Mapping the 2021/2022 Boulder County Marshall Fire

Evaluating and Comparing Landsat8 and Landsat9 Satellites to Map Wildfire Burn Areas

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GEOG 596B

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Figure 1. Wildfire flames and smoke rise above Superior, Colorado. (Van Denburg for CPR News, 2022) Reproduced here for educational purposes only.

Agenda

Introduction

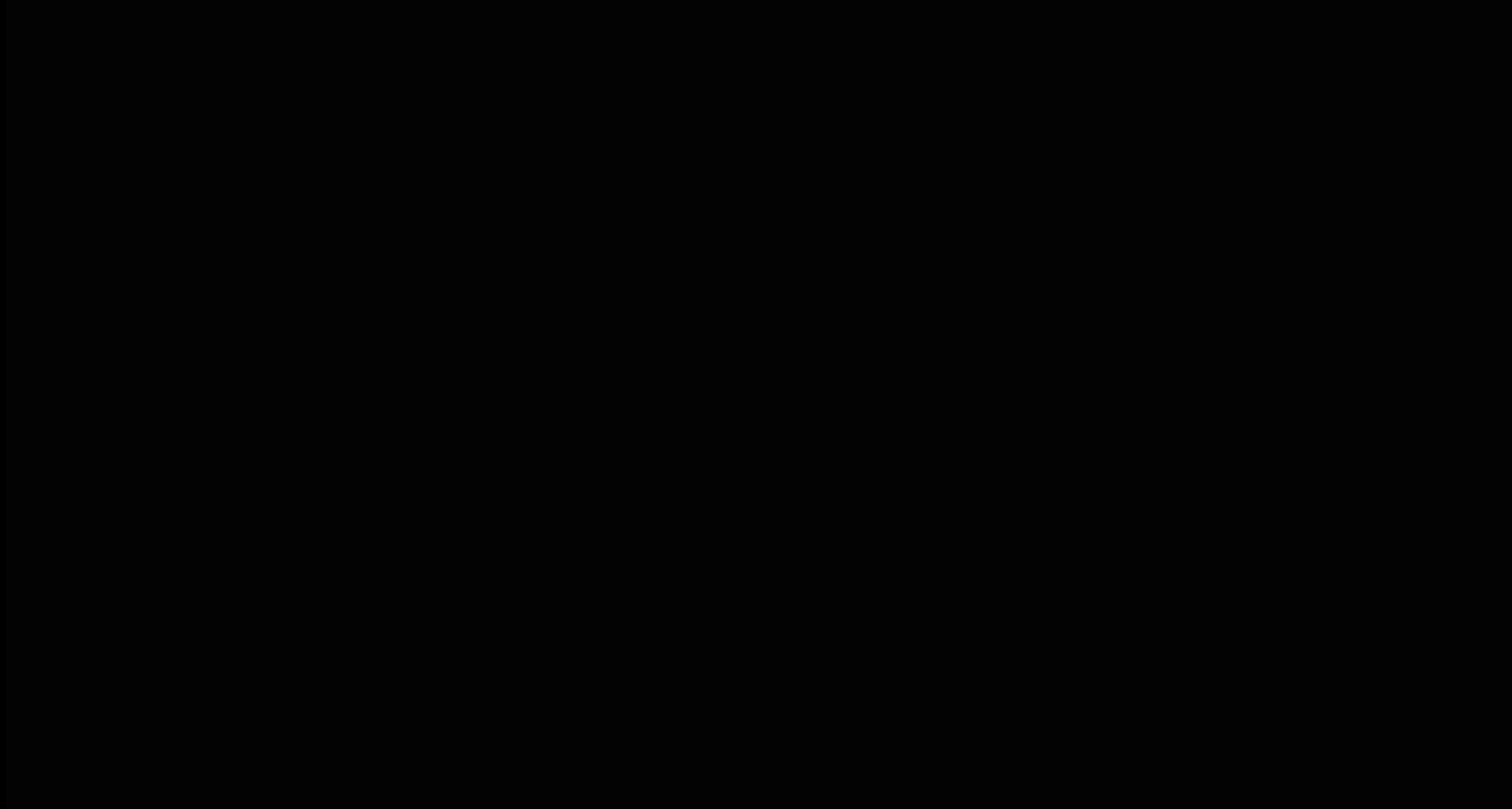Landsat8 OLI-2/TIRS-2

Landsat9 OLI-2/TIRS-2

Figure 2. Landsat program timeline. (NASA, 2020) Reproduced here for educational purposes only.

Expected Results

Increased radiometric resolution on Landsat9 will result in more accurate burn area detection and mapping.

Objectives

1. To define spectral profiles for landcover within the Marshall Fire for

   Landsat8 and Landsat9.

2. To identify and compare burn scars detected in Landsat8 and Landsat9

   using standard indices.

3. To classify landcover using supervised classification for Landsat8 and

   Landsat9.

