Hyperspectral and lidar derived vegetation species and biomass loss from wildfire: lessons from 2015 Soda Fire

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INTRODUCTION

In August 2015, the Soda Fire burned approximately 110,000 ha across Idaho and Oregon with a moderate-high fire severity (Figure 1). Reynolds Creek Experimental Watershed (RCEW), located in SW Idaho, covers ~3,000 ha of semiarid sagebrush-steppe ecosystem. The northern portion, approximately 30% of the total watershed, was burned by the Soda Fire (Figure 1).

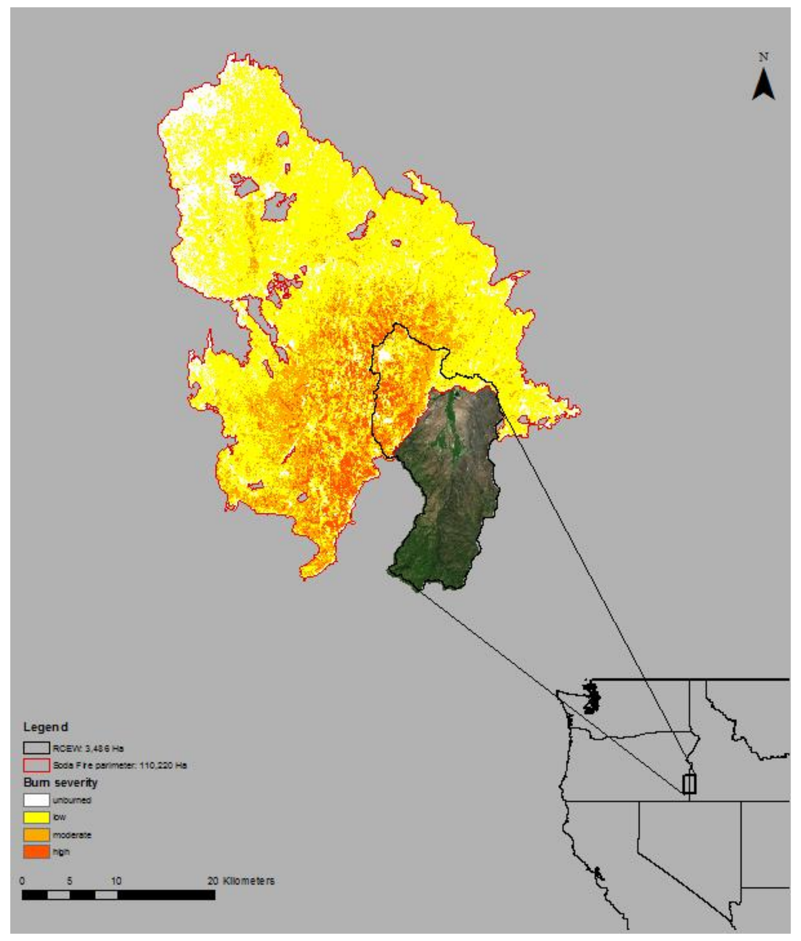


Figure 1: Reynolds Creek Experimental Watershed (RCEW), ID in relation to the Soda Fire and burn severity

OBJECTIVES

The primary objective of this study is to explore the application of using hyperspectral imagery to map vegetation in semi-arid ecosystems. Specific research questions include:

- How accurate is hyperspectral imagery at estimating shrub cover?
- Can full waveform lidar (FWL) be used to validate hyperspectral shrub cover?
- How accurate is hyperspectral imagery at estimating tree species?
- What vegetation species were burned within RCEW, and how much above-ground biomass (AGB) was lost during the Soda Fire?

DATA

Imagery	Sensor	Spatial resolution	Spectral resolution	Date
Hyperspectral	AVIRIS-ng	2.5 m Resampled 1 m	5 nm 400-2500 nm	June 2015
FWL	Riegl Q LMS 1560	1 m	15 cm vertical	June 2014

Field data	Number of polygons	Number of pixels	Date
Shrub	50	5000	2014 & 2015
Deciduous trees	22	1163	2016
Juniper (Juniperus occidentalis)	41	501	2016
Douglas Fir (Pseudotsuga menziesii)	44	700	2016

