**NASA DEVELOP National Program**



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Southeast Idaho Disasters II

Using Earth Observing Systems to Characterize Juniper Invasion and Assess Changes in Soil Moisture within Cheatgrass Dominated Sites Relative to Wildfire Susceptibility in East Idaho

 **Technical Report**

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# I. Abstract

[Placeholder - do not put anything here until the final draft submission. The abstract in the project summary is where the working draft of the abstract should “live”]

**Keywords**

Juniper (Juniperus spp.), Juniper Encroachment, Cheatgrass, Wildfire Susceptibility, Soil moisture, Idaho, Remote Sensing

# II. Introduction

## Overview

Two of the most pronounced vegetation changes throughout the Intermountain West is the expansion of Juniper (*Juniperus, spp.)* and the invasion of *Bromus tectorum L.,* anoxious weed, commonly known as cheatgrass. Both of these species are primary drivers of change in native semi-arid savanna ecosystems and play a large role in changing fire regimes. Though fire often plays an essential role in wildland ecology and helps maintain natural processes, too many occurrences of wildfire can induce a loss of biodiversity, disrupt ecosystems, and deplete resources (Oppenheimer, 2012; Whisenant, 1990). A study by Balch et al., conducted in 2013 found that cheatgrass-dominated landscapes were four times more likely to ignite than native vegetation types. Recent estimates have placed contemporary juniper stands at 18 million hectares (Williams et al., 2014). This increase in fuel loads combined with the fine under-story fuel of cheatgrass has changed fire regimes and intensified the severity of wildfires throughout this region (Miller 2005; Miller & Wigand 1994).

Juniper is native shrub species that has expanded from its traditional fire-safe habitats into fire-dependent communities as a result of climatic fluctuations, grazing patterns, and wildfire suppression efforts (Ansley & Wiedemann 2008; Barney & Frischknecht 1974; Dennison et al. 2014; Miller & Tausch 2001; Noson et al. 2006). The driving mechanisms for the increase in junipers is unknown and understanding the historical conditions and locations of juniper will help in understanding drivers of recent change (Miller, 2009). Researchers have discovered that phases of juniper encroachment are directly linked to juniper dominance over other ecological processes (Davis et al. 2010). As woody plants encroach on savannas there are ecological consequences such as habitat heterogeneity across the landscape, changes in soil chemistry, and lower species richness (Sahara et al., 2015).

In semi-arid climates, spring water and vegetative cover dictate the following growing season water use. Both juniper and cheatgrass are reducing the amount of water that native plants can use based on their root structure. Junipers draw from the deeper reserves over the winter period at much greater depths (>200cm) effectively reducing the amount of soil moisture during the growing season (Mollnau et al., 2014). Cheatgrass is a self-pollinating winter annual and can germinate in the fall or early spring. Its root structure primarily grows in the winter and can outcompete native species for water at shallow depth during the next growing season (Harris 1977; Melgoza & Nowak 1991). By using up available resources, cheatgrass can limit or stop the germination process of native species and diminish root length densities of nearby vegetation. (Melgoza & Nowak 1991) Multiple studies have shown that cheatgrass will out compete native perennial species for soil resources (Cline et al., 1977; Harris 1977; Melgoza & Nowak 1991).

Soil moisture plays is a significant factor on fire severity and may also exhibit different characteristics in a cheatgrass dominated site compared to native vegetation. This study combined NASA’s Soil Moisture Active Passive (SMAP) and Global Precipitation Measurements (GPM) to better understand the differences in soil moisture between cheatgrass dominated sites compared to sagebrush dominated sites relative to fire severity. Researchers suggest that cheatgrass dominates 2.5 million ha (6.2 million acres) of former sagebrush-grass rangelands in southern Idaho and roughly 10.1 million ha (25 million acres) in the Great Basin (Pellant et al., 2004; Laycock, 1991). This plant is flammable 4 to 6 weeks sooner than native plants and is susceptible to wildfire 1 to 2 months longer than native perennials (Platt & Jackman, 1946); this has effectively extended the fire season and has caused landscapes to burn more frequently (Chen & Weber et al., 2001; Mealor *et al.,* 2013; Pellant, 1996; Stewart & Hull, 1949).

It is important to determine links between encroachment and other environmental variable(s), such as drought, soil moisture, topography, and soil type, because it will improve land managers’ understanding of the general ecological processes at work in juniper vegetation (Miller, 2009). Past methods have included using various remote sensing data in correlation to ground truthing. Most ground truthing is conducted by using the line-intercept method which measures the amount and type of vegetation that crosses a study line (Caratti 2006). Remote sensing studies use a variety of data including Landsat and LIDAR (Campell et al. 2012; Chen et al. 2011; Noone et al. 2013; Sankey et al. 2010 ; Sankey & Germino 2008). Studies have focused on spectral reflectance (Bradley & Fleishman 2008; Campbell et al. 2012; Lupton 2008), near-infrared (NIR) (Everitt et al. 2001) and object-based image analysis (OBIA) (Davies et al. 2010; Roundy et al. 2015) to identify juniper encroachment.

## Objectives

There were two objectives of this study; the first was to characterize juniper encroachment by analyzing 30 meter Landsat imagery from 1985 to 2015 and the second was to assesses temporal changes in soil moisture in cheatgrass dominated sites and compare that to sagebrush dominated sites over the 2015 growing season; April 1st through September 30th.