4. To assess the accuracy of classifications results to identify burn scars.

Study Area

Marshall Fire

→ 12/30/2021 – 01/01/2022

→ 6,026 acres burned

→ Over 1,000 structures destroyed

→ Millions of dollars in losses
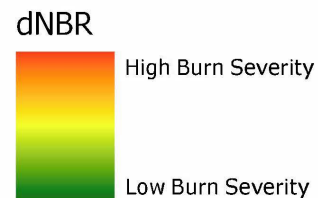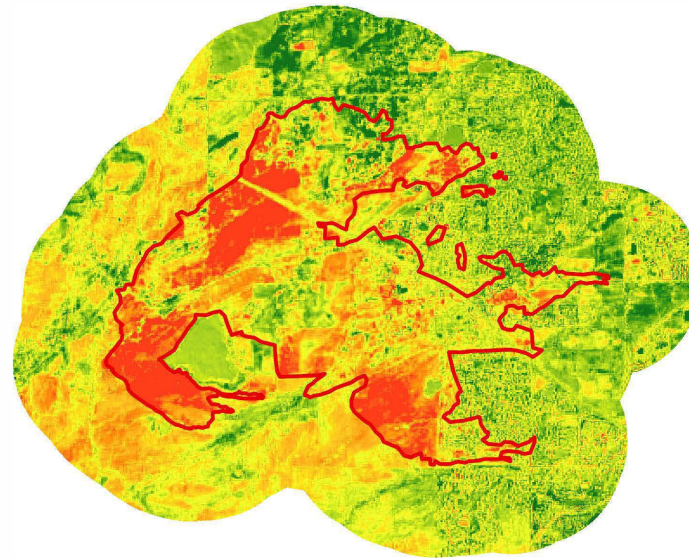
→ 35,000 people displaced
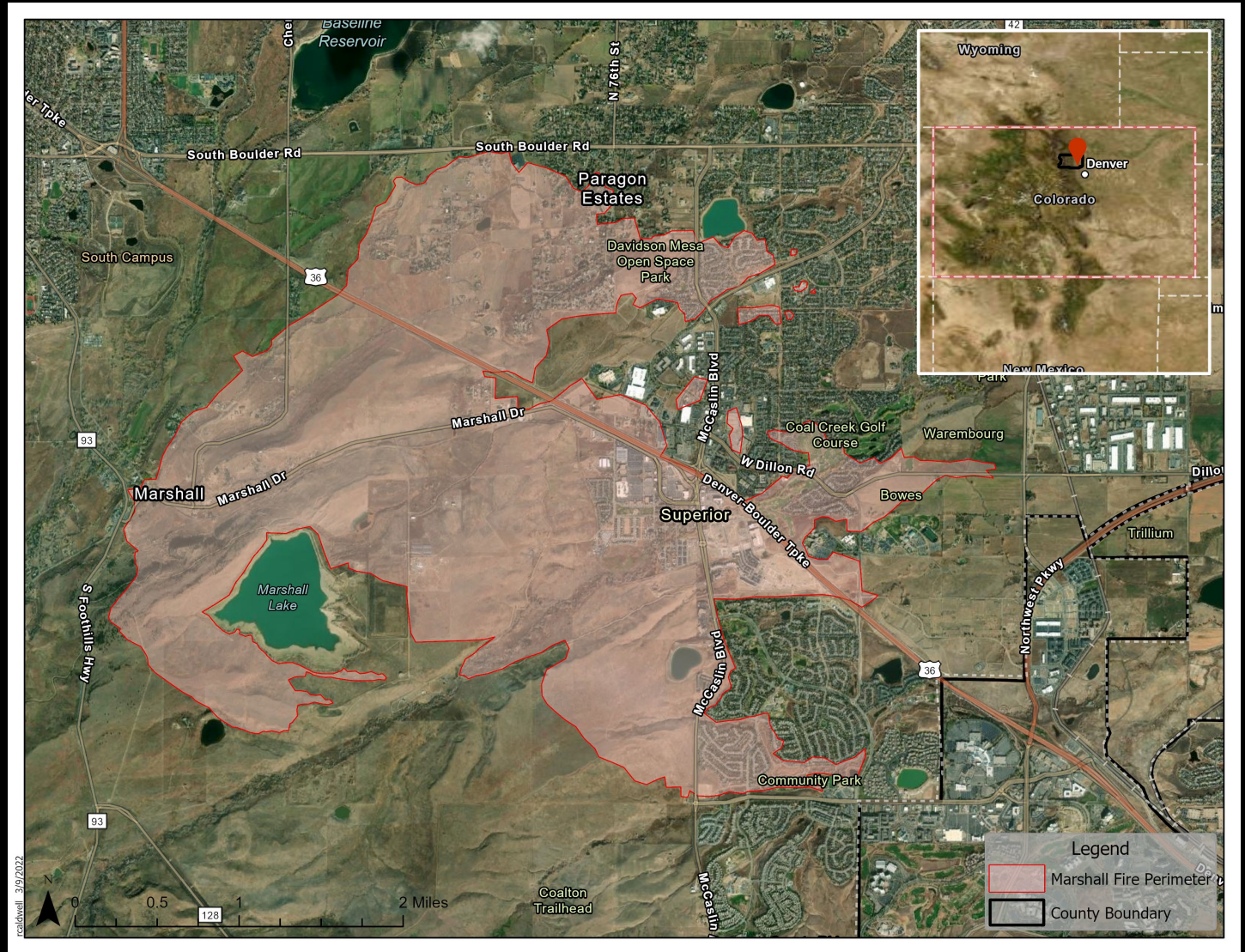
Methodology

1. Define the study area

2. Collect and preprocess vector and raster data

3. Identify burn scars using band combinations

4. Create spectral profile interpretation keys

5. Perform supervised classifications

6. Perform accuracy assessments

7. Efficacy Test

8. Analyze and discuss results

Burn Indices

$$NBR = \frac{NIR-SWIR}{NIR+SWIR}$$

- Normalized Burn Ratio (NBR)

- difference Normalized Burn Ratio (dNBR)

Landast8 dNBR Results

Landast9 dNBR Results

dNBR

High Burn Severity

Low Burn Severity

dNBR

High Burn Severity

-Low Burn Severity

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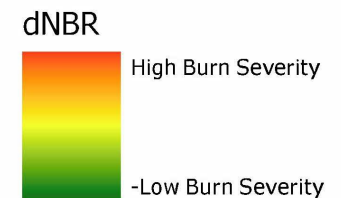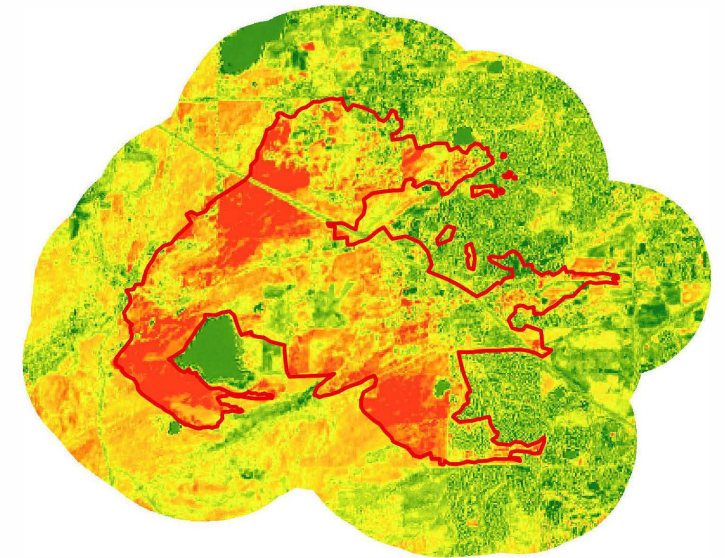
Landcover Types

