# Evaluating Vegetation Regrowth after the B&B Complex Fires in Oregon in 2003

Lucia Johnson

University at Albany

GOG 485: Remote Sensing II

Dr. Buyantuev

May 09, 2023

# Evaluating Vegetation Regrowth after the B&B Complex Fires in Oregon in 2003

## Introduction & Purpose

The number of large and severe wildfires in the United States are increasing. The area burned in Oregon increased from an average of 198,000 acres per year in the years between 1992 to 2001 to 433,541 acres between 2002 and 2017 (Urness, 2018). The intensity of wildfires has a big effect on the damage to vegetation and how vegetation rebounds after the fire. A low intensity fire mostly burns the undergrowth and dead vegetation close to the ground. Most of the trees will survive and the cleared undergrowth provides space and access to sunlight for new vegetation to grow (Snow, 2022). High intensity fires climb up into the tree canopy and scorch the roots in the ground which kills the trees and leaves the area bare. Often invasive plants will take over the area. It can take over 100 years for large trees to grow back in an area that has been cleared of trees (Snow, 2022). Severe fires are more likely when there are large amounts of fuel loads and ladder fuels (fuels such as flammable vegetation that allows fires to climb up to the tree canopies), which can accumulate due to forest management decisions such as fire suppression (Weldon, 2006). This paper aims to look at the vegetation regrowth after the B&B Complex fires which happened in Oregon in 2003.

## Study Area & Background

The study area (figure 1) is located in Oregon to the northeast of Bend, Oregon in the area where the B&B Complex fires occurred. The B&B Complex fires were two separate wildfires that merged, called the Bear Butte, and the Booth fires. Both fires started on August 19th in 2003 (Weldon, 2005). The former started on the northern side of Mount Jefferson Wilderness in Oregon and the latter near Henkel Butte, northeast of Camp Sherman. The fires merged on September 4th (Urness, 2018). The fire was contained in mid-September thanks to increased precipitation, but it kept burning for several weeks. The fires affected about 90,692 acres of land and was the largest in the history of the Deschutes National Forest (Weldon, 2005). I selected this fire for this study, because most of the fire affected forested areas and because the time it occurred, 2003, is long enough ago to be able to observe some vegetation regrowth, but recent enough to get good data in order to study it. Additionally, the fire was one of the more severe fires seen in the area. According to the Forest Supervisor in charge of the recovery from the fires, Leslie Weldon (2005),

> A substantial percentage of the Link can B&B Complex … burned with enough intensity to kill either the majority of trees in a stand or the entire stand (high mortality). Based on satellite imagery it was estimated that over 30,000 acres (~32%) burned with high mortality resulting in stand replacement (p.6)

The large study area and the proportion of intensely burned areas makes this area ideal for the study of vegetation regrowth. The study area includes some burned areas and some that were left untouched. The plants that grew in the area prior to the fire included “wet and dry mixed conifer, ponderosa pine, and lodgepole pine” (Weldon, 2005, p.5).

## Methodology

The first step in the project was to determine the area to study. For this I used the MODIS Burned Area Monthly Global 500m product (Giglio et al., 2015). I loaded it inside of Google Earth Engine using the code provided by the Earth Engine Data Catalog (Google Earth Engine, n.d.) with the dates adjusted to the time of the fire. From the visualization in Google Earth Engine, I was able to select the study area.

The next step was to map the severity of the burn. To do this, I used code from the United Nations SPIDER program (n.d.). I adapted the code to run with Landsat 5 data instead of Landsat 8, because the latter wasn't available during the time of the fire. For this code I selected Landsat 5 Level 2 Collection 1 Tier 1 Surface Reflectance images from a time window between June 20$^{th}$, 2003, and August 7$^{th}$ 2003 for before the fire and from September 28$^{th}$ to October 20$^{th}$ for after the fire. The code created a collection of images for both pre- and post-fire, masked any clouds in both collections and created a mosaic of the images. It then calculated the normalized burn ratio for both images and then created an image of the difference between the pre and post fire images (figure 2). The image was classified according to the burn severity classes listed on the UN-SPIDER page (n.d.) as seen in figure 3. In the later analysis, I decided to group the classes “Enhanced Regrowth, high”, “Enhanced Regrowth, low”, and “Unburned” together under the label “Unburned” as this research is more focused on the burn severity than the growth in unburned areas.

After this, I proceeded to prepare images for the years 2003 to 2009 in order to analyze the vegetation growth over time. I used Google Earth Engine to prepare the images. For each year, I created an image collection of images between June 20$^{th}$ and August 1$^{st}$. I selected these dates in because vegetation is likely to be at its highest in the summer, and I didn't want to get an image during the fire in late summer. For these images I selected to use Landsat 5 Level 2 Collection 2 Tier 1 Surface Reflectance and Land Surface Temperature Images which are atmospherically corrected and orthorectified. For each image collection, I applied a mask to any clouded areas and reduced the image collection to one median image. This was done in order to reduce the effects of clouds and other inconsistencies. I downloaded the completed images to do further analysis in ArcMap, with the help of the Batch tool in Google Earth Engine, created by Rodrigo E. Principe (2019).

Once I loaded all of the images into ArcMap, I verified that they lined up geographically as expected. Then I proceeded to calculate the NDVI for each year. For the first year post fire I subtracted the NDVI image for 2003, the summer prior to the fire, from the one from the year 2004, the summer immediately after the fire. The resulting image shows the damage of the fire a few months after it happened (figure 4). For the subsequent years, I subtracted the 2004 NDVI image from the NDVI images of each year between 2005 and 2009. The resulting images show the vegetation regrowth that has happened compared to the year after the fire (figures 5-9).

I divided the NDVI difference into classes to show regrowth or reduction in NDVI value as seen in figure 10. I combined each of the NDVI difference images with the burn severity image using the Combine tool in Spatial Analyst and created change matrices (figures 11-15) in order to see a correlation between the burn severity and the regrowth.

**Results and Discussions**

The change matrices (figures 11-15) show that a majority of the study area was unburned which was not the focus of the study. Out of the burned area, the majority was burned with a low or moderate-low severity. In each of the years, most of the area showed no significant difference to the year 2004, and the second largest category was in the low growth category. Only a very small percentage of the area fell into the “strong reduction”, “moderate reduction”, “moderate growth”, and “strong growth” categories.

