

Topographic Influences on Wildfire Burn Severity

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Introduction

Wildfires occur across diverse landscapes and rarely burn uniformly, with topographic variables playing a critical role in shaping burn severity patterns. California has a unique geography characterized by mountain ranges and coastal environments, many of which frequently experience wildfire activity. This study examines how topographic variables such as slope, elevation, and aspect influence wildfire burn severity across California. A differenced Normalized Burn Ratio (dNBR) was calculated using pre- and post-fire Landsat 8-9 imagery for selected fires occurring within the past 10 years. Statistical analyses were conducted to assess the relationship between these topographic variables, derived from Digital Elevation Models (DEMs), and burn severity. This analysis aims to identify how variations in terrain may influence burn severity across fire-affected landscapes. Understanding these relationships is key for improving wildfire risk assessment and mitigating impacts on communities in fire-prone regions.

Study Area



Figure 1 – Map of Study Area (California) for analysis

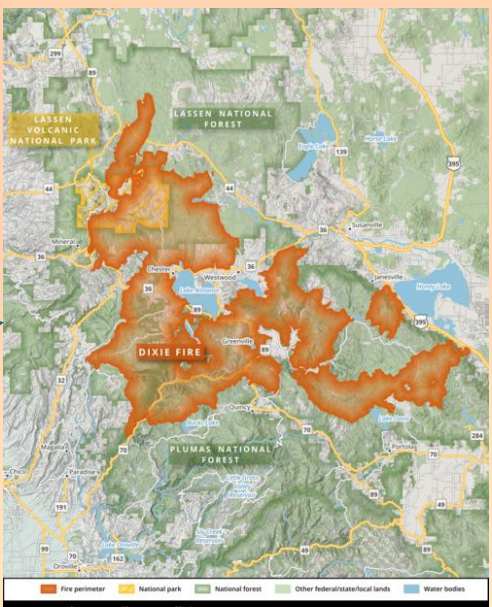


Figure 2 – Dixie Fire Burn Extent



