Evaluating the Effect of Snowpack on Post-fire Vegetation:
A Case Study of the 2002 Biscuit Fire

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Introduction

Snow in the Western United States acts as a vital water reservoir, storing winter precipitation and releasing it during the drier spring and summer months (Mote, 2006). Regenerating post-fire vegetation is partially dependent on soil moisture, and snow packs provide a vital source of moisture that extends into the drier seasons.

Climate change is impacting both snow and wildfires in the Western United States. Increased spring and summer temperatures and earlier snowmelt have caused a dramatic increase in Western United States' wildfire frequency and duration since the 1980's (Westerling, 2006). Increased spring and summer temperatures have also reduced the fraction of precipitation falling as snow (Knowles, 2006), and there is a predicted 9% Cascade snowpack reduction to occur from 1985-2025 (Stoelinga, 2010). It is important to understand how this will potentially impact vegetation.

There is ample research describing undisturbed vegetation's relationship with snow, however a knowledge gap must be filled to understand post-fire vegetation's relationship with snow for regeneration. This knowledge will be critical to predict how vegetation will regenerate in warmer future scenarios with little to no snow.

Objective

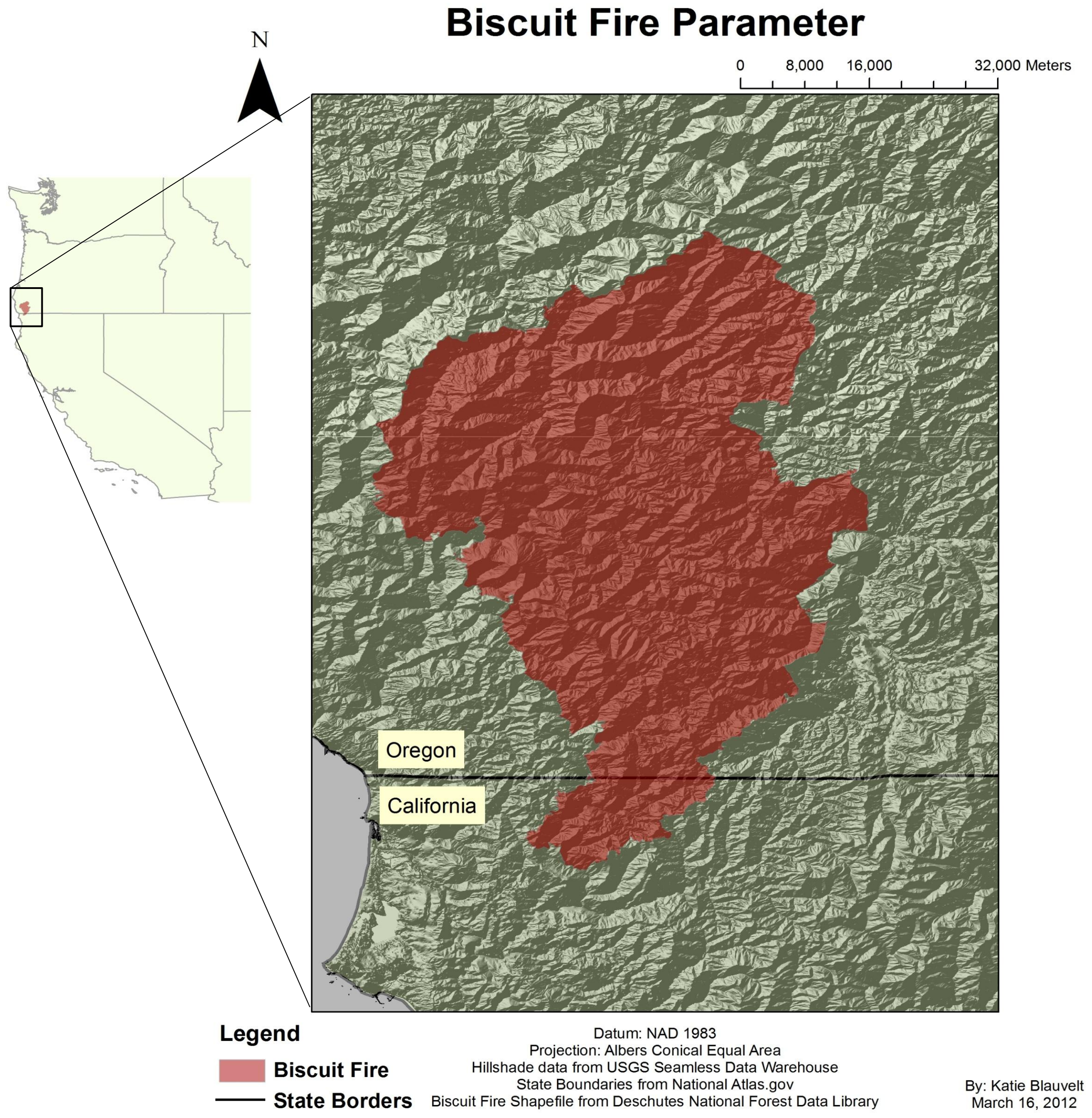
Determine the affects of snow on regenerating vegetation after the 2002 Biscuit Fire.

