

# Assessing Post-fire Burn Condition Using Remotely-sensed Commercial Imagery

Jess Clark



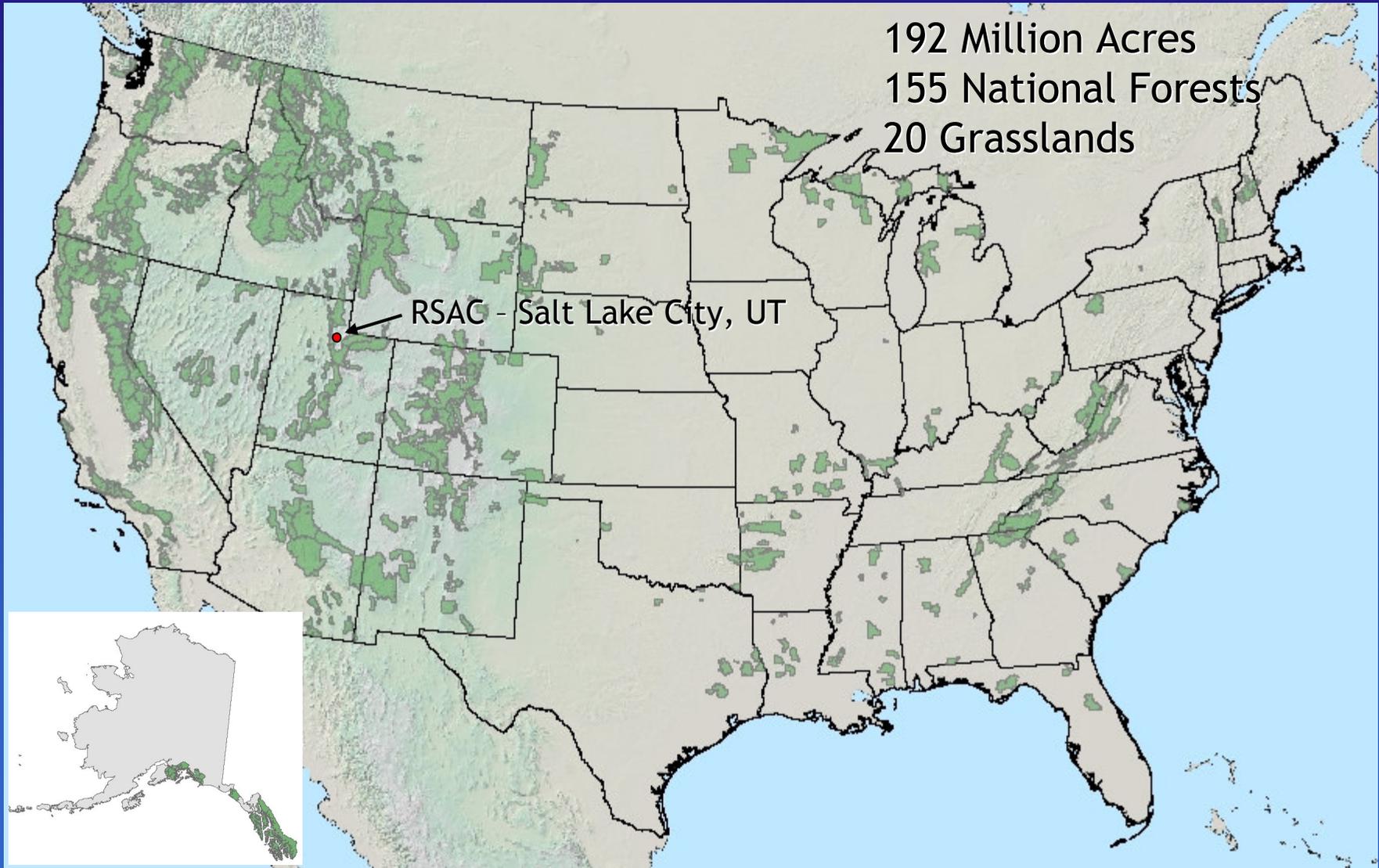
Civil Commercial Imagery Evaluation Workshop  
March 25-27, 2008 Fairfax, VA



USDA Forest Service Remote Sensing Applications Center (RSAC)



# Lands Managed by the USFS



# What is RSAC?

## Remote Sensing Applications Center

- Technical support - evaluating and developing remote sensing, image processing, GPS, and related geospatial technologies.
- Project support and assistance using remote sensing technologies.
- Technology transfer and training to field users.
- Operational support to tactical and strategic fire information needs.

# Operational Fire Support

- MODIS Active Fire Maps

USDA FOREST SERVICE      REMOTE SENSING APPLICATIONS CENTER      Canadian Fire Maps       Mexico Fire Maps 

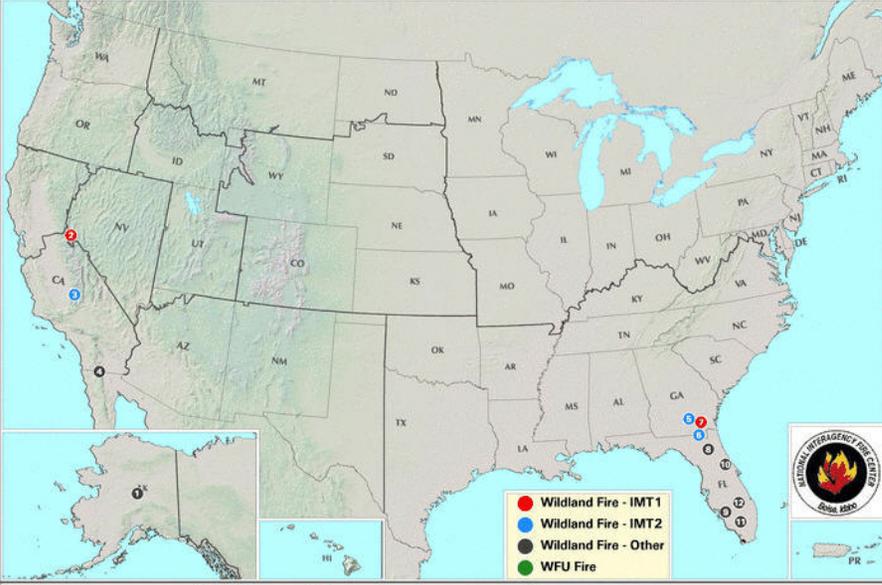
## MODIS Active Fire Mapping Program

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- ▶ BAER
- ▼ Active Fire Maps
  - Regional Maps
  - ArcIMS Maps
  - Imagery
  - GIS Data
  - Fire Detections
  - Other Products

Fire locations are based on data provided by the National Interagency Fire Center and are subject to change. Move your mouse over the fire indicators or click to see additional information (popups required).

