A GIS Approach to Monitoring Canopy Cover Regeneration Post Fire in the Mt. Hood National Forest, Oregon

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INTRODUCTION

Fire is a critical part of terrestrial ecosystems and plays an important role in forest ecology and regeneration, particularly in the Pacific Northwest (Ireland and Petropoulos, 2015). For this project, we used ArcGIS 10.2 to assess canopy cover regeneration during the 5-year period following a 2006 wildland fire within the Mt. Hood National Forest in Oregon (fig. 1). This methodology provides a safe and low cost means of remotely assessing long-term forest health and vegetation recovery post-fire.

METHODS

This study replicates work published in the journal of *Applied Geography* by Ireland and Petropoulos (2015). Seven Landsat Thematic Mapper (TM) images, spanning 2005-2011, were obtained for the 1,811-acre burn site in Mt. Hood National Forest. Additionally, burn perimeter information and burn severity classifications were obtained from the United States Geologic Survey and the United States Forest Service Monitoring Trends and Burn Severity Program. Finally, a DEM of the study area was acquired from ASTER Global DEM.

The Differenced Normalized Burn Ratio (dNBR) and the Normalized Differenced Vegetation Index (NDVI) were used to quantify the fire's impact and the subsequent vegetation regrowth. The dNBR measures soil and vegetation moisture change from pre- to post-fire, indicating burn severity, while the NDVI measures reflectance of photosynthetic surfaces, which correlates to vegetated growth and allows for extrapolation of vegetative regeneration in post-fire areas. In order to calculate the dNBR and the NDVI, seven years worth of composite images of the study area were created, with each image including bands 1-5 and band 7. A dNBR raster image (fig. 2) was then created using an ERDAS Imagine model, which was provided by the U.S. Fish and Wildlife Service Fire Management Program. ArcMap 10.2 was then used to calculate the NDVI for the burn area (fig. 4), using the near and short wave infrared bands 4 and 7 from the composite images. The NDVI was then used to calculate the Regeneration Index (RI) for the post-fire images (fig. 5a), which indicates regrowth of green vegetation from year to year. These calculations were completed using the ArcGIS Spatial Analyst Zonal Statistics tool. Additionally, the DEM was used to calculate RI for north (315-360° and 0-45°) versus south (135-225°) facing slopes (fig. 3). Lastly, RI was calculated for each burn severity class.

RESULTS

Immediately after the burn, the NDVI for the total area within the burn perimeter decreased (fig. 5a), showing a large drop in live green vegetation. There was a further decrease one year post-fire, likely due to delayed tree mortality from the fire. No measureable changes occurred 2007-2009, and there was an increase in NDVI in 2010, and from 2010-2011, a decrease is shown. With regards to aspect (north versus south), the 365 acres of north-facing slopes showed initial decreases in NDVI post-fire, and little change from 2007-2009 (fig. 5b). From 2009-2010 there was a slight increase in NDVI, and from 2010-2011 there was a decrease in NDVI. The 387 acres of south-facing slopes showed a similar decrease in NDVI post-fire, and a slight increase in NDVI from 2007-2010. A slight decrease in NDVI was seen in 2011. With regards to burn severity, the areas of highest burn severity showed the greatest initial decrease in NDVI, followed by the lowest burn severity areas (fig. 5c). From 2007-2010, the most severely burned and the unburned areas had the highest rates of regrowth. However, during 2011 all of the severity classifications showed decreases in NDVI.

