from 2350nm to 2500nm. Descriptive statistics were calculated for each target type describing mean reflectance and standard deviation among samples. Mean reflectance for each target were plotted on a line graph along with the variability in spectra (mean +/- 2 S.E.) and used to interpret the spectra for potential differentiation.

STATISTICAL ANALYSIS

To determine if differences exist between dead shrub and the other target spectra, pairwise single-factor ANOVA tests were used. The ANOVA is a statistical test which compares varying observations and describes how much the observations differ from the sample mean. Variability (@ 95% CI) within each target spectra was calculated by multiplying the standard error of each target spectra by 1.96 (or the z-score for a 95% confidence interval). These values were then applied to the calculated mean of each target type at each wavelength and plotted on a line graph. Targets were considered differentiable when separated by > 1.96 standard errors.

RESULTS AND DISCUSSION

Approximately 500 spectra were collected for each target type (bare soil [n = 525], basalt [n = 525], grass [n = 525], live sagebrush [n = 495], and dead shrub [n = 495]). Using visual analysis of the spectra (Figure 2), it seems that wavelengths having the greatest potential for differentiation of dead shrubs from other target types occur between 700 and 2500nm. These observations suggest that optimal spectral differentiation between dead shrubs and the four other target types might occur within those wavelengths associated with the red and infrared portions of the electromagnetic spectrum.

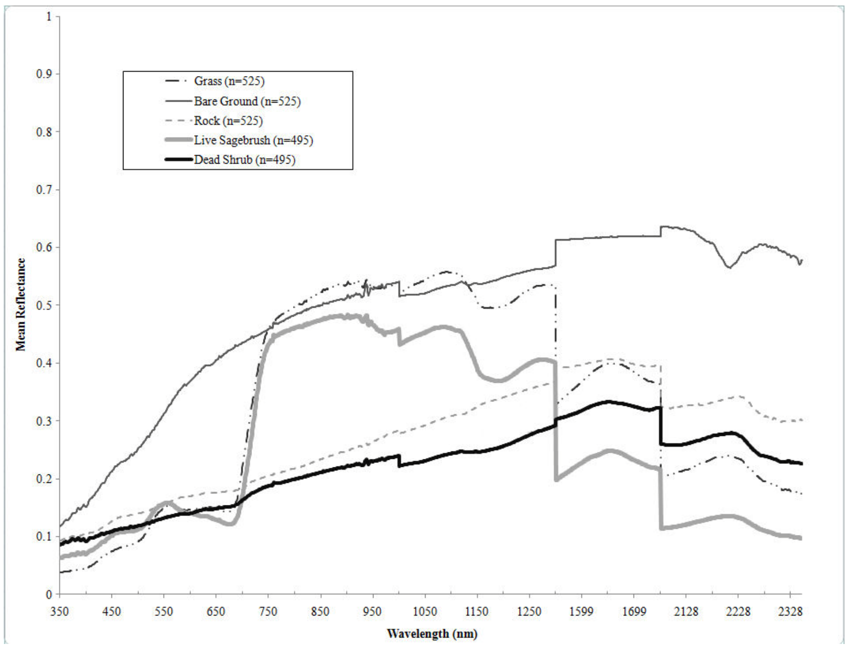

Figure 2. Mean reflectance for grass, bare ground, rock, live sagebrush and dead shrub by wavelength at the O'Neal Ecological Reserve.

Pairwise ANOVA tests revealed statistical difference between mean spectral responses (P < 0.001) (Table 1). This result suggests differentiation is possible between target types within the study area. Calculated variability for each target reveals that spectra are sufficiently separated to support the initial conclusion that differentiation between targets is possible (Figure 3).