The “low growth” section is the most relevant to this section. Out of the total burned area, the portion that displayed low growth increased from 29.913% in 2005, to 34.949% in 2006. In 2007 it decreased slightly to 30.275%. Then it increased again to 31.308% in 2008 and 42.724% in 2009. The initial expectation was the burned area would show consistent growth from year to year as the area recovers from the fire. This was not completely the case as there was a lower value in 2007 and 2008 than in 2006. This can be explained by the local weather conditions during the time. Deschutes and Jefferson counties, where the fire was located, experienced a period of above average wetness in the spring and summer of 2006 compared to periods of drought in the years 2005, 2007, and 2008 as seen in using the drought conditions tool on the Drought.gov website shown in figure 16. These conditions could explain the abnormally high vegetation regrowth in 2006 as well as the reductions in following years. The overall trend is still upwards as expected.

The change matrices also show that the burned areas consistently showed more regrowth than the unburned areas. Over 90% of the unburned areas either remained the same or showed declines in NDVI while in the total burned areas the percentage was under 70% after the first year of regrowth. This was expected.

Another expectation of mine was that the areas that were burned with a low, or moderate-low severity would show more regrowth than areas that showed a higher burn severity. This was only partially true. The areas burned with high severity consistently showed the lowest level of regrowth of all of the burned areas ranging from 8.629% in 2005 to 16.025% in 2009. None of this area showed moderate or strong growth. This was what I expected as it was likely that areas that were burned with a high severity would be more damaged and have less surviving plant matter that can grow back. Surprisingly, the category that showed the next lowest growth percentage was the area burned with low severity. The percentage of area that showed growth here ranged from 24.447% and 22.380% in 2007 to 35.626 in 2009. The reason for this could be that because this area only had a low burn severity, that much of the vegetation survived and the NDVI values in 2004 were already comparatively high so there wasn’t as much that could grow back. The moderate-low and the miderate-high severity categories both showed the highest percentage of regrowth both in the low and the moderate growth categories with the moderate-low category showing a slightly higher percentage of area regrown.

There are some limitations of the study. Fist, only a small percentage of the burned area was in the higher burn severity categories with 3.795% of burned area being in the miderate-high category and 0.162% in the high severity category. With a larger study areas the findings on growth would be more statistically significant. Additionally, the growth was measured based on the summer after the fire happened. At this point some of the initial regrowth may have already happened which makes the regrowth difference seem lower than anticipated. This is especially significant because the year 2004 was slightly wetter than usual (NOAA, NIDIS, n.d.) so there may have been more regrowth than anticipated. Further studies should be done comparing the NDVI levels to what they were prior to the fire as well as immediately following the fire. An accuracy assessment should also be done on the values taken from this study, ideally using measurements taken onsite.

The study also doesn’t touch on what type of vegetation grew back. This could be studied by using higher resolution imagery or multispectral imagery and classifying the area based on vegetation types. Using LiDAR to measure tree height over time would also be interesting here, however a search of the USGS LiDAR coverage map only shows a partial coverage of the area in the years 2009-2011. For a future fire, it could be interesting to capture the LiDAR data in regular intervals after the fire.

Studying the area over a larger timeframe would be interesting to see how long it would take for the NDVI values to level out and stop rising, signifying that the forest has grown back to a stable level.

Another thing that could be incorporated into future study is to compare areas where vegetation recovery efforts took place to those that were left to recover naturally. In order to do that, an accurate map of the vegetation recovery efforts.

**Conclusions**

The area burned by the B&B Complex fires was mostly burned with a low or moderate severity. More of the burned areas showed vegetation growth than unburned areas, and of those, the moderate-low and miderate-high burn severity areas showed the most area that had regrowth. Areas with high or low burn severity showed slightly less regrown areas. While the area did show overall regrowth over the years, there was a bit of a dip in regrowth between 2007 and 2008, likely due to environmental factors.

