

# Using Remote Sensing to Map Burn Severity and Assess Relationship with Environmental Factors in The Alaskan Boreal Forest

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Alaska Space Grant Program

# Collaborators

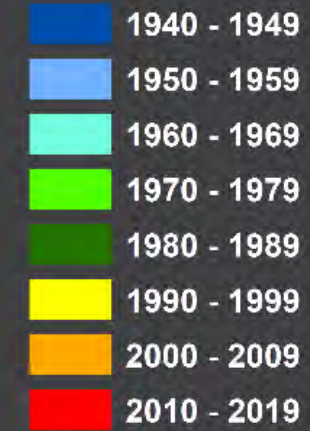
- Santosh Panda
- Uma Bhatt
- Franz Meyer
- Jennifer Hrobak
- Anushree Badola
- Jennifer Barnes
- Alison York
- Colleen Haan
- Lisa Saperstein
- Heidi Strader
- GaBriella Branson



Photo Credit: Tom Moran

# Burned Area Map 1940 – 2019 80.1 million acres

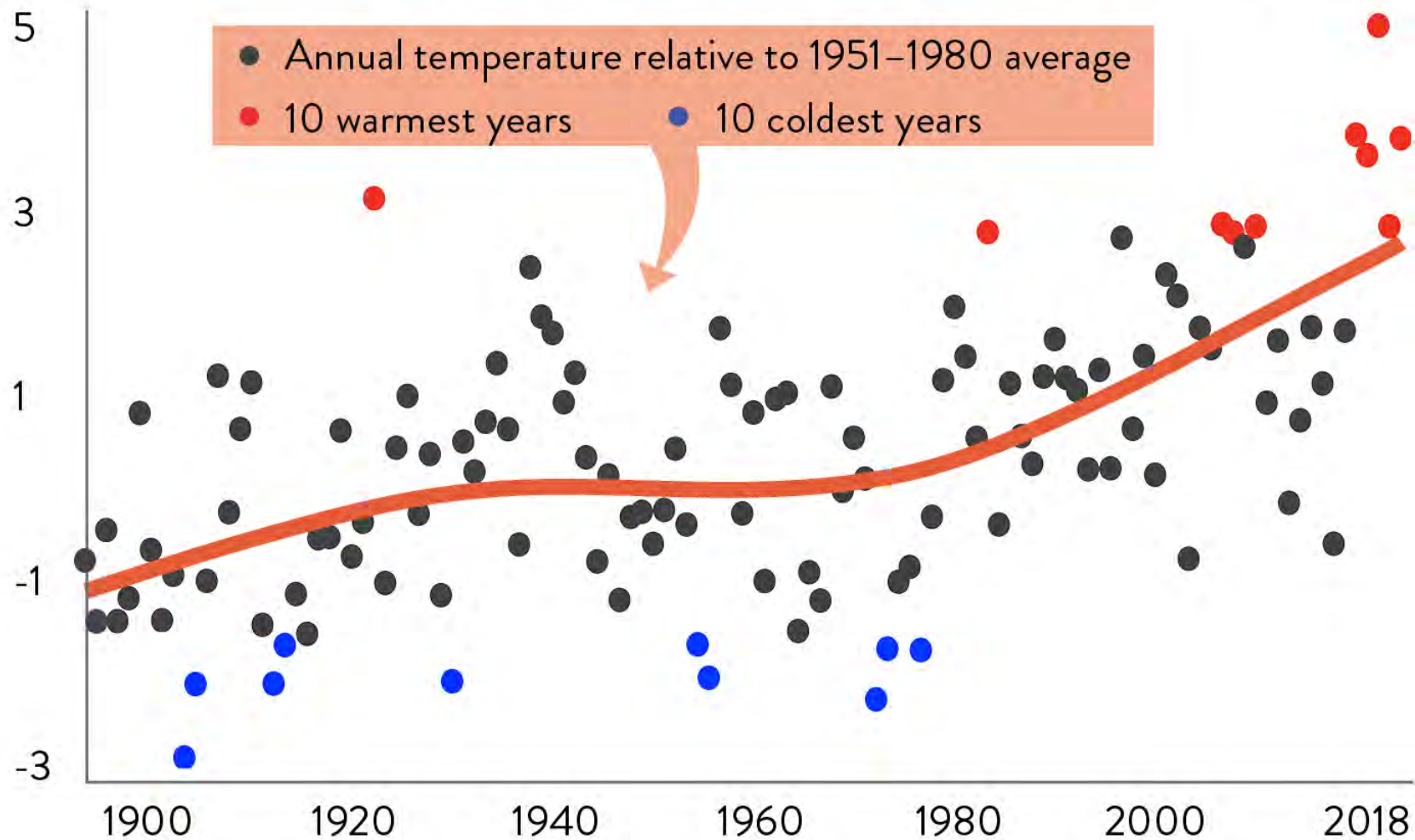
Fire Polygons 1940-2019



Data: Alaska Interagency Coordination Center  
Credit: Santosh Panda, Remote Sensing of Wildfire  
edX Course

Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community

# Annual temperatures for Alaska, 1900–2018

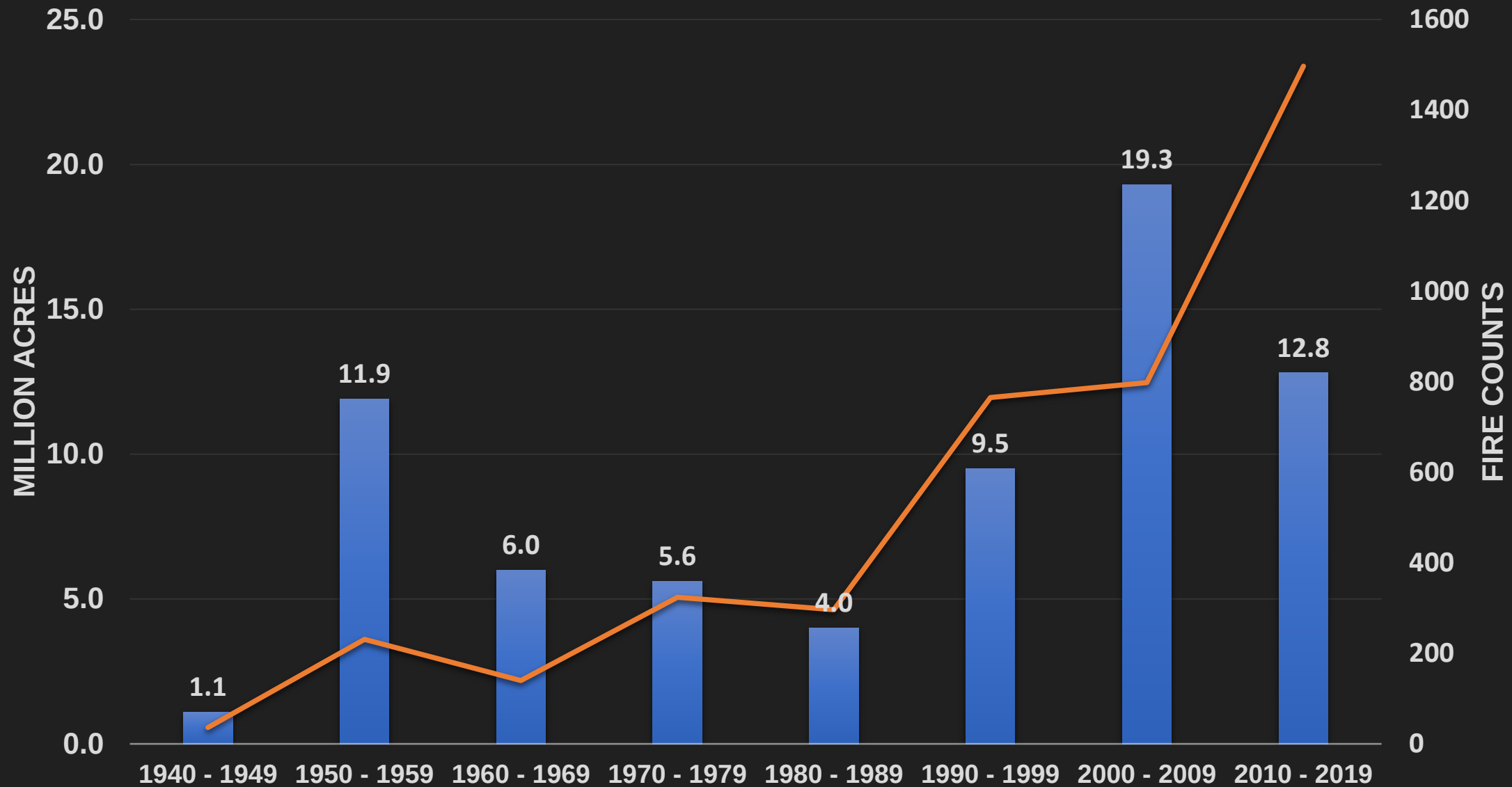


Credit: Rick Thoman, Alaska Center for Climate Assessment and Policy.

Data source: NASA GISS & UAF/Brian Brettschneider

# Wildfire Decadal Area Burned (1940 – 2019)

Burn area in million acres    Fire Count



Credit: Santosh  
Panda, Remote  
Sensing of Wildfire  
edX Course

# Assessing Burn Severity

## Research Question:

What remote sensing techniques are most effective for assessing boreal wildfire burn severity?

## Objectives:

1. Survey burn severity within Shovel and Nugget Creek fire scars.
2. Map burn severity using Sentinel-2 satellite imagery.
3. How is fire behavior affected by environmental factors?



Location of Shovel and Nugget Creek Fires

# Burn Severity Background

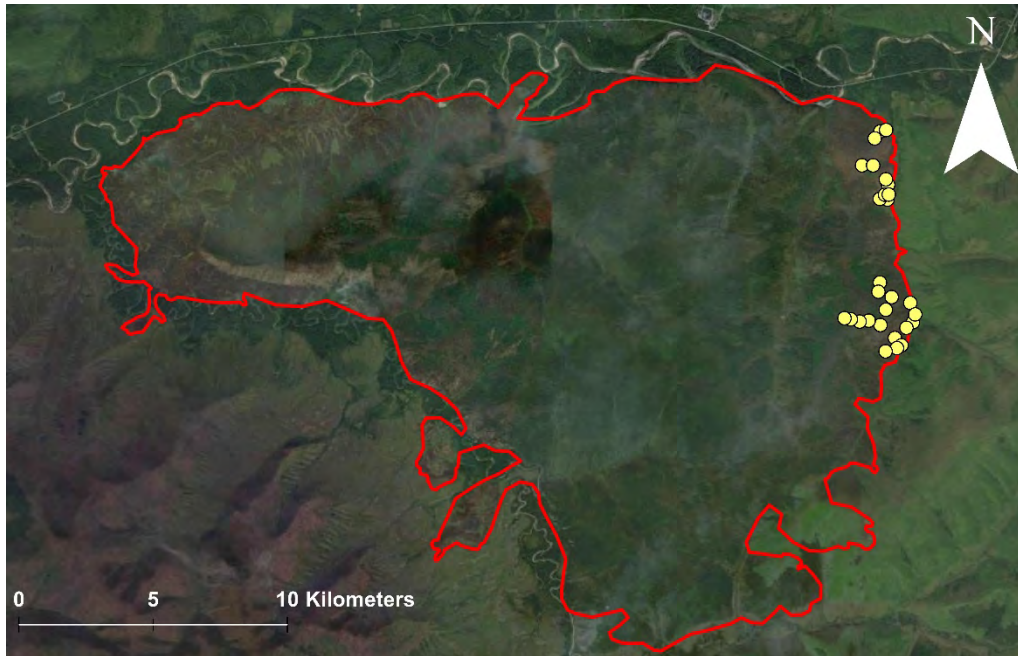
- Burn severity needs to be assessed within 18-24 months after fire (Key and Benson 2006)
- Two local fires (Shovel Creek and Nugget Creek) provide great opportunity to assess burn severity
- Data availability and techniques have improved since burn severity in the boreal forest was last studied



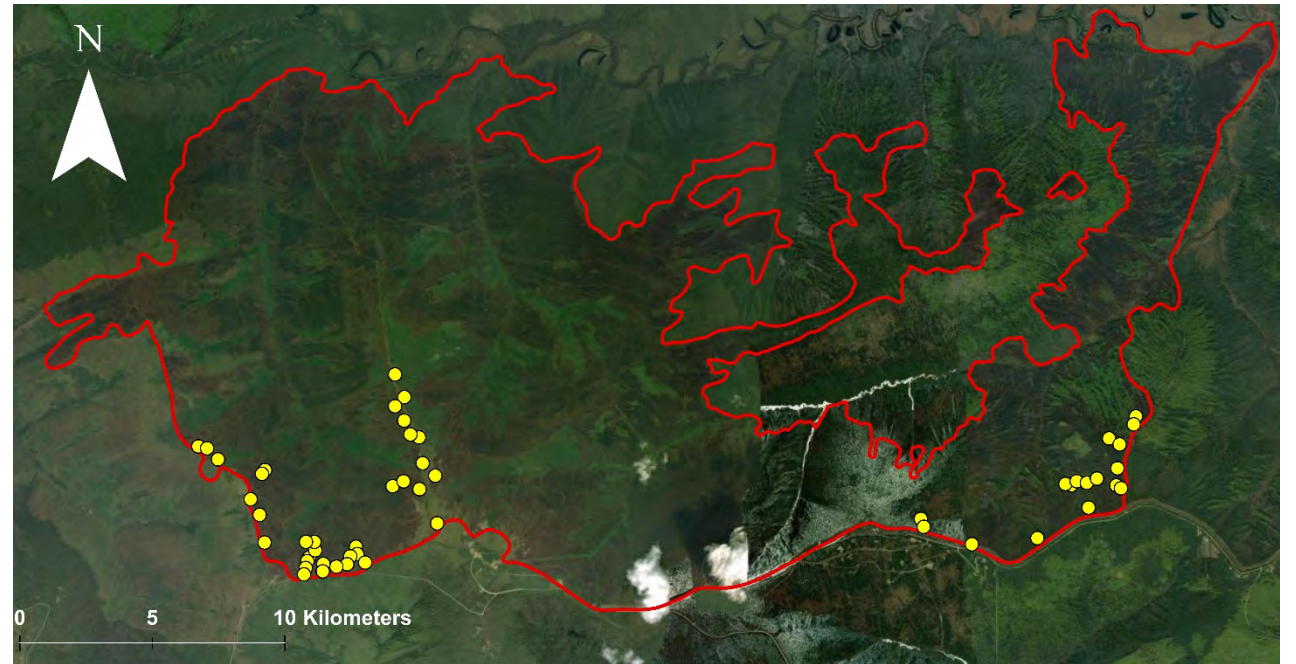
Photo Credit: Tom Moran

# Data

- Multispectral imagery (Sentinel-2)
- 30m circular modified CBI Plots assessing burn severity (Branes et al., 2020; Key and Benson, 2006)
- 2 m Arctic DEM (Source: Polar Geospatial Center, Univ. of Minnesota)
- Alaska Vegetation and Wetland Composite (Source: Alaska Center for Conservation Science, University of Alaska Anchorage )