Table 1. Results of pairwise ANOVA tests between mean reflectance of dead shrub and four other common ground targets (basalt, bare ground, grass, and live sagebrush) (F-critical = 3.84)

Target	P-Value	F-Value
Basalt	<0.001	269.39
Bare Ground	<0.001	4456.30
Grass	<0.001	519.49
Live Sagebrush	<0.001	95.71

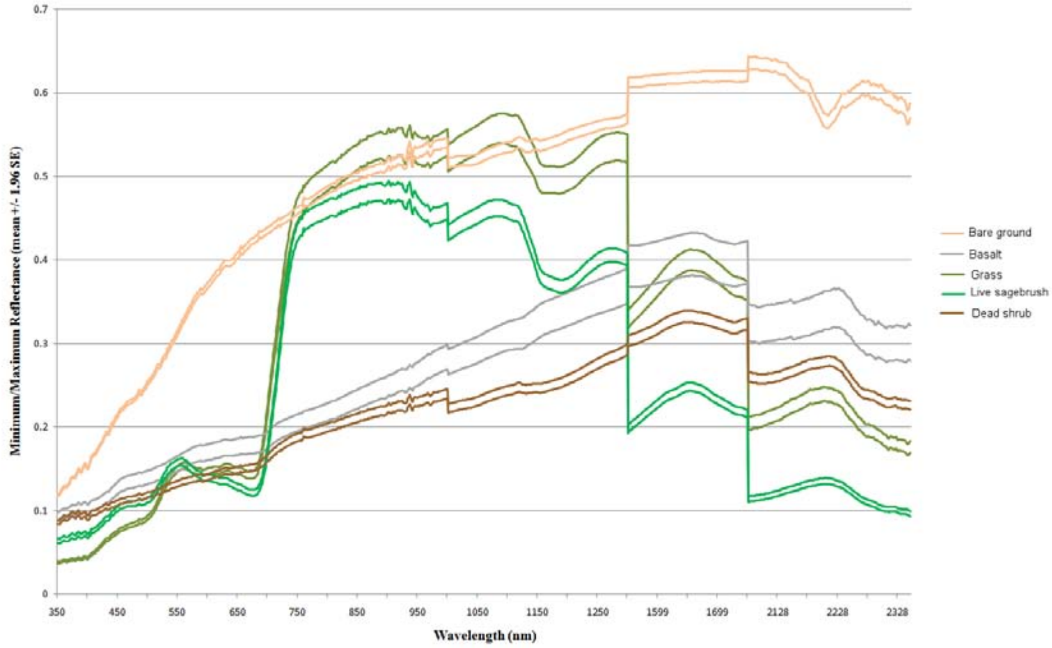

Figure 3. Variability in target spectra are shown as the minimum and maximum reflectance (@ 95% CI) based upon mean reflectance +/- 1.96 SE.

CONCLUSIONS

Pairwise ANOVA results from the spectrometry data collected during the 2010 field season demonstrated statistical difference between mean reflectance of dead shrub and each of the other four target spectra ($P < 0.001$). This suggests that differentiation of dead shrubs from the other ground target types was possible. The variability in spectral reflectance within each target type further supports the conclusion that separation is possible because there are specific wavelengths/ wavebands where dead shrub spectra are distinct among the other target spectra. However, influences such as atmospheric scattering (Rayleigh, Mie, Nonselective) and the signal to noise ratio (SNR) of a satellite sensor could make differentiation of dead shrubs extremely difficult. Aside from these potential influences, the greatest potential for differentiation appears to occur at approximately 950 nm to 1300 nm, 1550 nm to 1750 nm, and 2080 nm to 2350 nm wavelengths.

Field spectral data collected for ground targets with a handheld sensor may not correspond perfectly with spectral data collected by satellite sensors because reflectance values collected from a ground perspective do not undergo as much atmospheric influence. For many satellite sensors, there is a much larger FOV per pixel than for handheld spectroradiometers, so there is much more opportunity for adjacent objects, or underlying objects with stronger spectral reflectance characteristics to influence the overall reflectance received at the sensor. While a reference library for target spectral reflectance can be useful in isolating wavelengths where spectral differentiation seems likely, spectra collected with a handheld sensor should not be expected to perfectly correspond to a satellite sensor.

Field spectrometry can be very useful for aiding in understanding how an object of interest might be detected using remote sensing or serving as a spectral reference library for more precise image analysis and interpretation. This study represents only one part of a larger scientific analysis attempting to accurately classify dead shrubs using satellite imagery. Shrub die off is a phenomenon that affects the quality of Sage Grouse habitat and if it is possible to detect dead shrubs with remotely sensed imagery, this would represent an important management opportunity.

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