Study Area

The 2002 Biscuit Fire of Southwest Oregon, shown in Figures 2 and 3, was chosen to examine post-fire vegetation response to snow because of its size and elevation span; ignited by lightning on July 13, 2002, the Biscuit Fire burned 499,965 acres from 40m-1500m elevation in the Siskiyou National Forest.


Source: http://www.wildlandfire.com/pics/biscuit/biscuit.htm
Source: https://ncfp.wordpress.com/2011/03/12/biscuit-fire-photos-from-foto/

Figure 1. Photos of fire and post-fire vegetation.



Datum: NAD 1983
Projection: Albers Conical Equal Area
Hillshade data from USGS Seamless Data Warehouse
State Boundaries from National Atlas.gov
Biscuit Fire Shapefile from Deschutes National Forest Data Library
By: Katie Blauvelt
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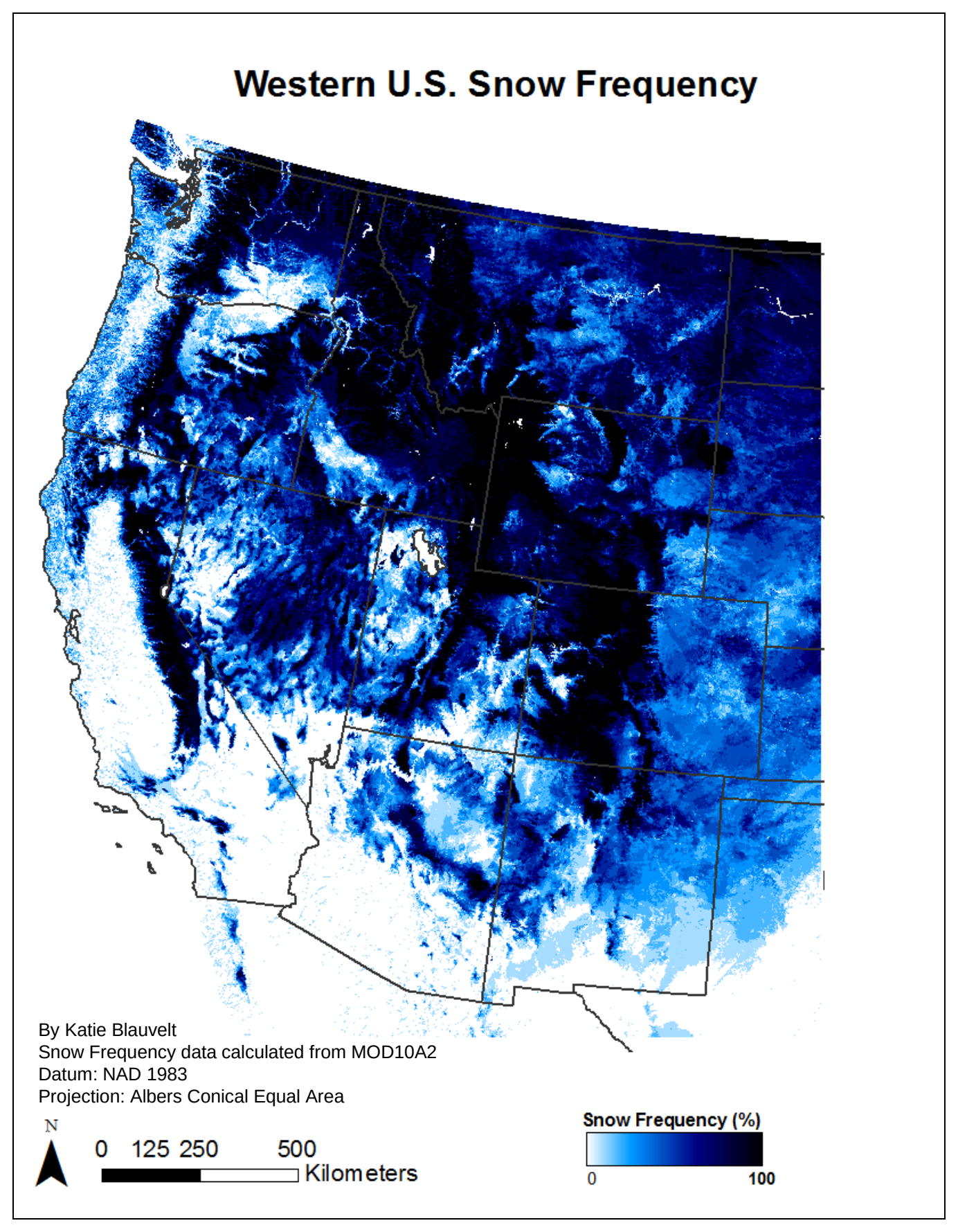
Figure 2. Locator map showing the Biscuit Fire

Remote Sensing Data

We examined the relationship between snow frequency, depicted in Figure 3, and the enhanced vegetation index (EVI), which is a proxy for vegetation biomass, shown in Figure 4. Snow frequency was calculated from the MODIS satellite's MOD10A2 snow cover product, as the number of times snow was detected divided by the total number of valid observations per 3-month season. Median EVI was calculated from the MODIS satellites MOD09A1 reflectance product. Both datasets are at 500m resolution, span from 2001-2009, and are separated into seasons of the water year. In this study we examined the correlation between winter snow frequency and subsequent spring EVI. Figure 5 illustrates the Biscuit Fire's impact on EVI in spring 2003 and subsequent years.

The snow frequency and EVI data set were layer stacked in ENVI with a mosaicked USGS 30 arc second DEM to extract elevation per pixel. An ascii dataset of the Biscuit Fire area's winter snow frequency, spring EVI, and elevation for each year from 2001-2009 was created.