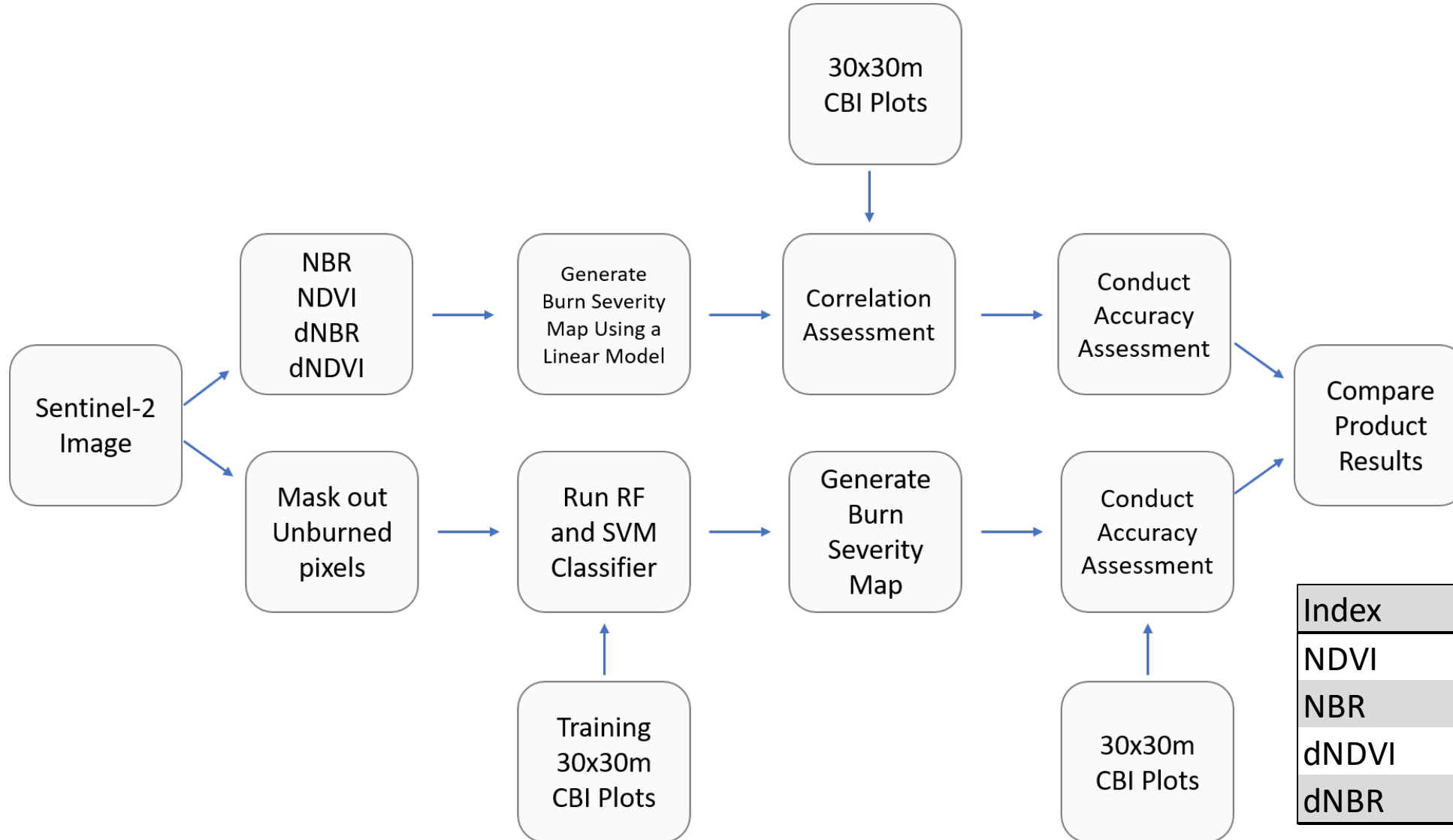


28 CBI plots at Nugget Creek



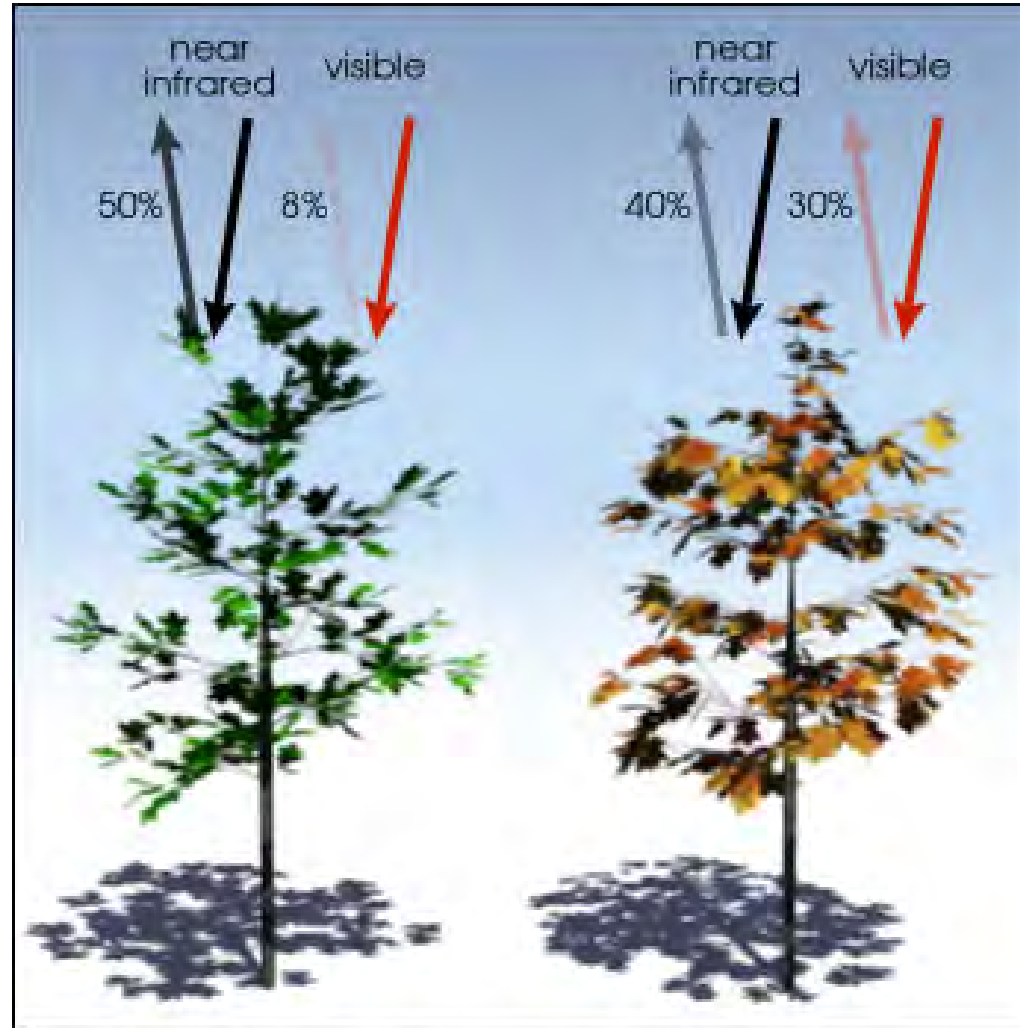
52 CBI plots at Shovel Creek

# Creating Burn Severity Map



| Index | Formula                      |
|-------|------------------------------|
| NDVI  | $(B4 - B8) / (B4 + B8)$      |
| NBR   | $(B8 - B12) / (B8 + B12)$    |
| dNDVI | Prefire NDVI - Postfire NDVI |
| dNBR  | Prefire NBR - Postfire NBR   |

