

National Aeronautics and
Space Administration



Using NASA Earth Observations to Quantify Tree Mortality and Fire Burn Severity in Southern Colorado to Inform Management on Ranches and Open Lands

Kristen Dennis

Sophia Leiker

Kristen Davis

Leorah McGinnis

Christa Torrens





Spring Creek Fire By The Numbers

- ▶ Started in June 2018
- ▶ 3rd largest fire in Colorado's recorded history
- ▶ Burned 108,000 acres
- ▶ Destroyed 140 homes

Did standing dead trees impact the severity of this fire?

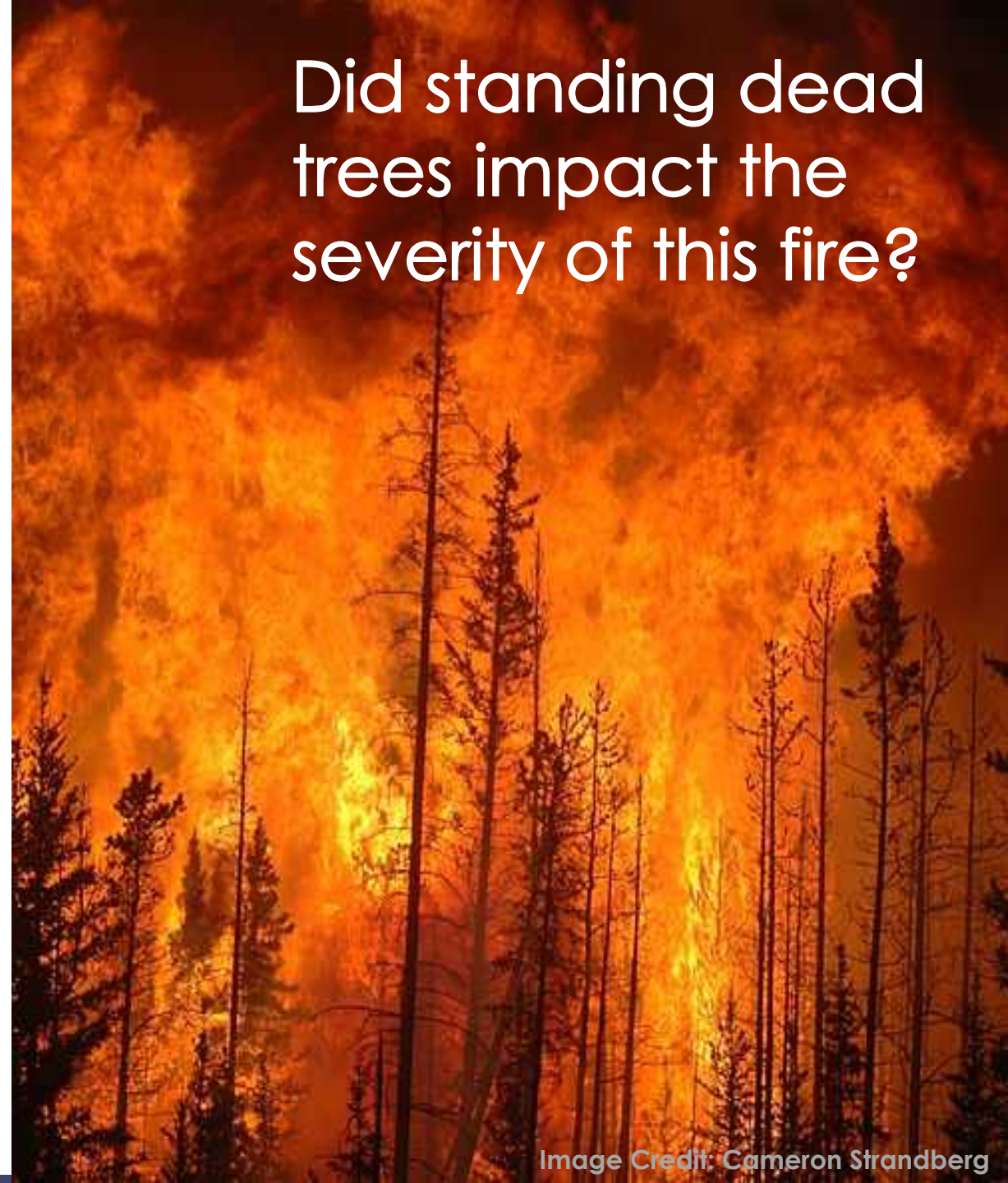


Image Credit: Cameron Strandberg



Western Spruce Budworm

Choristoneura freemani

- ▶ Defoliator species
- ▶ Consumes current year's growth
- ▶ Douglas-Fir, Spruce, Fir

Impacts

- ▶ Kills crowns of coniferous trees
- ▶ Inhibits regeneration
- ▶ Contributes to tree mortality