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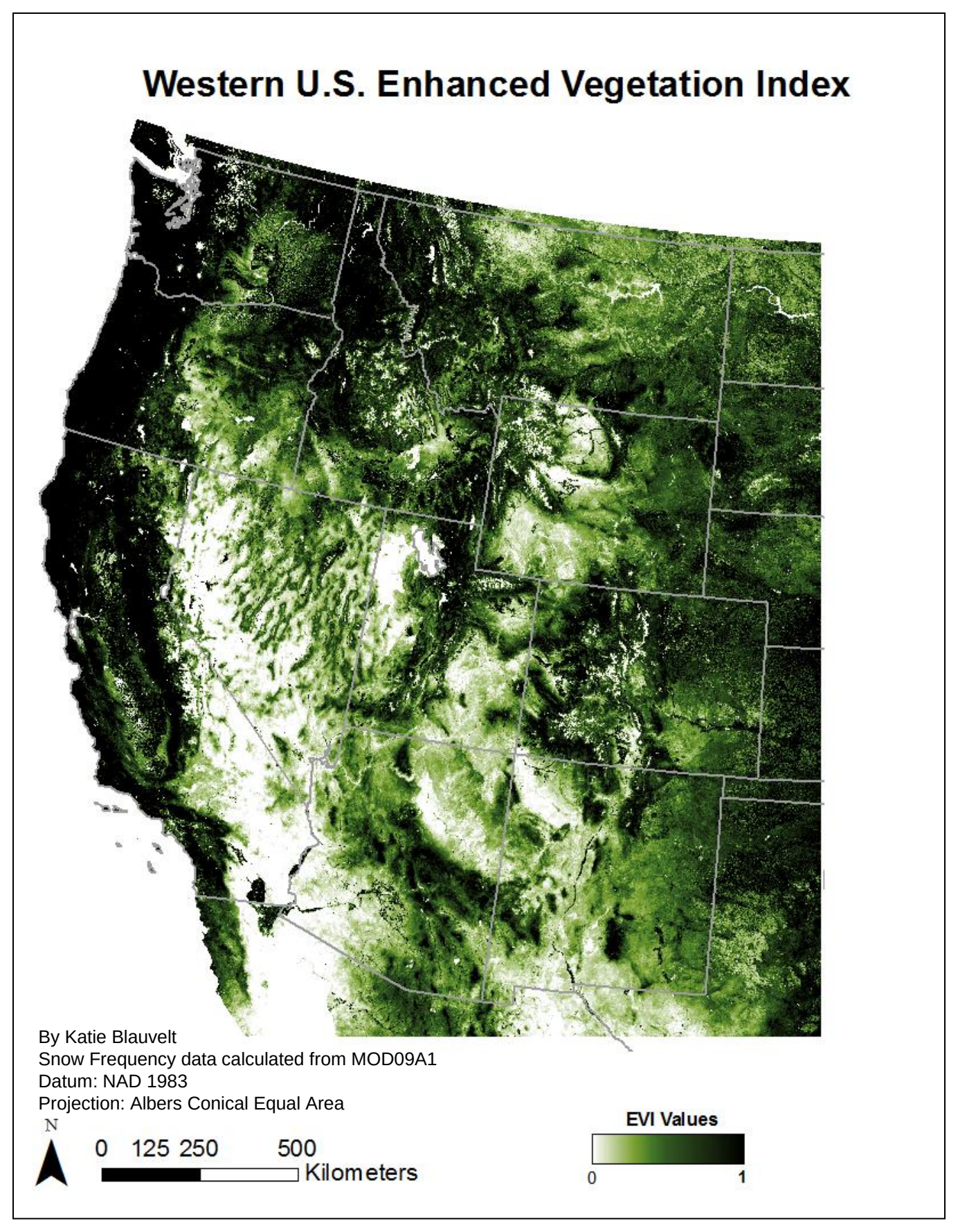
Snow Frequency data calculated from MOD10A2
Datum: NAD 1983
Projection: Albers Conical Equal Area

Figure 3. Winter snow frequency for the western US.



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Snow Frequency data calculated from MOD09A1
Datum: NAD 1983
Projection: Albers Conical Equal Area

Figure 4. Median spring EVI for the western US.