# Normalized Differenced Vegetation Index



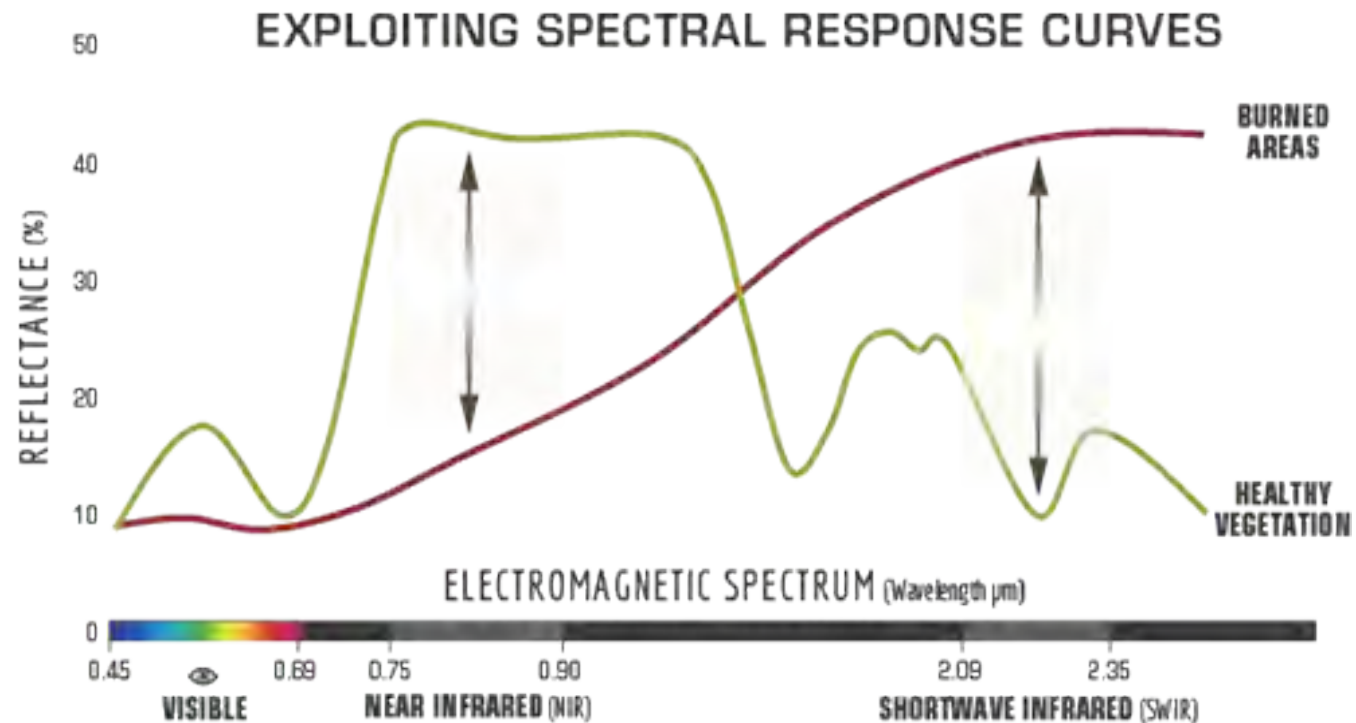
$$\frac{(0.50 - 0.08)}{(0.50 + 0.08)} = 0.72$$

$$\frac{(0.4 - 0.30)}{(0.4 + 0.30)} = 0.14$$

Image Credit: NASA

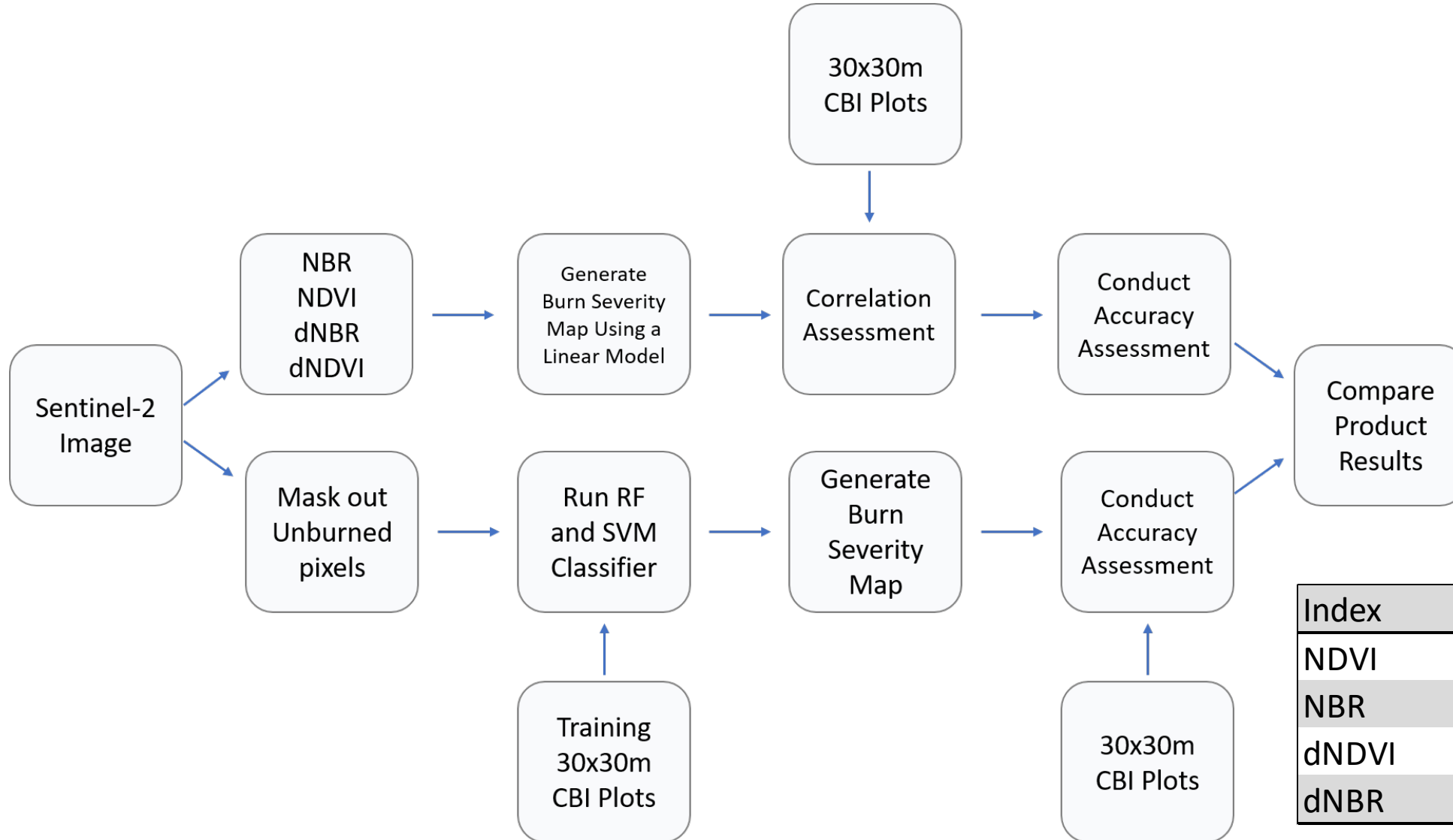
# Normalized Burn Ratio

Typical spectral signature curves for: **healthy vegetation** and **burned areas**



