**NASA DEVELOP National Program**



BLM at Idaho State University GIS TReC

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Southeast Idaho Disasters

Juniper Encroachment and Management in the Western U.S. Relative to Catastrophic Wildfires

 **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., Remote Sensing, wildfire, encroachment, wildland urban interface, WUI

# II. Introduction

## Overview

Juniper (*Juniperus* spp.) are native shrub species important to wildfire regimes that have expanded their traditional habitats throughout the Western United States as a result of climatic fluctuations, grazing patterns, and wildfires suppression efforts (Ansley & Wiedemann, 2008; Dennison et al., 2014). Climate fluctuations have caused expansion and recession of these species throughout the Holocene (Miller & Wigand 1994). Prior to European settlement (>140 years ago) 90% of this area was sagebrush steppe (Williams et al., 2014). Recent estimates have placed contemporary juniper stands at 18 million hectares (Williams et al., 2014). This increase in fuel loads has changed fire regimes and intensified the severity of wildfires throughout this region.

Increasing juniper dominance has resulted in the die-off of shrubs, grasses and forbs, thus reducing species richness and diversity. The loss of species diversity decreases habitat values such as cover and forage for the many birds, mammals and plants that rely upon sagebrush communities for survival. These sagebrush obligate species include the greater sage-grouse (*Centrocercus urophasianus*), pygmy rabbit (*Brachylagus idahoensis*), pronghorn antelope (*Antilocapra americana*), and the sage thrasher (*Oreoscoptes montanus*). Other large mammalian fauna that frequent sagebrush steppe communities include mule deer (*Odocoileus hemionus*), mountain lion (*Puma concolor*), and bighorn sheep (*Ovis canadensis*.

Over the past 130 years, the Great Basin and Intermountain West have seen juniper stands increase tenfold, fundamentally altering this landscape (Miller et al., 2001). Researchers have discovered that juniper encroachment phases are directly linked to juniper dominance over other ecological processes (Davis et al., 2010). In the first phase of juniper encroachment, shrubs and herbaceous plants are dominant and tree cover is less than 15%. By phase two, junipers are actively expanding and becoming co-dominate with shrubs, grasses, and forbs with tree cover between 15 and 45%. In phase three, tree cover is greater than 45% with >75% shrub die-off and severe limitations on grass and forb species (Barrett et al., 2007; Davis et al., 2010; Williams et al., 2014).

When woody vegetation overtakes a habitat and becomes the dominate species, this is referred to as a “woodland steady state.” During this stage it is unlikely that the area will return to sagebrush/herbaceous habitats without anthropological influence such as chemical, mechanical or prescribed burning (Ansley & Wiedemann 2008). Identifying phase extent is important in determining which restoration method is best suited for an area. Identification 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 (Noone et al., 2013; Sankey et al., 2010). Studies have focused on spectral reflectance (Bradley et al., 2008; Campbell et al., 2012), near-infrared (NIR) (Everitt et al., 2001), and object-based image analysis (OBIA) (Roundy et al., 2015) to identify juniper encroachment.

In addition to the ecological degradation, humans are directly affected by overwhelming juniper encroachment due to the increased potential for devastating wildfires. Community concerns are shifted into the wildland-urban interface (WUI), an area with at least 6.17 housing units/km2 as defined by the Federal Register (Randloff et al., 2005). As more humans inhabit and develop these remote areas they come into contact with the increasing fuel loads and are therefore exposed to a higher chance of a catastrophic wildfire. The increasing cost of fire suppression is thought to be related to the expansion of people and property moving into the wildlands. In 2014, the National Interagency Fire Center (NIFC) reported that around 3.6 million acres burned due to outbreaks of wildfire (NIFC, 2015). It is also estimated that the US Forest Service and the Department of the Interior spent $1.8 billion in 2014, $470 million more than was budgeted, to combat wildfire (USDA, 2015). These estimates were direct suppression costs which did not include damage to property and land rehabilitation. Currently, land management agencies such as the Bureau of Land Management (BLM) and the Idaho Department of Lands (IDL) are focusing land rehabilitation and fuel reduction plans to these WUI areas and seeking new tools to detect areas where mitigation is needed most.

## Objectives

The objective of this study was to create a juniper distribution map, identifying areas with high concentrations of juniper species. Using Landsat 5 Thematic Mapper (TM) and Landsat 8 Operational Land Imager (OLI) in combination with a decision-tree-based-classification the Southeast Idaho Disasters project mapped out *Juniperus spp*. species to determine overall land cover, as well as tree density and frequency. Identifying juniper dense areas will help end-users manage risk in areas with large fuel loads and allocate pre- and post-fire resources efficiently.