### Large Incidents - June 08, 2007



1 MOOSEHEART	5 SWEAT FARM ROAD	9 MIDDLE OF NOWHERE
2 LARSON	6 BUGABOO SCRUB 2	10 DELAND COMPLEX
3 GOLDLEDGE	7 BIG TURNAROUND COMPLEX	11 BICY COMPLEX
4 INKOPAH	8 DAIRY ROAD	12 OKEECHOBEE COMPLEX


  
**Remote Sensing Applications Center**  
 2222 W. 2300 South  
 Salt Lake City, UT  
 84119 - 2020  
 voice: (801) 975-3737  
 fax: (801) 975-3478







# Operational Fire Support

- National Infrared Operations (NIROPS)

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## National Infrared Operations

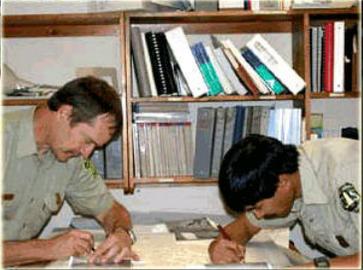
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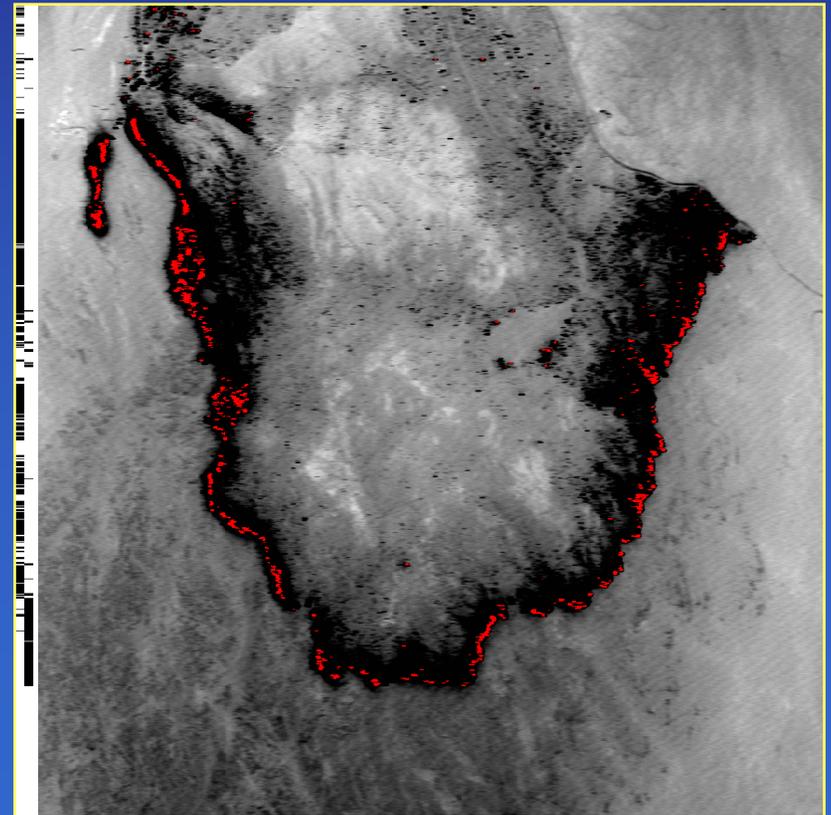
NIROPS  
3833 S Development Ave  
Boise, ID 83705  
voice: (208) 387-5647  
fax: (208) 387-5560



Serving the Fire Management Community with Infrared Imagery Since 1964



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# Operational Fire Support

- Post-fire Assessment - Rapid, Immediate, and Extended
  - Burned Area Emergency Response (BAER)
  - Rapid Assessment of Vegetation condition after Wildfire (RAVG)
  - Monitoring Trends in Burn Severity (MTBS)

# Operational Fire Support

- Burned Area Emergency Response (BAER)

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## Remote Sensing Applications Center

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- ▶ Digital Aerial Sketch Mapping
- ▶ Lidar Introduction
- ▶ Lidar Fusion Tutorial
- ▶ Monitoring Trends in Burn Severity (MTBS)

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**USGS Center for EROS**  
47914 252nd Street  
Sioux Falls, SD  
57198 - 0001  
800-252-4547  
605-594-6589 fax  
[EROS Website](#)



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### Burned Area Emergency Response (BAER) Imagery Support

The BAER Imagery Support program is a cooperative effort between the USDA Forest Service Remote Sensing Applications Center and the US Geological Survey Center for Earth Resources Observation and Science. The Centers have teamed up to provide rapid delivery of satellite imagery, Burned Area Reflectance Classifications (BARC), and other geospatial data to Forest Service and DOI BAER teams.

- Request Imagery & BARC Maps
- Image Acquisition Status & Summary
- Download BARC Data
- About BARC
- Remote Sensing Training Module
- Joint Fire Science Program
- Links



# Burned Area Emergency Response (BAER)

## Emergency Stabilization and Rehabilitation

- Fast-Track emergency assessment
- Assess effects of the fire on the soil and watershed hydrologic function (erosion and flood potential) for risks to:
  - life
  - property
  - long-term soil productivity
  - water quality
  - resources



# BAER Team Objective

## Develop a Rehabilitation Plan Within 7 Days



Inventory T&E  
species habitat  
affected

Evaluate artifacts  
and cultural  
resources

Predict runoff,  
flooding, threats  
to water quality

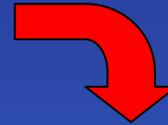
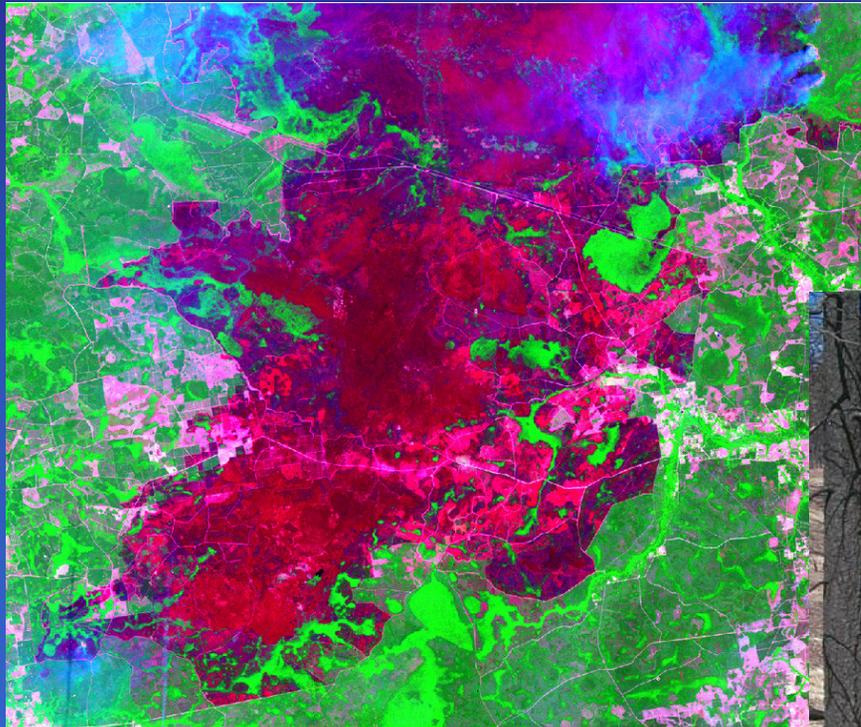
Determine erosion  
potential, threats to  
soil productivity

