Modeling rangeland performance and climate change effects on Big Sagebrush in the Owyhee Uplands

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Introduction

Vegetation response in an ecosystem is contingent on multiple variables, and we present here a method to separate the influences of climate and site potential from disturbance in the Owyhee Uplands for five vegetation types (Wylie *et al.* 2008) (Figure 1). Seasonal remotely sensed vegetation greenness measures from Moderate Resolution Imaging Spectroradiometer (eMODIS) 250 m Normalized Difference Vegetation Index (NDVI) is used as a proxy for ecosystem performance. The proxy measurements are placed within a context of over performance and underperformance based on modeled expected ecosystem performance measures. We also isolated one of the vegetation types, Big Sagebrush (*Artemisia tridentata*), which provides critical habitat for multiple species in the Great Basin (Chambers and Pellant 2008), and projected its future extent and productivity based on a future climate scenario in the Owyhee Uplands.

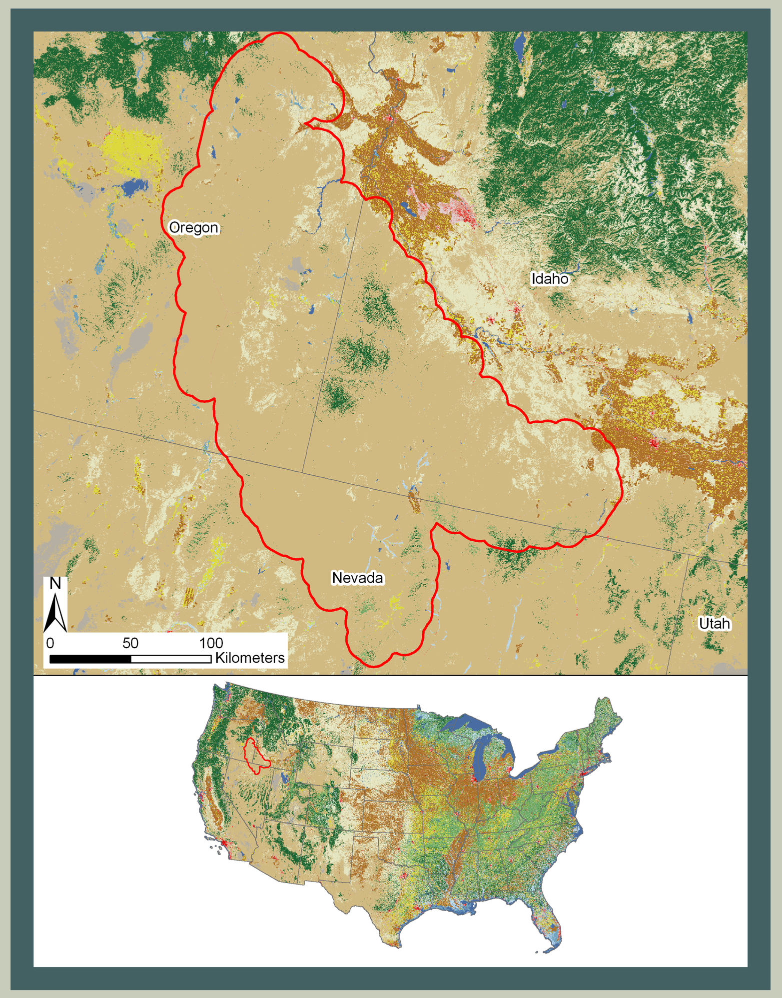

Figure 1. The Owyhee Uplands study area over 2001 NLCD.

Methods

We used a regression tree modeling approach to predict site potential and expected ecosystem performance for five vegetation types in the Owyhee Uplands. The models were trained on areas that had not burned in the five years prior. Site potential is defined as long-term, expected ecosystem performance and was estimated with inputs of PRISM long-term climate (PRISM Climate Group, Oregon State University, http://www.prismclimate.org) elevation and its derivatives, and land cover (Wylie *et al.* 2008). The vegetation classes accounted for in the model include Big Sagebrush, Low Sagebrush (*Artemisia arbuscula*) Purshia (*Purshia tridentata*), Grass, including eighty-three genus types, and a catch-all "other vegetation" class. Then we integrated site potential, seasonally averaged annual weather, and land cover to determine annual expected ecosystem performance for 2000 - 2008. We compared the annual expected ecosystem performance to an actual growing season NDVI (GSN) for the identical time period to determine the performance of the ecosystem, highlighting areas as anomalies that either performed better or worse than expected.