Image Credit: Province of British Columbia

Weakened trees → prone to insect/disease attacks

Community Concerns

Insect-related tree mortality

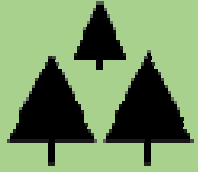
Wildfire

Monitoring techniques



Image Credit: Justin Hirsch

Objectives



Map tree mortality prior to the Spring Creek Fire



Map burn severity for the Spring Creek Fire



Model relationship between pre-fire tree mortality and burn severity

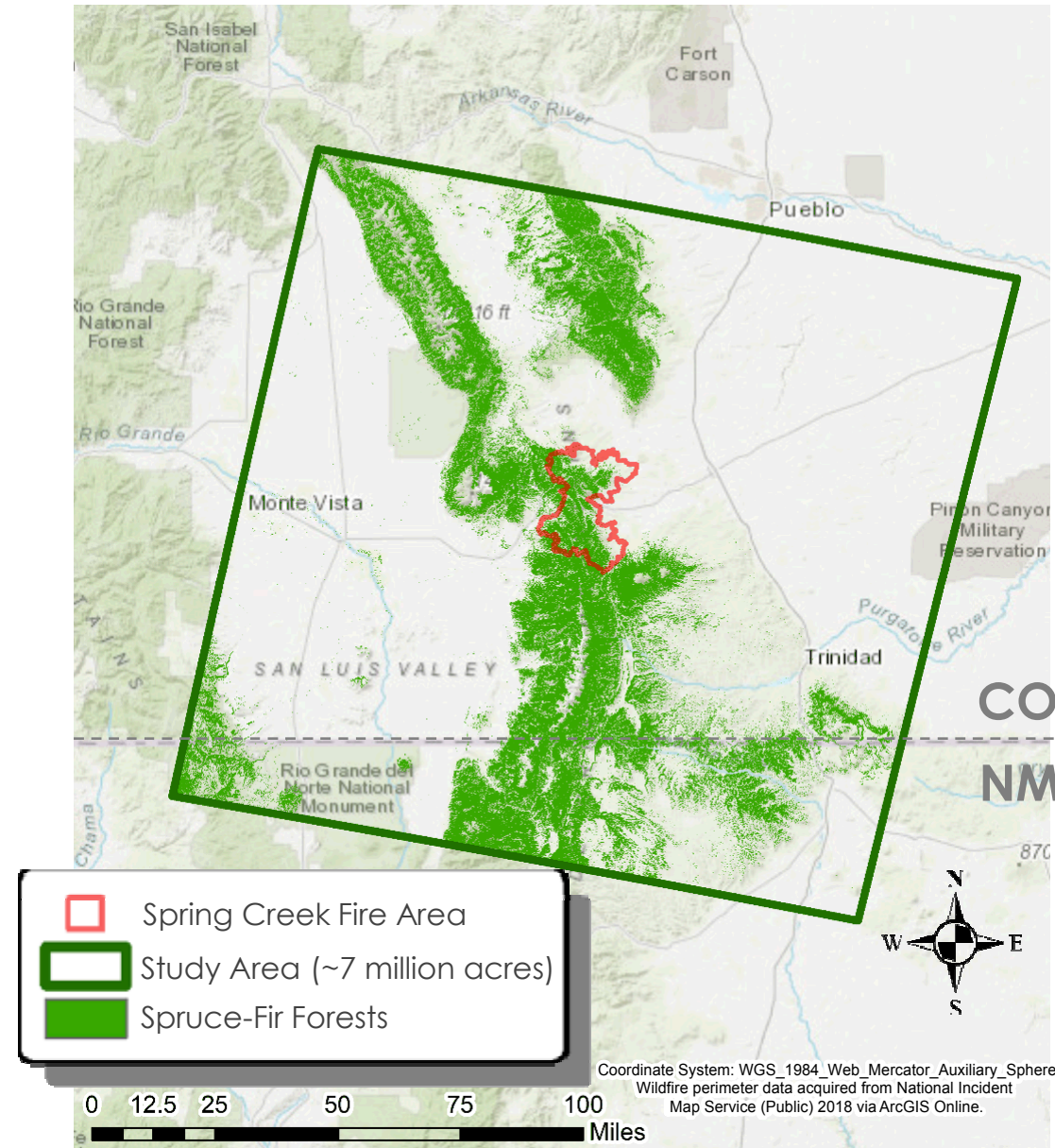
Partners & Study Area

Aaron Swallow

Colorado State Forest Service

Ranch Environmental
Manager

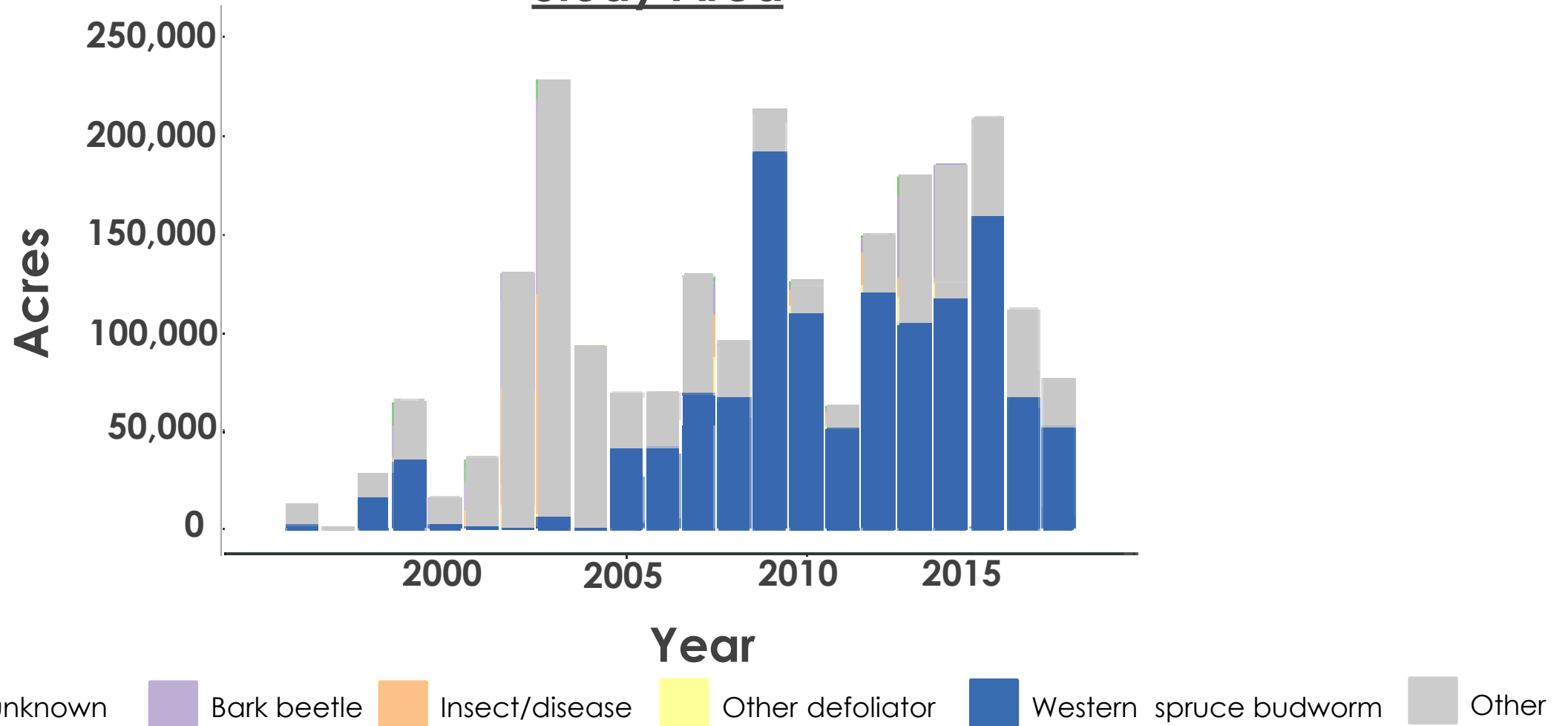
Amanda West,
Manager of Science
Information