**Figures and Tables**

Study Area

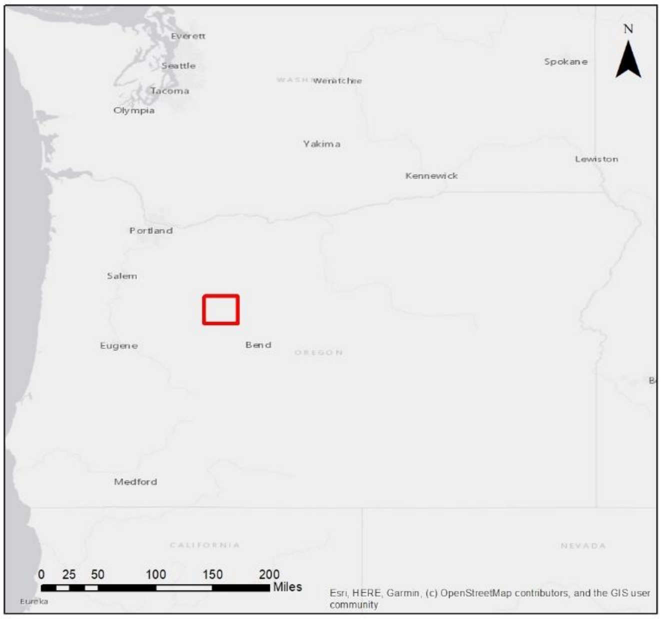


*Figure 1- Study area outlined in red.*

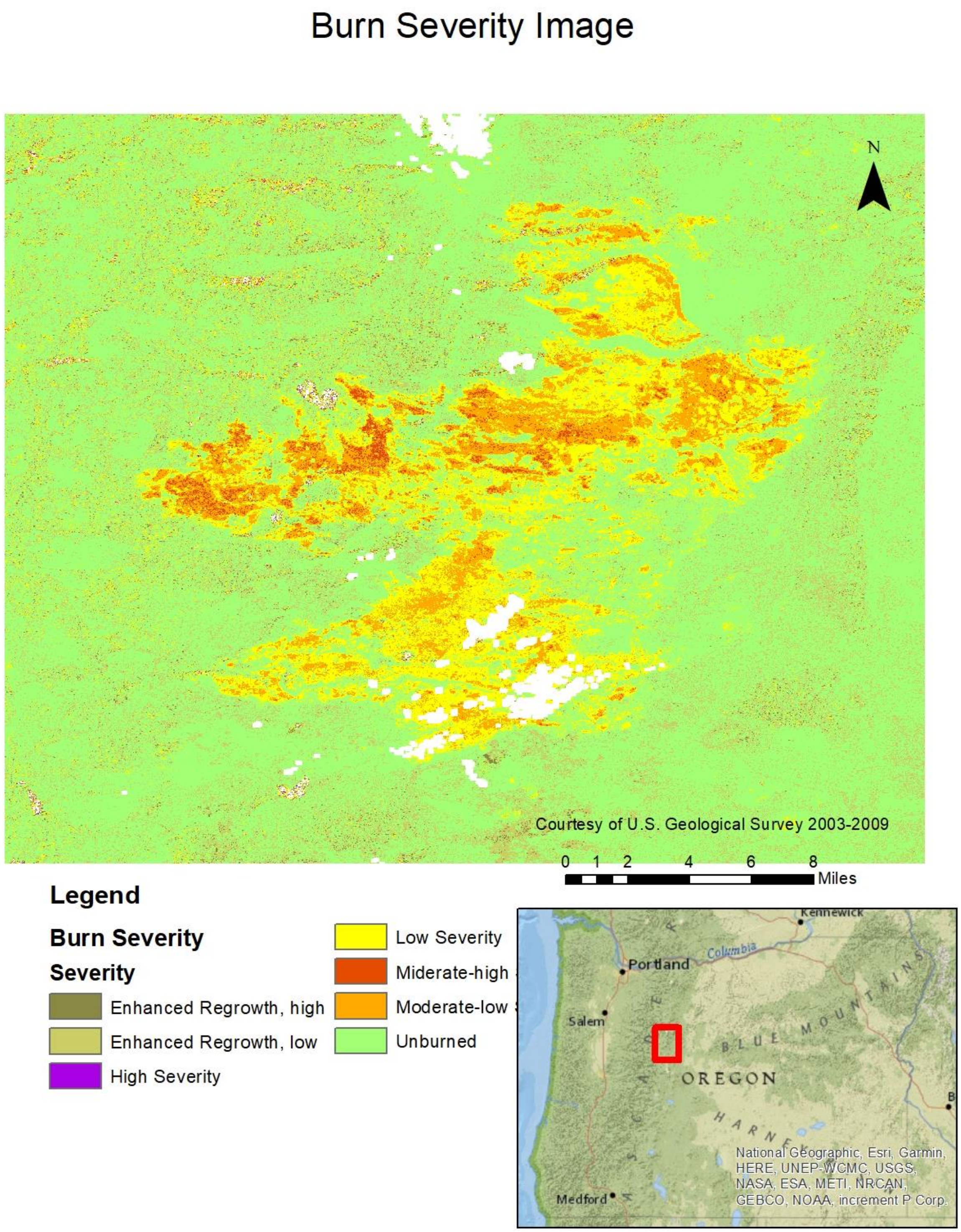


*Figure 2- Burn Severity courtesy of U.S. Geological Survey 2003.*

| Severity Level | dNBR Range (scaled by $10^3$) | dNBR Range (not scaled) |
|---|---|---|
| Enhanced Regrowth, high (post-fire) | -500 to -251 | -0.500 to -0.251 |
| Enhanced Regrowth, low (post-fire) | -250 to -101 | -0.250 to -0.101 |
| Unburned | -100 to +99 | -0.100 to +0.99 |
| Low Severity | +100 to +269 | +0.100 to +0.269 |
| Moderate-low Severity | +270 to +439 | +0.270 to +0.439 |
| Miderate-high Severity | +440 to +659 | +0.440 to +0.659 |
| High Severity | +660 to +1300 | +0.660 to +1.300 |

*Figure 3- Burn severity classes and thresholds proposed by USGS. Color coding established by UN-SPIDER (n.d.).*

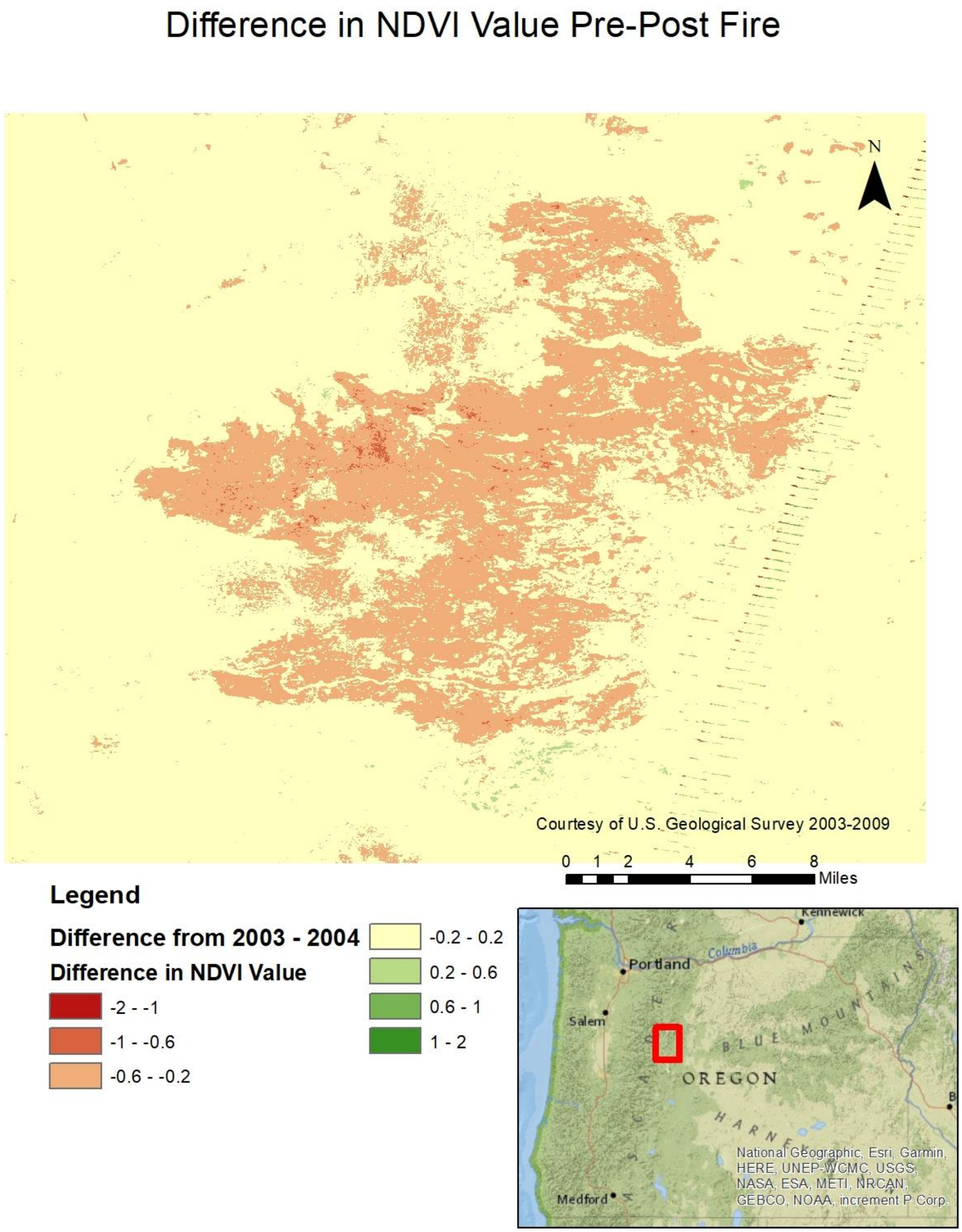


*Figure 4 - Pre to Post Fire Damage image courtesy of U.S. Geological Survey 2003-2009*