To project the future extent and productivity of Big Sagebrush, we downloaded National Center for Atmospheric Research (CCSM3) future climate data for the year 2040, available on the Bias Corrected and Downscaled WCRP CMIP3 Climate Projections website (http://gdo-dcp.ucllnl.org/downscaled_cmip3_projections/dcpInterface.html#). This data was rescaled and averaged to match the PRISM climate inputs units that were used to establish the current land cover extents for Big Sagebrush in the Owyhee Uplands. The future extent was predicted using the regression tree model with future climate, long-term GSN, elevation and derivatives and land cover as inputs. The future productivity model utilized seasonally averaged future climate, land cover and site potential data.

Validation

We validated model data using LANDFIRE vegetation composition data from LANDFIRE zones 9 and 18, the Bureau of Land Management's Jarbidge District Ecological Site Inventory (ESI) vegetation composition data, and 2006 and 2007 stocking rates that were based on the number of acres grazed per animal unit by month (Figures 2 and 3). The ESI and stocking rate data were limited geographically to the southeast portion of the Owyhee Uplands. As expected, normal performing pixels were correlated to the percentage of bare ground for both LANDFIRE and ESI data sets (R^2=.50) where the percent of bare ground corresponds to site potential value. In the grassland area of the southeast Owyhee Uplands, grazing pressure was related to ecosystem performance anomalies (R^2=.37). One non-grazed pasture in 2007 experienced a very high performance anomaly value of 130 and another non-grazed pasture in 2007 that burned in 2006 experienced a very low value. The burned pasture, even though rested in 2007, was not included in the regression calculation because the underperforming pixels would skew the result because of the fire disturbance.

Results and Discussion

Anomaly maps were produced for five vegetation types for the years 2000 – 2008 in the Owyhee Uplands. The southeast area in 2008 shows an expected response to the Murphy Complex Fire that burned during late summer of 2007 (Figure 4). Areas of underperforming pixels (red) and low normal performing pixels (dark brown) dominate the landscape within the fire boundary. Areas of overperforming pixels (yellow to green) cover a small portion of the landscape and generally are located outside the fire boundary. We expected that grassland areas burned in 2007 would take two growing seasons to recover and start performing at or above normal levels. Figure 5 shows a compilation of performance anomalies for each year from the 2000 – 2008 maps. If a pixel consistently underperformed or consistently overperformed, it is displayed as a color other than tan. Tan colored pixels represent areas that performed as expected for most, if not all, of the years from 2000 – 2008. Figure 6 shows the trend of each pixel in the study area. The largest areas with a negative trend were mostly distributed outside of the Owyhee Uplands area, although there is a portion in the northern area with a significant negative trend within the Uplands boundary. Fire disturbances account for some of these negative trends found within the Uplands boundary. Significant positive trending areas in the Uplands are scattered throughout, but large patches exist in the northwest, central, and southeast areas.

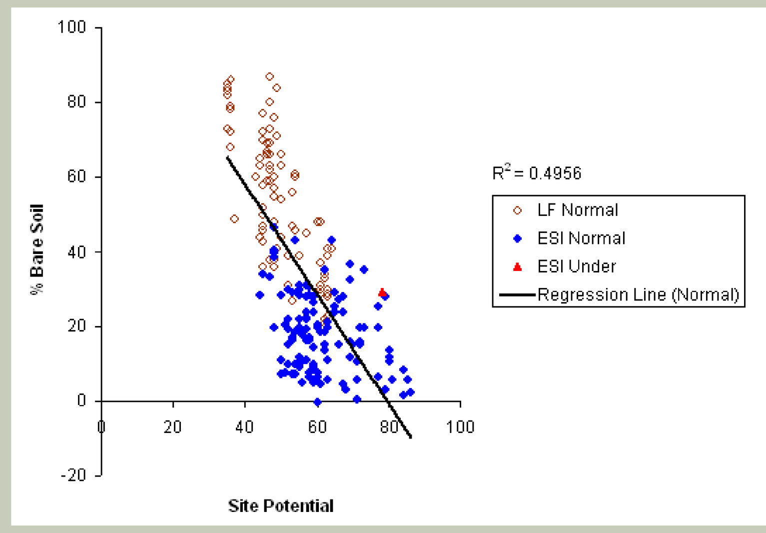

Figure 2. Validation of Big Sagebrush site potential in southeast Owyhee Uplands using 2003 LANDFIRE (LF) and 2006 ESI data.