Figure 3 – Carr Fire Burn Extent

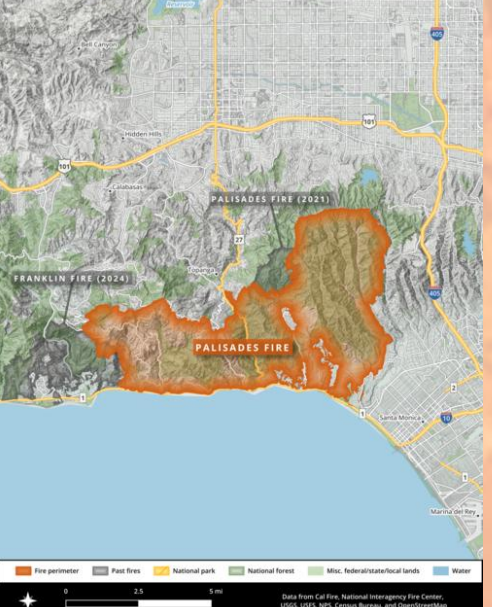


Figure 4 – Palisades Fire Burn Extent

Methods

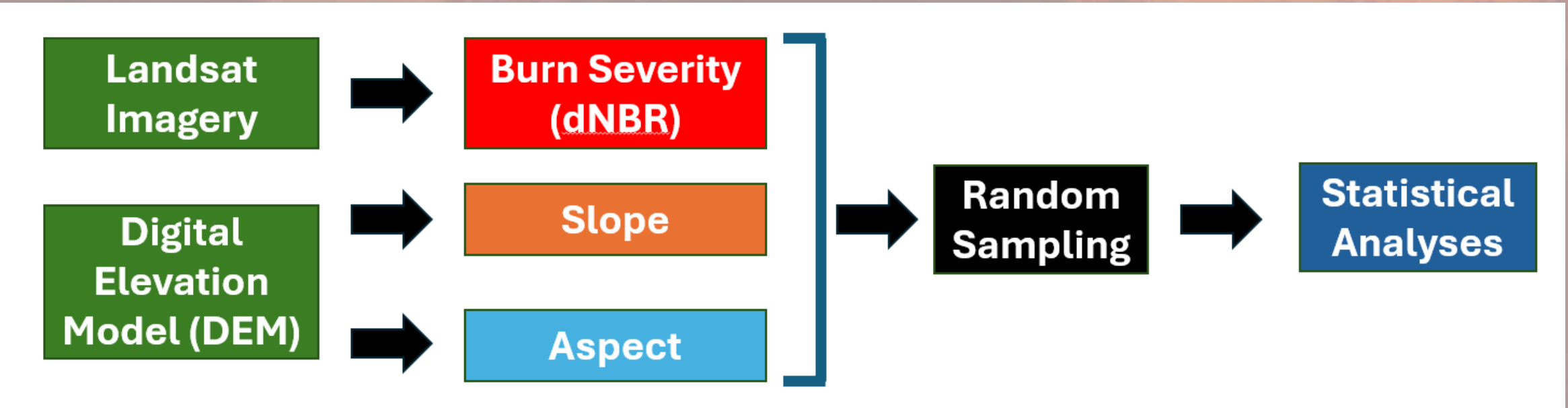


Figure 5 – Flowchart of Project Methodology

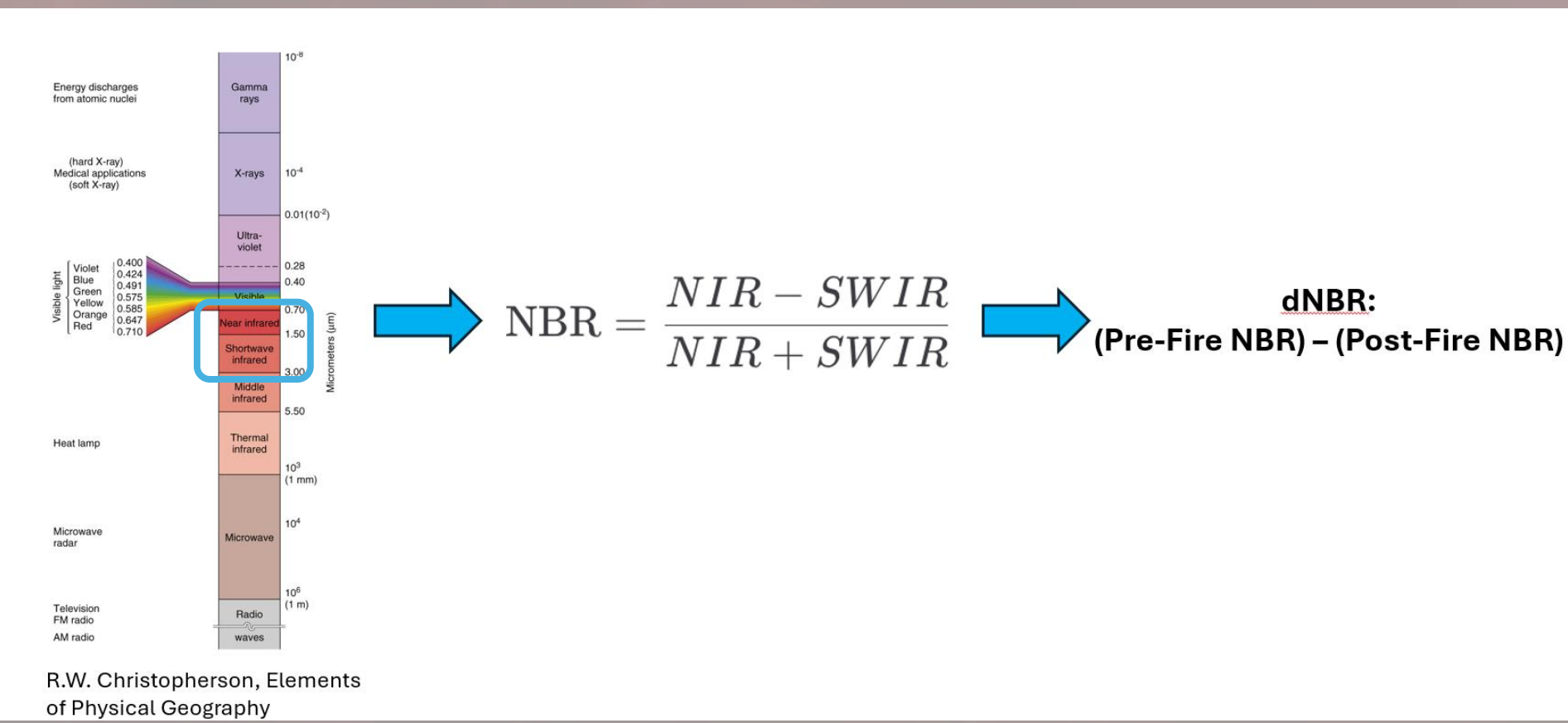


Figure 6 – Graphic Displaying how dNBR (Differenced Normalized Burn Ratio) is calculated

Results – Dixie Fire: Burn Severity

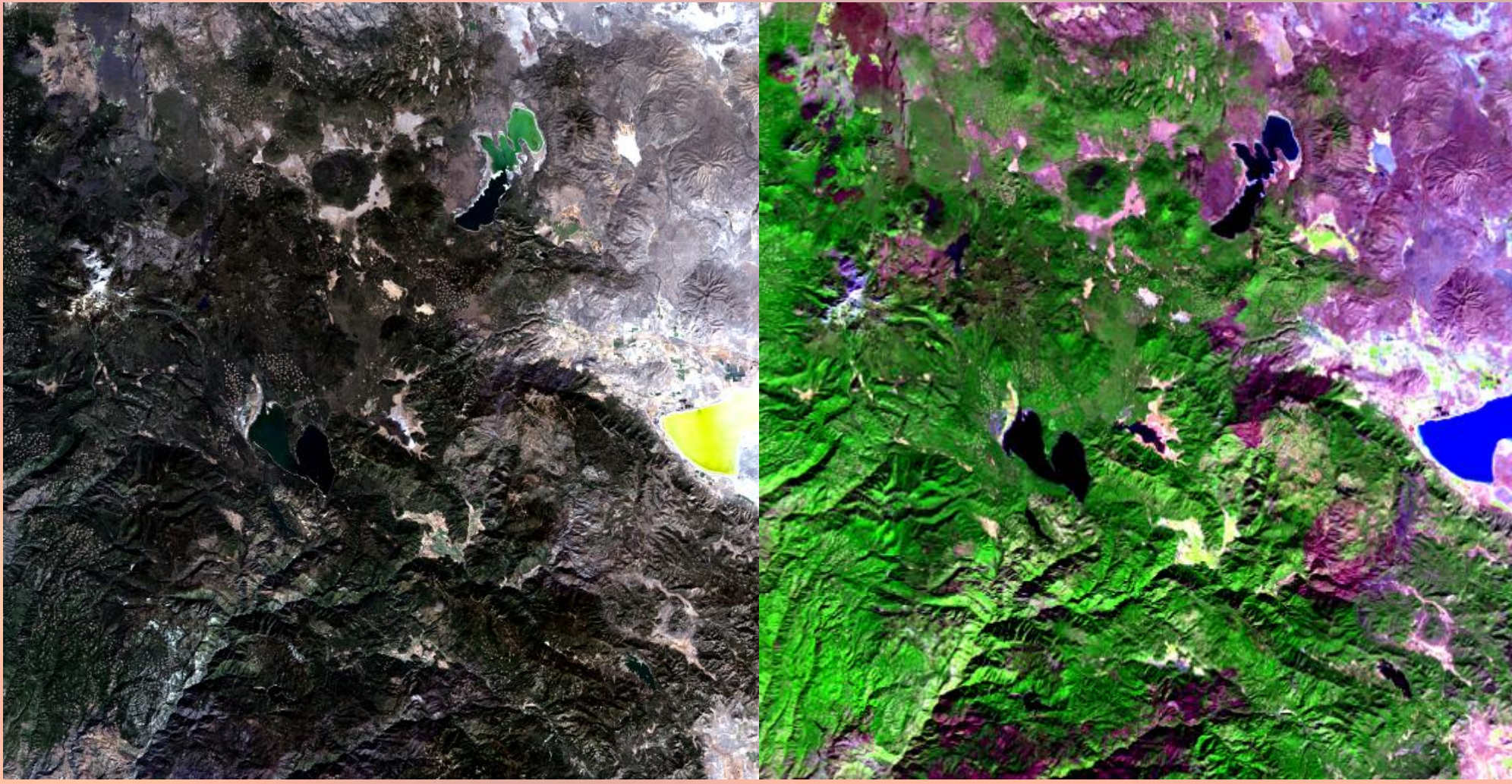


Figure 7 – Pre-fire imagery of the Dixie Fire region, including a natural color composite and a shortwave-infrared (SWIR) color composite. Images are derived from Landsat 8-9 data obtained from USGS Earth Explorer.