- Water

- Developed

- Barren

- Vegetation

- Grassland

- Pavement

- Shadows

LC08 Pre-Fire Training Samples

Classcode
- Water
- Developed
- Barren
- Vegetation
- Grassland
- Pavement
- Shadow
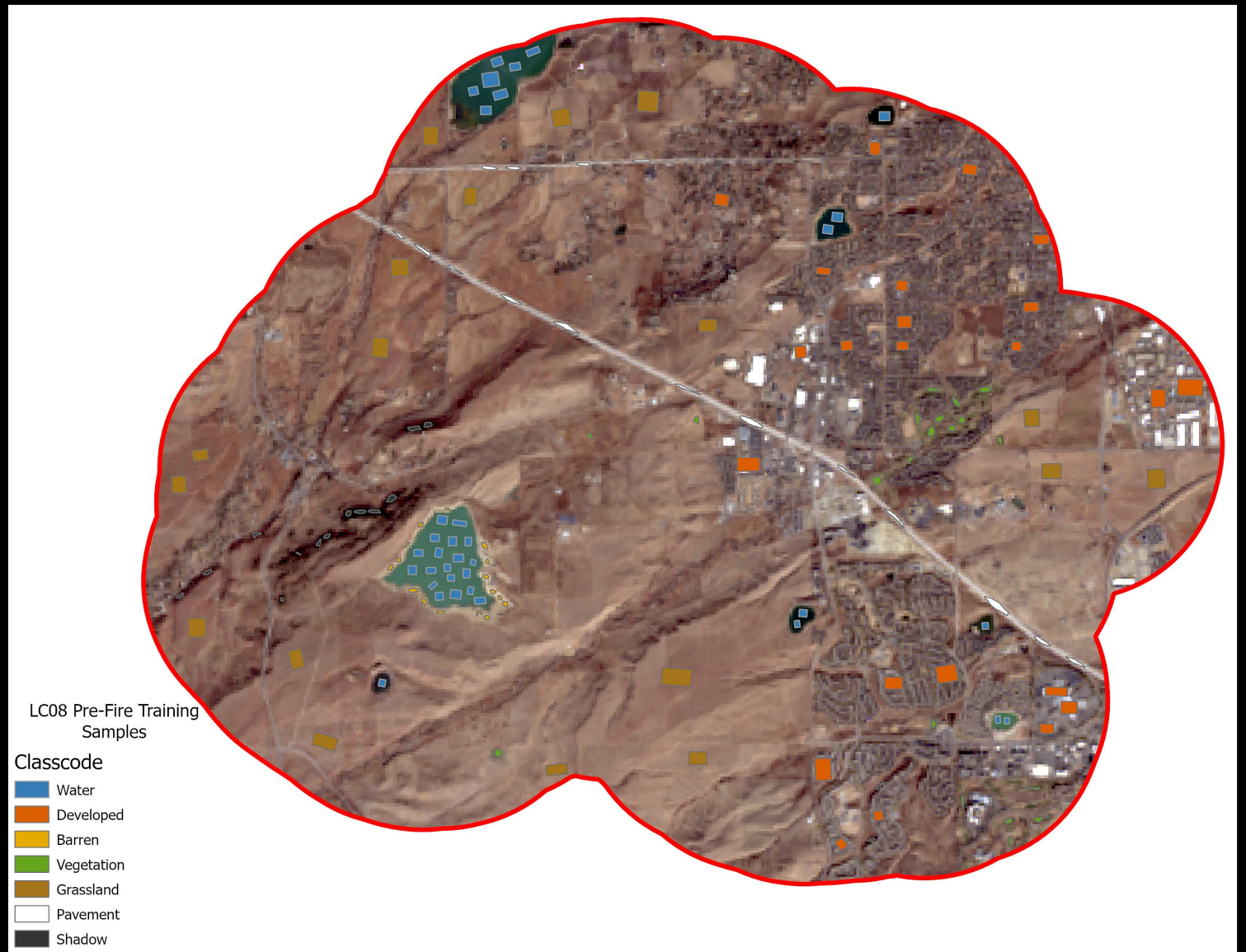