*Image Credit: US Forest Service*

# Creating Burn Severity Map



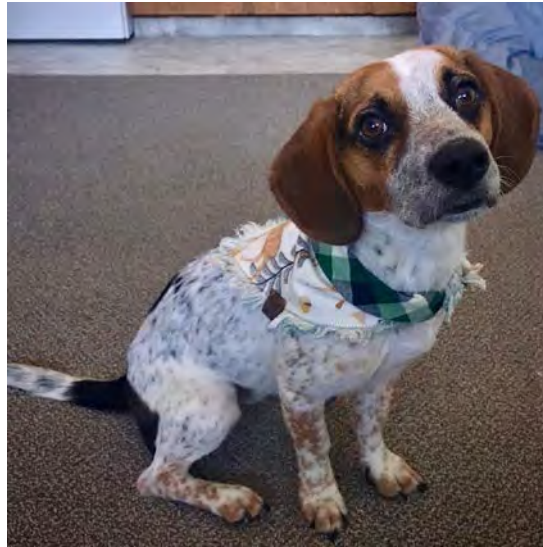
| Index | Formula                   |
|-------|---------------------------|
| NDVI  | $(B4 - B8) / (B4 + B8)$   |
| NBR   | $(B8 - B12) / (B8 + B12)$ |
| dNDVI | Prefire NDVI-PostfireNDVI |
| dNBR  | Prefire NBR-PostfireNBR   |

# Example of Decision Tree

You have three animals



Squirrel



Dog



Lion

Does the animal eat meat?

No

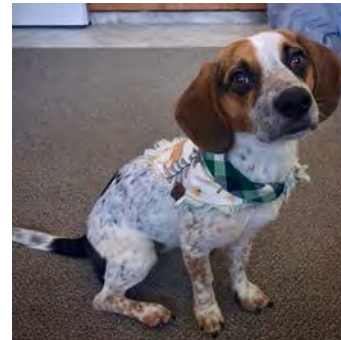
Yes



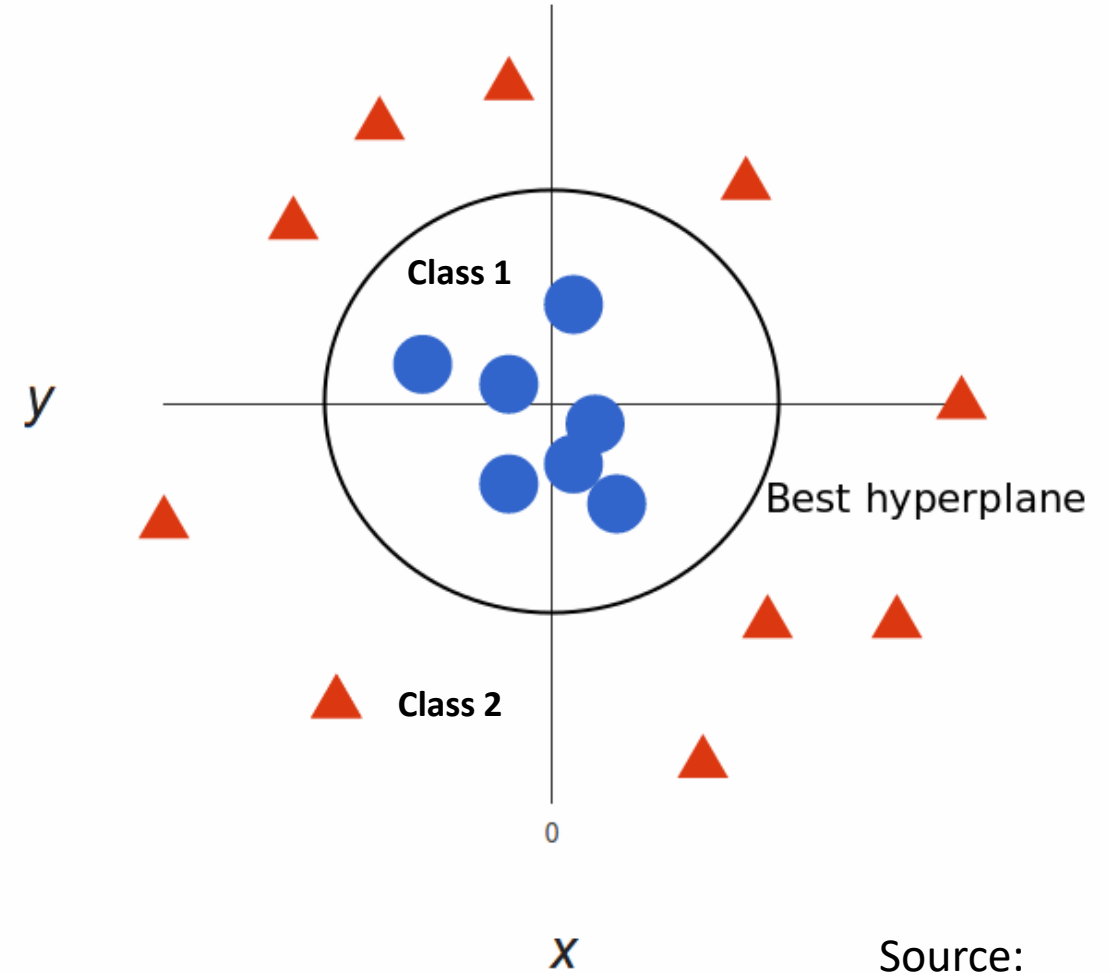
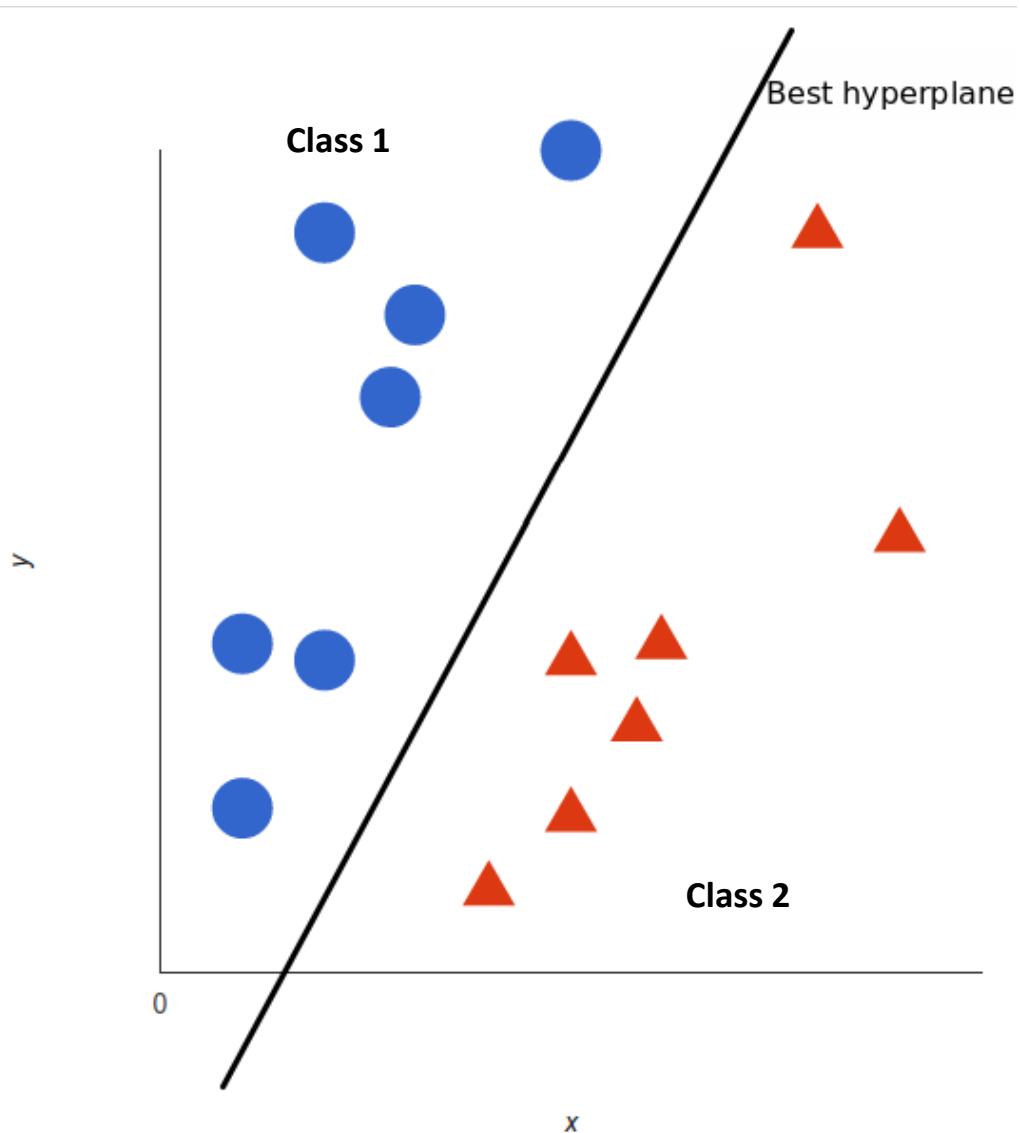
Does the  
animal bark?