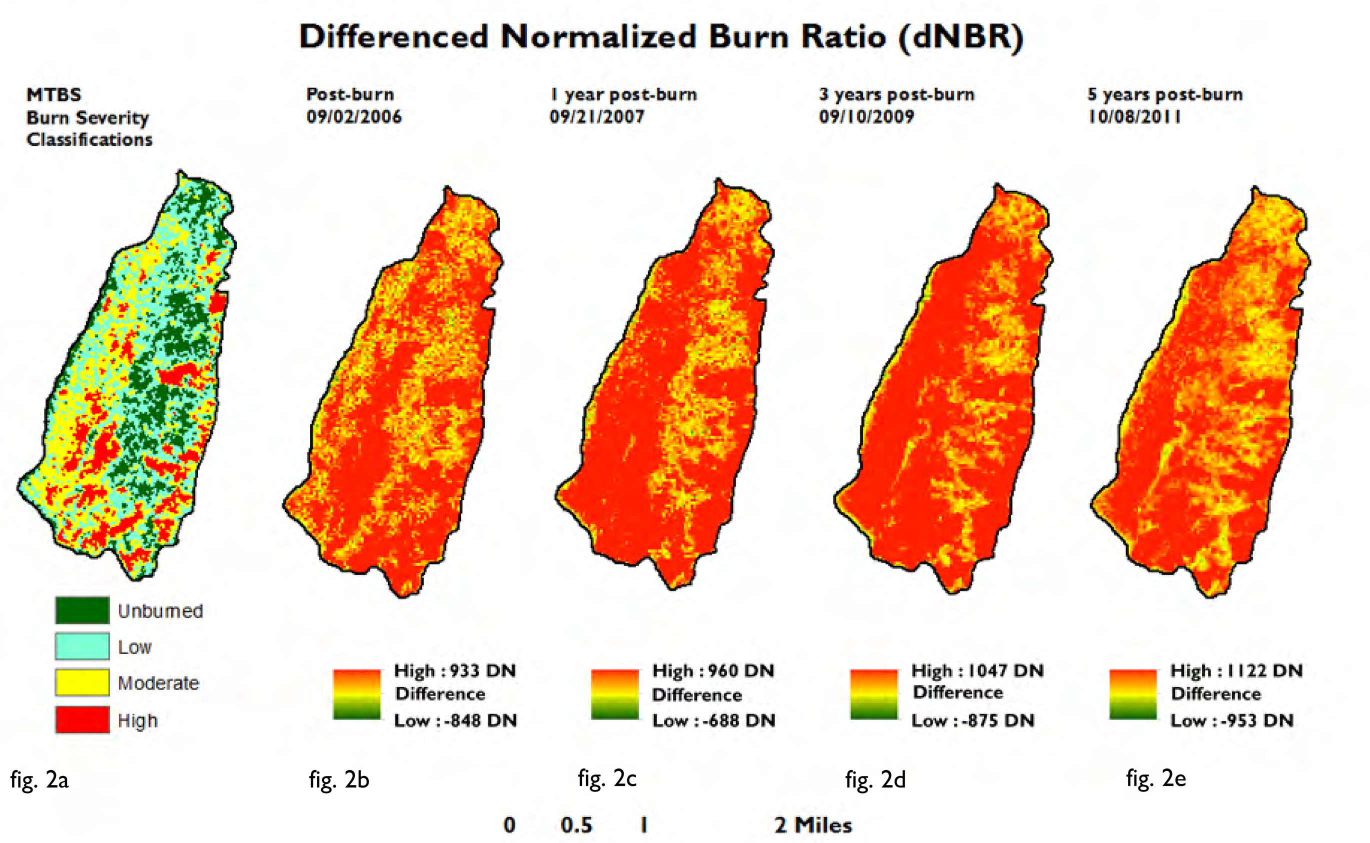
CONCLUSIONS

This study's methodology provides a safe and low cost means of remotely assessing long-term vegetation recovery post-fire, and can contribute to a growing understanding of fire ecology and post-fire landscape processes. Overall, this study's findings matched the expected outcome-- the forest took approximately 4-5 years to begin recovering from a wildfire event (as seen in fig. 5). Slope was also found to have an effect on forest recovery, with south-facing slopes showing greater increases in NDVI than north-facing slopes (fig. 5b). This is likely due to greater exposure to sunlight, and corroborates earlier findings by Ireland and Petropoulos (2015). Moreover, the data indicates that burn severity also has an effect on recovery rate (fig. 5c). Variations and incongruities in the 2011 data show evidence of the year effects of drought, which is not reflected in the control plots.