Spectral Profiles of Landsat 8
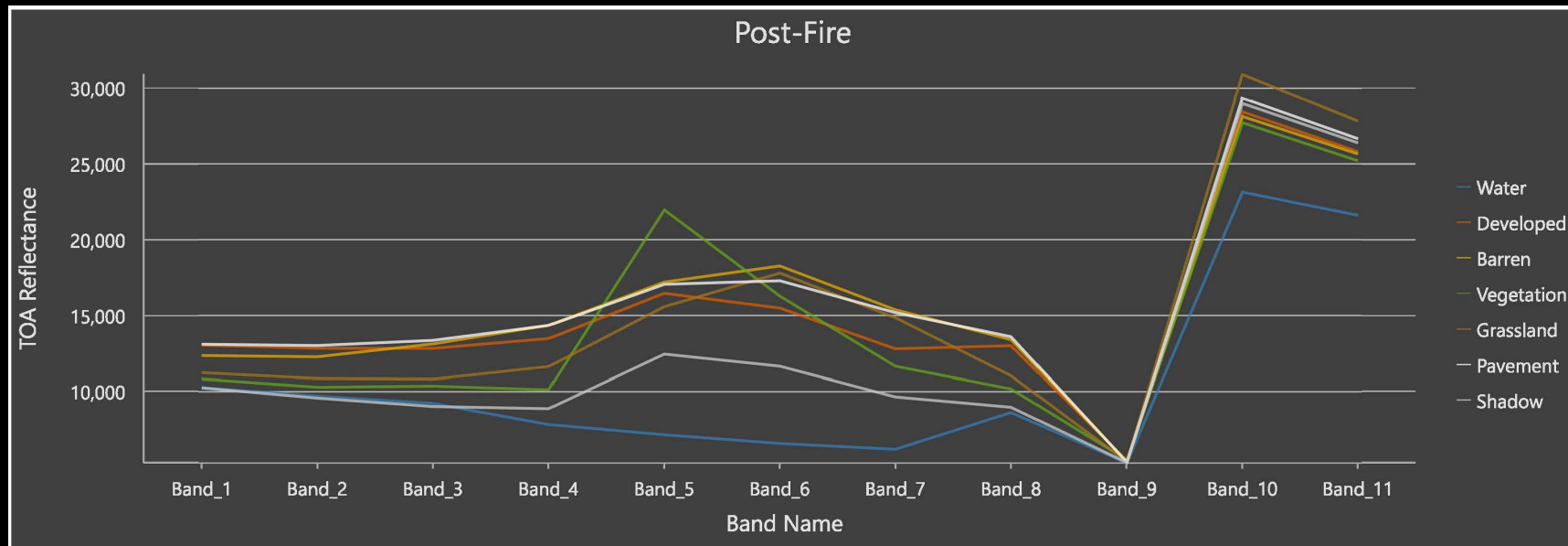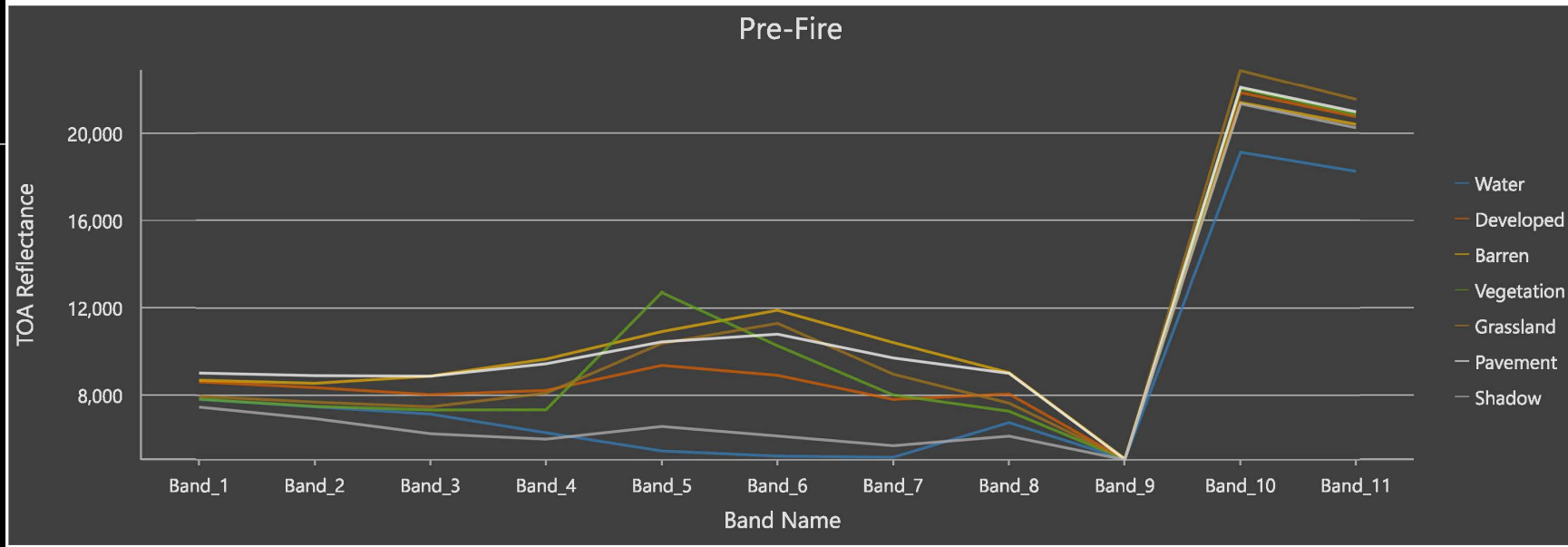
Spectral Profiles of Landsat 9
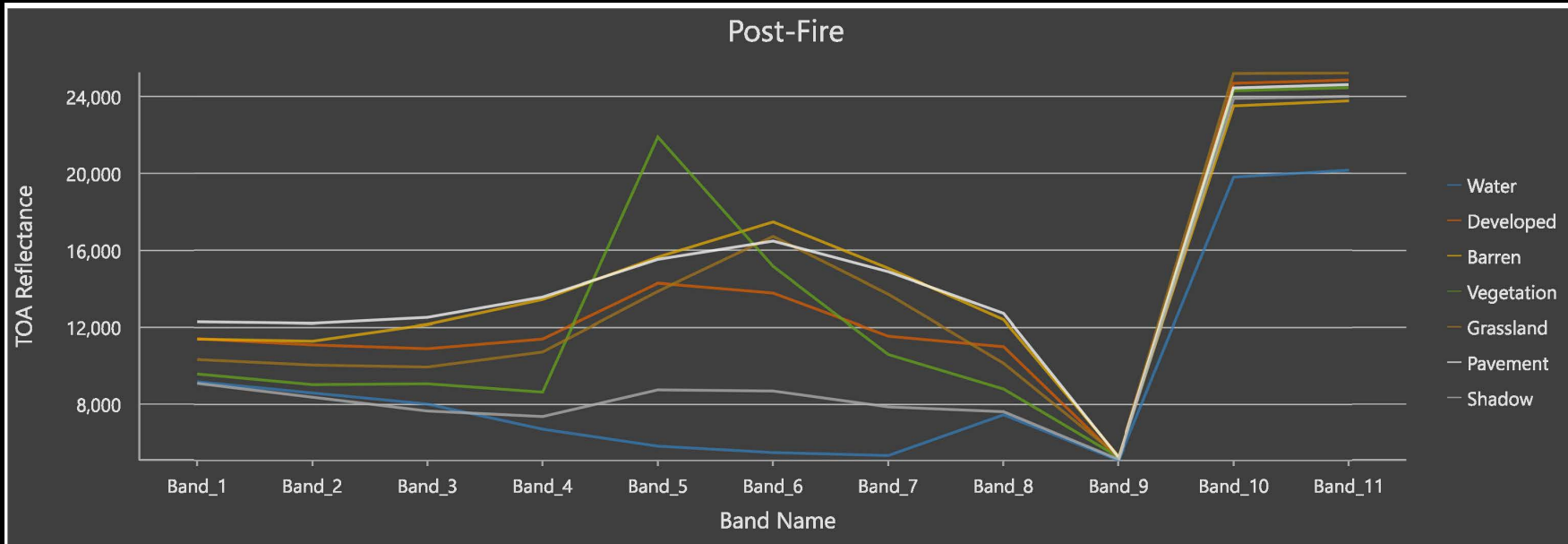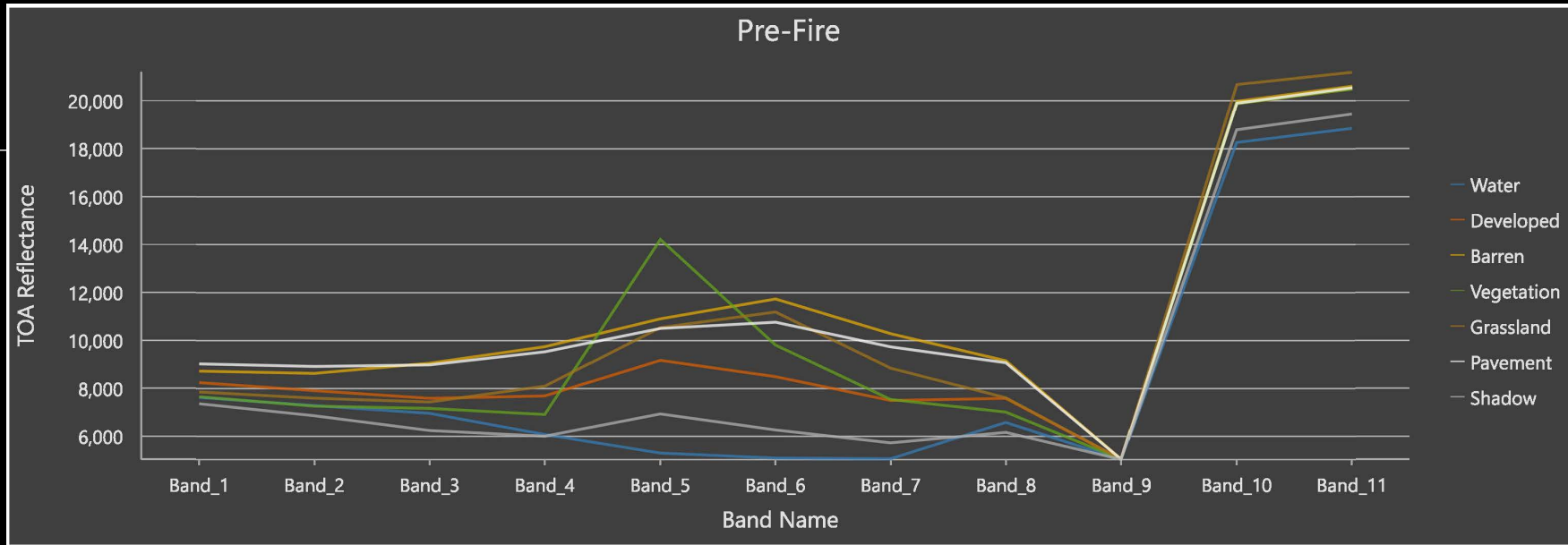
Image Classification