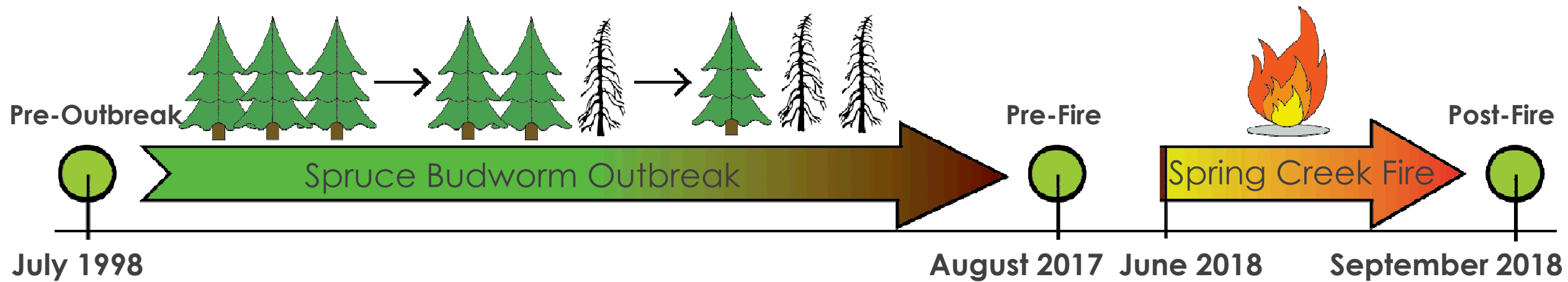


Budworm Outbreak Dates

Causes of Tree Damage in Colorado Study Area

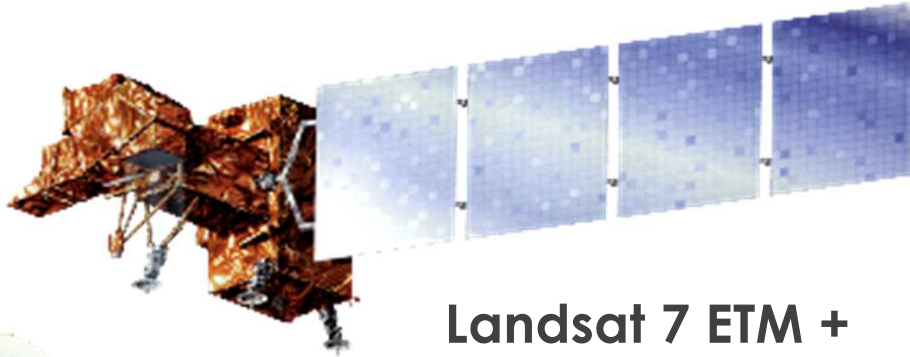


Study Timeline





NASA Satellites and Sensors



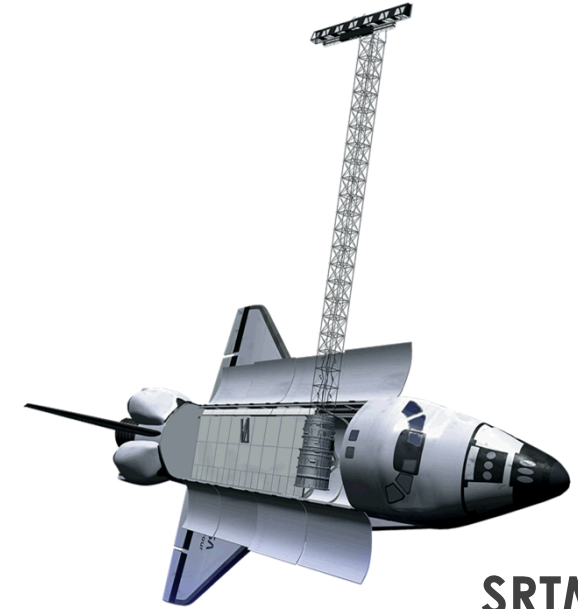
Landsat 7 ETM +



Landsat 5 TM



Landsat 8 OLI

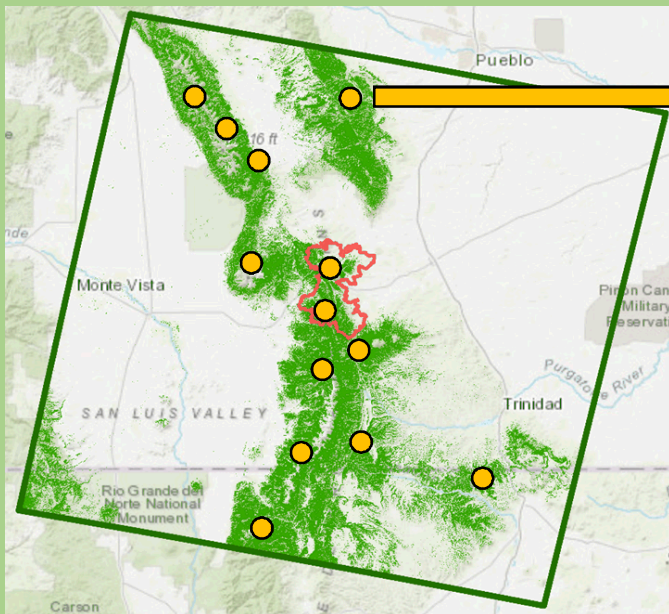


SRTM



Sampling

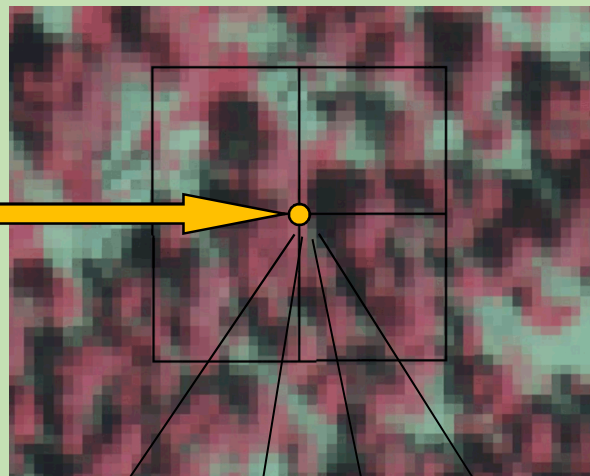
GEE, ArcMap



Sampling locations in specific forest classes

Processing

GEE



NIR
NDMI
ET
TCG

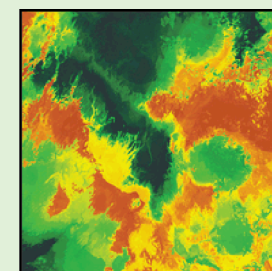
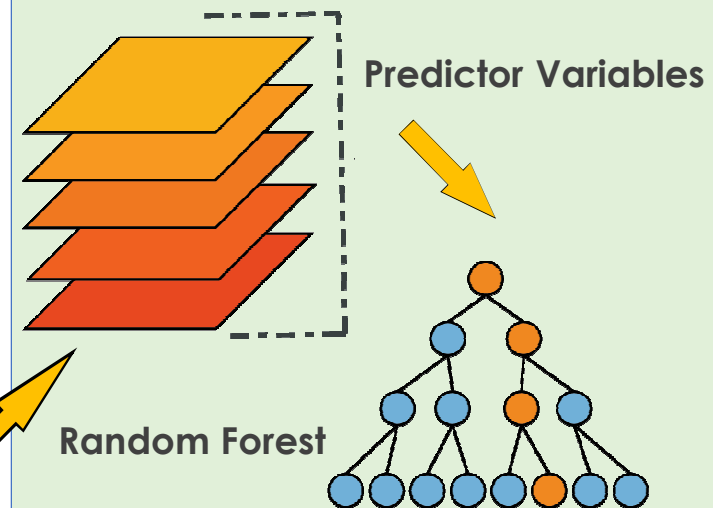
PREDICTOR VARIABLES

+

DOS → % Tree Mortality

Modeling

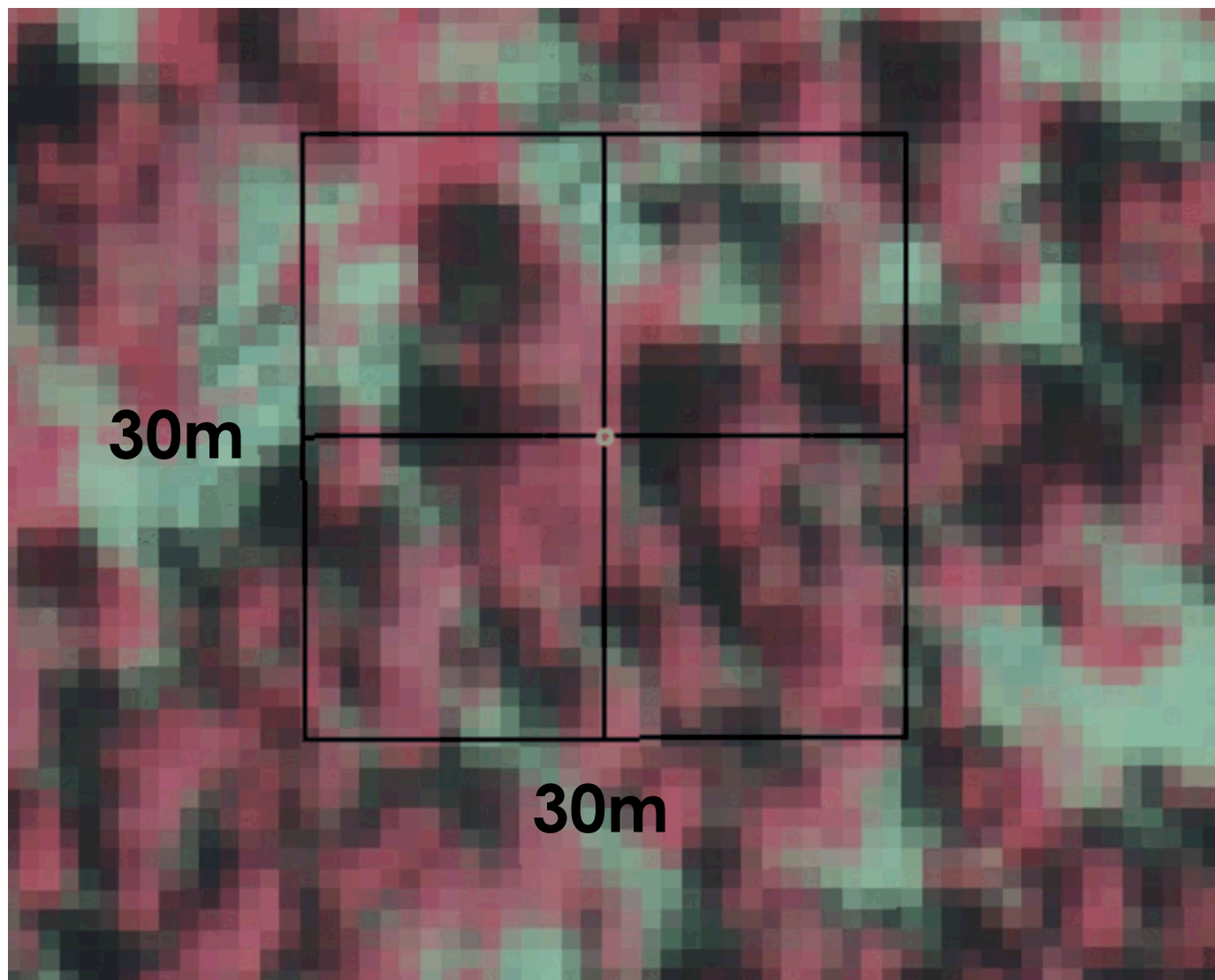
R



Tree Mortality Maps



Digital Ocular Sampling



- ▶ 600 sampling points
- ▶ Random within select forest types
- ▶ Sampled % cover in each pixel using 2015, 2017 NAIP
- ▶ *Categories:* dead woody vegetation, live vegetation, other, and shadow
- ▶ 2 Sampler approach



Processing Imagery



Landtrendr:

- 1) Harmonize Imagery
- 2) Mask Clouds
- 3) Median Reduce
- 4) Select years of interest



VSURF:

Variable Selection
Using Random Forest



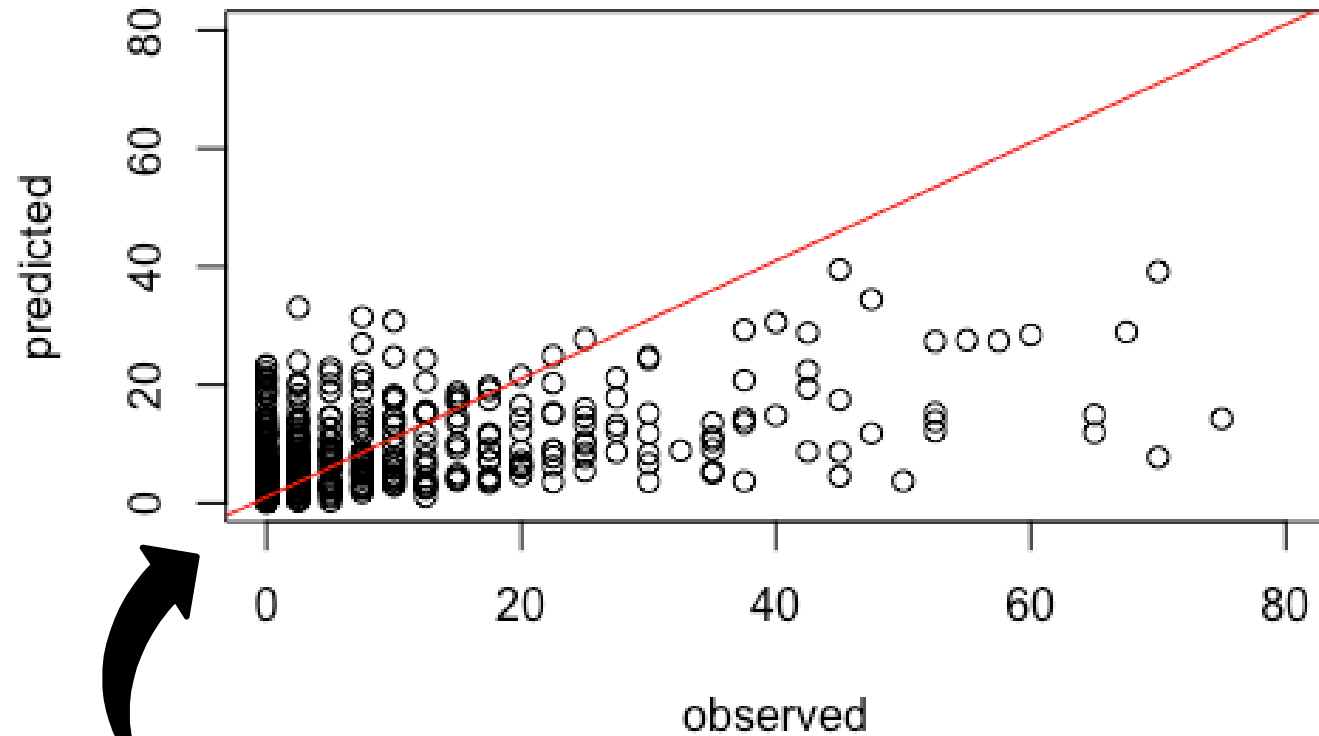
Year	Months	Predictors
1998	Jul & Aug	NIR, NDVI, Tasseled Cap Brightness
2017	Jul & Aug	Tasseled Cap Wetness, elevation
Differenced	Jul & Aug	NDMI



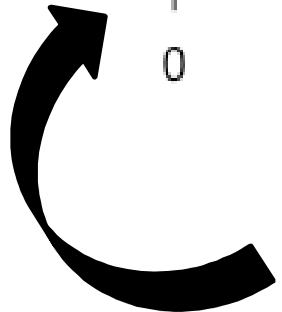
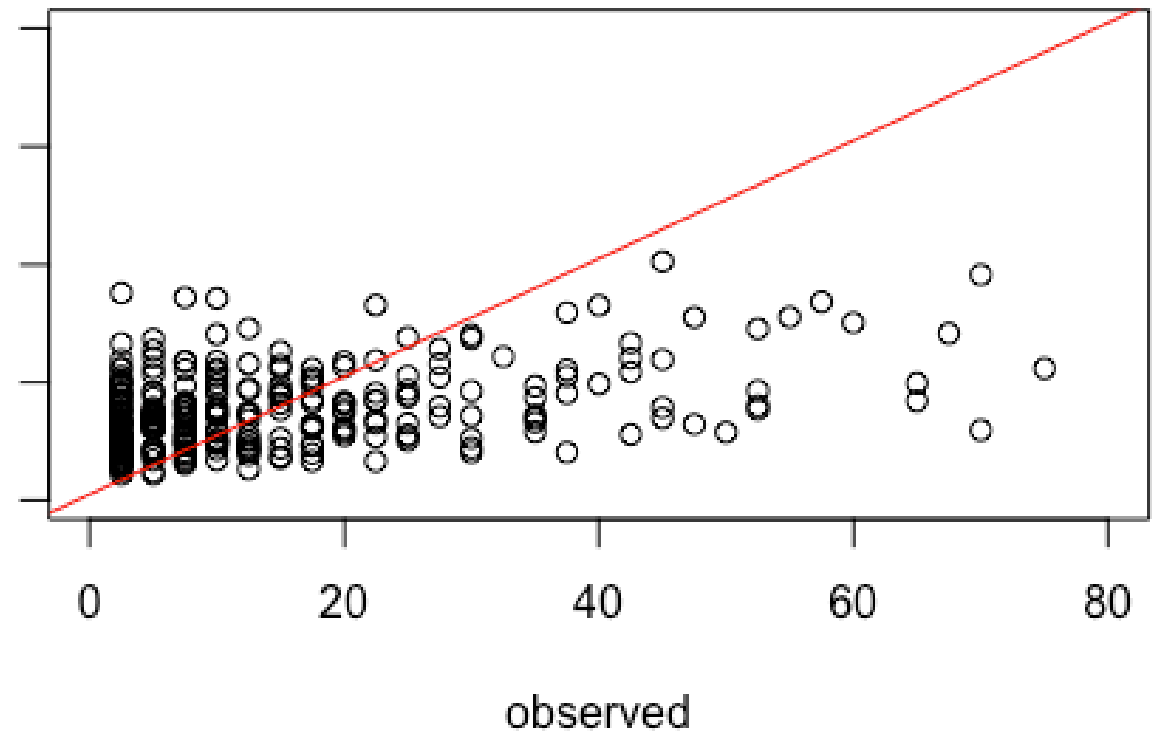
Tree Mortality with RF



ONE STEP MODEL ($R^2 = 0.246$)



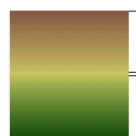
TWO STEP MODEL ($R^2 = 0.174$)



Zero Inflated



One-Step Tree Mortality Map

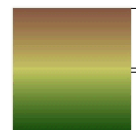
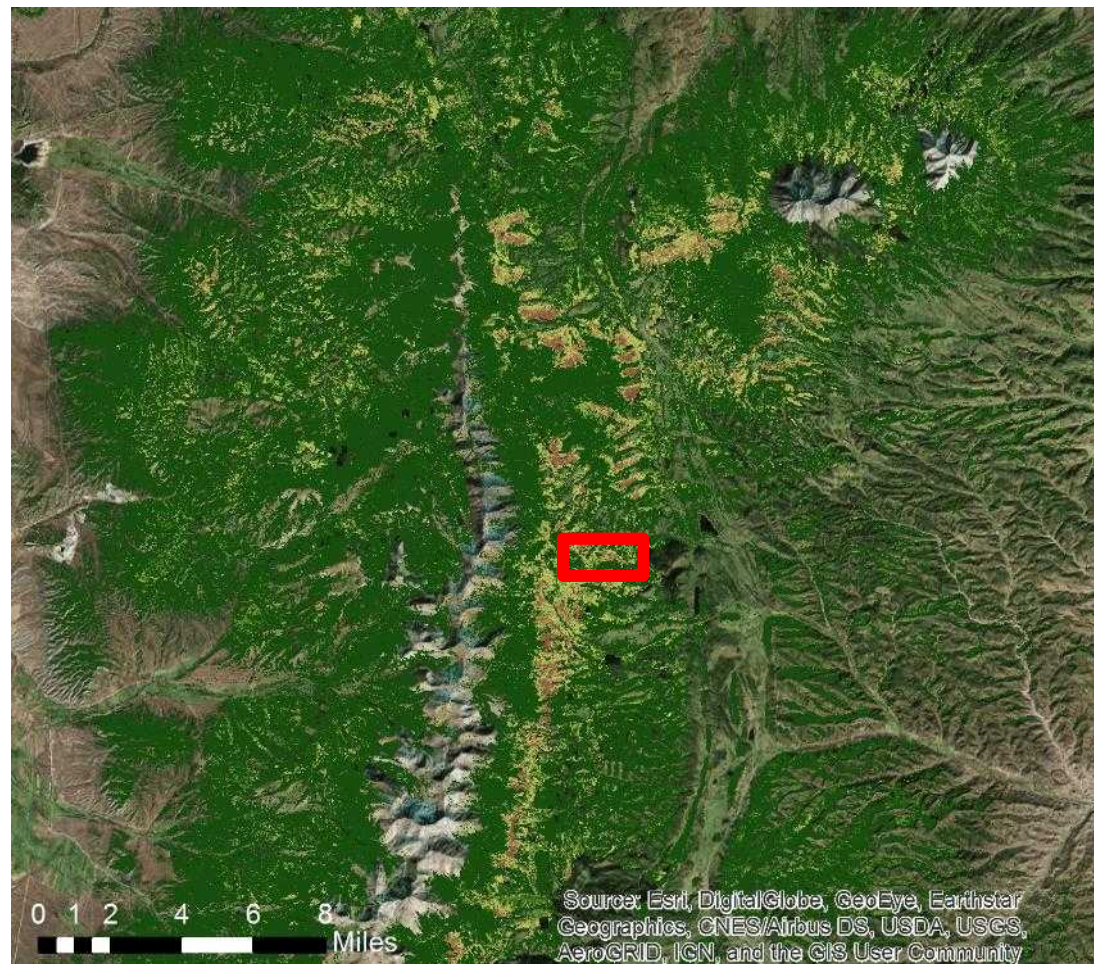