Having a better understanding of fire's role on the landscape, as well as forest recovery post-fire, can provide support for fire and resource management policy and decision-making. This is particularly important in the Pacific Northwest, where fires are relatively common. The findings of this study can open up new avenues for future research. Further analyses may include a comparison of aspect and fire severity, ground-truthing the NDVI, forest succession surveys and analysis, as well as providing the statistical significance of the findings.

Figure 1a (left): A Landsat Image of the study area, with the burn area oulined in orange.

Figure 1b-1e (above): The images above show the 2006 wildfire which burned approximately 1,811 acres in the northeastern quadrant of the Mt. Hood National Forest, in Oregon. According to Fire Management Specialist, Brian Gales, "the overall incident management strategy was to manage the fire with the intent to mimic its natural role in the ecosystem by allowing it to burn within the wilderness. A mosaic burn pattern was achieved across the fire footprint, promoting greater forest health and a resilient landscape."



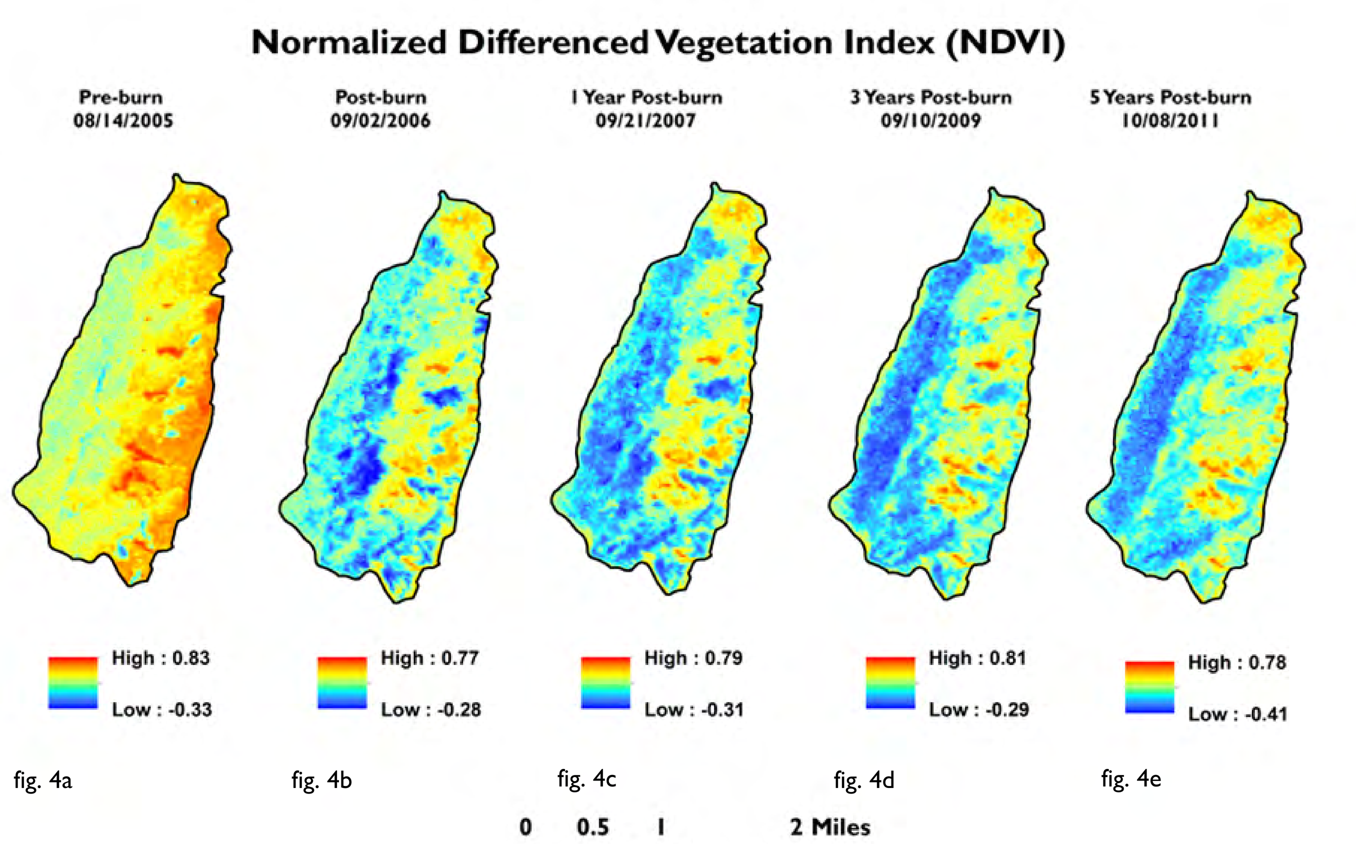
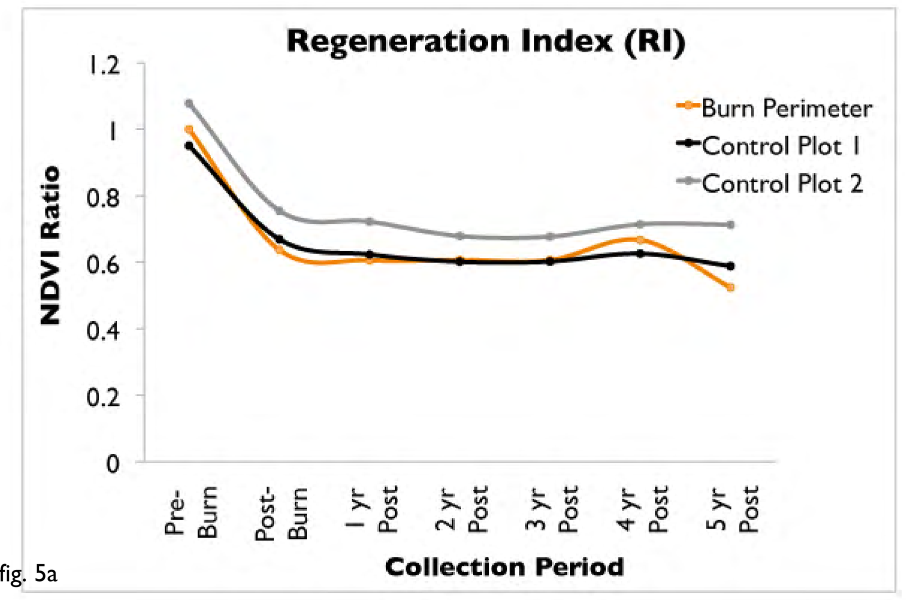
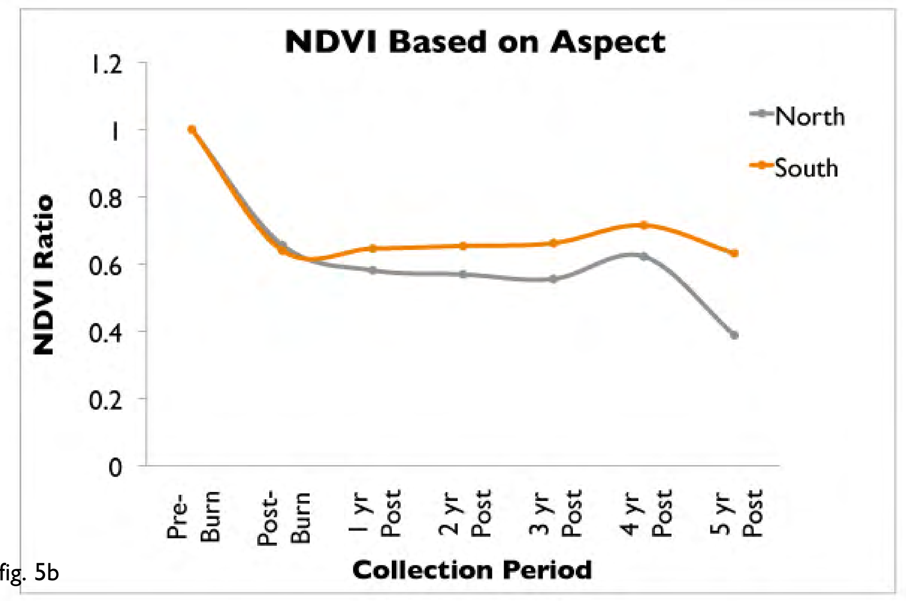