Supervised pixel-based classifications to map landcover classes

Classifications using the Maximum Likelihood algorithm

Classified Landsat8 Pre-Fire Imagery

Classified Landsat9 Pre-Fire Imagery

Classified Landsat8 Post-Fire Imagery

Classified Landsat9 Post-Fire Imagery

Class
- Water
- Developed
- Barren
- Vegetation
- Grassland
- Pavement
- Shadow
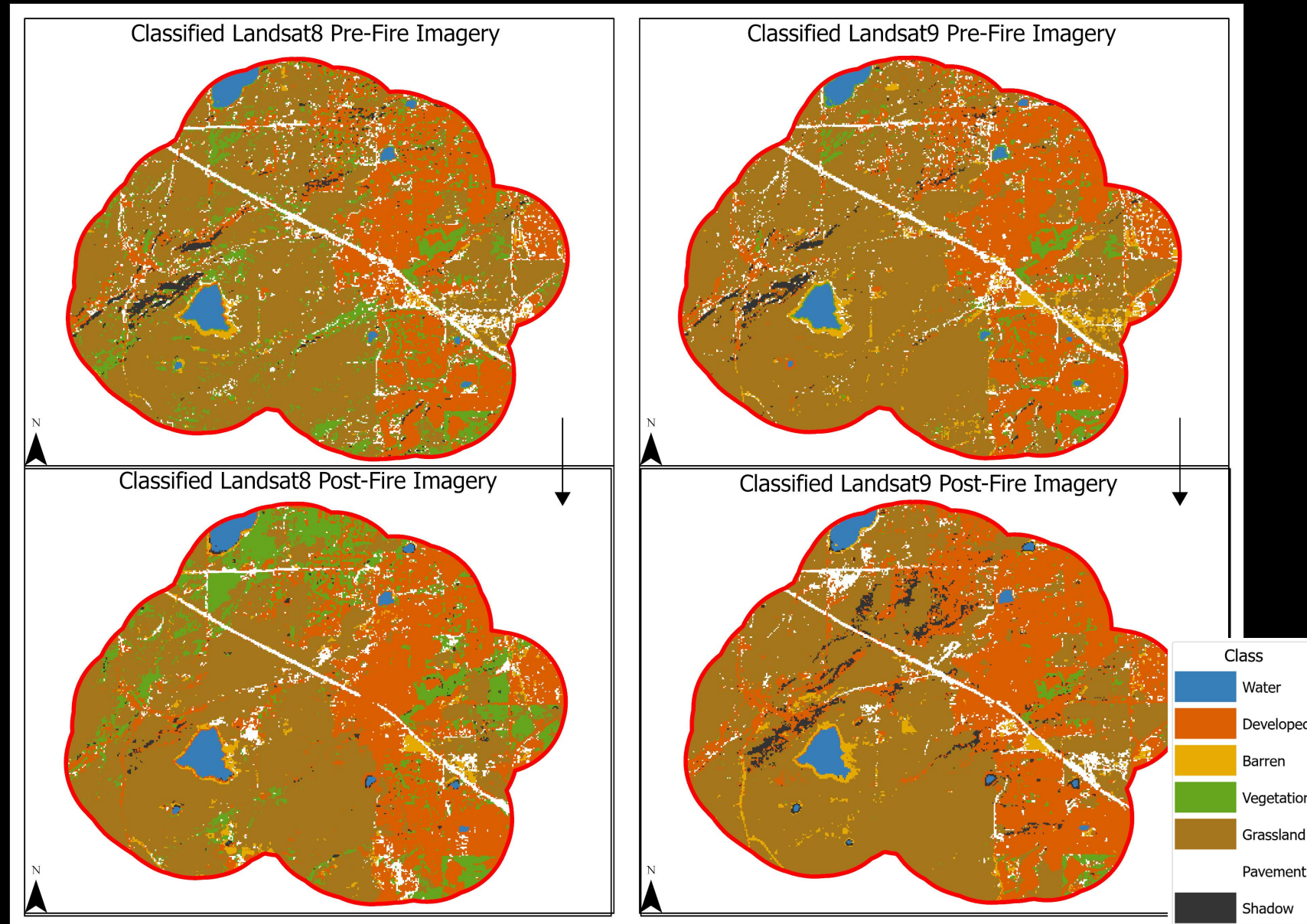
Burn Area
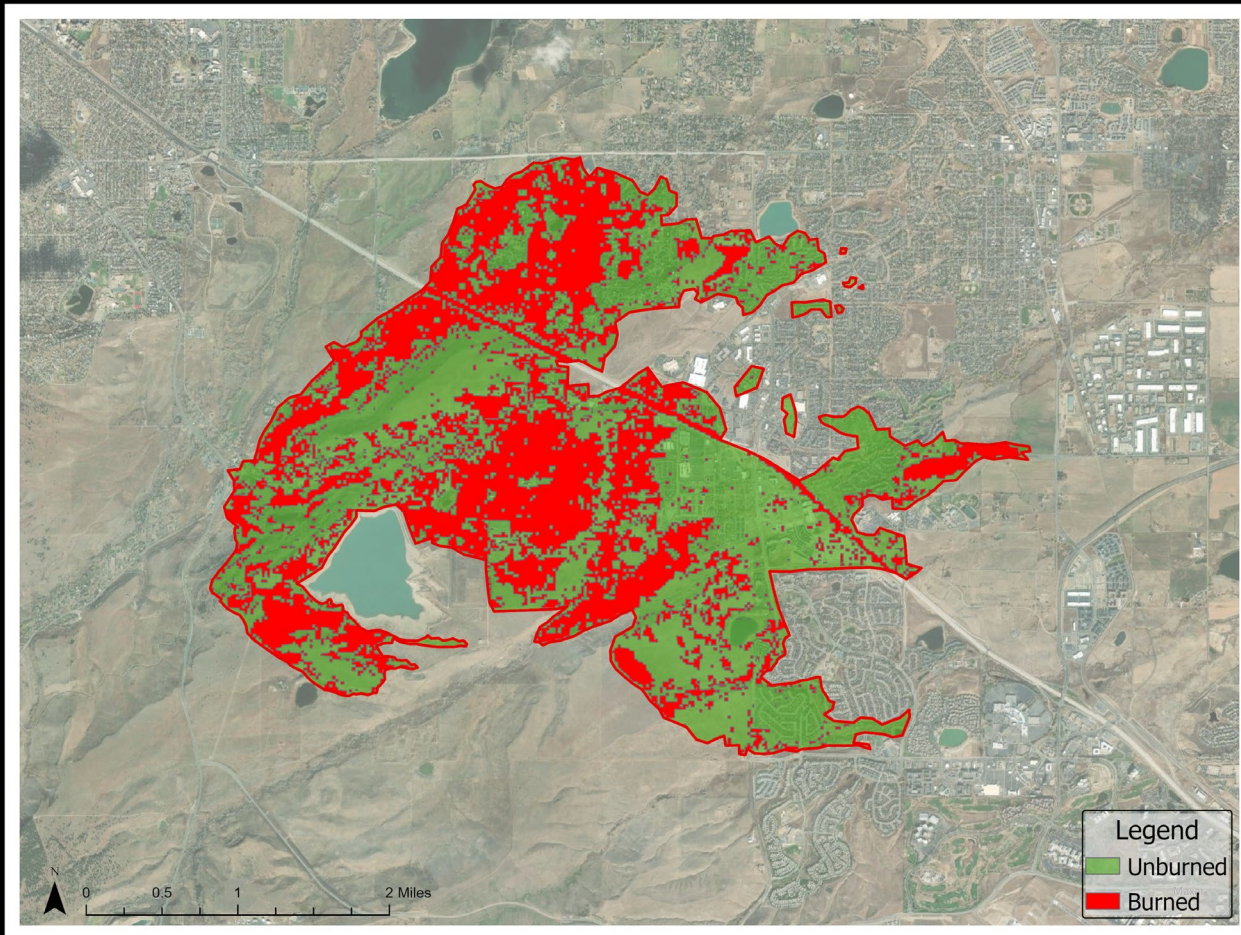
Burned Area (acres)	Unburned Area (acres)
2,635.85	3,392.40
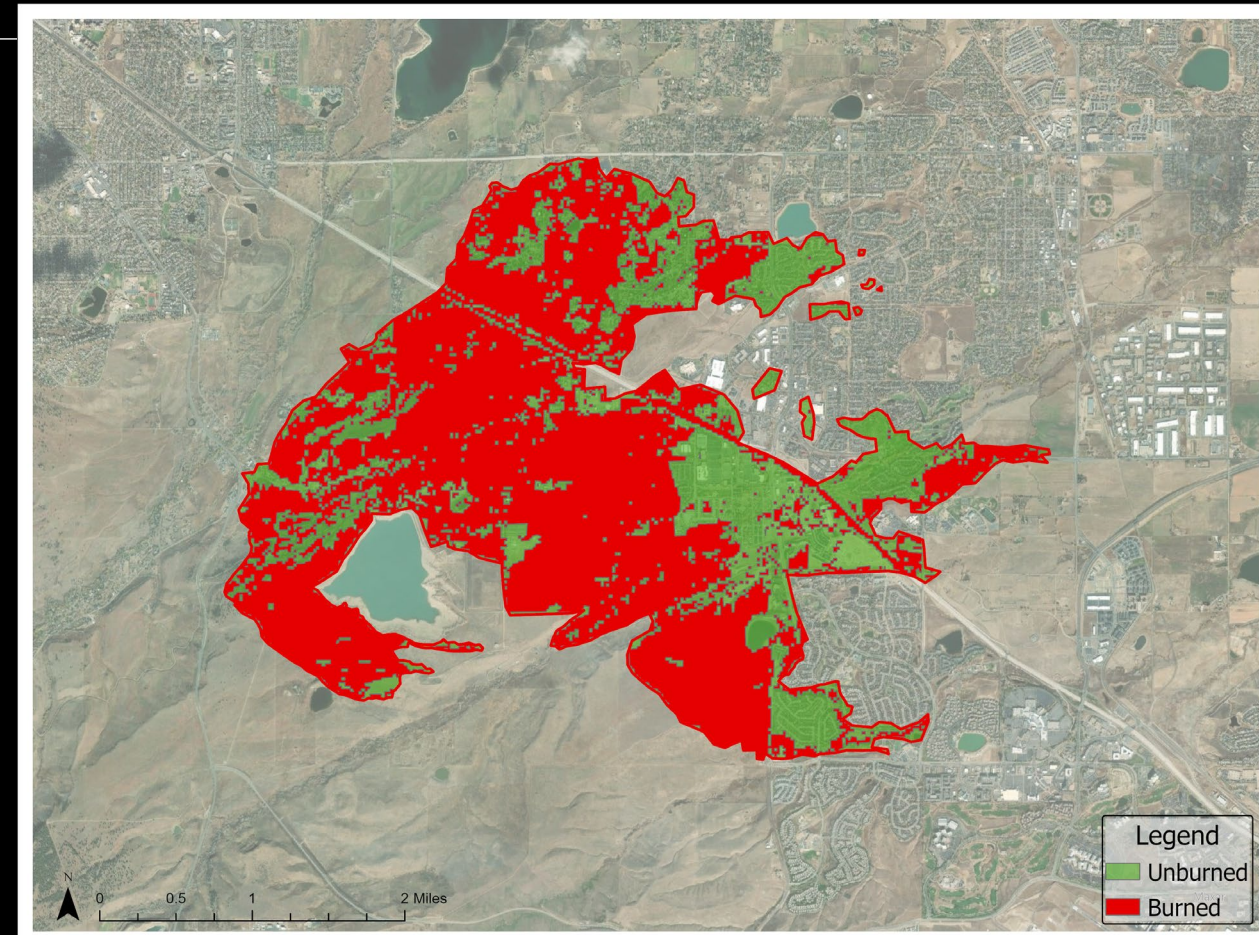
Burned Area (acres)	Unburned Area (acres)
4,055.05	1,970.20