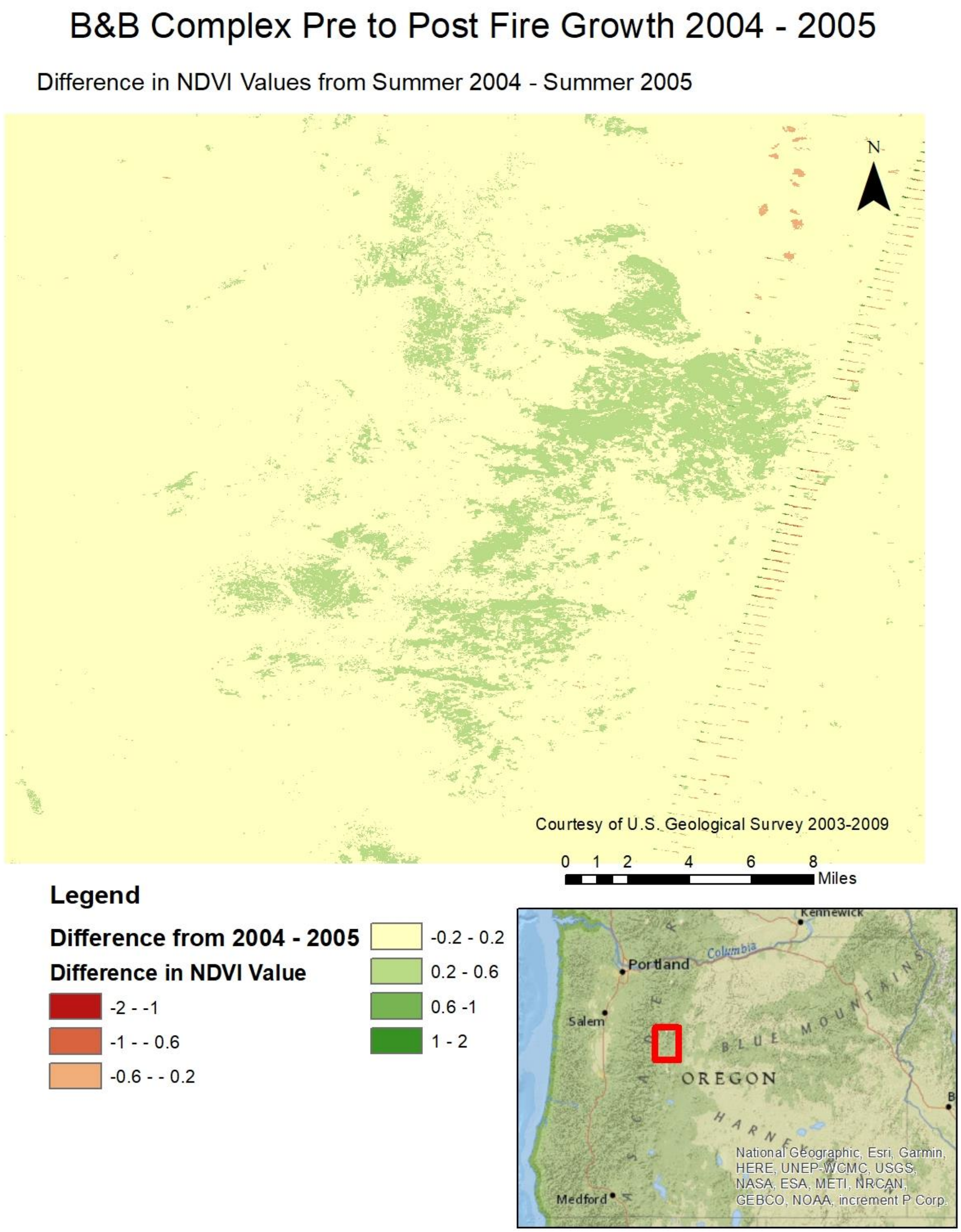


*Figure 5- Post Fire Growth 2004 - 2005 image courtesy of U.S. Geological Survey 2003-2009*