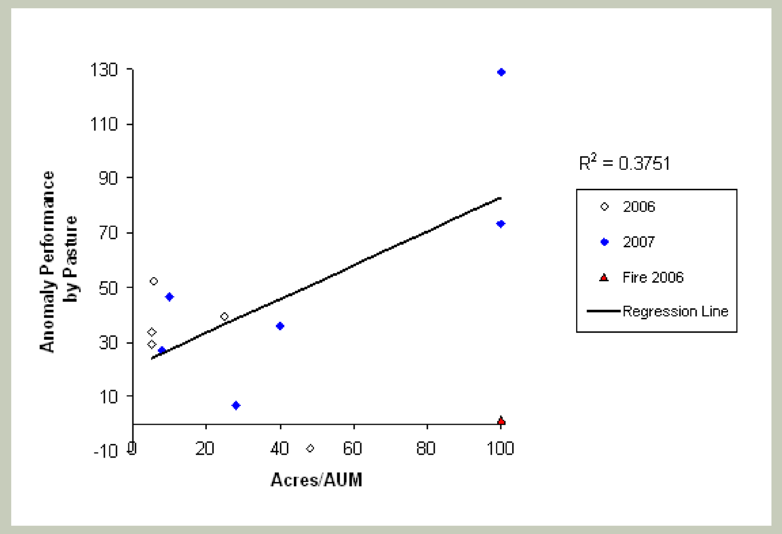

Figure 3. Validation of southeast Owyhee Upland grass performance anomalies using 2006 and 2007 stocking rate data (The pasture that burned in 2006 was excluded from regression.).

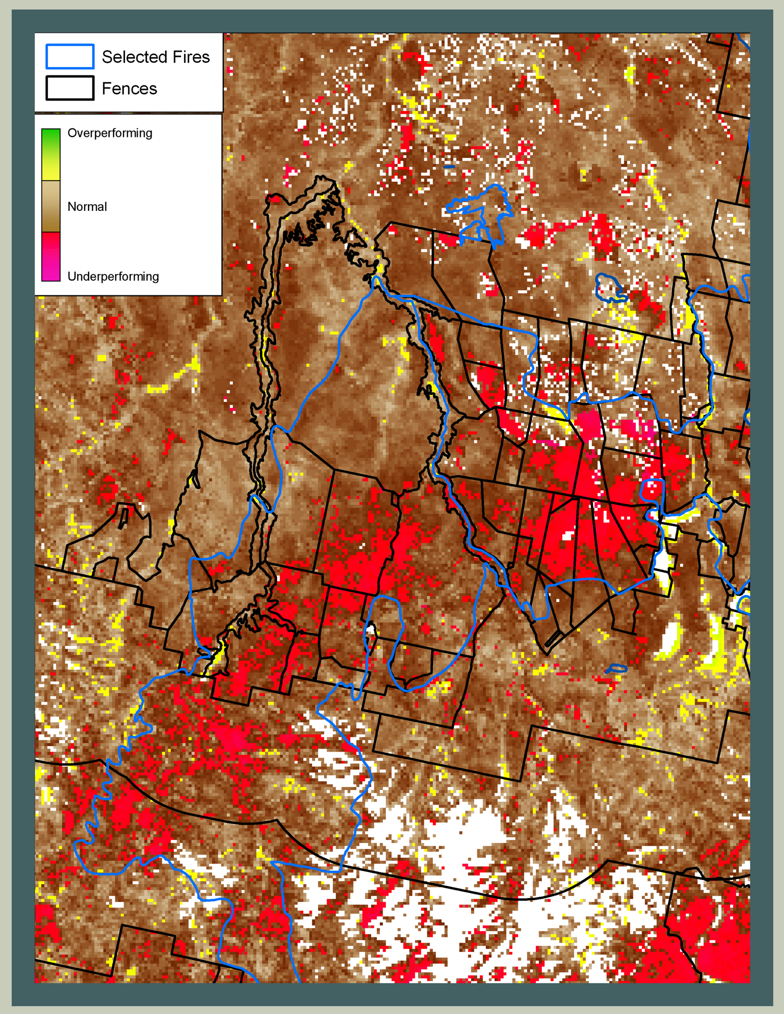

Figure 4. 2008 performance anomaly for 5 vegetation types in southeast Owyhee Uplands showed expected response to recent fires.