HYPERSPECTRAL DERIVED SHRUB COVER

- Sparse shrub vegetation and high soil exposure in semi-arid ecosystems lead to mixed pixels and classification errors
- Multiple Endmember Spectral Mixture Analysis (MESMA) can derive shrub cover from mixed pixels (Roth et al., 2015)
- Optimal endmember bundles were derived using VIPER tools to capture spectral variability of the image (Roberts et al., 2016)

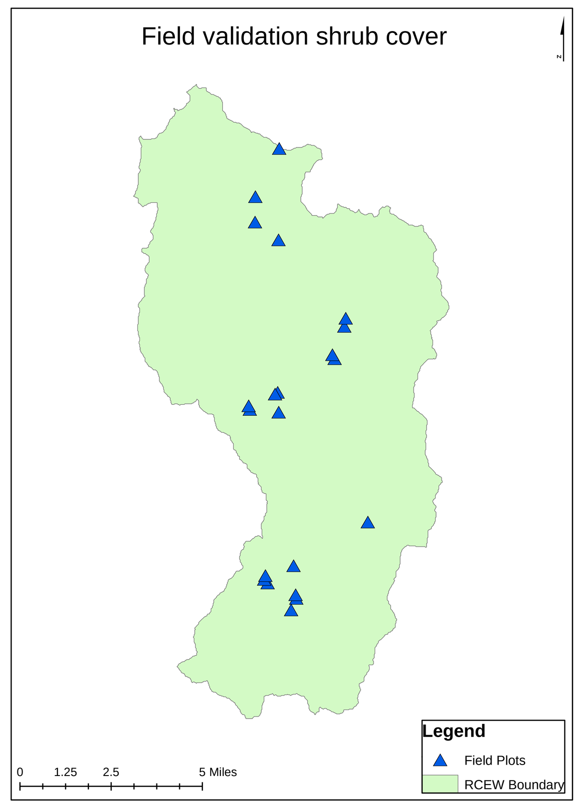


Figure 2: Locations of field measured shrub cover used to validate hyperspectral shrub estimates

HYPERSPECTRAL VS. FWL SHRUB COVER

- FWL can be used to capture vegetation structure from the backscatter cross-section
- Thresholds of vegetation structure were developed based on field data, and used to derive shrub cover
- FWL was used as an alternative independent validation to test hyperspectral shrub cover

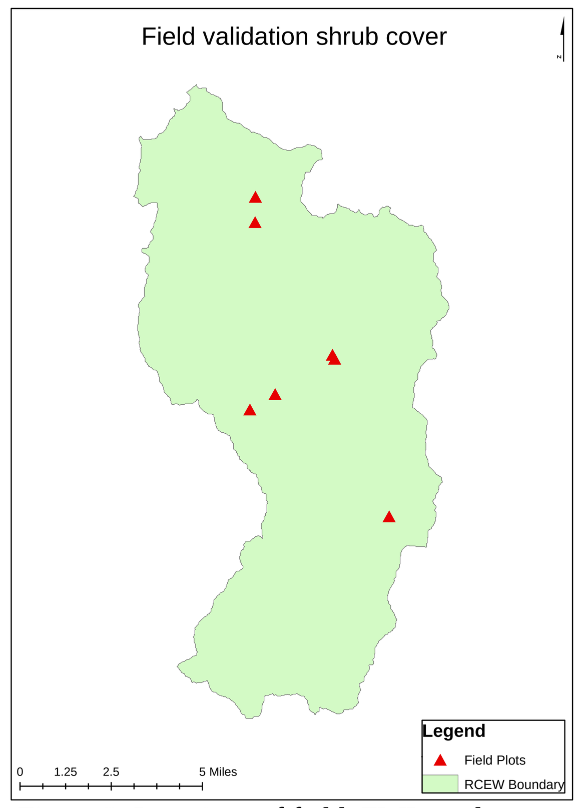


Figure 3: Locations of field, FWL, and hyperspectral shrub cover

TREE SPECIES CLASSIFICATION

- Spectral Angle Mapper (SAM) was used for species identification
- Spectral libraries used in SAM were created from field data independent of validation set
- Tree classes were chosen to represent dominate cover types in RCEW
- Due to their spectral similarities, several deciduous tree species were combined into a single class for SAM