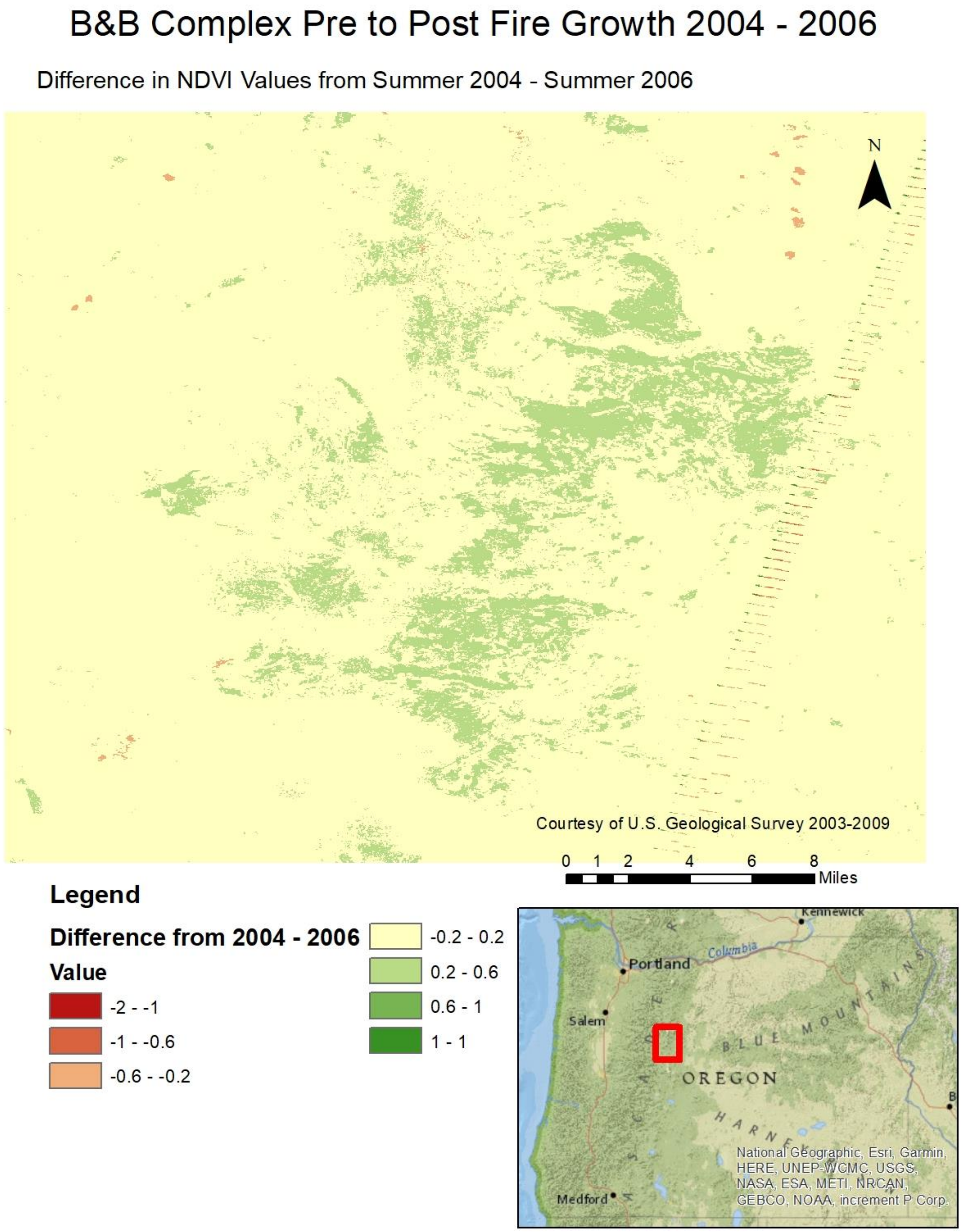


*Figure 6 - Post Fire Growth 2004 - 2006 image courtesy of U.S. Geological Survey 2003-2009*

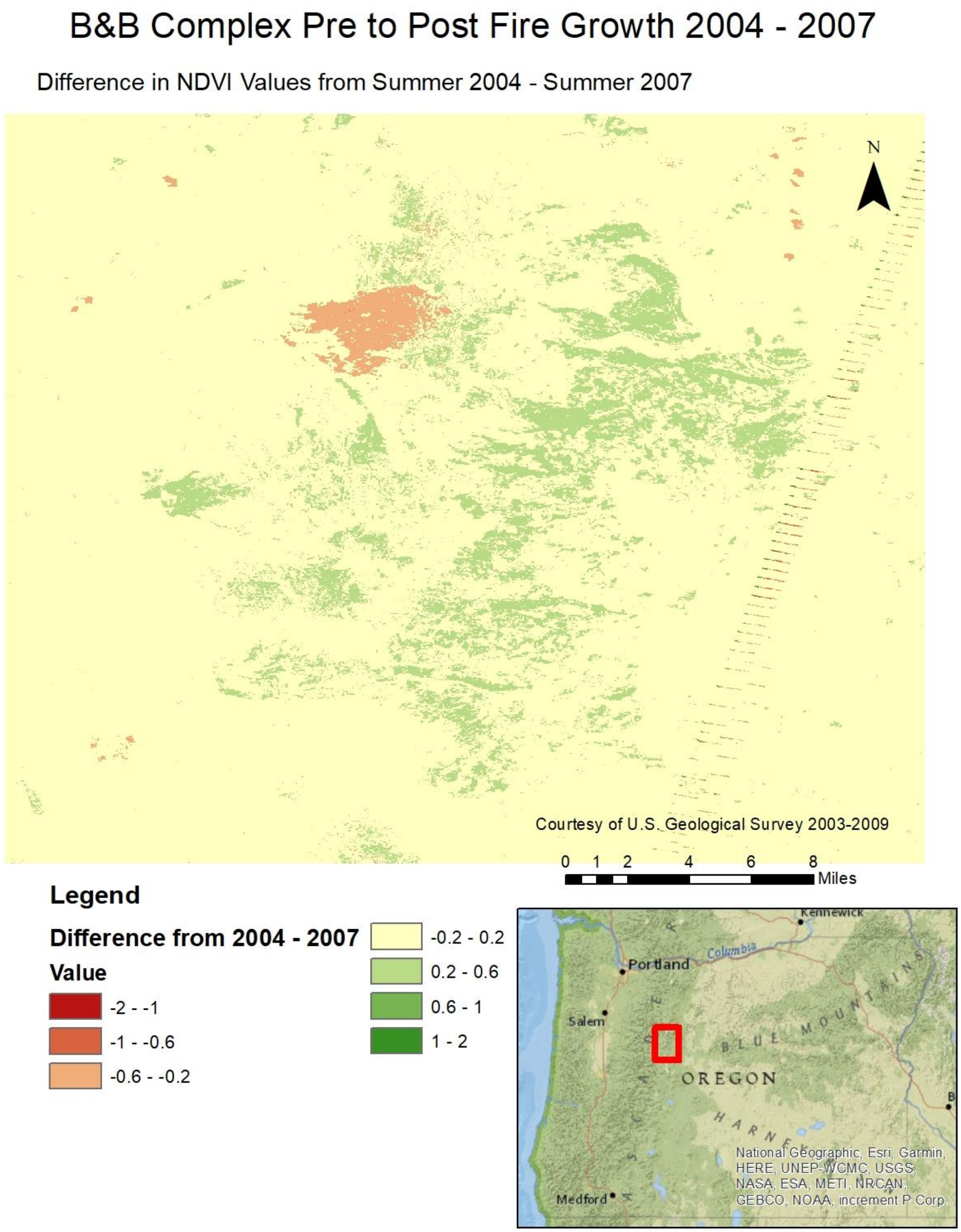


*Figure 7- Post Fire Growth 2004 - 2007 image courtesy of U.S. Geological Survey 2003-2009*