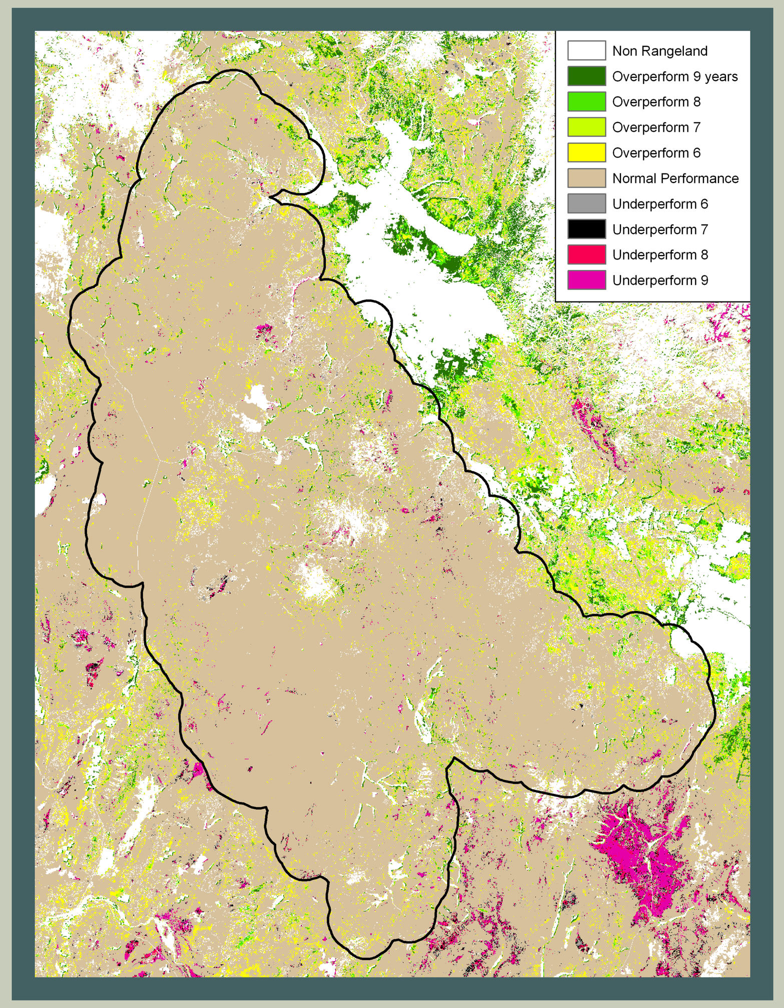

Figure 5. The persistent anomaly map shows areas that underperformed for at least 6 of 9 years, overperformed for at least 6 of 9 years, or performed as expected.