High: 56%

Low: 0%

More “false positive” pixels

Two-Step Tree Mortality Map



High: 58%

Low: 0%

More “false negative” pixels



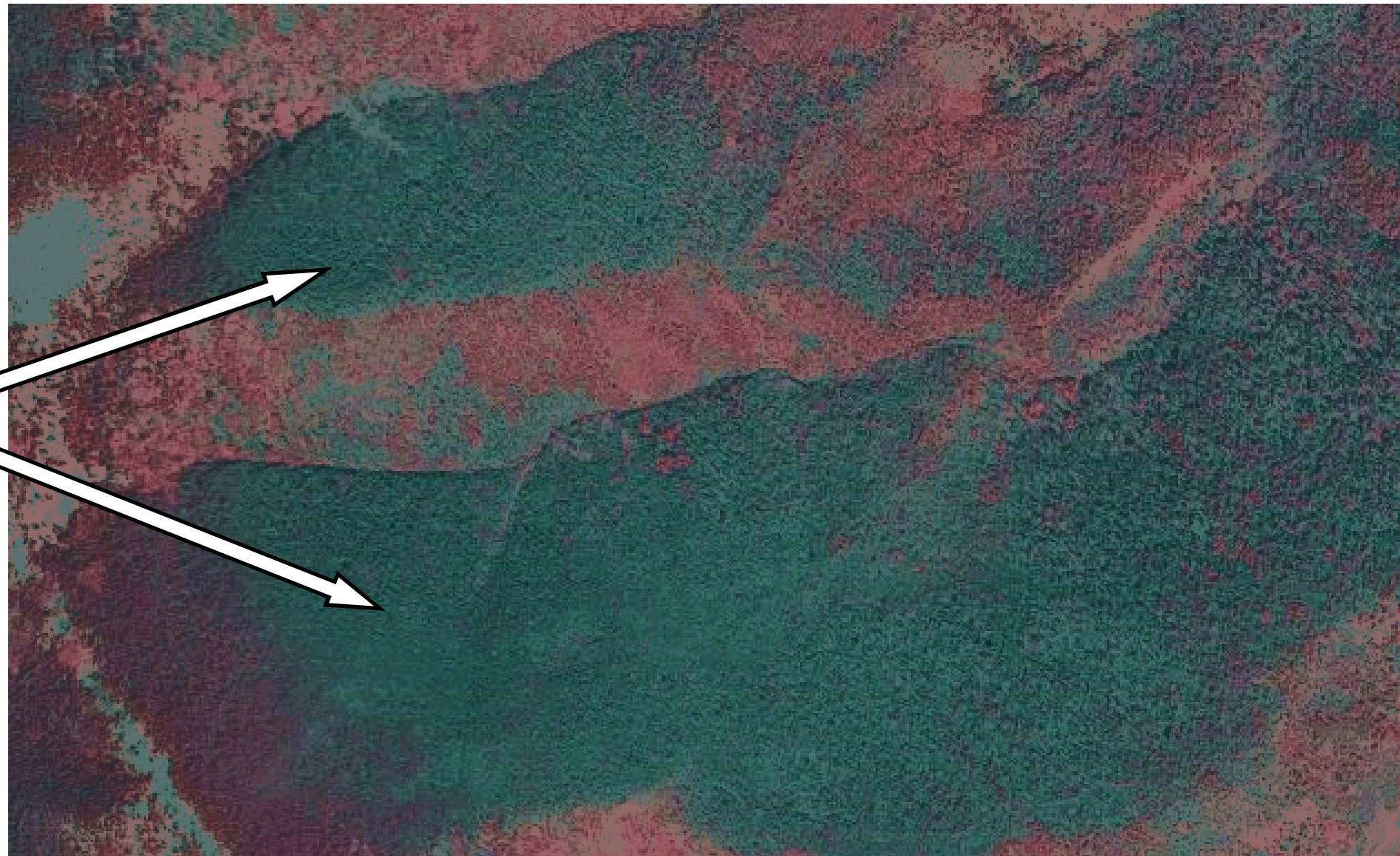
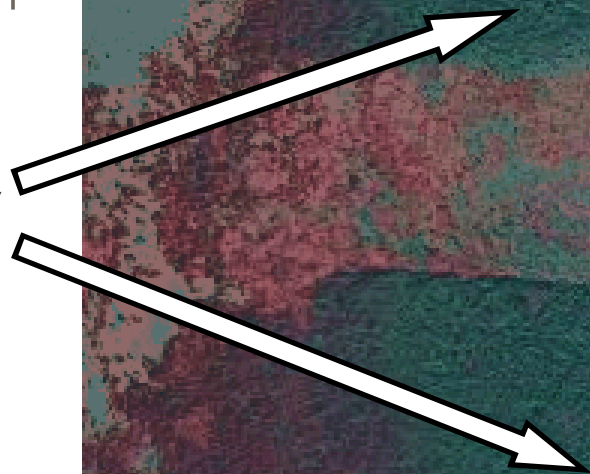
Map Comparison NAIP Imagery



Pink = Live Woody
Vegetation

Gray/Blue = Dead
Woody Vegetation

Tree Mortality

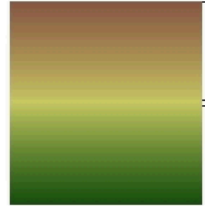




Map Comparison One-Step



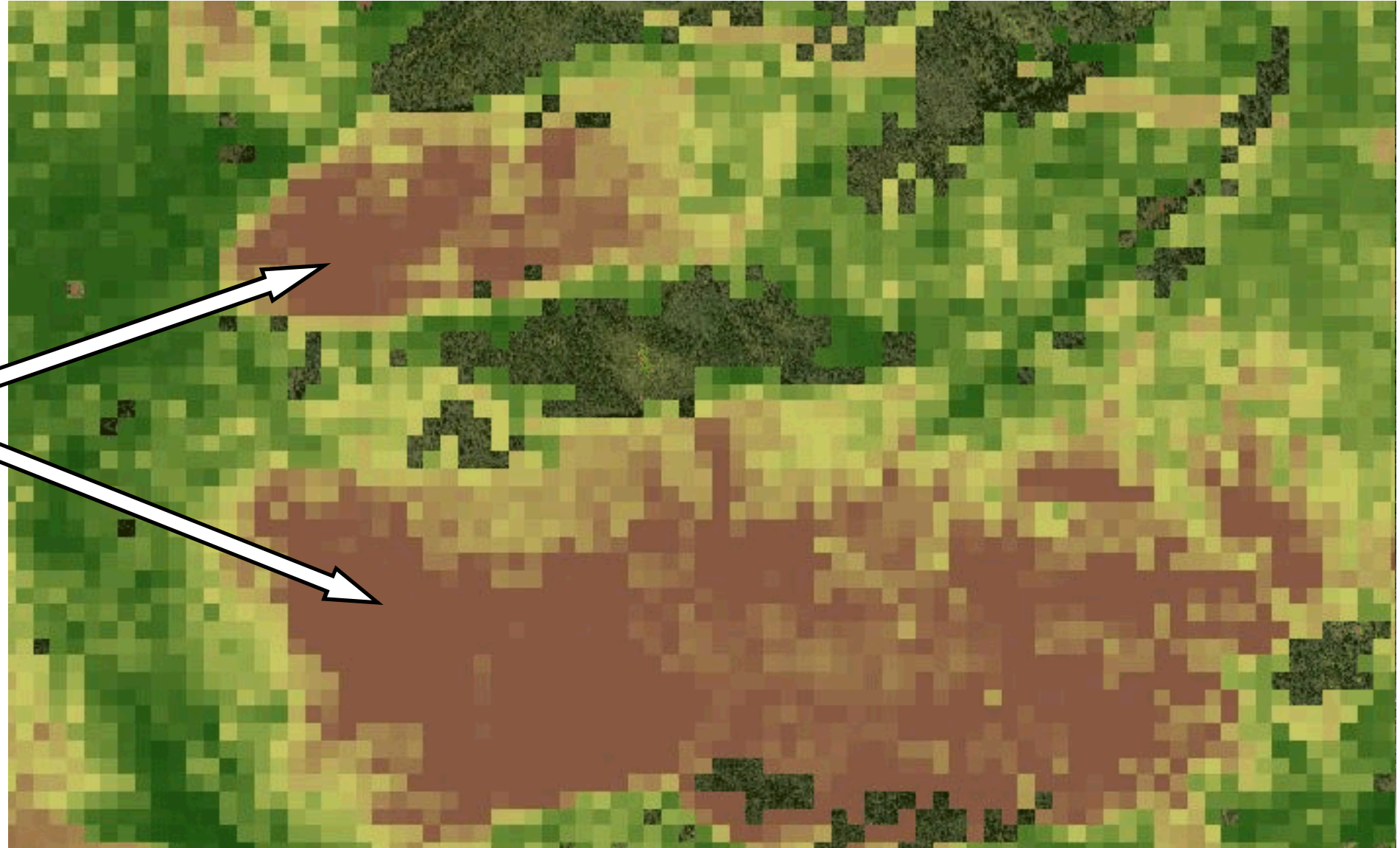
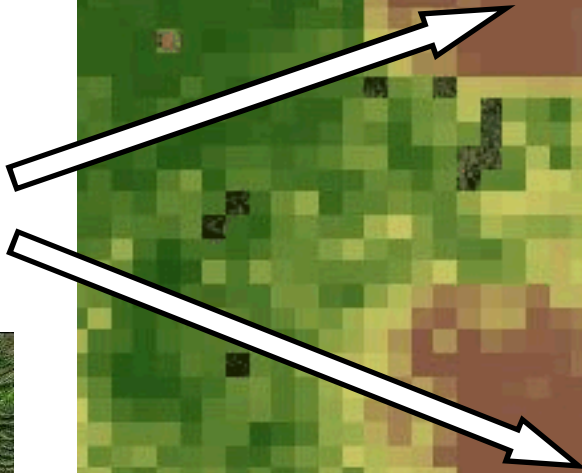
Percent Tree Mortality