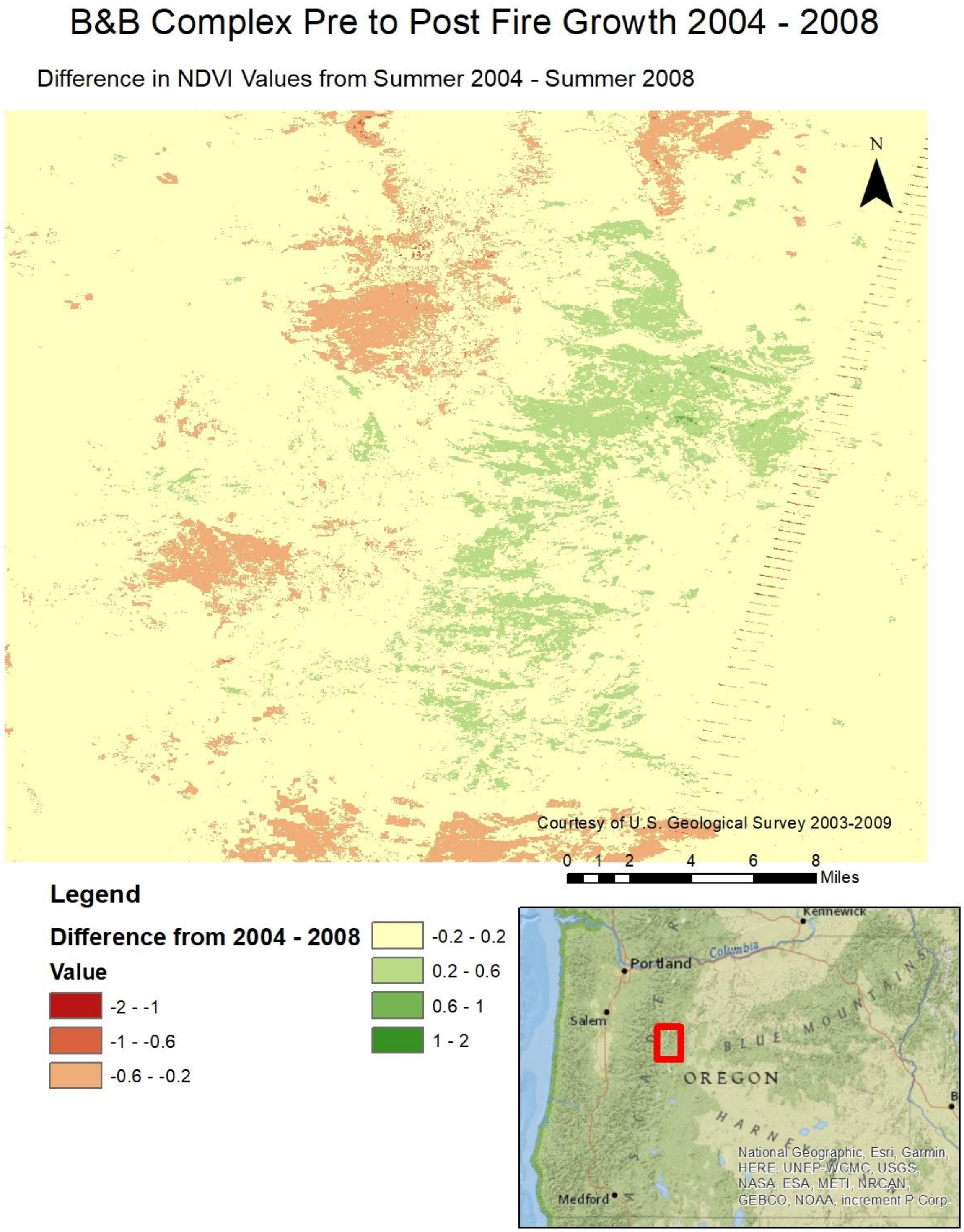


*Figure 8- Post Fire Growth 2004 - 2008 image courtesy of U.S. Geological Survey 2003-2009*

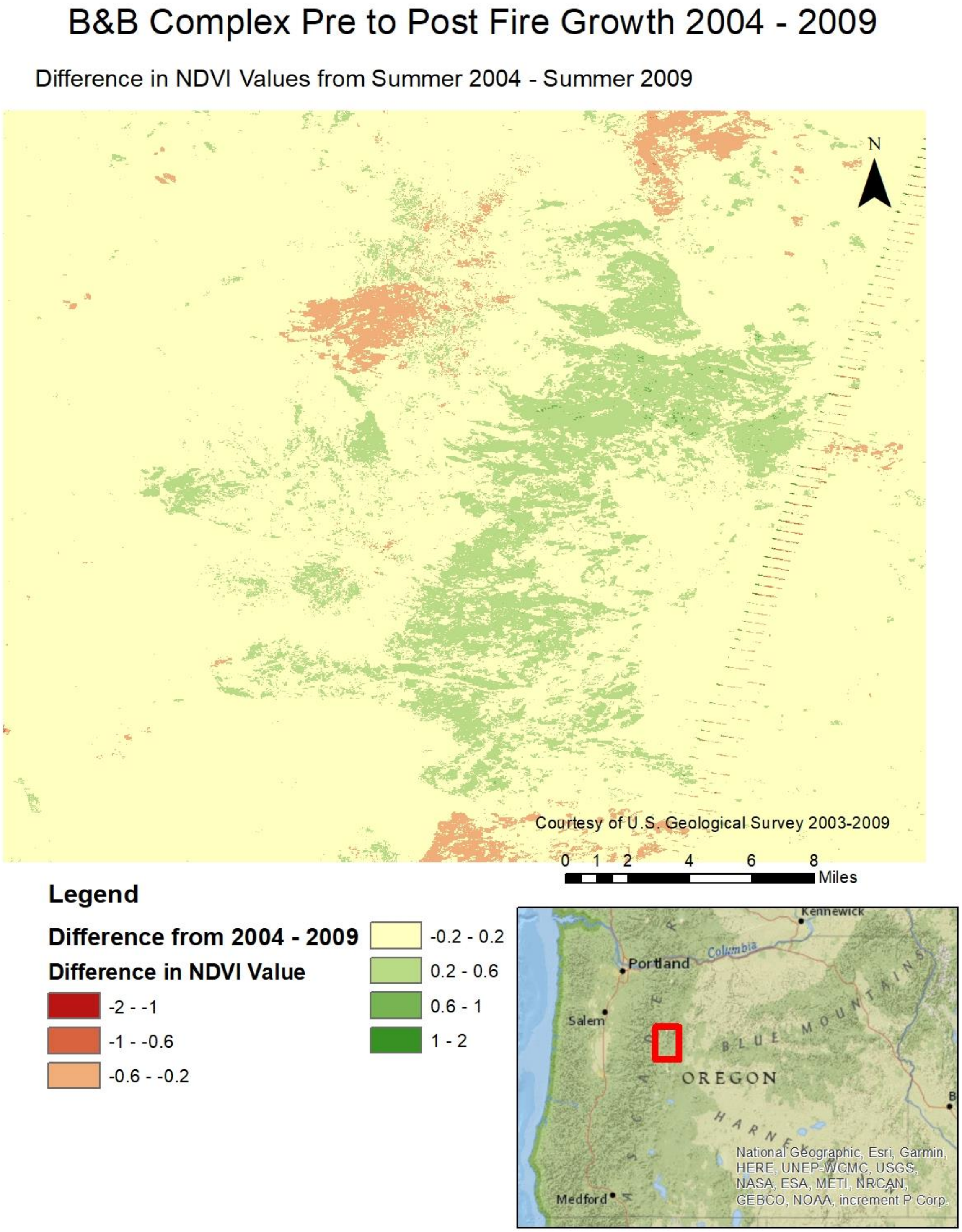


*Figure 9- Post Fire Growth 2004 - 2009 image courtesy of U.S. Geological Survey 2003-2009*