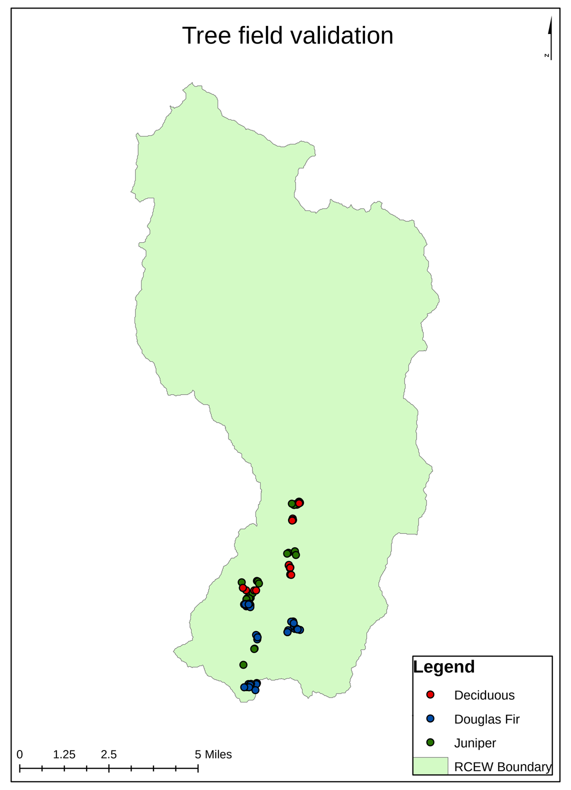


Figure 4: Locations of tree species validation data

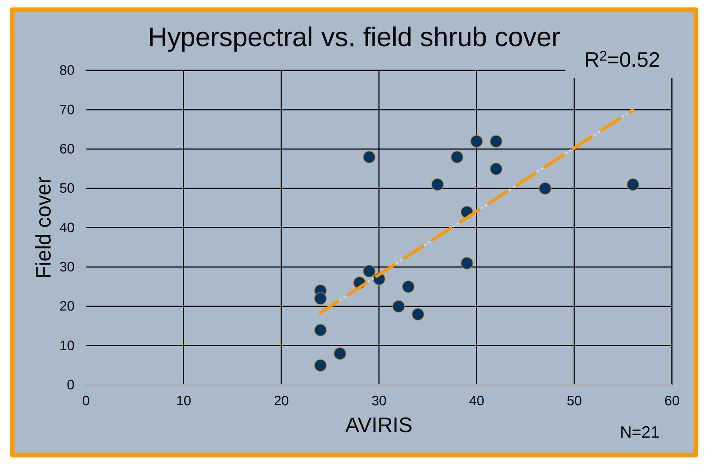
RESULTS

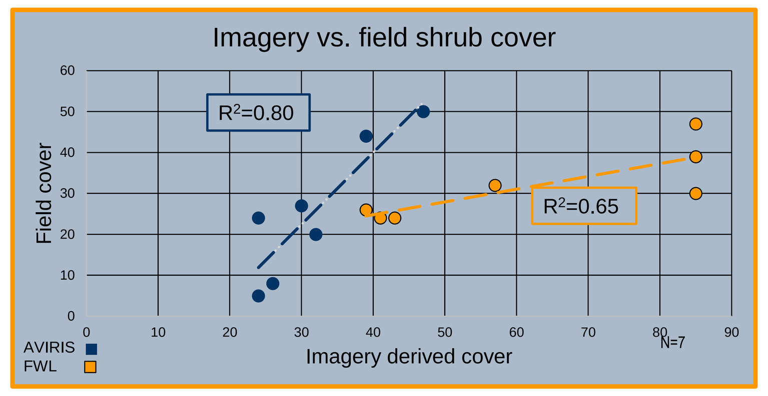
IMAGE DERIVED SHRUB COVER

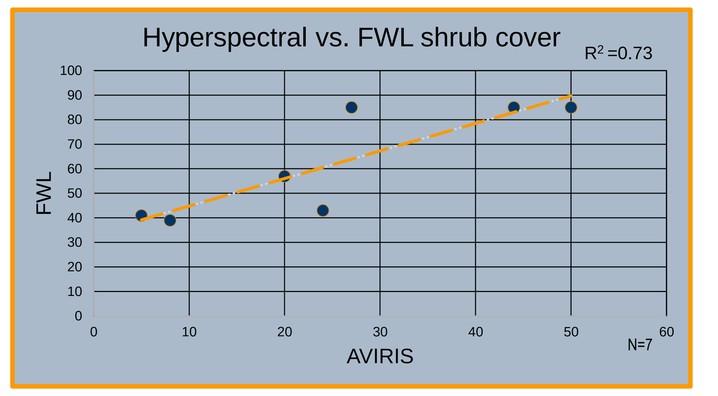
Hyperspectral shrub cover showed a positive linear relationship with field plots where >25% shrub cover was measured (R^2=0.52).