Figure 2: (a) Burn severity classification data layers provided by the Monitoring Trends in Burn Severity Program. (b-e) dNBR data layers created from composite images using an ERDAS Imagine model. The Normalized Burn Ratio (NBR) is an index emphasizing the contrast between the spectral reflectance of burnt and healthy vegetation. dNBR is a differenced image of the two NBR layers (pre and post-fire) which calculates the change between the two images. In the dNBR image, a positive digital number (DN) pixel value expresses change in vegetation due to fire. Higher DN values correspond to higher burn severity.

Figure 3: This image displays the aspect polygons, including 387 acres of south-facing slopes and 365 acres of north-facing slopes. Slopes derived from a 30 meter DEM.

Figure 4: Normalized Differenced Vegetation Indices were created for each year of the fire using ArcGIS 10.2. A higher NDVI indicates a higher concentration of photosynthetic-producing vegetation. Here, areas within the burn boundary shown in red indicate the highest amount of vegetation and areas shown in blue indicate the lowest amount of vegetation.





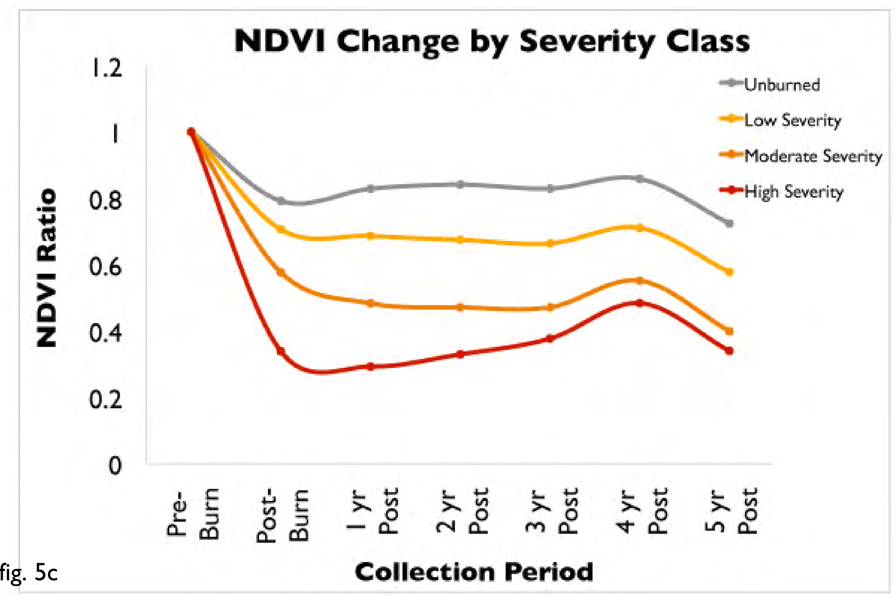


Figure 5: (a) The Regeneration Index (RI) indicates regrowth of green vegetation from year to year. Immediately post-fire the NDVI for the total area within the burn perimeter decreased 37%, showing a large drop in live green vegetation, and does not start to increase until four years post-burn. (b) Here, NDVI is graphed based on aspect. The south-facing slopes show a greater increase in NDVI over time. (c) NDVI is graphed here based on burn severity class. Starting in 2007, at one-year post fire, both the most severely burned and the unburned areas had higher rates of rerowth, in comparison to the low and moderately-burned areas. However, similar decreases in NDVI for all severity classes are shown in 2011, due to it being a drought year.

SOURCES

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