No

Yes



# What is Support Vector Machine?



Source:  
Monkeylearn.com

# Vegetation Cover

| Shovel Creek     |           |
|------------------|-----------|
| Fuel Type        | Cover (%) |
| Conifer Forest   | 80.085    |
| Mixed Forest     | 11.781    |
| Shrub            | 4.427     |
| Deciduous Forest | 3.370     |
| Bare             | 0.337     |
| Grass            | 0         |

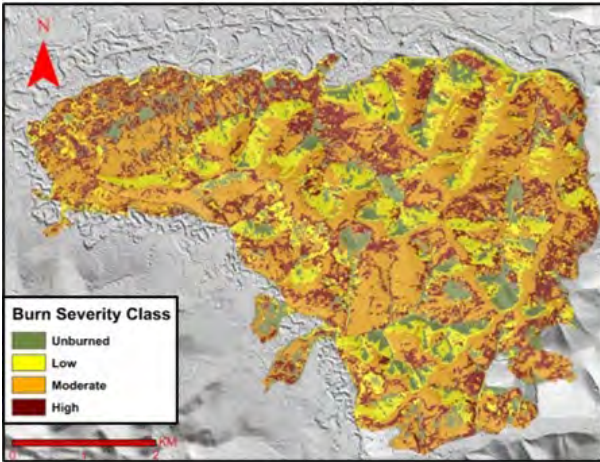
| Nugget Creek     |           |
|------------------|-----------|
| Fuel Type        | Cover (%) |
| Conifer Forest   | 72.728    |
| Mixed Forest     | 25.495    |
| Deciduous Forest | 1.424     |
| Shrub            | 0.290     |
| Bare             | 0.061     |
| Grass            | 0.003     |

**At both sites a majority of the vegetation that was burned were conifers**

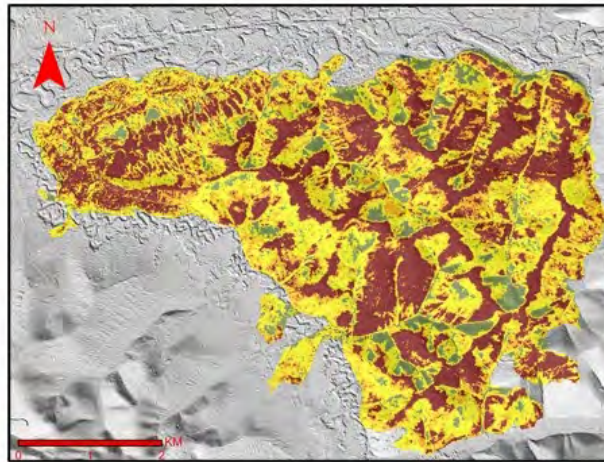
\* Based on Alaska Vegetation and Wetland  
Composite Source: Alaska Center for  
Conservation Science 2017