Prepare timber  
salvage plans and  
estimate  
reforestation needs

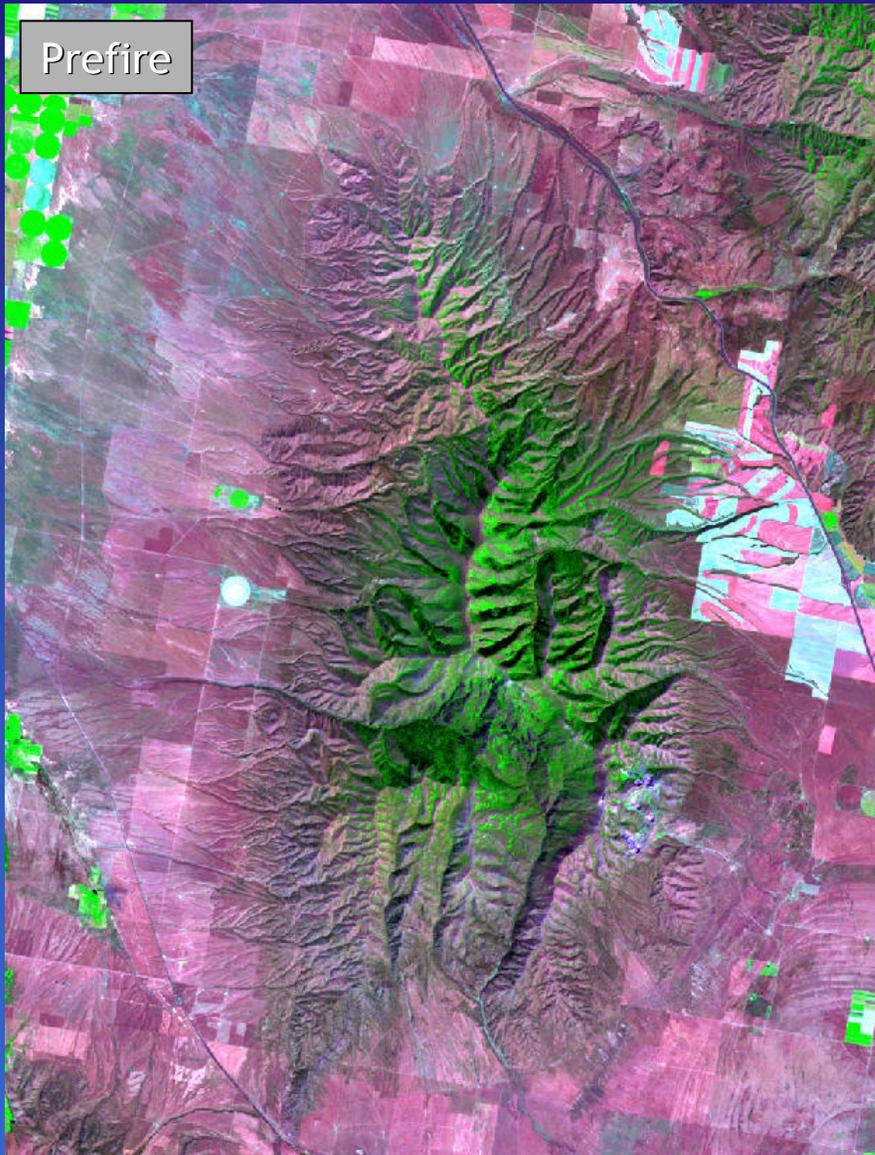


# Operational Fire Support

- How do we go from satellite imagery to hillslope treatments?



# Creation of the BARC



Black Pine 2 Fire  
Sawtooth NF  
73,000 Acres

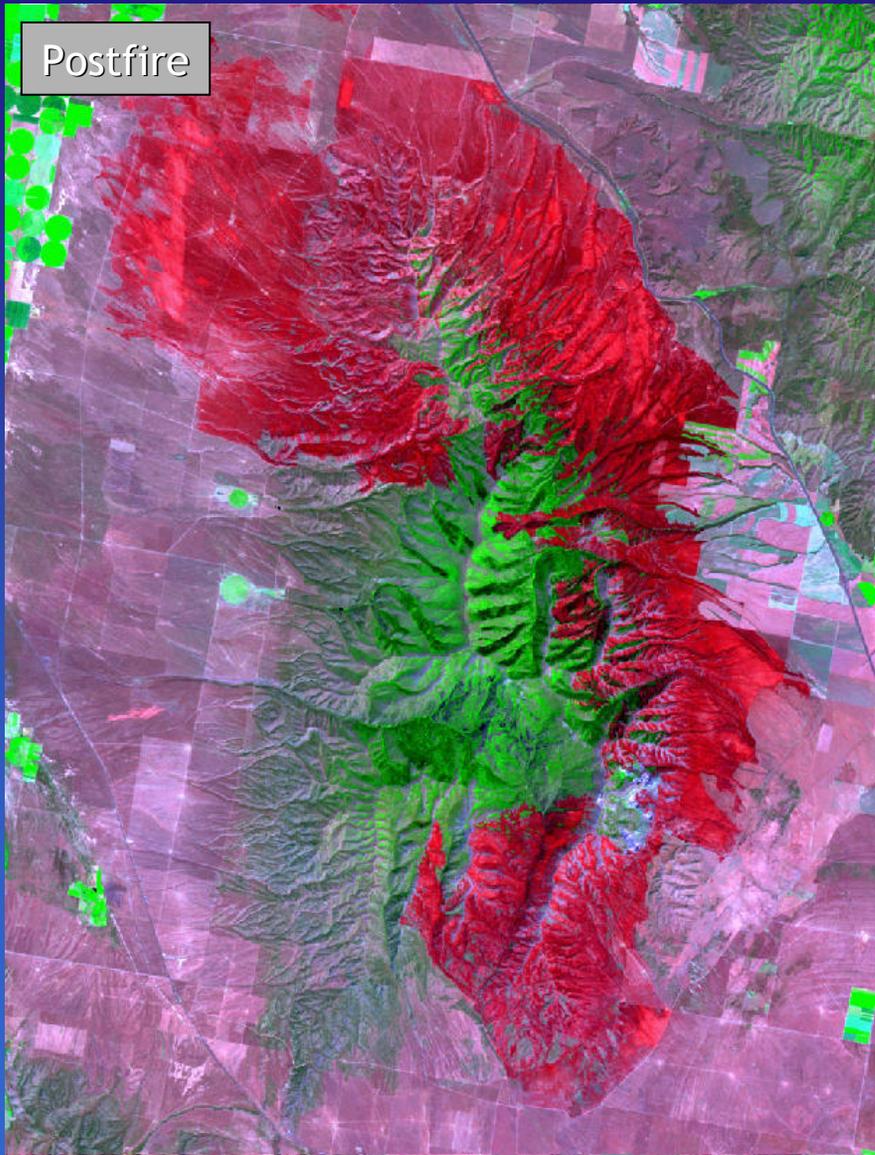
Normalized Burn Ratio (NBR)  
Differenced Normalized Burn Ratio (dNBR)