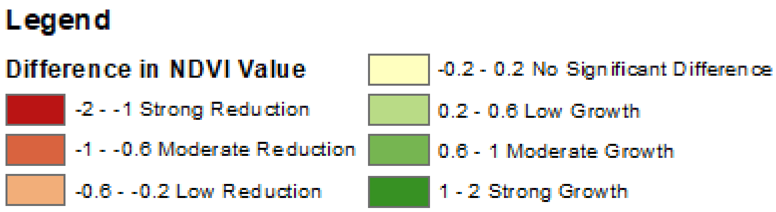


*Figure 10 - NDVI Difference Classes*

**2004-2005**

| | NDVI Difference | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Burn Severity Class** | Strong reduction | Moderate reduction | Low reduction | No significant difference | Low growth | Moderate growth | Strong growth | Total Area |
| Unburned | 0.002% | 0.034% | 0.287% | 96.082% | 3.540% | 0.038% | 0.017% | **80.266%** |
| Low | 0.000% | 0.003% | 0.053% | 75.497% | 24.432% | 0.012% | 0.003% | **13.149%** |
| Moderate-low | 0.000% | 0.000% | 0.007% | 57.292% | 42.673% | 0.028% | 0.000% | **5.804%** |
| Miderate-high | 0.000% | 0.000% | 0.026% | 71.800% | 28.174% | 0.000% | 0.000% | **0.749%** |
| High | 0.000% | 0.000% | 0.924% | 90.447% | 8.629% | 0.000% | 0.000% | **0.032%** |
| Total Burned | **0.000%** | **0.002%** | **0.040%** | **70.027%** | **29.913%** | **0.016%** | **0.002%** | **19.734%** |
| Total | **0.002%** | **0.027%** | **0.239%** | **90.940%** | **8.745%** | **0.033%** | **0.014%** | |

*Figure 11 - Change Matrix 2004-2005*

**2004-2006**

| | NDVI Difference | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Burn Severity Class** | Strong reduction | Moderate reduction | Low reduction | No significant difference | Low growth | Moderate growth | Strong growth | Total Area |
| Unburned | 0.001% | 0.029% | 0.368% | 95.981% | 3.568% | 0.034% | 0.019% | **80.266%** |
| Low | 0.000% | 0.001% | 0.091% | 71.940% | 27.959% | 0.007% | 0.003% | **13.149%** |
| Moderate-low | 0.000% | 0.000% | 0.009% | 49.819% | 50.166% | 0.005% | 0.000% | **5.804%** |
| Miderate-high | 0.000% | 0.000% | 0.059% | 59.349% | 40.579% | 0.013% | 0.000% | **0.749%** |
| High | 0.000% | 0.000% | 0.770% | 83.513% | 15.716% | 0.000% | 0.000% | **0.032%** |
| Total Burned | **0.000%** | **0.001%** | **0.067%** | **64.975%** | **34.949%** | **0.006%** | **0.002%** | **19.734%** |
| Total | **0.001%** | **0.024%** | **0.308%** | **89.862%** | **9.760%** | **0.029%** | **0.015%** | |

*Figure 12 - Change Matrix 2004-2006*

## 2004-2007

| Burn Severity Class | NDVI Difference: Strong reduction | Moderate reduction | Low reduction | No significant difference | Low growth | Moderate growth | Strong growth | Total Area |
|---|---|---|---|---|---|---|---|---|
| Unburned | 0.002% | 0.033% | 1.581% | 95.469% | 2.864% | 0.034% | 0.017% | **80.266%** |
| Low | 0.000% | 0.001% | 0.405% | 77.214% | 22.371% | 0.006% | 0.003% | **13.149%** |
| Moderate-low | 0.000% | 0.000% | 0.027% | 53.649% | 46.323% | 0.002% | 0.000% | **5.804%** |
| Miderate-high | 0.000% | 0.000% | 0.020% | 54.528% | 45.452% | 0.000% | 0.000% | **0.749%** |
| High | 0.000% | 0.000% | 0.154% | 87.365% | 12.481% | 0.000% | 0.000% | **0.032%** |
| Total Burned | **0.000%** | **0.001%** | **0.279%** | **69.439%** | **30.275%** | **0.004%** | **0.002%** | 19.734% |
| Total | **0.001%** | **0.027%** | **1.324%** | **90.332%** | **8.273%** | **0.028%** | **0.014%** | |

*Figure 13 - Change Matrix 2004-2007*

## 2004-2008

| Burn Severity Class | NDVI Difference: Strong reduction | Moderate reduction | Low reduction | No significant difference | Low growth | Moderate growth | Strong growth | Total Area |
|---|---|---|---|---|---|---|---|---|
| Unburned | 0.002% | 0.088% | 8.551% | 89.688% | 1.622% | 0.032% | 0.018% | **80.266%** |
| Low | 0.000% | 0.021% | 1.869% | 73.743% | 24.320% | 0.045% | 0.003% | **13.149%** |
| Moderate-low | 0.000% | 0.006% | 0.263% | 52.906% | 46.488% | 0.337% | 0.000% | **5.804%** |
| Miderate-high | 0.000% | 0.000% | 0.394% | 62.212% | 37.236% | 0.158% | 0.000% | **0.749%** |
| High | 0.000% | 0.000% | 1.541% | 87.365% | 11.094% | 0.000% | 0.000% | **0.032%** |
| Total Burned | **0.000%** | **0.016%** | **1.340%** | **67.199%** | **31.308%** | **0.135%** | **0.002%** | 19.734% |
| Total | **0.001%** | **0.074%** | **7.128%** | **85.250%** | **7.480%** | **0.052%** | **0.015%** | |

*Figure 14 - Change Matrix 2004-2008*

## 2004-2009

| Burn Severity Class | NDVI Difference: Strong reduction | Moderate reduction | Low reduction | No significant difference | Low growth | Moderate growth | Strong growth | Total Area |
|---|---|---|---|---|---|---|---|---|
| Unburned | 0.001% | 0.034% | 3.595% | 92.671% | 3.646% | 0.034% | 0.018% | **80.266%** |
| Low | 0.000% | 0.004% | 0.687% | 63.683% | 35.477% | 0.146% | 0.003% | **13.149%** |
| Moderate-low | 0.000% | 0.001% | 0.069% | 41.325% | 58.121% | 0.484% | 0.000% | **5.804%** |
| Miderate-high | 0.000% | 0.000% | 0.066% | 47.895% | 51.776% | 0.263% | 0.000% | **0.749%** |
| High | 0.000% | 0.000% | 0.770% | 83.205% | 16.025% | 0.000% | 0.000% | **0.032%** |
| Total Burned | **0.000%** | **0.003%** | **0.482%** | **56.540%** | **42.724%** | **0.250%** | **0.002%** | 19.734% |
| Total | **0.001%** | **0.028%** | **2.981%** | **85.541%** | **11.357%** | **0.077%** | **0.015%** | |