Hyperspectral imagery was not able to accurately estimate lower shrub covers due to the strong albedo of soil.

Both hyperspectral and FWL shrub covers show positive relationships with field cover (R^2=0.80 and R^2=0.65, respectively). There is also a strong correlation between hyperspectral and FWL shrub covers (R^2=0.73).







TREE SPECIES CLASSIFICATION

Hyperspectral imagery was able to classify vegetation species with high accuracy (k=0.68)

A majority of the burned area was found to be composed of shrubs and deciduous trees located in the riparian areas

	Ground Truth			
Class	Deciduous	Juniper	Douglas Fir	Total
Deciduous	**1116**	75	166	1357
Juniper	0	**356**	71	427
Douglas Fir	28	26	**431**	485
Unclassified	19	44	32	95
Total	1163	501	700	**2364**

Overall Accuracy	80.50%
Kappa coeff.	0.68
Deciduous	95.96%
Juniper	71.06%
Douglas Fir	61.57%

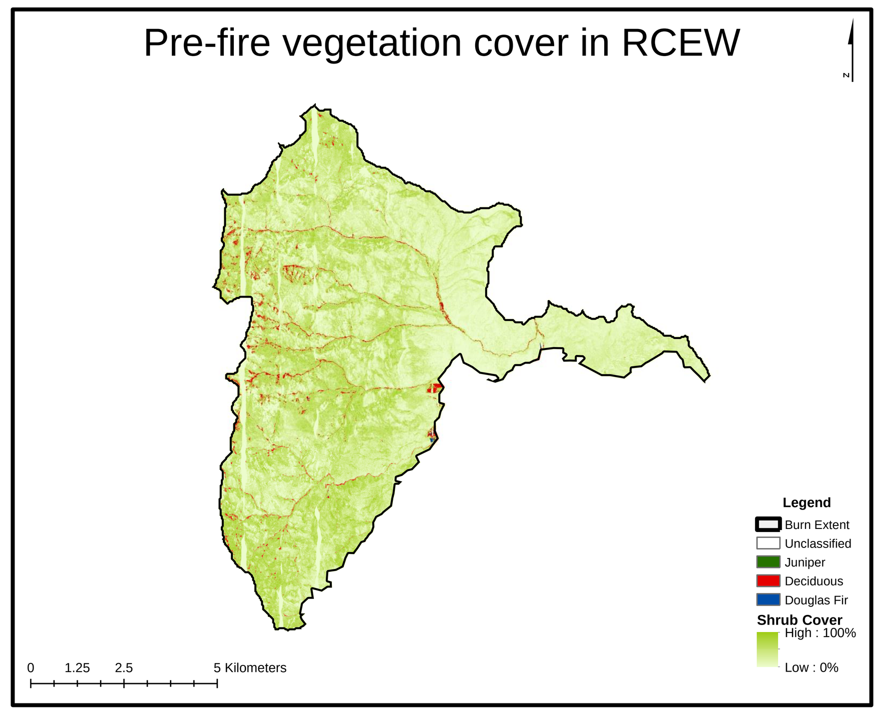


Figure 5: Vegetation present in RCEW prior to the 2015 Soda Fire derived from AVIRIS imagery

CONCLUSION & FUTURE WORK

- Hyperspectral imagery, compared to field observations, is an effective method to derive shrub cover in semi-arid ecosystems where lower resolution imagery may not be as effective
- FWL can be used as an independent accuracy assessment to hyperspectral derived vegetation where field data may not be present
- AGB of the burned area in RCEW will be estimated from the classified vegetation using a series of allometric equations (Goodenough et al., 2008; Zhou et al,. 2009; Mirik et al., 2013; Li et al., 2015)
- Upcoming NASA missions GEDI and HyspIRI could be used in conjunction with each other to better classify vegetation cover and biomass in semi-arid ecosystems

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