---

$$\text{NBR} = (\text{NIR} - \text{Mid IR}) / (\text{NIR} + \text{Mid IR})$$

$$\text{dNBR} = \text{Pre NBR} - \text{Post NBR}$$

# Creation of the BARC



Black Pine 2 Fire  
Sawtooth NF  
73,000 Acres

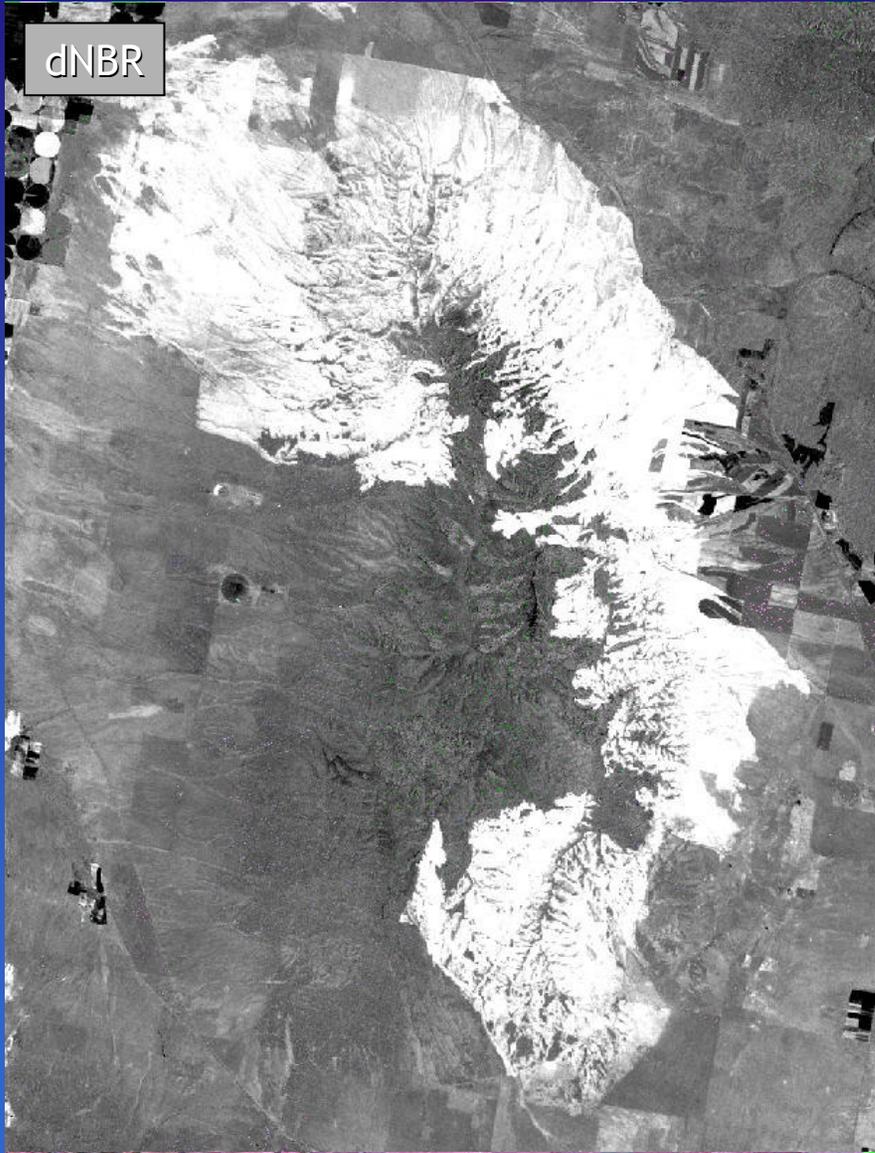
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# Creation of the BARC



## Black Pine 2 Fire Sawtooth NF 73,000 Acres

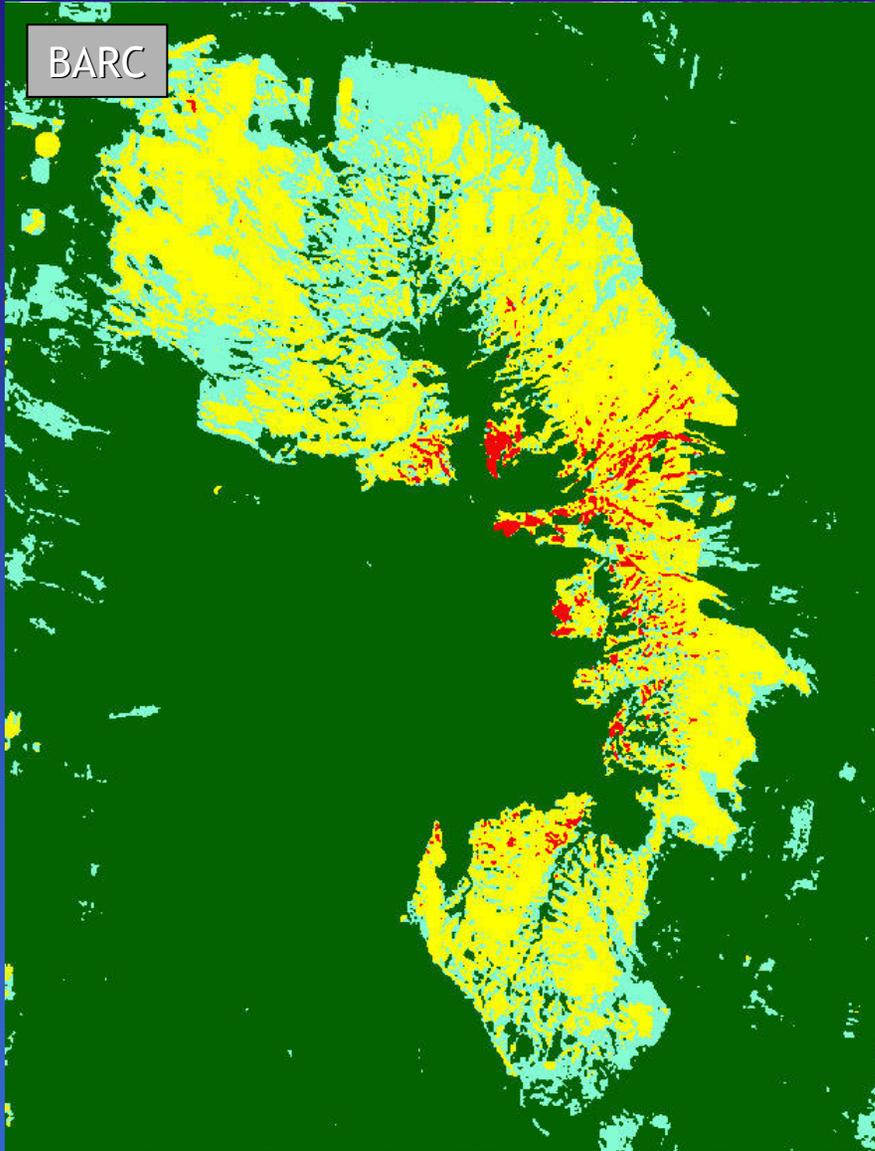
Normalized Burn Ratio (NBR)  
Differenced Normalized Burn Ratio (dNBR)