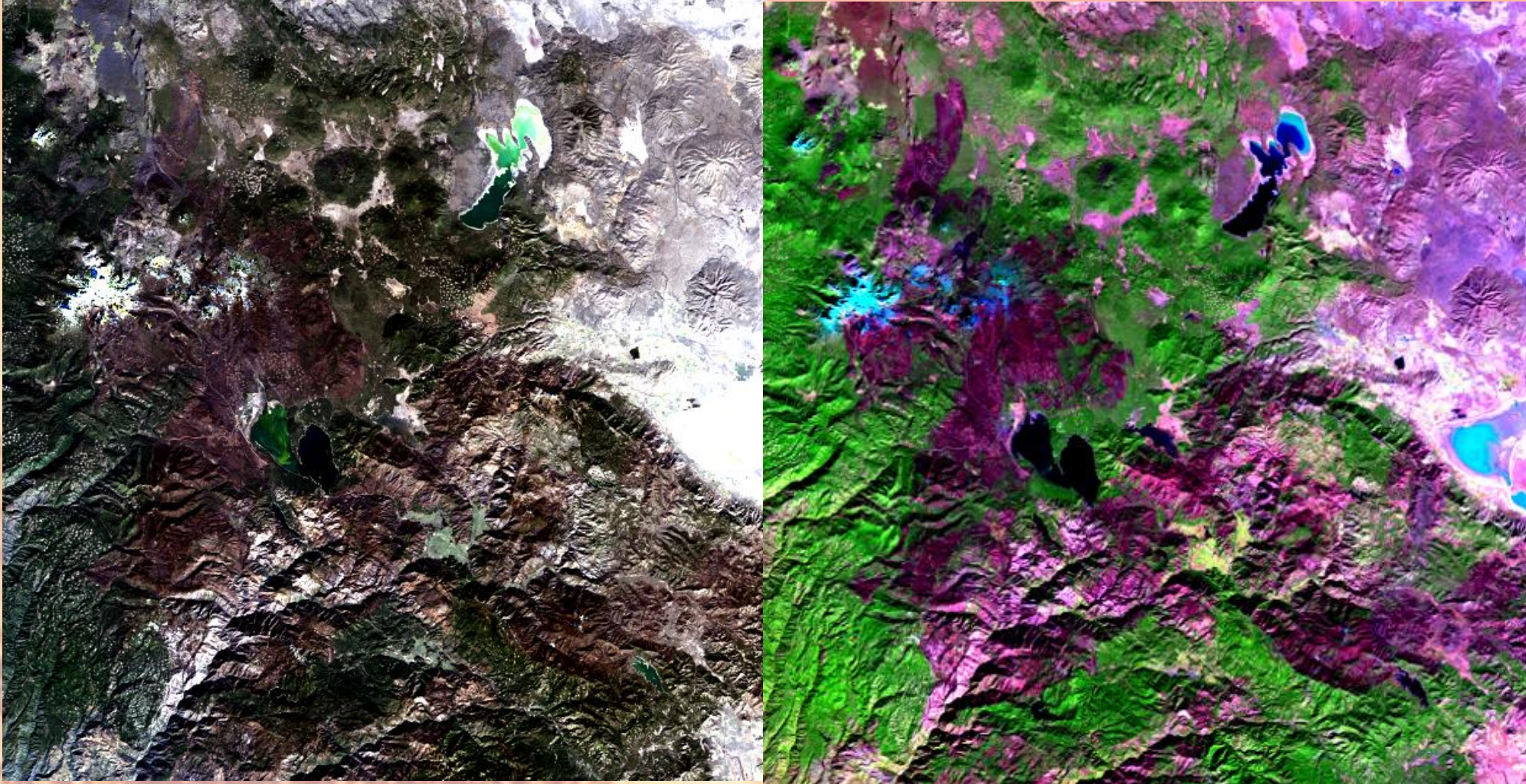