Accuracy Assessment

Landsat8 Error Matrix

ClassValue	Water	Developed	Barren	Vegetation	Grassland	Pavement	Shadow	Total	User's Accuracy
Water	10	0	0	0	0	0	0	10	1
Developed	0	21	1	2	0	0	1	25	0.84
Barren	0	0	5	0	5	0	0	10	0.5
Vegetation	0	3	0	0	8	0	0	11	0
Grassland	0	2	0	0	50	0	0	52	0.96
Pavement	0	3	1	0	3	3	0	10	0.3
Shadow	0	0	0	0	1	0	9	10	0.9
Total	10	29	7	2	67	3	10	128	
Producer's Accuracy	1	0.72	0.71	0	0.75	1	0.9		0.77

Overall Accuracy 0.68

Landsat9 Error Matrix

Class	Water	Developed	Barren	Vegetation	Grassland	Pavement	Shadow	Total	User's Accuracy
Water	14	0	0	0	0	0	0	14	1
Developed	0	12	1	1	0	0	0	14	0.86
Barren	0	2	8	0	3	1	0	14	0.57
Vegetation	0	1	0	10	3	0	0	14	0.71
Grassland	0	0	0	0	14	0	0	14	1.00
Pavement	0	4	2	0	4	4	0	14	0.29
Shadow	0	1	0	0	0	0	13	14	0.93
Total	14	20	11	11	24	5	13	98	
Producer's Accuracy	1	0.60	0.73	0.91	0.58	0.80	1		0.77

Overall Accuracy 0.73

Class	Water	Developed	Barren	Vegetation	Grassland	Pavement	Shadow	Total	User's Accuracy
Water	14	0	0	0	0	0	0	14	1
Developed	0	11	0	1	2	0	0	14	0.79
Barren	0	2	9	0	1	2	0	14	0.64
Vegetation	0	4	0	9	1	0	0	14	0.64
Grassland	0	0	1	0	13	0	0	14	0.93
Pavement	0	3	4	0	3	4	0	14	0.29
Shadow	0	3	0	0	1	0	10	14	0.71
Total	14	23	14	10	21	6	10	98	
Producer's Accuracy	1	0.48	0.64	0.9	0.62	0.67	1		0.71

Overall Accuracy 0.67

Class	Water	Developed	Barren	Vegetation	Grassland	Pavement	Shadow	Total	User's Accuracy
Water	14	0	0	0	0	0	0	14	1
Developed	0	10	0	0	1	3	0	14	0.71
Barren	1	1	8	0	2	2	0	14	0.57
Vegetation	0	1	0	13	0	0	0	14	0.93
Grassland	0	1	0	0	13	0	0	14	0.93
Pavement	0	4	0	0	3	7	0	14	0.50
Shadow	1	2	0	0	0	0	11	14	0.79
Total	16	19	8	13	19	12	11	98	
Producer's Accuracy	0.875	0.53	1.00	1.00	0.68	0.58	1		0.78

Overall Accuracy 0.74

Key Results

- Accuracy assessments show Landsat9 produced 5% more accuracy results.

  - Pre-fire classification more accurately classified barren, vegetation, and shadow features.