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# Creation of the BARC



Black Pine 2 Fire  
Sawtooth NF  
73,000 Acres

Normalized Burn Ratio (NBR)  
Differenced Normalized Burn Ratio (dNBR)

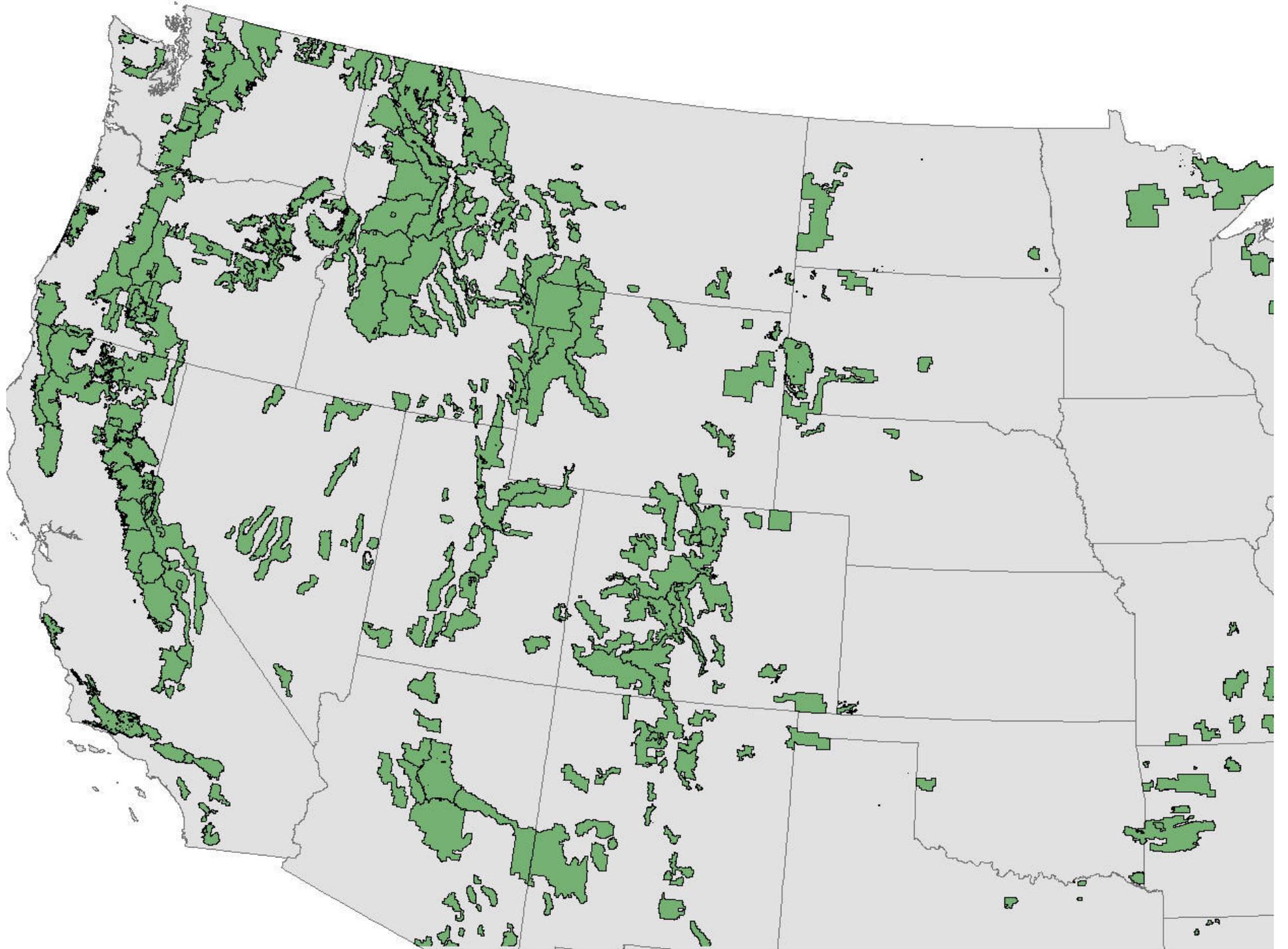
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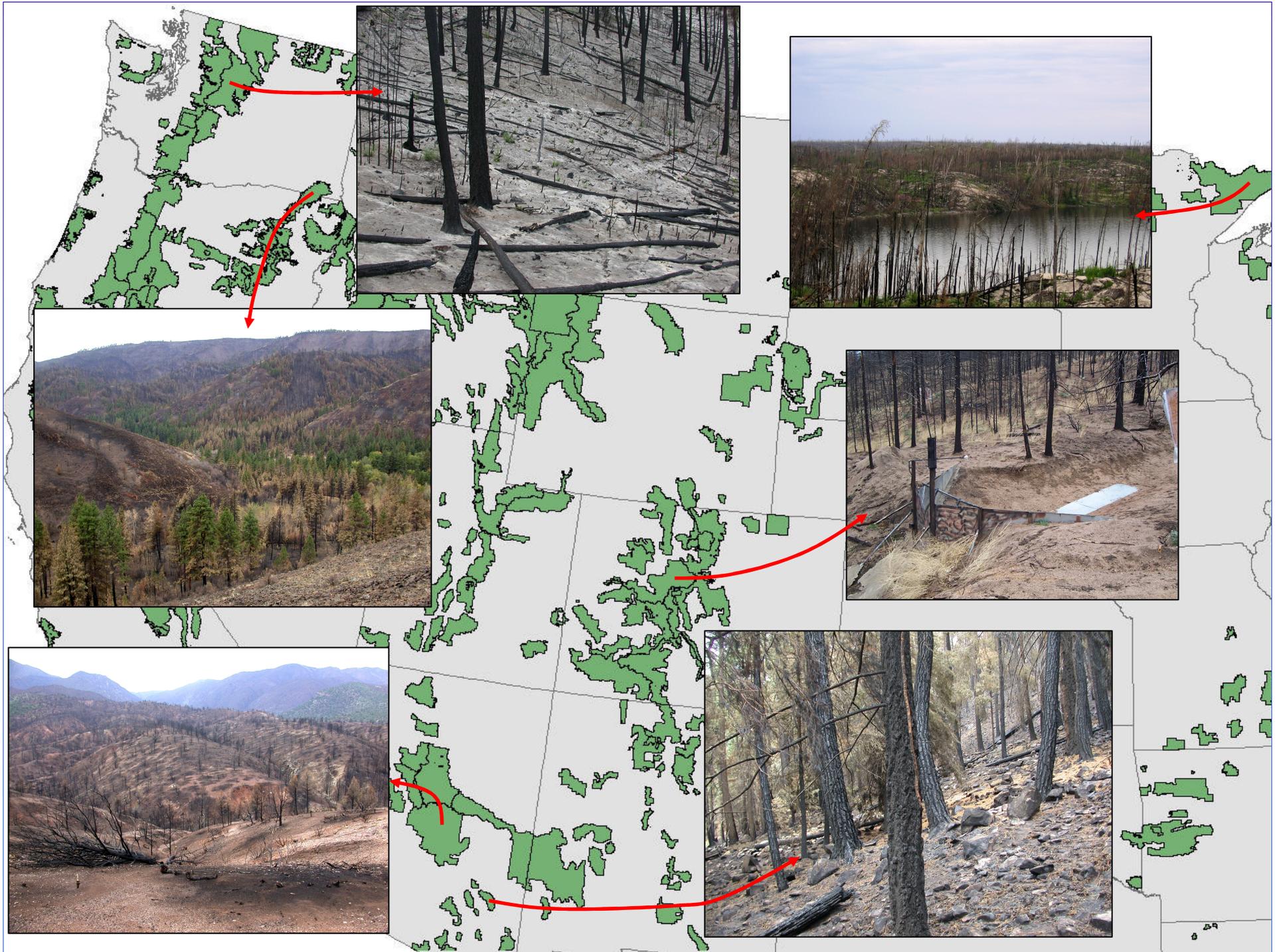
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$$\text{dNBR} = \text{Pre NBR} - \text{Post NBR}$$