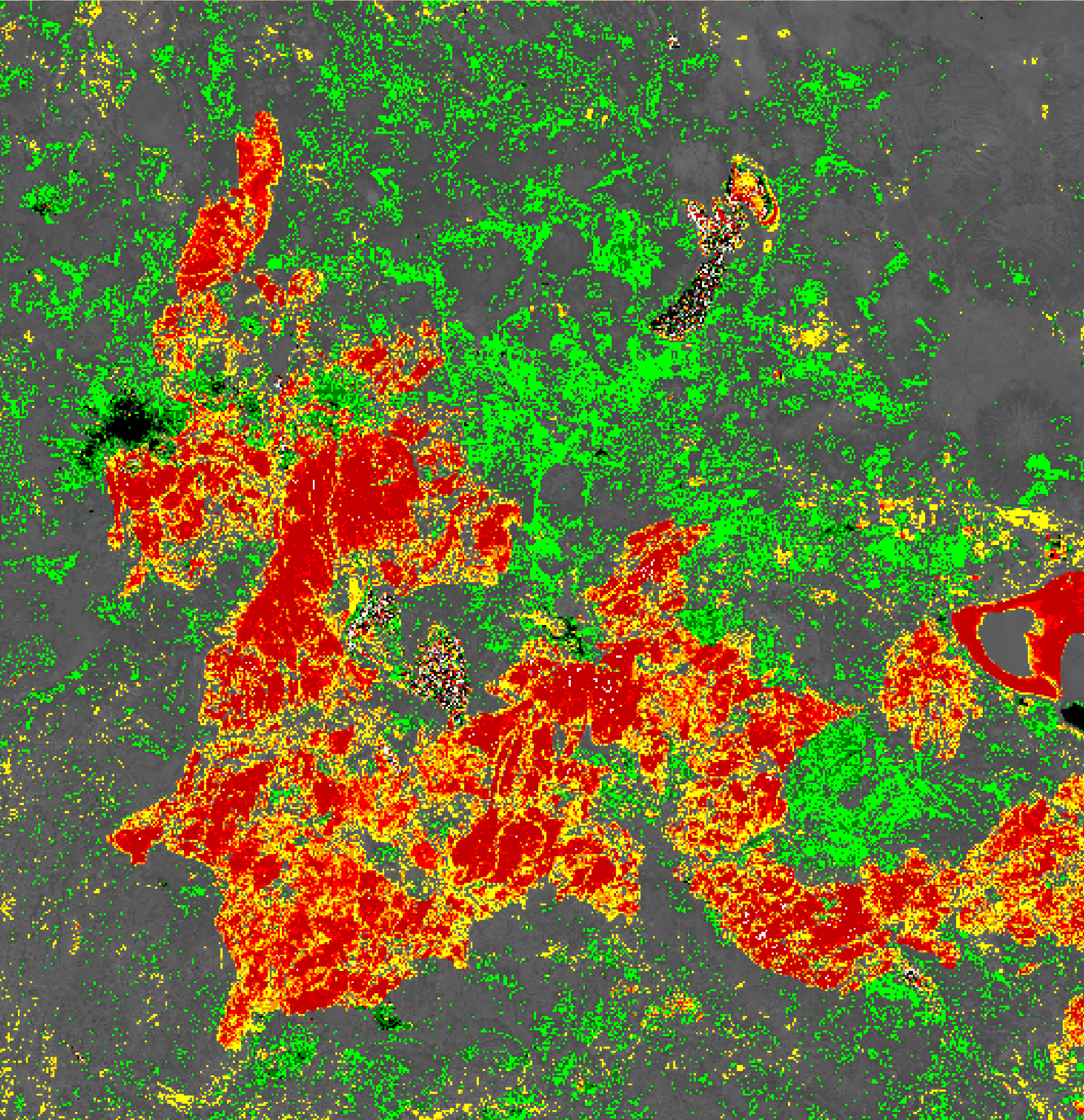