*Figure 15 - Change Matrix 2004-2009*

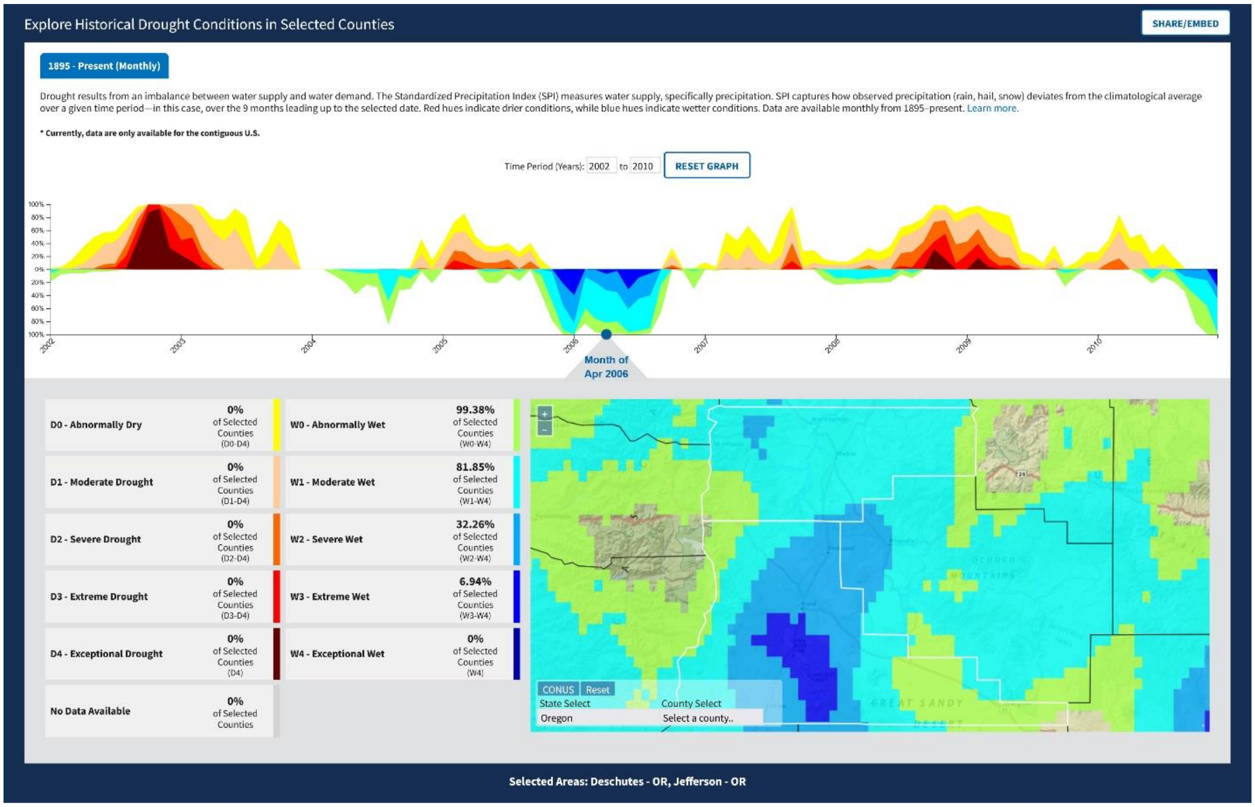


*Figure 16 - Drought and Wetness Patterns in Deschutes and Jefferson Counties in Oregon between 2002 and 2010, (NOAA, NIDIS, n.d.)*

# References


Giglio, L., Justice, C., Boschetti, L., Roy, D. (2015). *MCD64A1 MODIS/Terra+Aqua Burned Area Monthly L3 Global 500m SIN Grid V006* [Data set]. NASA EOSDIS Land Processes DAAC. Accessed 2023-04-08 from https://doi.org/10.5067/MODIS/MCD64A1.006

Google Earth Engine. (n.d.). *MCD64A1.061 Modis burned area monthly global 500m | Earth Engine Data catalog | google developers*. Earth Engine Data Catalog. Retrieved April 23, 2023, from https://developers.google.com/earth-engine/datasets/catalog/MODIS_061_MCD64A1#dois

NOAA, NIDIS. (n.d.). *Historical data and conditions*. Drought.gov. Retrieved April 27, 2023, from https://www.drought.gov/historical-information?state=oregon&dataset=1&selectedDateUSDM=20060829&selectedDateSpi=20060701&selectedDatePaleo=1941&dateRangeSpi=2002-2010

Principe , R. E. (2019, September 13). *Batch*. GitHub. Retrieved April 23, 2023, from https://github.com/fitoprincipe/geetools-code-editor/wiki/Batch

Snow, M. (2022, October 11). *How does wildfire impact wildlife and forests?: U.S. Fish & Wildlife Service*. FWS.gov. Retrieved April 22, 2023, from https://www.fws.gov/story/2022-10/how-does-wildfire-impact-wildlife-and-forests

UN-SPIDER. (n.d.). *Step by step: Burn severity mapping in Google Earth engine*. United Nations - Office for Outer Space Affairs - UN SPIDER Knowledge Portal. Retrieved April 23, 2023, from https://un-spider.org/advisory-support/recommended-practices/recommended-practice-burn-severity/burn-severity-earth-engine

Urness, Z. (2018, September 29). *15 years ago, a titanic wildfire in Oregon's cascades changed how we view wildfires*. kgw.com. Retrieved April 21, 2023, from https://www.kgw.com/article/weather/wildfires/15-years-ago-a-titanic-wildfire-in-oregons-cascades-changed-how-we-view-wildfires/283-599401152

U.S. Geological Survey, 2003-2009, Landsat 5 Level 2 Collection 2 Tier 1 Surface Reflectance and Land Surface Temperature Images, accessed 2023-04-014 from https://code.earthengine.google.com/

U.S. Geological Survey, 2003, Landsat 5 Level 2 Collection 1 Tier 1 Surface Reflectance Images, accessed 2023-04-014 from https://code.earthengine.google.com/

Weldon, L. A. C. (2005, August 2). *B&B Fire Recovery Project Record of Decision*. Retrieved April 21, 2023, from https://scholarsbank.uoregon.edu/xmlui/bitstream/handle/1794/7103/B%26B_Fire_Recovery_Project_ROD.pdf?sequence=1