High: 56%

Low: 0%

Tree Mortality





Map Comparison Two-Step



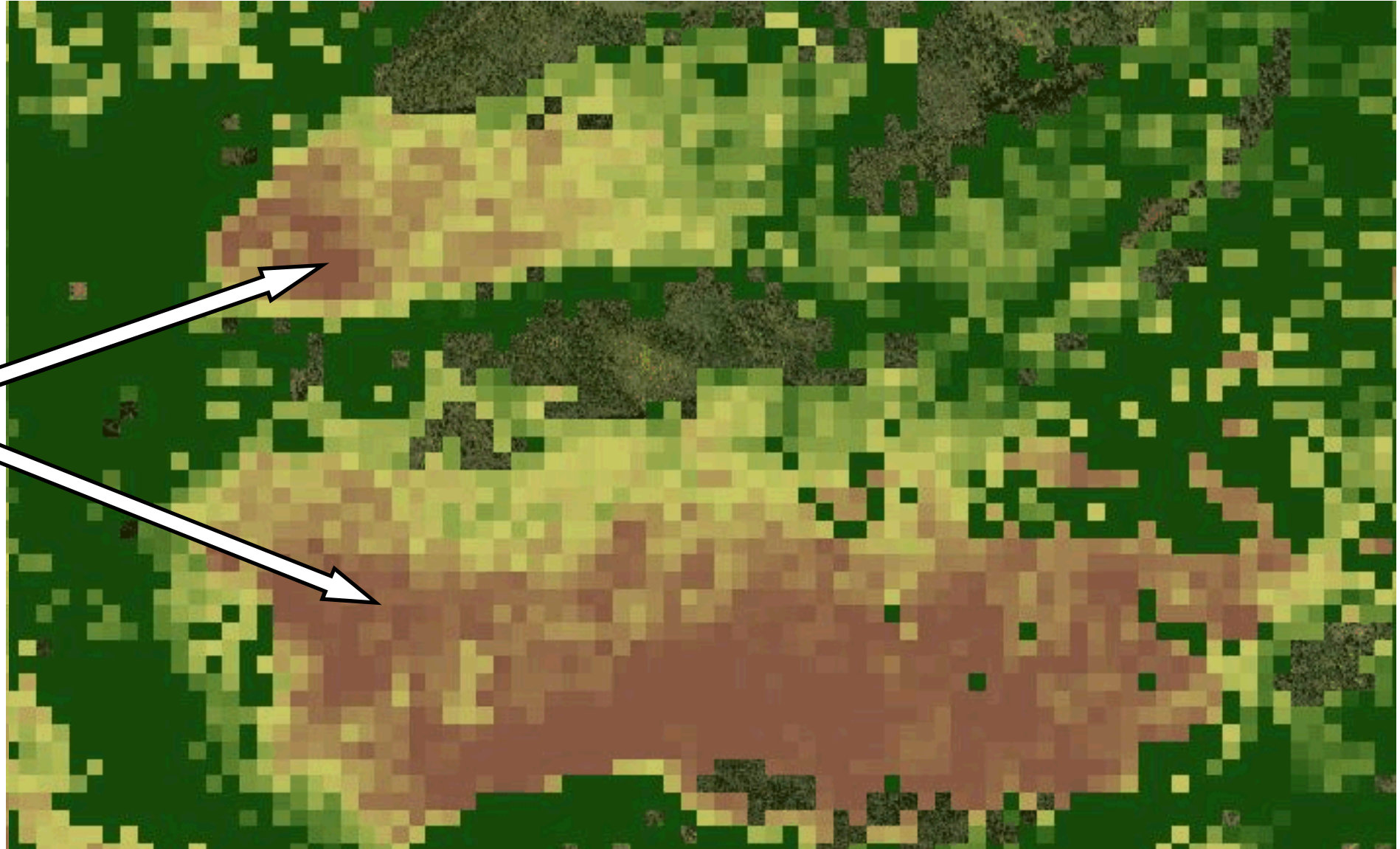
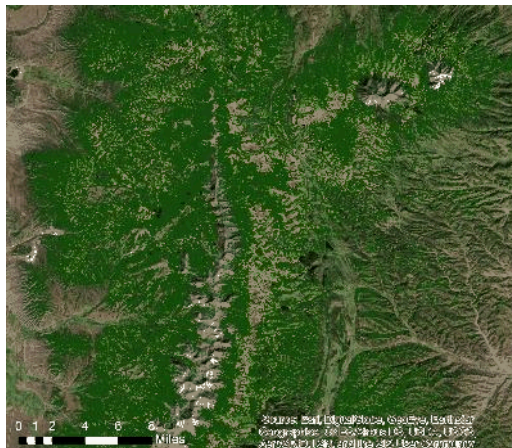
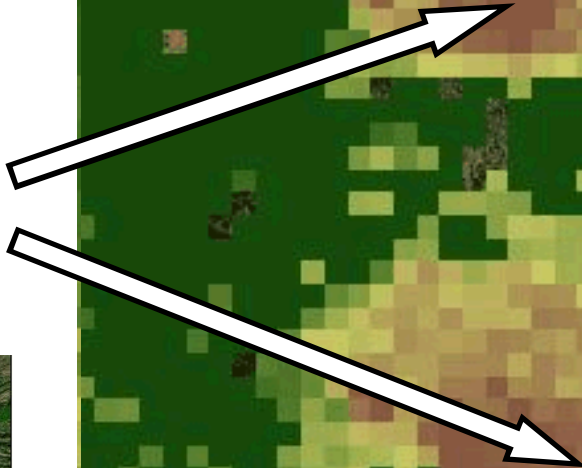
Percent Tree Mortality



High: 58%

Low: 0%

Tree Mortality





Burn Severity

Commonly used indices

delta Normalized Burn Ratio (dNBR)

Relativized dNBR (RdNBR)