Figure 8 – Post-fire imagery of the Dixie Fire region, including a natural color composite and a shortwave-infrared (SWIR) color composite. Images are derived from Landsat 8-9 data obtained from USGS Earth Explorer.



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
Moderate-high Severity	+440 to +659	+0.440 to +0.659
High Severity	+660 to +1300	+0.660 to +1.300

Figure 9 – dNBR (Differenced Normalized Burn Ratio) of the Dixie Fire. Calculated using pre- and post- fire Landsat 8-9 imagery obtained from USGS Earth Explorer. A standard dNBR classification scheme was utilized to categorize burn severity level into discrete classes.

Results – Dixie Fire: Topographic Analysis

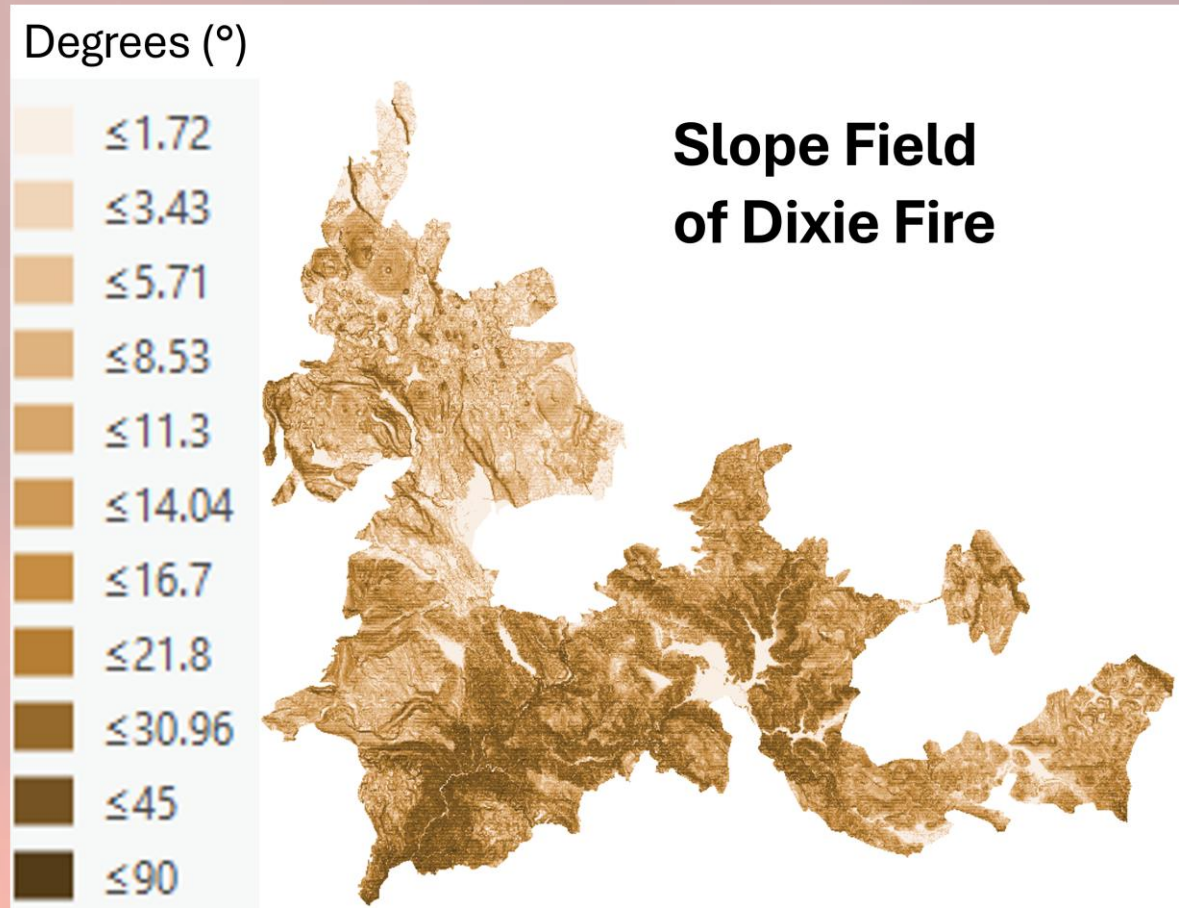


Figure 10 – Slope of the Dixie Fire region, derived from a mosaicked digital elevation model (DEM) obtained from the USGS National Map. Slope represents the rate of elevation change over a horizontal distance and is measured in degrees from 0° to 90°.