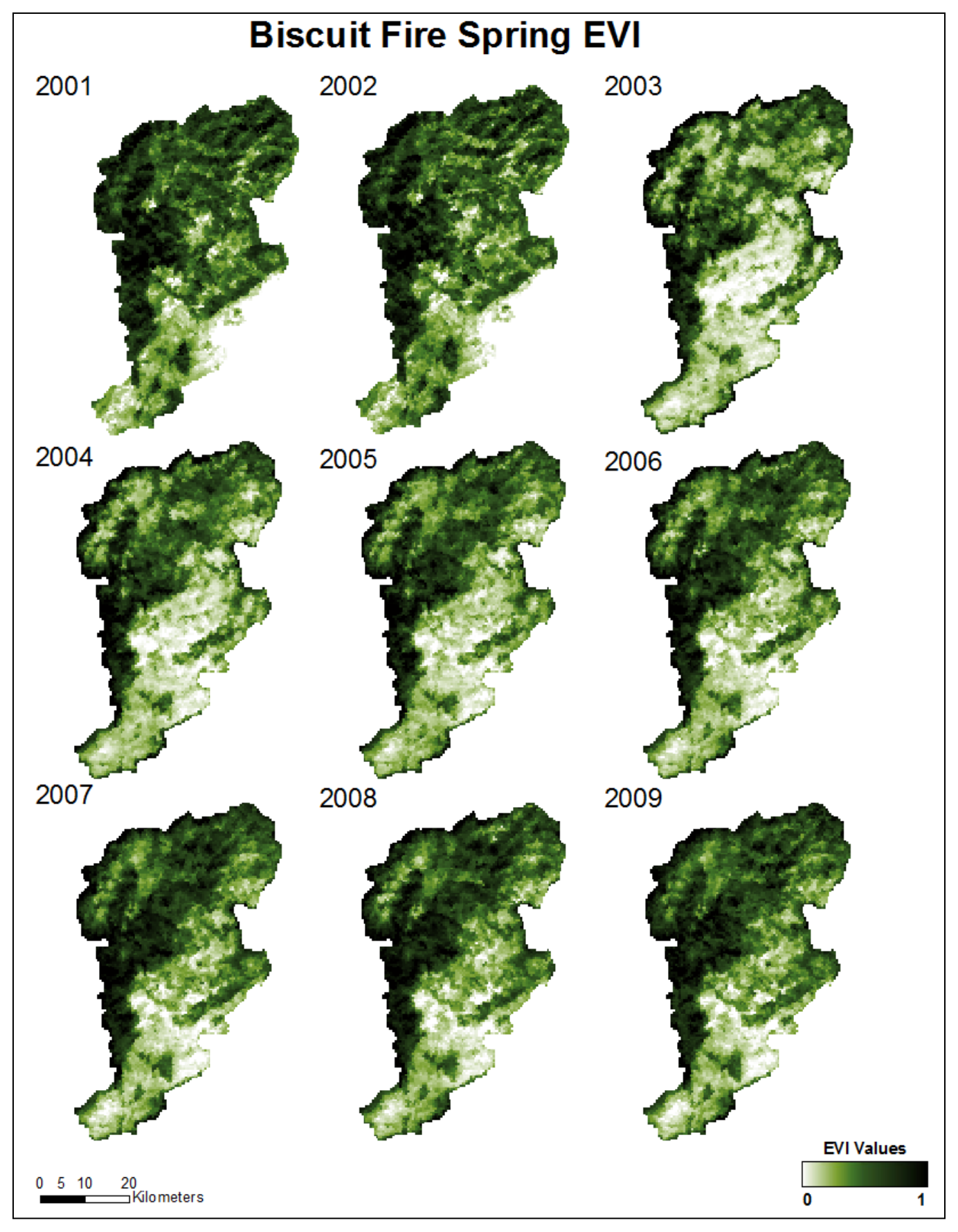

Figure 5. Median spring EVI for the Biscuit Fire area, WY 2001-2009.