Newer index

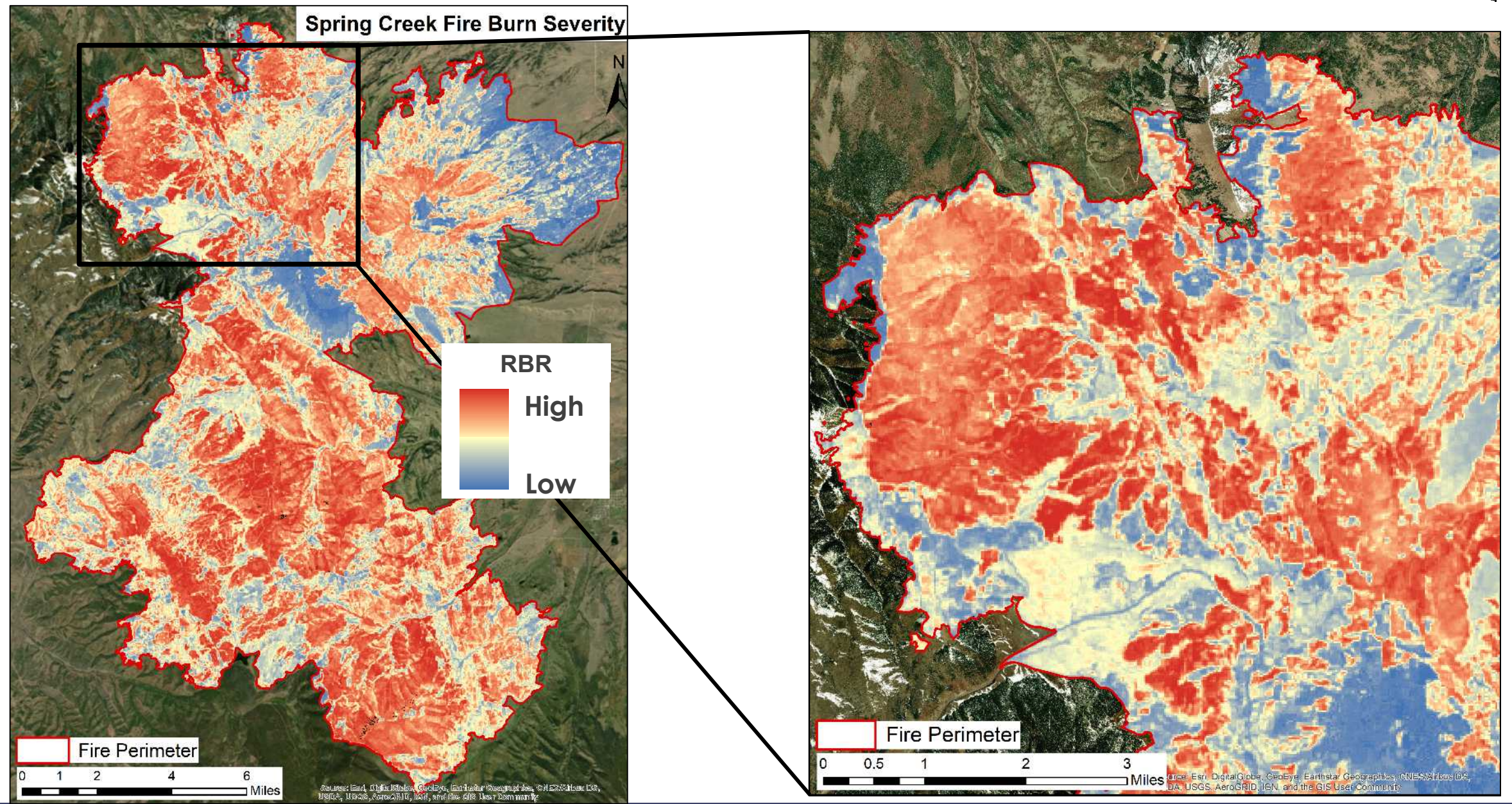
Relativized Burn Ratio (RBR)



Image Credit: Dr. Bill Romme



Relativized Burn Ratio

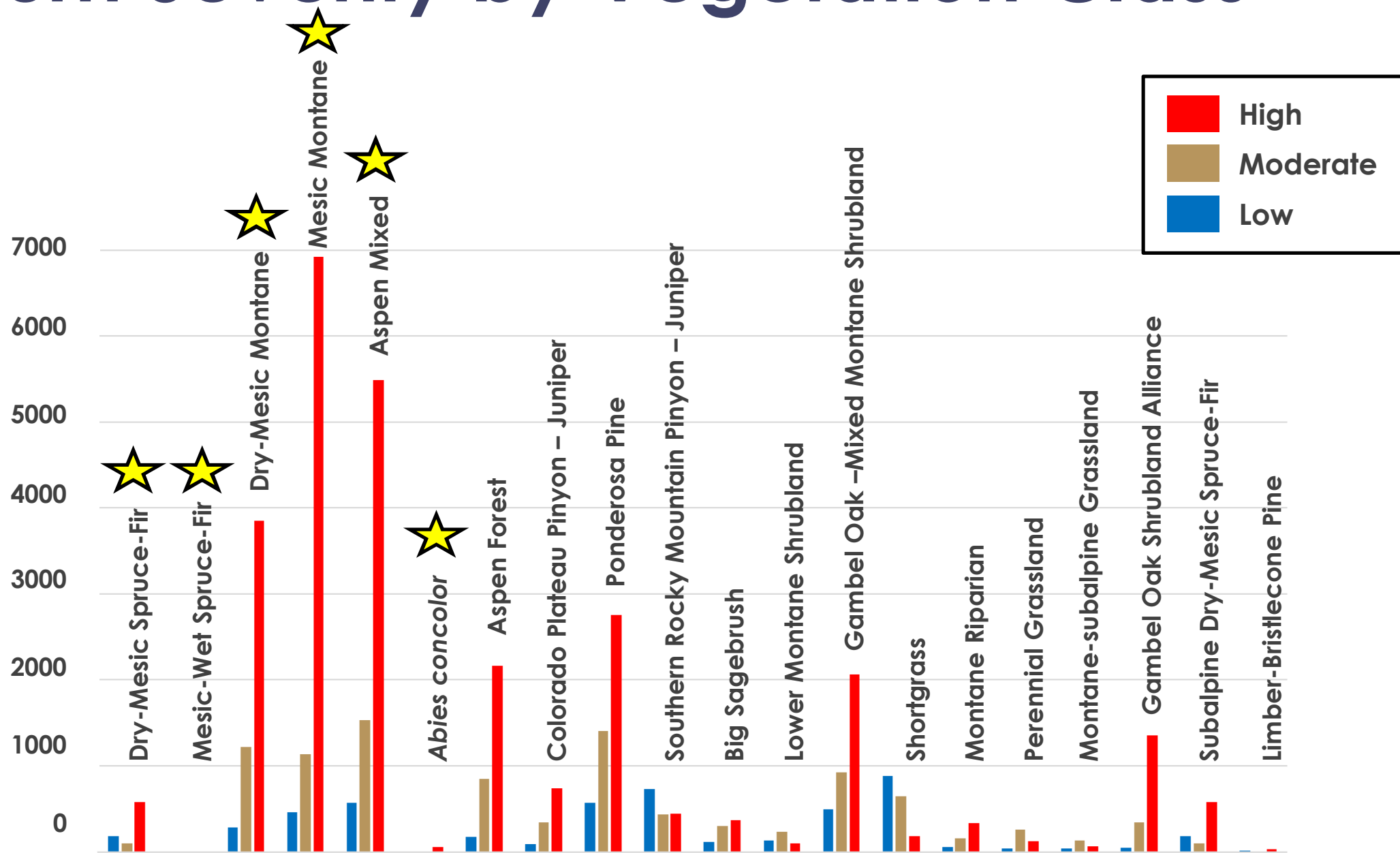




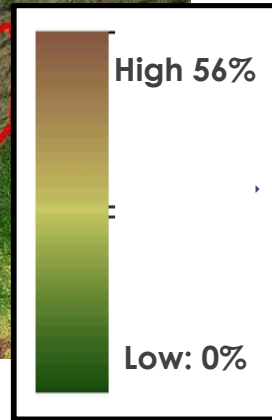
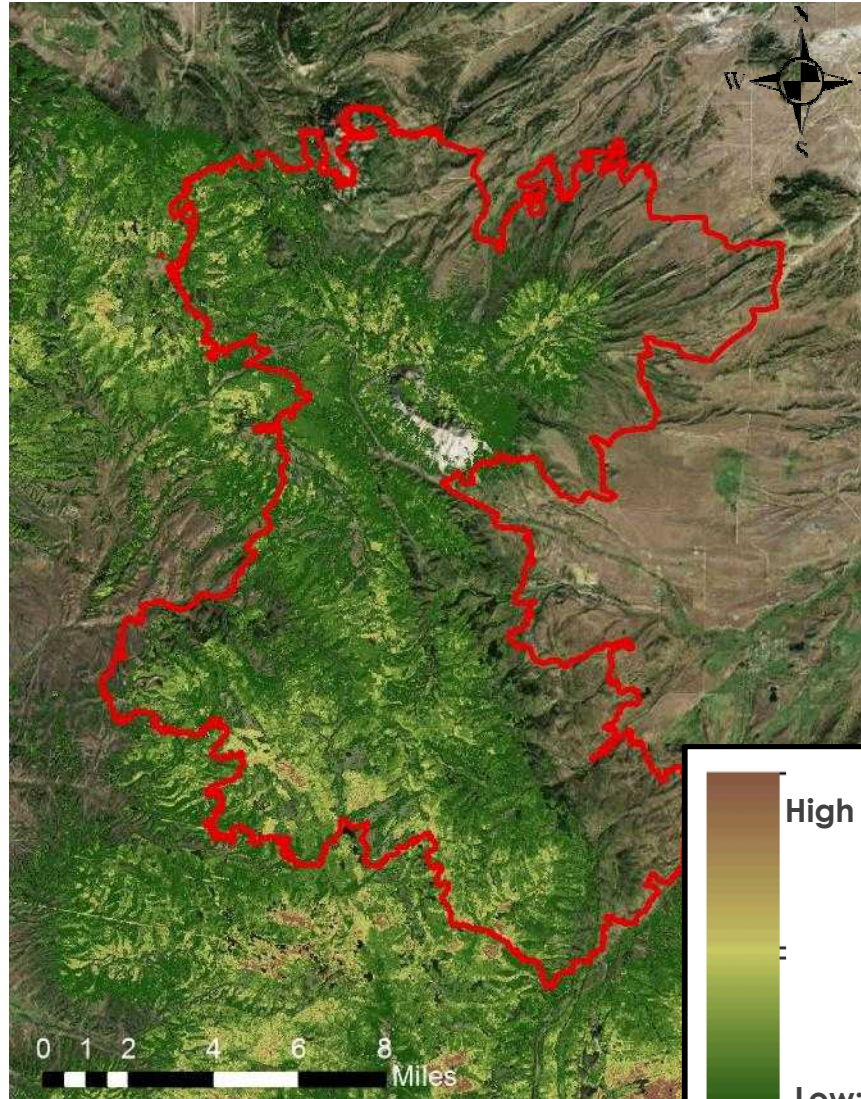
Burn Severity by Vegetation Class