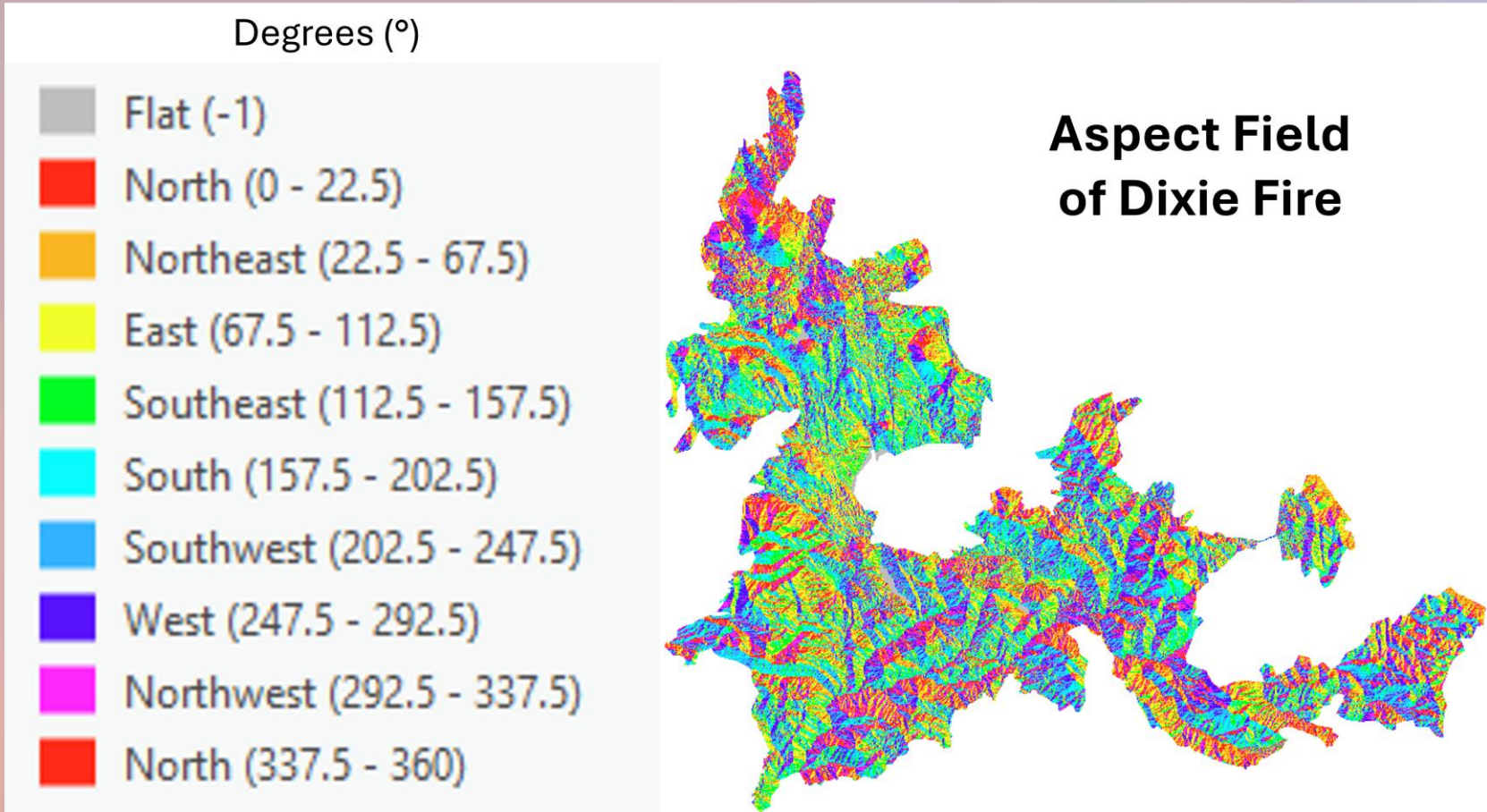


Figure 11 – Aspect of the Dixie Fire region, derived from a mosaicked digital elevation model (DEM) obtained from the USGS National Map. Aspect represents the compass direction that a terrain surface faces relative to true north and is measured in degrees from 0° to 90°.