# Nugget Creek Results

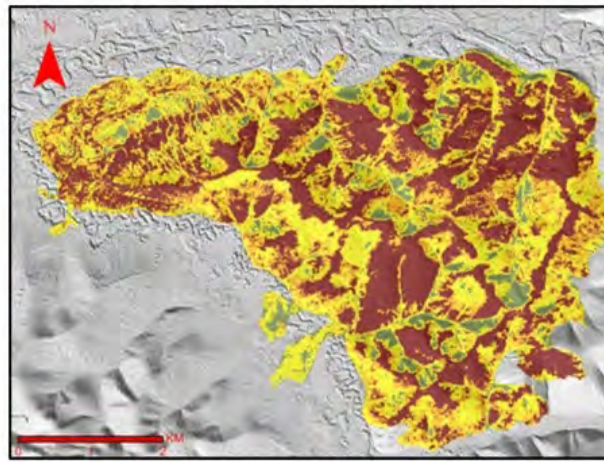
Random Forest



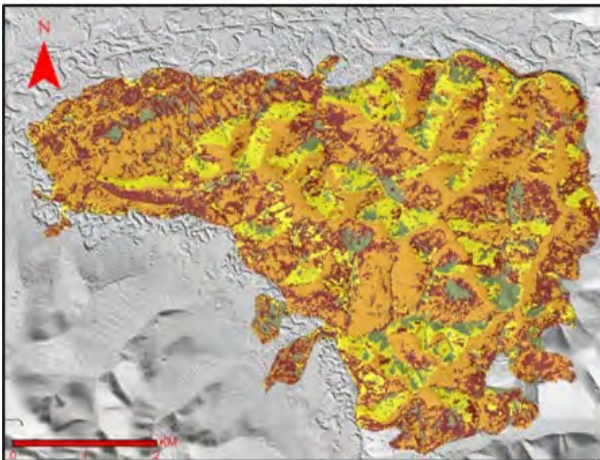
NBR



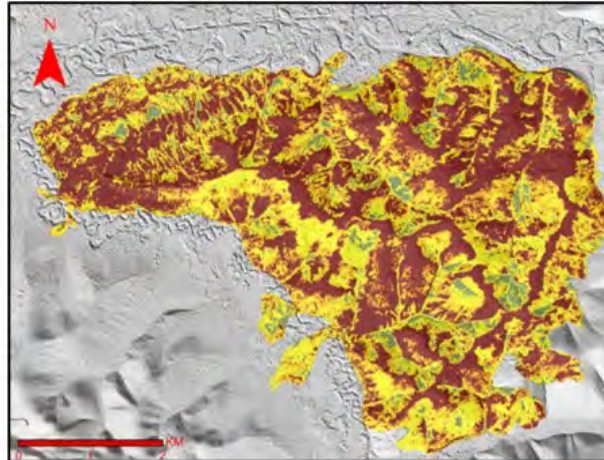
dNBR



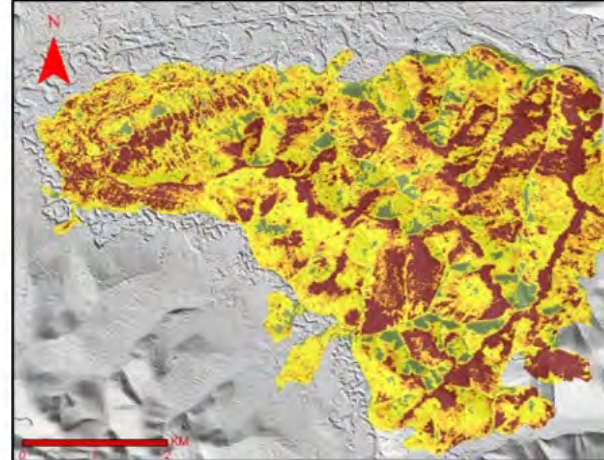
Support Vector Machine



NDVI



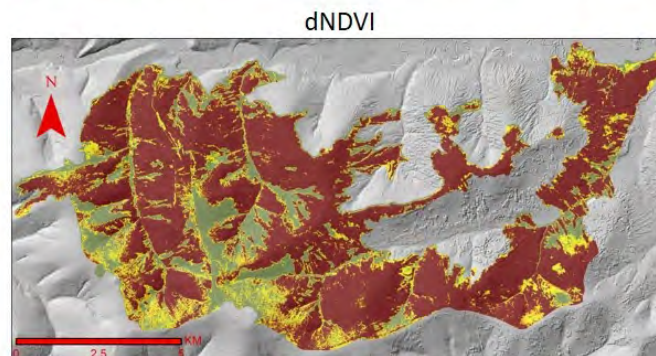
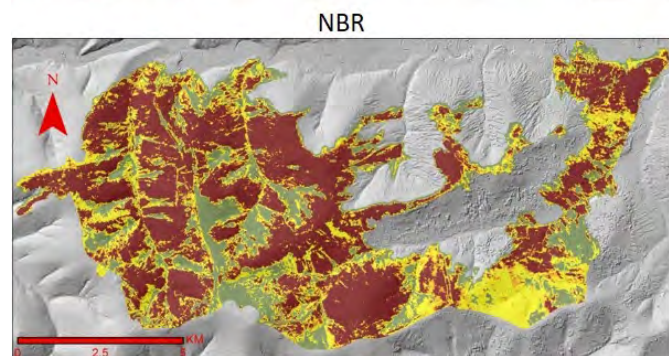
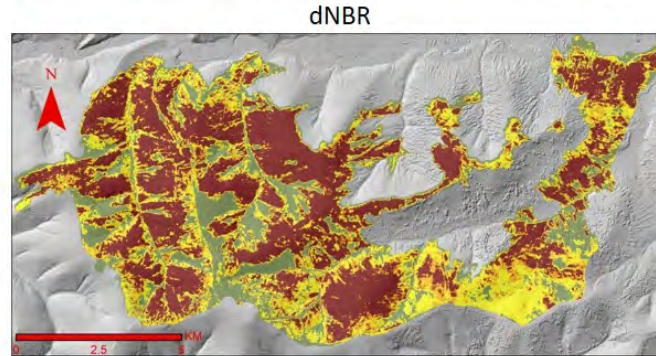
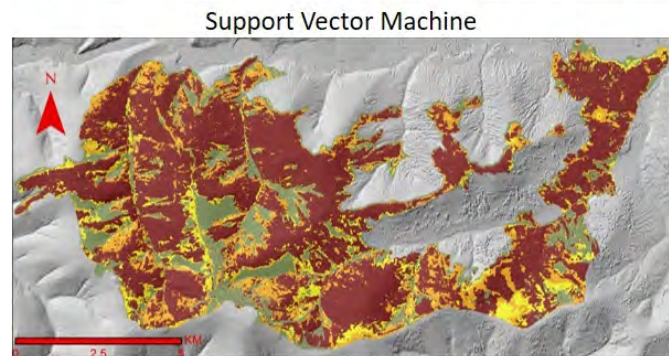
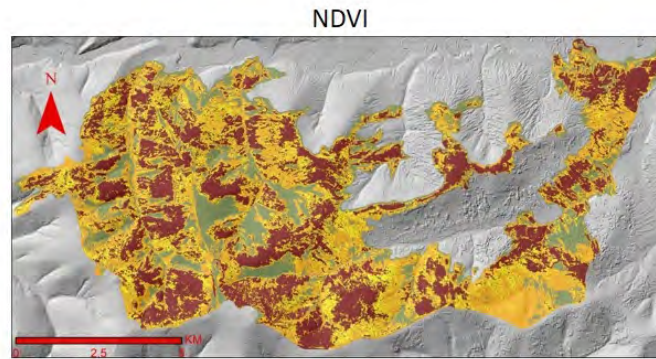
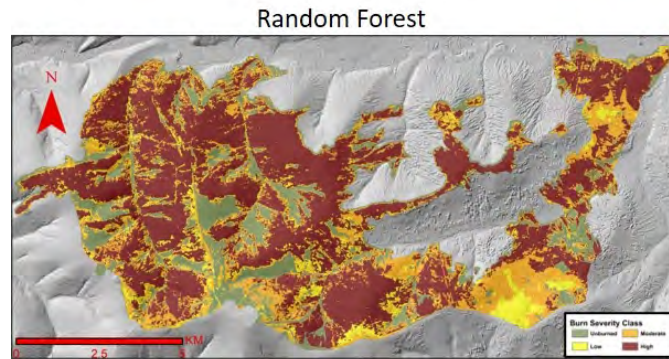
dNDVI



| Product | Accuracy |
|---------|----------|
| NDVI    | 96%      |
| dNBR    | 89%      |
| RF      | 78%      |
| NBR     | 75%      |
| dNDVI   | 71%      |
| SVM     | 67%      |