Area
(ha)



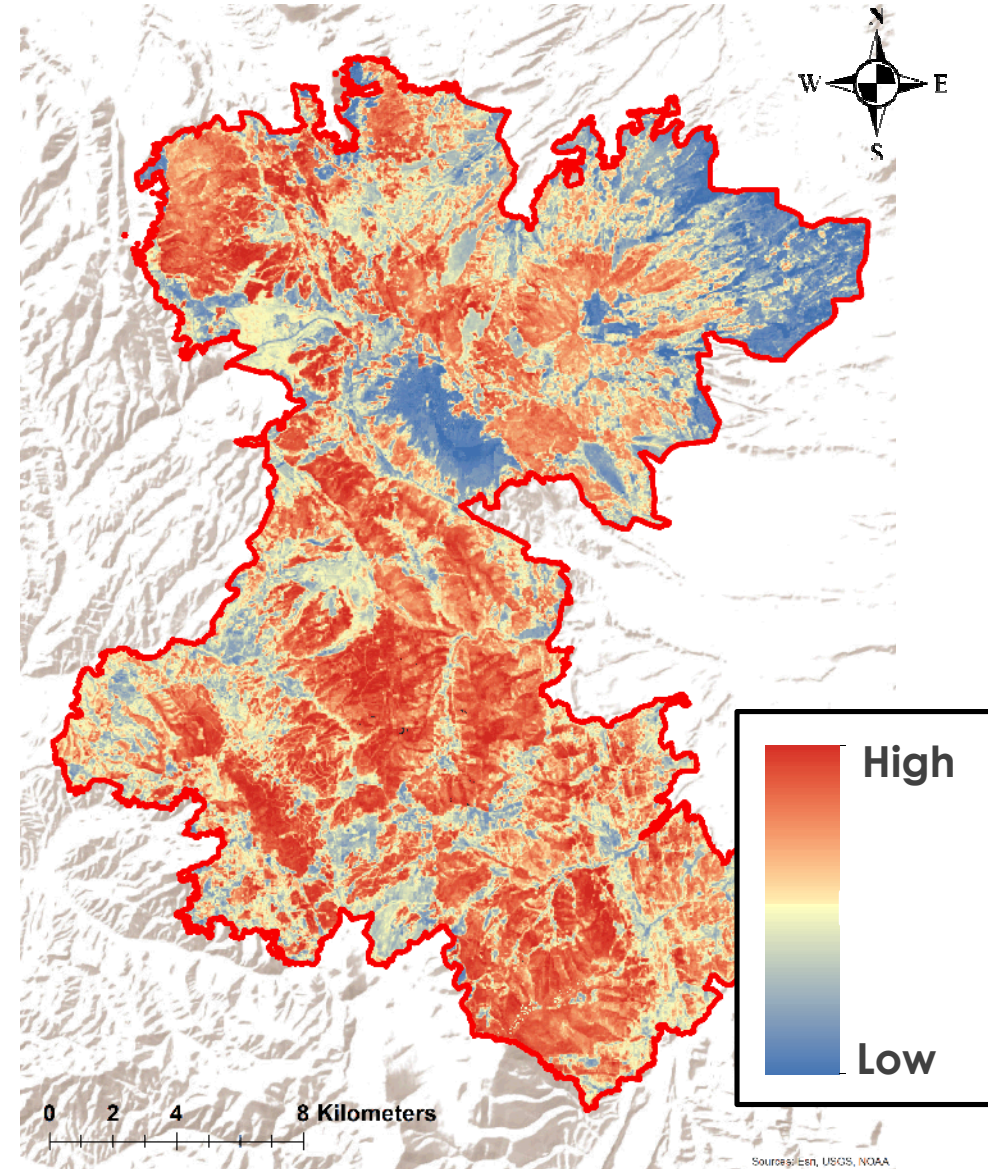
Tree Mortality & Burn Severity



► Random forest

► Tree mortality → not a high predictor for burn severity

► Cannot say if tree mortality influenced burn severity

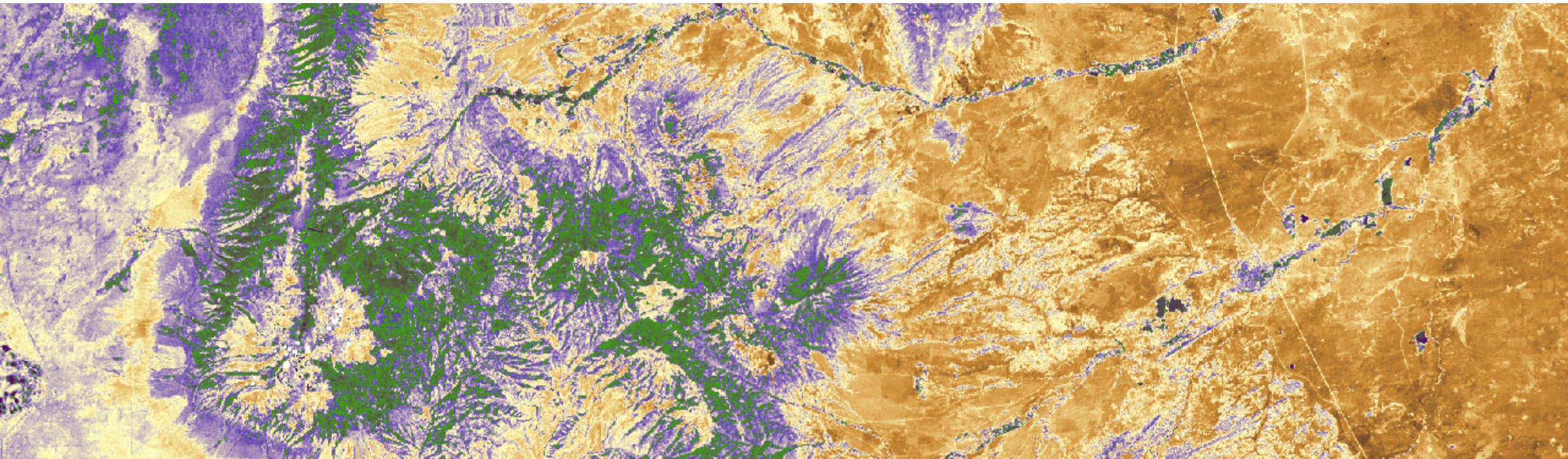




Conclusions



- ▶ **One-step vs two-step** approaches both **identified tree mortality** within study area → analysis differed at the lower values
- ▶ Spring Creek Fire → burned largely at **high severity** across forest types
- ▶ **Tree mortality** was of **low importance** for predicting burn severity when compared to other environmental predictors





Future Work

- ▶ Using Sentinel-2 MSI to quantify burn severity
 - ▶ More detailed resolution
- ▶ Other modeling approaches for fire dynamics
 - ▶ Using additional variables





Acknowledgements

Dr. Paul Evangelista (Colorado State University, Natural Resource Ecology Laboratory)

Tony Vorster (Colorado State University, Natural Resource Ecology Laboratory)

Brian Woodward (Colorado State University, Natural Resource Ecology Laboratory)

Nicholas Young (Colorado State University, Natural Resource Ecology Laboratory)

Dr. Catherine Jarnevich (United States Geologic Survey – Fort Collins Science Center)

Aaron Swallow (Ranch Environmental Manager)

Dr. Amanda West (Colorado State Forest Service, Manager of Science Information)