# Deliverables

- Prefire image subset
- Postfire image subset
- BARC4
  - ◆ Thematic raster image thresholded into 4 discrete classes (unburned, low, moderate, high).
- BARC256
  - ◆ Continuous raster image with values between 0-255, colored like the BARC4. Thresholds easily adjustable.
- Metadata
  - ◆ FGDC-compliant metadata for delivered products.
- 3D Drapes / Applications
  - ◆ Static images, video flyby's, Google Earth KMZ files
- All delivered within 2 hours of receipt of imagery from providers



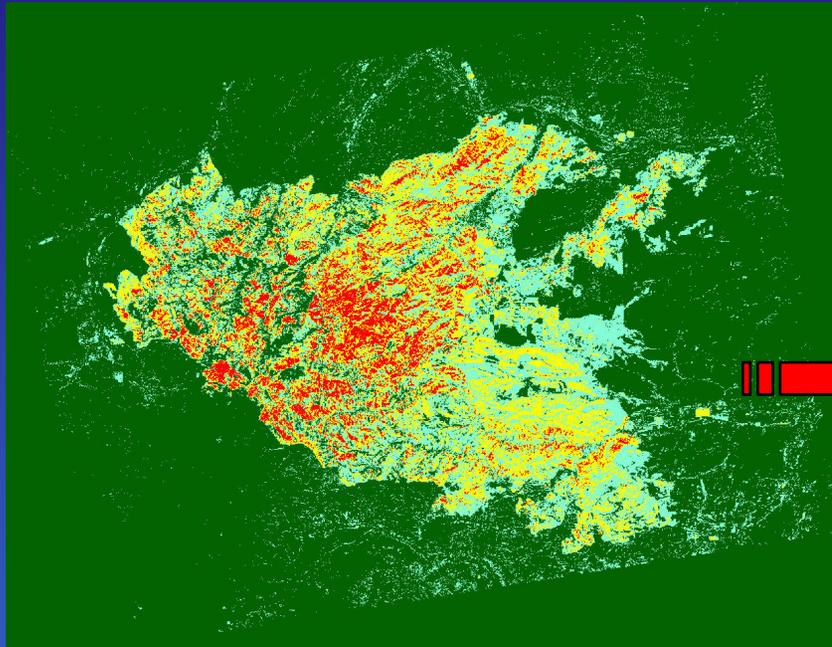


# BARC to Soil Burn Severity

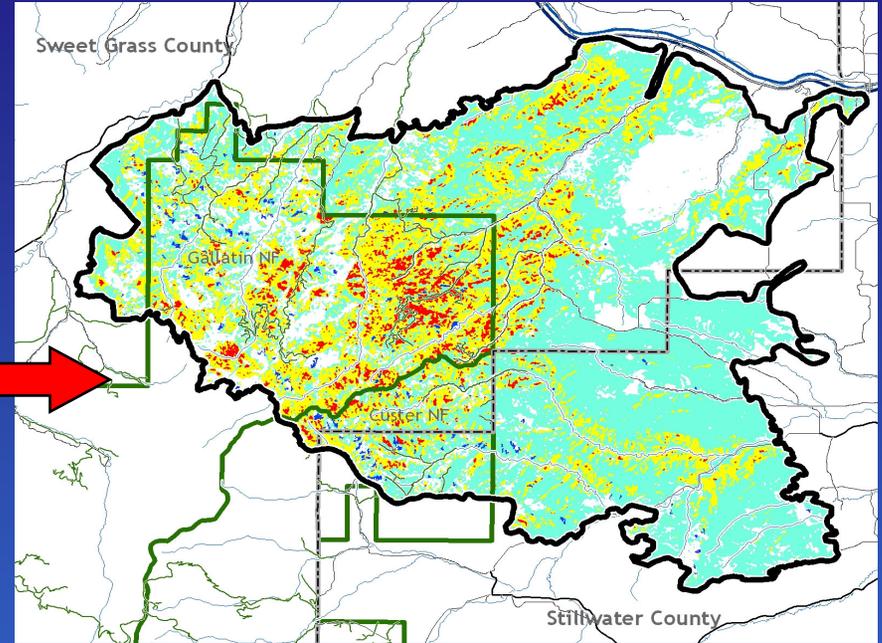
- Teams are required to:
  - ◆ Clip to fire perimeter
  - ◆ Verify accuracy with field observations
  - ◆ Adjust thresholds between severity classes
  - ◆ Map unknown areas obscured in imagery by clouds, smoke, active fire, snow...