Statistical Analysis

Nonparametric Multiplicative Regression (NPMR) and Hyperniche were used to determine the best 3D regression model to describe the interaction between snow and vegetation. NPMR is ideal because it does not assume a linear regression and is capable of expressing complex interactions between multiple predictors and a response. For this study, we included 2 quantitative predictors, (snow and elevation), and one categorical predictor, (pre-fire (0) or post-fire (1)), for the quantitative EVI response. Incorporating elevation revealed how the snow-vegetation relationship varied according to altitude. From a random sample of 1,000 pre-fire pixels and 1,000 post-fire pixels, the model of best fit included all three predictors with a cross-validated R sq. of .4. To illustrate the pre and post fire snow-elevation-vegetation relationships, we took slices from pre and post fire, shown in Figure 6. Because two different random samples were taken, the minimum and maximum values differ from pre to post fire.

Results

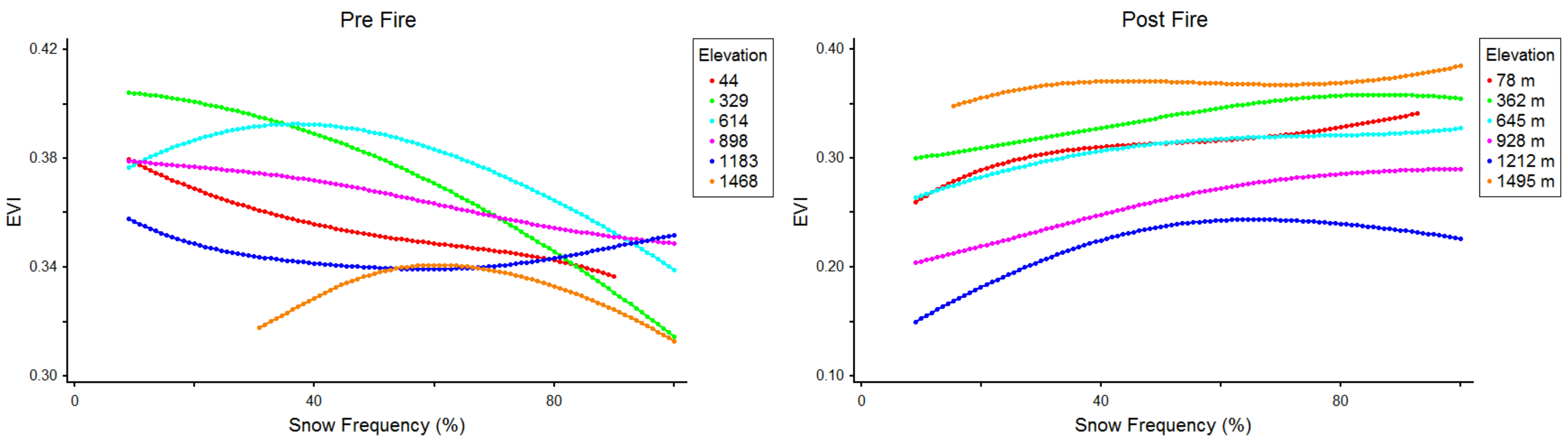

Figure 6. Elevation slices from their 3D regression surface produced by NPMR for the pre-fire (left) and post-fire (right) periods.

Conclusions

These preliminary results suggest that snow may aid in post-fire vegetation regeneration; pre-fire spring EVI decreases as antecedent winter snow frequency increases, but post-fire spring EVI increases as antecedent winter snow frequency increases. They also suggest that vegetation at higher elevations have a stronger positive correlation with winter snow frequency.

Further investigation is required to be able to create a model with a higher cross-validated R sq. This may include finding the correct combination of predictor variables to describe the EVI response. This could include incorporating slope, aspect, burn severity, vegetation type, etc.

References

- *Knowles, N., M. D. Dettinger & D. R. Cayan (2006) Trends in snowfall versus rainfall in the Western United States. Journal of Climate, 19, 4545-4559.*
- *Mote, P.W. (2006) Climate-driven variability and trends in mountain snowpack in western North America. Journal of Climate, 19, 6209-6220.*
- *Westerling, A. L., H.G. Hidalgo, D.R.Cayan & T.W. Swetnman (2006) Warming and earlier spring increase western US forest wildfire activity. Science, 313, 940-943.*