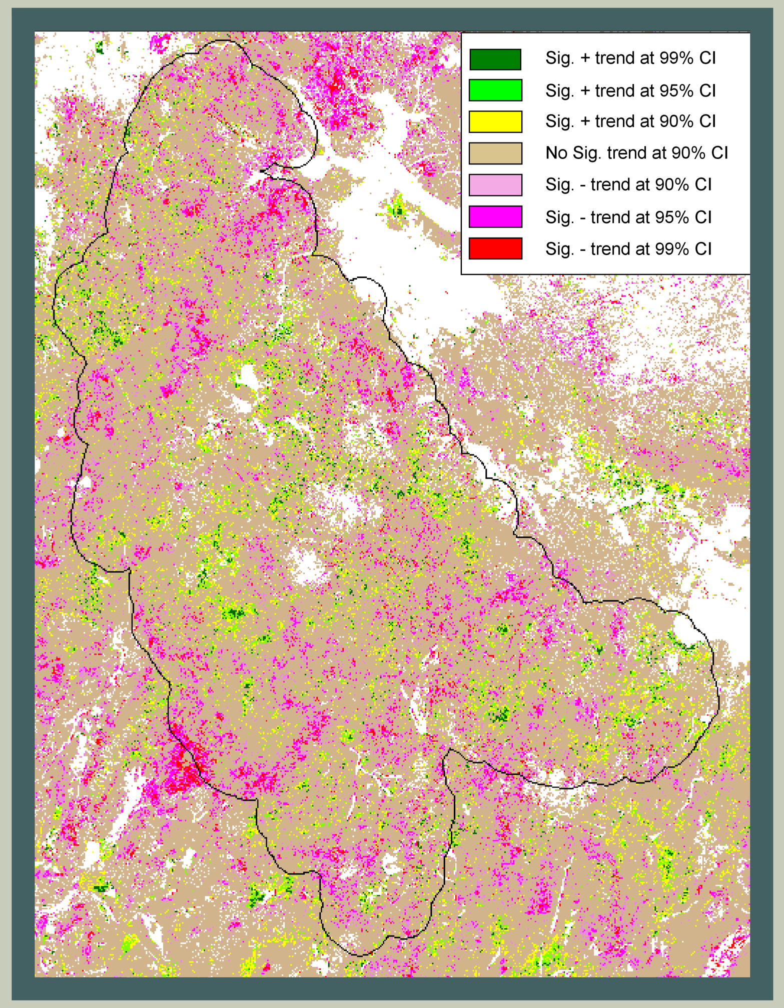

Figure 6. The trend map displays the significance of each pixel's trend in a positive or negative direction at different confidence intervals.

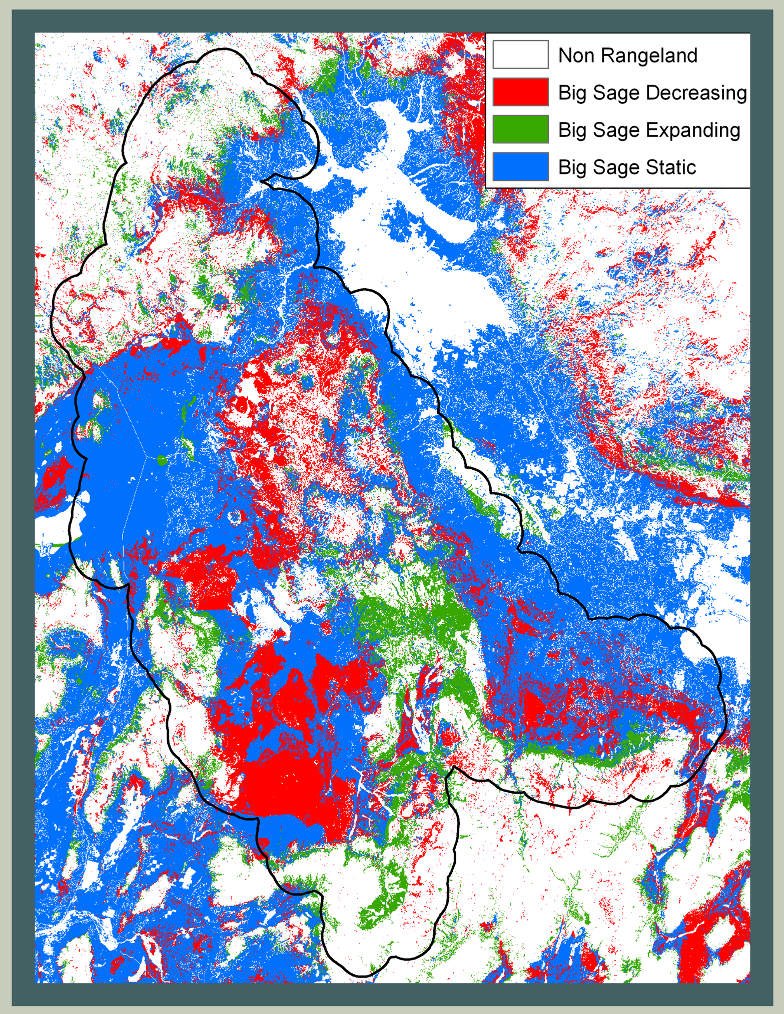

Figure 7. The future distribution of Big Sagebrush in the Owyhee Uplands shows areas of change and stability.