Results: Statistical Analyses

Correlation Graphs – Dixie Fire

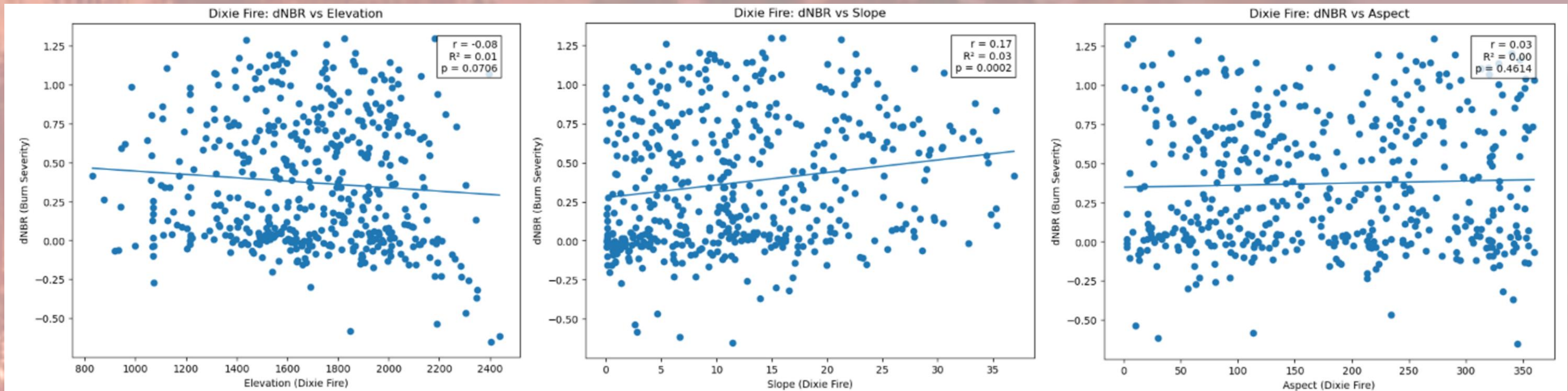


Figure 12 – Correlation Graphs for the Dixie Fire showing relationships between dNBR (Difference Normalized Burn Ratio) and the topographic variables of interest: elevation, slope, and aspect. A Pearson's Correlation Coefficient (r), Coefficient of Determination (R²), and P-Value (p) were calculated for each fire to assess the strength and significance of these relationships.

Correlation Table – Dixie, Carr, and Palisades Fires

	Elevation	Slope	Aspect
Dixie Fire			
Pearson's Correlation Coefficient (r)	-0.08	0.17	0.03
Coefficient of Determination (R ²)	0.01	0.03	<0.00
P-value (p)	0.07	<0.00	0.4614
Carr Fire			
Pearson's Correlation Coefficient (r)	0.02	0.02	<0.00
Coefficient of Determination (R ²)	<0.00	<0.00	<0.00
P-value (p)	0.62	0.62	0.98
Palisades Fire			
Pearson's Correlation Coefficient (r)	0.38	0.39	-0.08
Coefficient of Determination (R ²)	0.14	0.15	0.01
P-value (p)	<0.00	<0.00	0.07

Figure 13 – Summary table of Pearson's Correlation Coefficient (r), Coefficient of Determination (R²) and P-Values (p) for relationships between dNBR and topographic variables (elevation, slope, and aspect) across the Dixie, Carr, and Palisades Fires.

Conclusions

- Slope shows the strongest relationship with burn severity among the analyzed topographic variables.
- Aspect appears to be the least influential variable.
- Elevation impacts may be context-dependent.
- Additional factors (e.g., fire extent, location, vegetative characteristics) may influence how strongly topography impacts burn severity.

Software Used

- ArcGIS Pro (Esri)
- ENVI (L3 Harris Geospatial Solutions)
- Python
- Jupyter Notebook

References

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