  - Post-fire classification increased accuracy of developed, barren, vegetation, and grassland features.

- Burn area rasters accurately identified 4,055 acres of burn area

Limitations

- Inability to truly ground-truth accuracy assessment points in study area

- Unable to use eCognition to develop spectral profile interpretation keys

- Snow in post-fire imagery

- Usable post-fire imagery was captured in April resulting in regrowth detected in the fire burn area perimeter

Efficacy Test

Thunder Fire

→06/22/2022–
06/27/2022

→2,500 acres burned
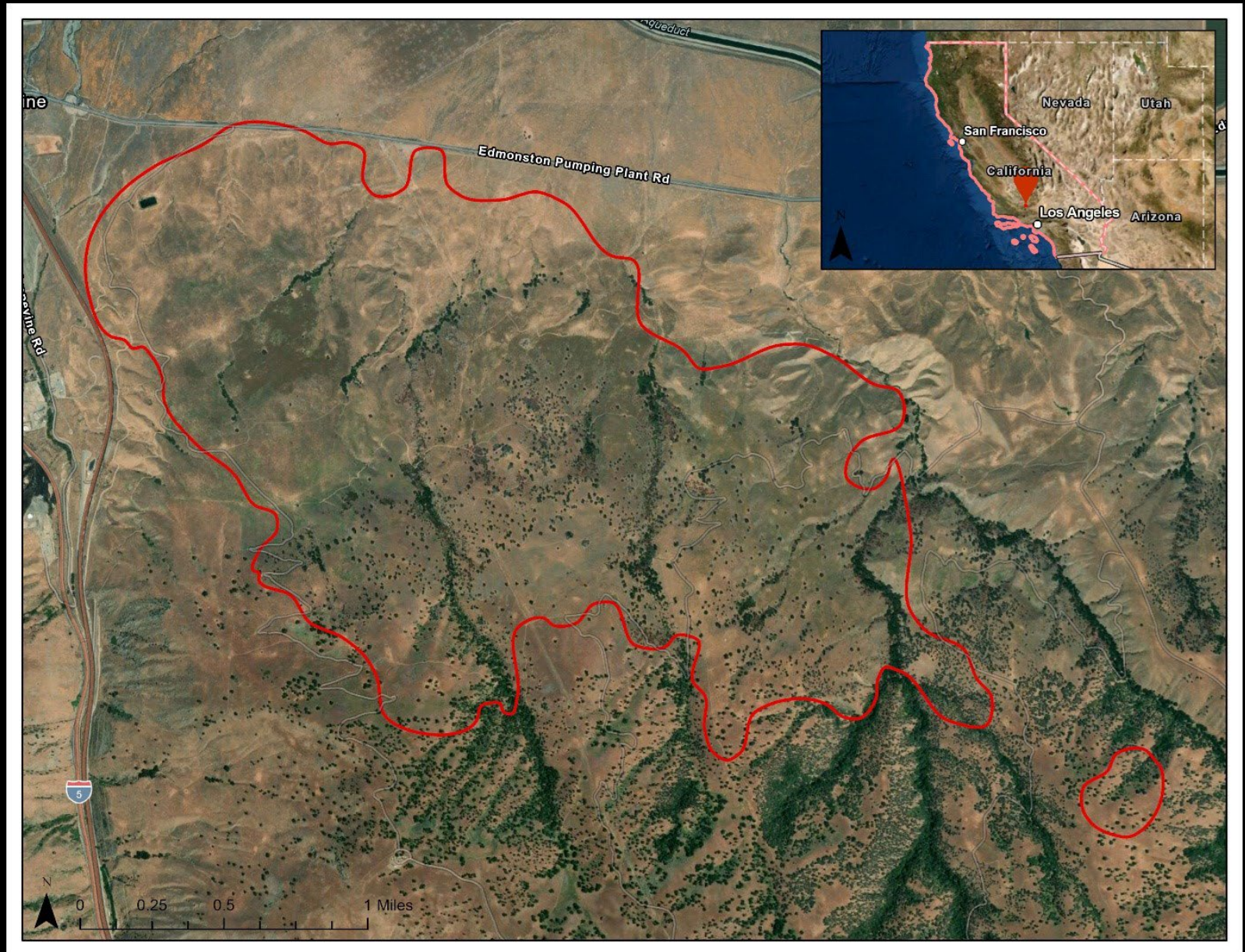
Burn Area– Thunder Fire