# BARC to Soil Burn Severity



Delivered BARC



Final Soil Burn Severity

The final soil burn severity map acts as a baseline layer for further analysis

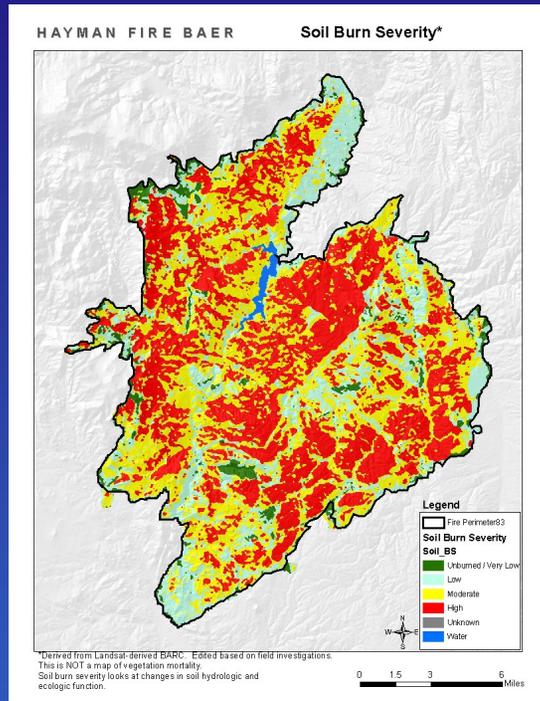
# Soil Burn Severity to Derivatives

- Watershed Response
  - How much **runoff** and **sedimentation** can we expect during a particular weather event?
- Ecosystem Response
  - What **values** (cultural / health and human safety / private property / infrastructure / etc.) **are at risk** downstream due to the wildfire?

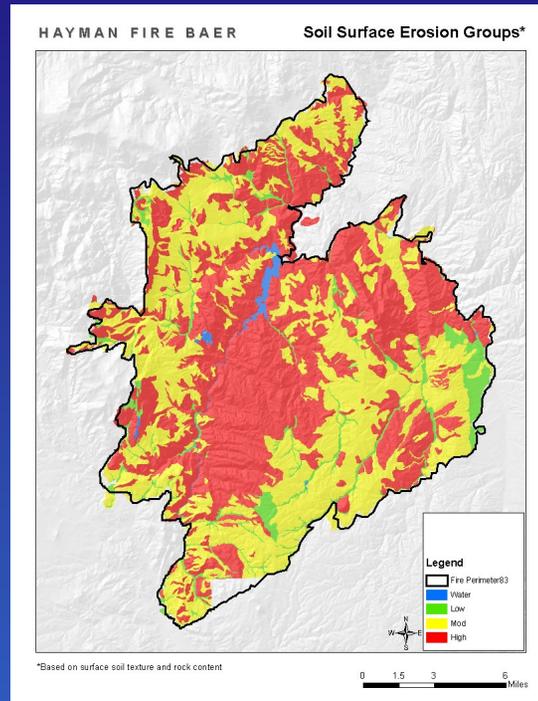
# Progression of Modeling Tools - BAER

- Revised Universal Soil Loss Equation (RUSLE)
  - Estimates average annual soil loss and sediment yield resulting from interrill and rill erosion.
- Water Erosion Prediction Project (WEPP)
  - Simulates interrill and rill erosion processes and incorporates the processes of evapotranspiration, infiltration, runoff, soil detachment, sediment transport, and sediment deposition to predict runoff and erosion at the hillslope scale.
- Erosion Risk Management Tool (ERMiT)
  - Uses multiple runs of WEPP over a range of input parameters to predict event sediment delivery in probabilistic terms on burned and recovering forest, range, and chaparral lands.

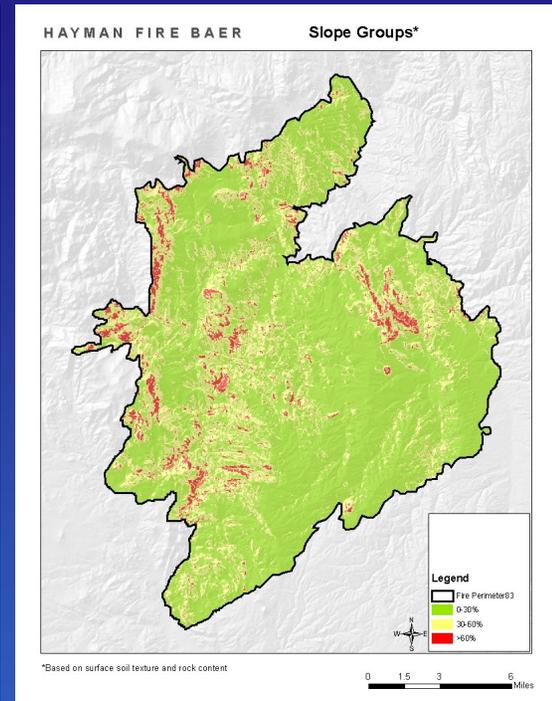
# Pre-processing for ERMiT



Soil Burn Severity



Soil Erosion Groups



Slope Groups

Overlay layers to determine unique combinations and the number of ERMiT runs necessary to characterize burned area

# ERMiT Web Interface



## Erosion Risk Management Tool



(- \*) Climate (+)

CHARLESTON KAN AP WV  
MOSCOW U OF I ID  
DENVER WB AP CO  
BIRMINGHAM WB AP AL  
FLAGSTAFF WB AP AZ  
MOUNT SHASTA CA  
SEXTON SUMMIT WB OR

Custom Climate

Soil Texture ?

clay loam  
silt loam  
sandy loam  
loam

Rock content ?

20 %

<u>Vegetation type</u> ?	<u>Hillslope gradient</u> ?	<u>Hillslope horizontal length</u> ?	<u>Soil burn severity class</u> ?
Forest Range Chaparral	Top 0 % Middle 50 % Toe 30 %	300 ft	<input type="radio"/> High <input type="radio"/> Moderate <input checked="" type="radio"/> Low
<u>Range/chaparral pre-fire community description</u> ?			■■■■
% shrub	% grass	% bare	

Run ERMiT

### Citation:

Robichaud, Peter R.; Elliot, William J.; Pierson, Fredrick B.; Hall, David E.; Moffet, Corey A. 2006. **Erosion Risk Management Tool (ERMiT) Ver. 2006.01.18**. [Online at <<http://forest.moscowfs.wsu.edu/fswepp/>>.] Moscow, ID: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station.