## Study Area

The study focuses on southeastern Idaho for September in 1990 and 2015. These dates were chosen because evergreens will be easily distinguishable compared to the less photosynthetically active deciduous vegetation. This area encompasses the semi-arid savanna rangelands and mountainous forest regions of Southeast Idaho and extends from the Teton Mountain Range in the northeast to the Curlew National Grasslands in the southwest. This area encompasses the Snake River Plain, an area formed as the North American tectonic plate drifted over the Yellowstone hotspot. The volcanic activity has modified this landscape and creating the Snake River channel that flows west through this ‘cold desert’ sustaining much of the plant and animal life unique to this area. A subset of the mosaicked Landsat images was created to encompass an area of interest provided by the BLM and because of the critical habitat of the candidate species the greater sage-grouse (*C. urophasianus*), the Curlew National Grassland was also evaluated thoroughly.

## Project partners

This project falls under the Disaster Application Area, and seeks to improve the BLM, IDL, and the broader fire community's access to information regarding juniper land cover as well as tree density and frequency. The BLM and IDL are the primary end-user for this project. Over the past few decades, the western US has seen a steady expansion of juniper. 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. These efforts are meet with 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. Under this scenario, juniper can be entirely eliminated if needed to favor sagebrush or other essential plant species. The results of this study will provide these organizations information will be used in resource allocation pre- and post-fire and land restoration planning.

# III. Methodology

## Data Acquisition

### Satellite Imagery

Landsat 5 TM and Level 1T Landsat 8 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 from September 1990 were compared to imagery from September 2015 to produce a map that displays juniper expansion over the last fifteen years. Also, a stand-alone map of current juniper stands was produced locating dense juniper cover (phase three). Corrections for atmospheric effects were applied to the imagery using the *Cos*(t) model and calculations to derive surface reflectance from multispectral bands were computed using the IDRISI TerrSet Landsat archive import module.

### Classification sites

Four classes of land cover were analyzed: bare ground, juniper mix, mixed forest and sagebrush/herbaceous. The juniper classification is an umbrella classification for all juniper species that occur in the study region; pinyon-juniper, Western Juniper, and Utah Juniper, and Rocky Mountain juniper. The mixed forest classification included: conifer, douglas-fir, pine, spruce, aspen, maple and mahogany. These points were digitized using 2013 NAIP (National Agriculture Imagery Program) imagery and correlated with 2014 Caribou-Targhee National Forest mid-level vegetation data from the US Forest Service Remote Sensing Application Center RSAC to correctly identify species type. The data consisted of 1,111 classification sites in total: 201 bare ground, 224 juniper mix, 433 mixed forest, and 253 sagebrush/ herbaceous.

A classification tree (CT) analysis of these sites was used because it is a non- parametric data driven analysis allowing for the development of a decision tree training and model validation of this data set (Miller & Franklin, 2002). These sites were randomly divided up into a 60% training sites that were used to build the model and 40% test sites that were used to assess the accuracy of the model.

### Data Processing

The two Landsat images that defined the study area were mosaicked together in Idrisi TerrSet for both 1990 and 2015 imagery. These images had less than 1% cloud cover. Prior to deriving mSAVI2, TCT brightness, wetness, and greenness (Huang et al., 2002), and near difference bare soil (NDBI) indices, a mask was applied to remove cultivated fields, water, and basalt outcrops. These data were standardized prior to being put into a CTA by ensuring all data was projected to WGS 84 UTM zone 12N.

### Data Analysis

Based on the spectral signatures exposed by results from mSAVI2 and TCT, a CTA was produced to analyze class purity and classify individual pixels based on the classification sites. Percent cover was calculated through Raster Calculator by dividing juniper canopy area by total area. The resulting raster contained data of percent cover which was then symbolized to show different phases of juniper encroachment.

# IV. Results & Discussion

Insert images, graphs, maps, charts, etc. here. Choose the most important results to highlight here. No word cap, but two to six pages is a good range.

Things to discuss:

* Analysis of Results: What can you tell from your graphs, images, etc? What does this mean for your project?
* Errors & Uncertainty: What factors could you not account for, what things didn’t work out like you expected they would, etc.
* Future Work: If this project was to be selected for another term, what would be the focus? What other areas would be of interest?

# 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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