Landsat8

Landsat9
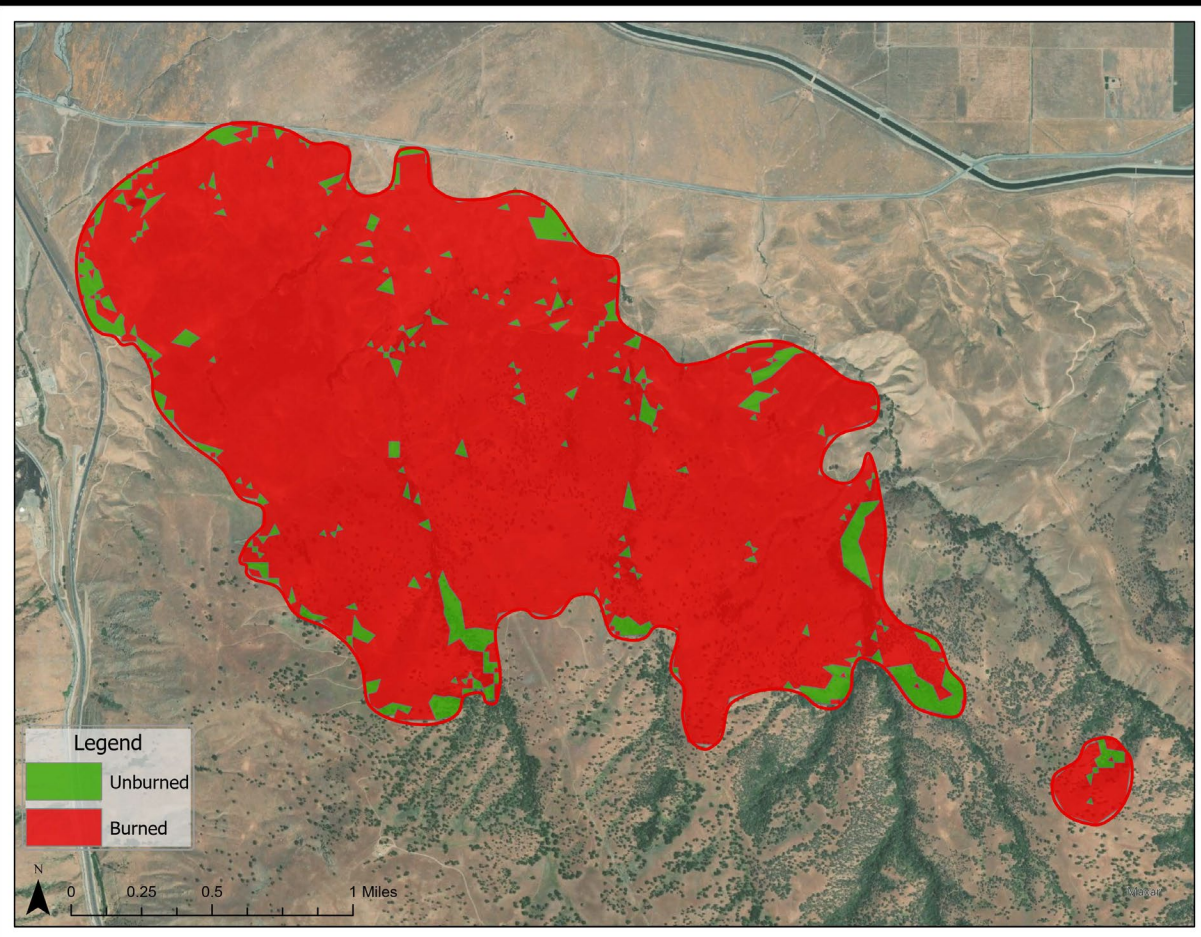
Burned Area (acres)	Unburned Area (acres)
2,289.39	170.91
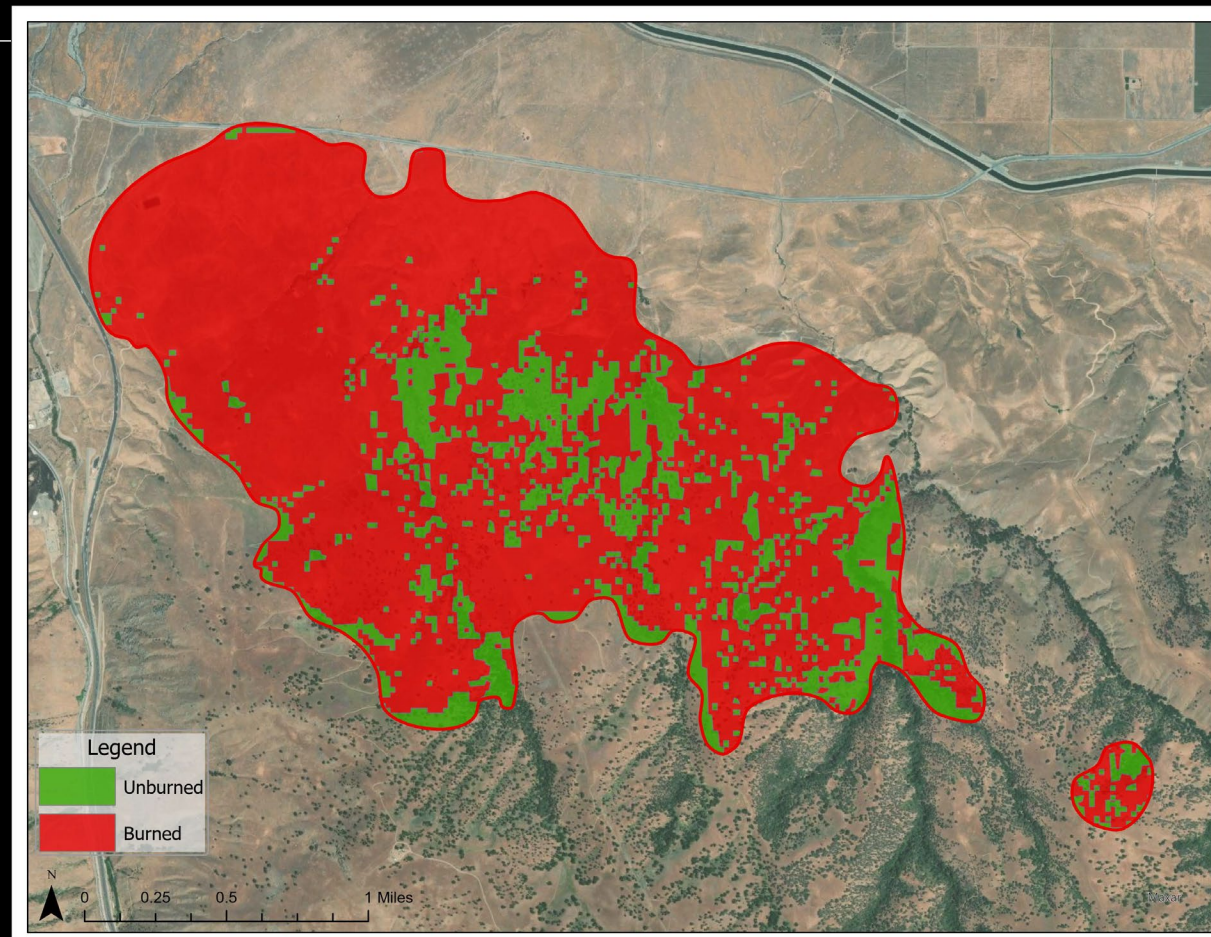
Burned Area (acres)	Unburned Area (acres)
1,974.74	499.77

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Accuracy Assessment – Thunder Fire

Landsat8 Error Matrix

Class	Barren	Vegetation	Grassland	Pavement	Total	User's Accuracy
Barren	6	0	3	0	9	0.7
Vegetation	0	10	7	0	17	0.59
Grassland	3	3	67	0	73	0.92
Pavement	0	0	0	1	1	1
Total	9	13	77	1	100	
Producer's Accuracy	0.67	0.77	0.87	1		0.84
					Overall Accuracy	0.61

Class	Barren	Vegetation	Grassland	Pavement	Total	User's Accuracy
Barren	72	4	9	0	85	0.8
Vegetation	4	4	2	0	10	0.40
Grassland	3	1	8	0	12	0.67
Pavement	1	0	0	9	10	0.9
Total	80	9	19	9	117	
Producer's Accuracy	0.9	0.44	0.42	1		0.79
					Overall Accuracy	0.57

Landsat9 Error Matrix

Class	Barren	Vegetation	Grassland	Pavement	Total	User's Accuracy
Barren	14	1	1	0	16	0.9
Vegetation	0	25	1	0	26	0.96
Grassland	0	0	33	0	33	1
Pavement	0	0	7	18	25	0.72
Total	14	26	42	18	100	
Producer's Accuracy	1	0.96	0.79	1		0.9
					Overall Accuracy	0.86

Class	Barren	Vegetation	Grassland	Pavement	Total	User's Accuracy
Barren	25	0	0	0	25	1.0
Vegetation	1	24	0	0	25	0.96
Grassland	1	0	24	0	25	0.96
Pavement	0	0	6	19	25	0.76
Total	27	24	30	19	100	
Producer's Accuracy	0.93	1.00	0.80	1		0.92
					Overall Accuracy	0.89

Conclusions

- Increased radiometric resolution in Landsat9 will increase our capacity to more accurately detect and map wildfires and their effects.

- Marshall Fire & Thunder Fire analyses demonstrate accuracy gains from Landsat9's improved sensor capabilities

Thank you!

Questions?

Sources

NASA's Goddard Media Studios (Producer). (2020, March 26). *Landsat Program Timeline* [Video file]. Retrieved March 13, 2022, from https://svs.gsfc.nasa.gov/11433

Van Denburg, H. (2022). *Wildfire flames and smoke rise above Superior, Colorado, on Thursday, Dec. 30, 2021*. CPR News. Retrieved July 7, 2022, from https://www.cpr.org/2022/01/05/boulder-county-marshall-fire-timeline/.