**NDVI outperformed all products at Nugget Creek**

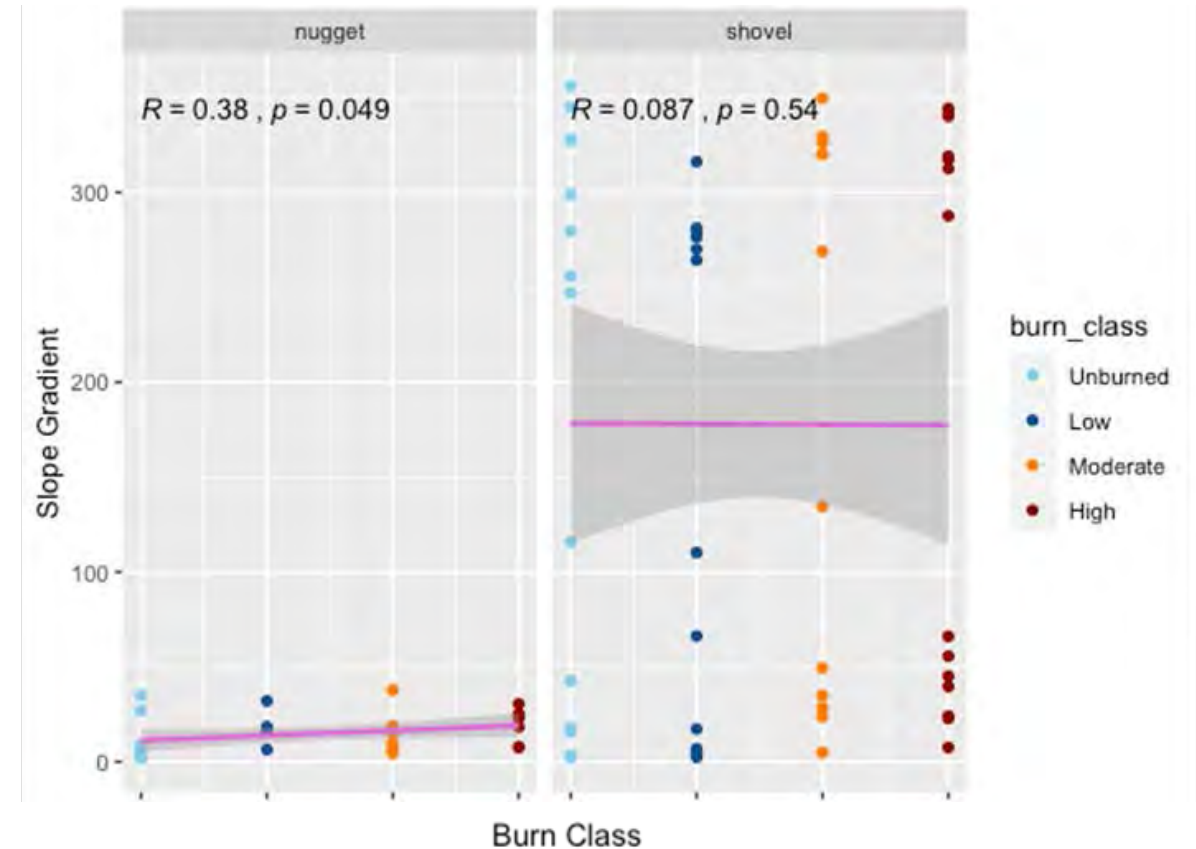
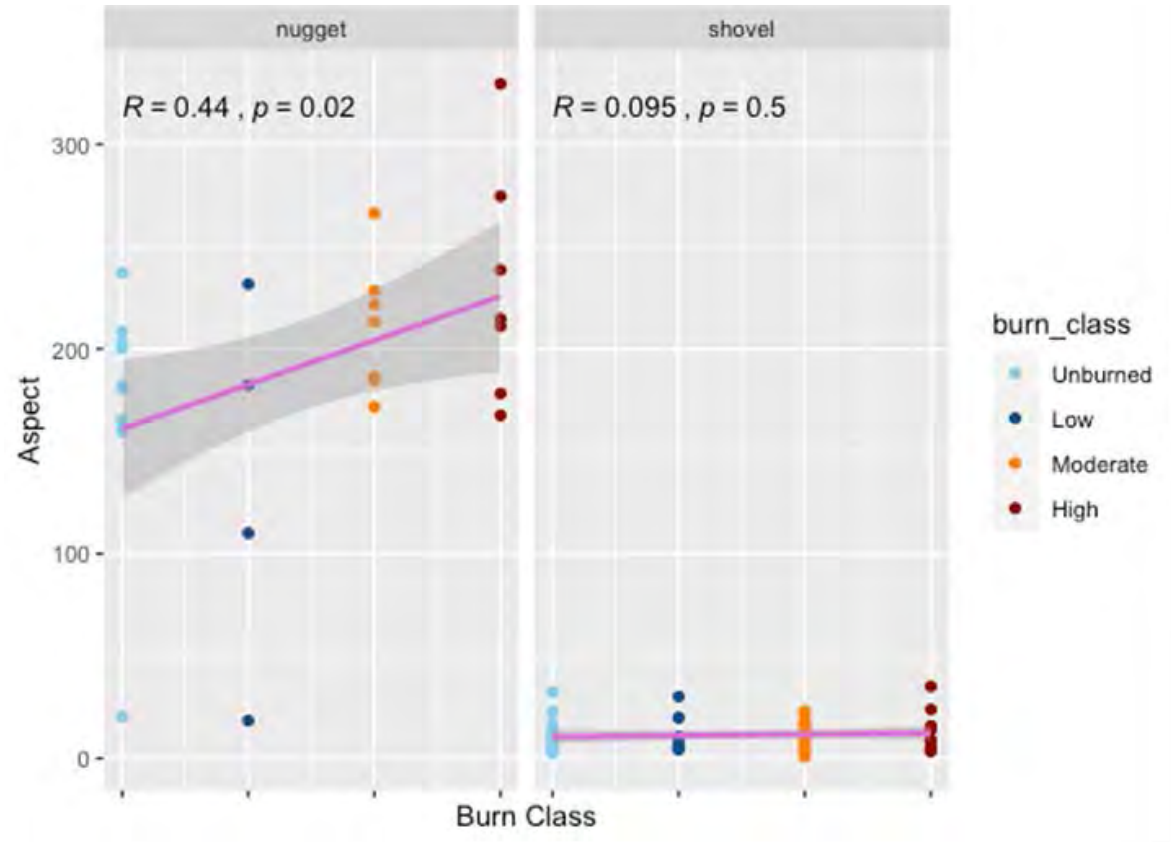
# Shovel Creek Results



| Product | Accuracy |
|---------|----------|
| SVM     | 83%      |
| RF      | 83%      |
| NBR     | 73%      |
| dNBR    | 73%      |
| NDVI    | 65%      |
| dNDVI   | 60%      |

**Machine Learning classifiers outperformed traditional indices at Shovel Creek**

# Burn Severity Relationship to Fire Factors



\* Based on Arctic DEM Source: Polar Geospatial Center, Univ. of Minnesota

## Key Findings:

- **Shovel Creek** products had an accuracy of:
  - **83%** using **Random Forest**
  - **83%** using **Support Vector Machine**
- **Nugget Creek** products had an accuracy of
  - **96%** using **NDVI**
- When field data is adequate supervised classification perform better than spectral indices
- When field data is limited spectral indices outperform supervised classification products
- Unlike prior studies differenced indices did not assess burn severity more accurately than post fire indices



Photo Credit: KTUU

## Boarder Impacts:

- Further investigate burn severity relationships to environmental characteristics

Can be used by managers to understand:

- Vegetation regrowth
- Erosion following fire
- Invasive species
- Changes in wildlife habitat
- Changes in recreation



Photo Credit: Tom Moran

# Questions?



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