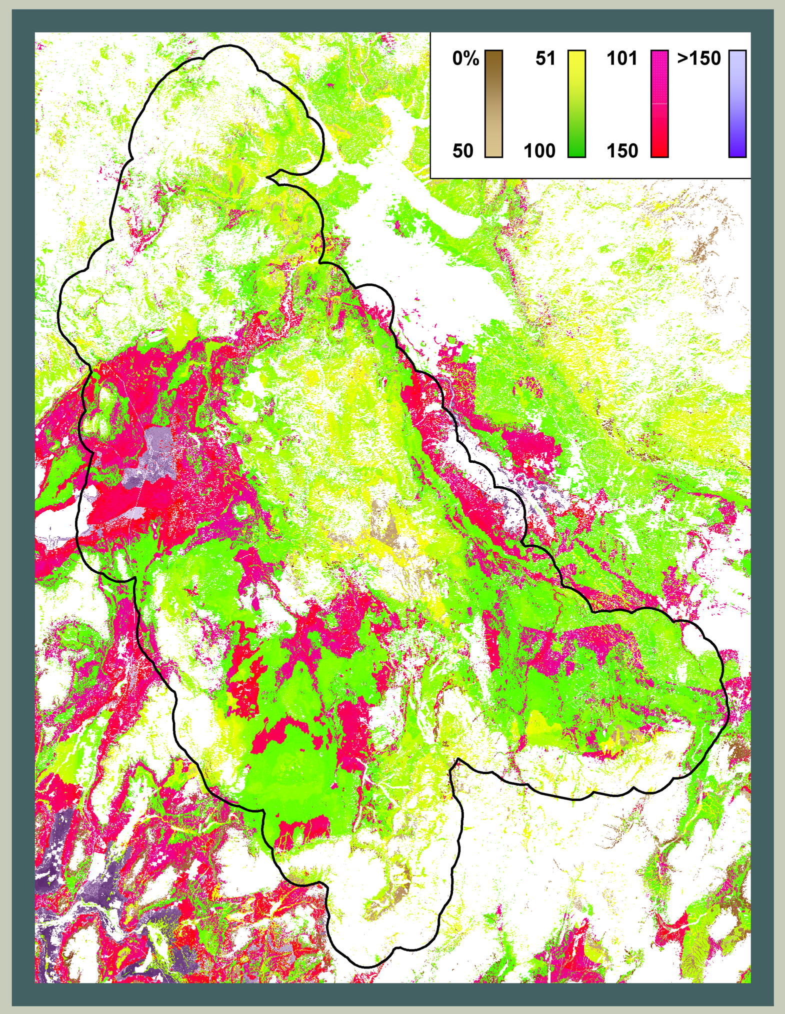

Figure 8. 2040 predicted productivity of Big Sagebrush as a percent of current Big Sagebrush productivity show areas of expected decline and increase.

The spatial distribution and productivity of Big Sagebrush in the Owyhee Uplands are expected to be affected by a changing climate that is projected to be warmer with more precipitation (http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch14s14-3.html#14-3-1, date accessed April 7, 2010) (Figures 7 and 8). Big Sagebrush should expand in the south central part of the Uplands with areas of declining extent in the southeast, southwest and central areas. Areas in the southern most part of the Owyhee Uplands should experience both decline and expansion of Big Sagebrush. Overall, within the Owyhee Uplands, 58% of the area that is currently Big Sagebrush is predicted to remain Big Sagebrush, 29% of the area is predicted to change from Big Sagebrush to another land cover, and more than 12% is expected to change from another land cover to Big Sagebrush. The map comparing 2040 Big Sagebrush productivity with current Big Sagebrush productivity shows variable increases and decreases. Generally, areas of Big Sagebrush expansion experienced increased productivity whereas areas representing Big Sagebrush decline are areas of decreasing productivity.

Conclusions

Pixels that show both negative persistent anomalies and a negative trend reveal areas that could benefit the most from focused management efforts. Likewise, focusing management efforts in the Owyhee Uplands on areas predicted to remain as, or transition to, Big Sagebrush could be a management strategy that helps this land cover, and the species that rely on it for survival, continue to be productive through a changing climate.

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