## Study Area

The study area includes the semi-arid savanna rangelands and mountainous forest regions of Southeast Idaho. The ecology of this region encompasses the Snake River Plain, an area classified as a ‘cold desert’ that sustains much of the plant and animal life unique to this area. A focused study area was provided by the Bureau of Land Management (BLM) due to their interest in future management of areas effected by juniper encroachment.

## Project Partners

This project falls under the Disasters NASA National Application Area. We worked with the BLM, Idaho Fish and Game, and Carabou Targhee National Forest to gain a better understanding of where junipers are encroaching and why they are moving into those areas. Information was also provided about changes in soil moisture between cheatgrass dominated sites and sage-brush dominated sites. The BLM is the primary end user for this project. Recent efforts to manage juniper expansion has included mechanical treatments such as thinning (removing a proportion of trees within a dense stand), limbing (removing the lower limbs on all trees within a stand to reduce the potential for a fire to enter the crown), and shredding juniper stands (C. Burger, personal communication, October 27th 2015). These efforts have limited success in part because pre- and post-treatment of juniper density is unknown. The ideal management process requires action when juniper plants are first entering an area. The results of this study will provide these organizations with information, which will be used in resource allocation pre- and post-fire and land restoration planning.

Similarly, cheatgrass invasion is a concern for our end-users and the broader wildfire management community. Currently, there are no active cheatgrass management plans in Idaho.

# III. Methodology

## Data Acquisition

### Satellite Imagery

Landsat 5 Thematic Mapper (TM) and Landsat 8 Operational Land Imager (OLI) imagery was acquired from the United States Geological Survey’s (USGS) Earth Explorer for WRS-2 Path 39 Row 30 and WRS-2 Path 38 Row 30. Images were downloaded in five year increments from 1985 to 2015. August or September imagery was chosen because evergreens are easily distinguishable compared to the less photosynthetically active vegetation.

Soil Moisture Active Passive (SMAP) data was visualized and then downloaded using EOSDIS Worldview. Level 3 Active/Passive soil moisture data was available for our study area from April 15 until July 7th, when the passive sensor stopped transmitting data. These data had a spatial resolution of 9 km.

Global Precipitation Measurement (GPM) mission data was visualized and acquired through Giovanni. This mission incorporates satellite data from 10 different satellites and 5 countries providing consistent coverage of global precipitation. GPM was chosen over TRMM data because it has coverage in higher latitudes and TRMM is being retired. North American Land Data Assimilation Systems (NLDAS) model was used in addition to IMERG “Final” product data because these data incorporated rain gauge data from land monitoring systems and is recommended for research use.

### Classification Sites

Five classes of land cover vegetation were analyzed: juniper mix, bare ground, mixed forest, cheatgrass and sagebrush/herbaceous. The juniper mix classification included: Western Juniper, Utah Juniper, Pinyon-Juniper, and Rocky Mountain Juniper. The mixed forest classification included: confier, douglas-fir, pine, spruce, aspen, maple, and mahogany.

The classification dataset was created from digitized points from the 2009, 2011, and 2013 National Agricultural Imagery Program (NAIP), Landsat 8 derived Modified Soil-adjusted Vegetation Index (mSAVI2), and a classified cheatgrass map from Clinton *et al*., 2010. These data were correlated with 2014 Caribou-Targhee National Forest mid-level vegetation data from RSAC to correctly identify species type. Also included in the classification dataset were *in situ* point data from the University of Georgia’s Center for Invasive Species and Ecosystem Health, 2013 BLM summer field season, and Idaho State University GIS Training and Research Center’s 2014 and 2015 summer field season(fig. Appendix). The data consisted of X# of classification sites in total.

### Supplemental Imagery

Surface Management Agency (SMA) data, created in 2015, was acquired through the NASA RECOVER program. This data was chosen for the ability to distinguish between privately and publically owned lands. US Forest Service Remote Sensing Application Center (RSAC) mid-level vegetation data, created in 2015, was acquired through the United States Forest Service. This data was chosen to help identify and verify vegetation type.

## Data Processing

### Juniper encroachment model

The seven Landsat images all had less than 10 % cloud cover and were mosaicked together using IDRISI TerrSet. Corrections for atmospheric effects were applied using the Cos(t) model; while calculations to derive surface reflectance from multispectral bands were computed using the IDRISI TerrSet Landsat archive import model. 30 mslope and aspect were derived from the National Elevation Dataset. mSAVI2, Tassel Cap Transformation (TCT) brightness, wetness, and greenness (Huang et al. 2002), near difference bare soil indices (NDBSI), and topographic variables were standardized by ensuring all data were projected to WGS 84 UTM zone 12N. Standardization of rows and columns was accomplished by applying a window of 20,325 km² (7,847 miles²) that did not extend past the boundary of any image used in the CTA.

### Soil Moisture Model

## Data Analysis

### Juniper Encroachment Model

### Soil Moisture Model

# IV. Results & Discussion

## Results

## Discussion

### Juniper Encroachment Model

### Soil Moisture Model

# V. Conclusions

Final conclusions. Word count: 200-600 (~a page).

# VI. Acknowledgments

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Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration.

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# IV. Appendices

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