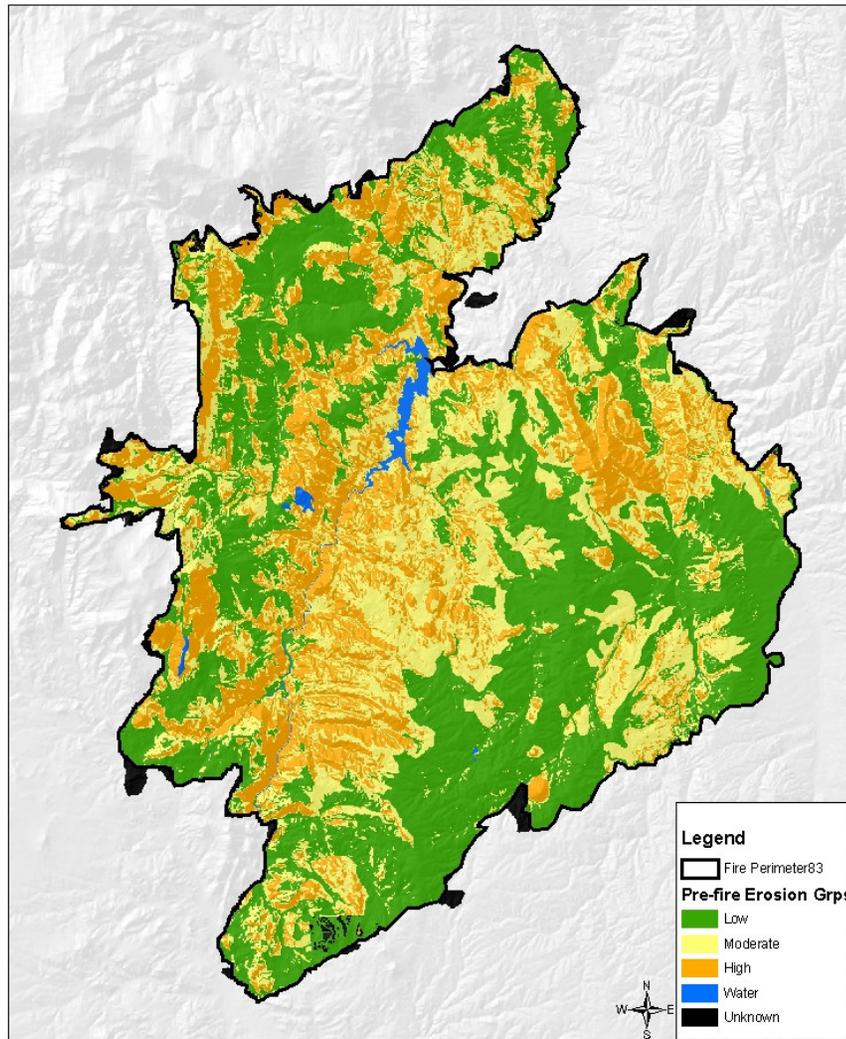
73 ERMiT runs to date in 2008 (2,874 runs in 2007). Personality ""



# ERMiT Results Spatially Applied

HAYMAN FIRE BAER

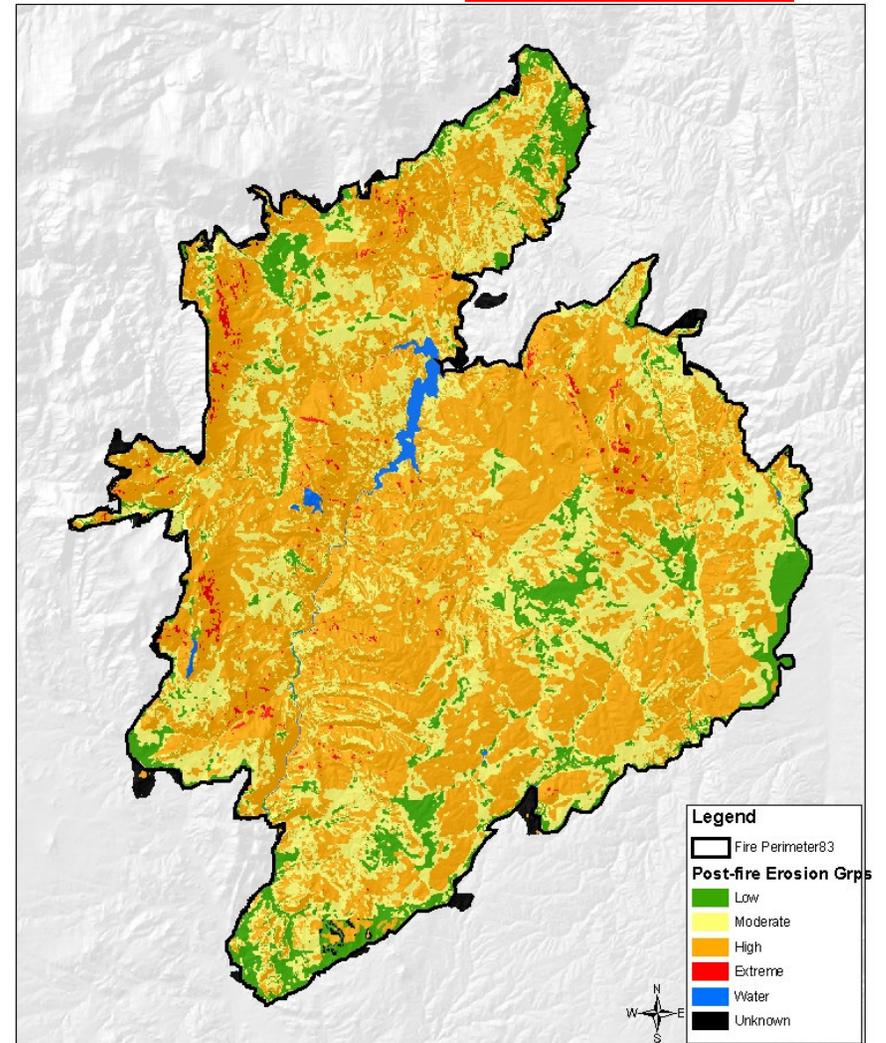
Pre-Fire Erosion Rate\*



\*Using ERMiT Erosion Modeling Tool  
<http://forest.moscowfsl.su.edu/cgi-bin/fswpep>

HAYMAN FIRE BAER

Post-Fire Erosion Rate\*



\*Using ERMiT Erosion Modeling Tool  
<http://forest.moscowfsl.su.edu/cgi-bin/fswpep>

# Treatment Implementation

- Model results drive treatment location and amounts:
  - ◆ Hydromulching
  - ◆ Log erosion barriers...



*Photos courtesy of Pete Robichaud, USFS RMRS*

# Treatment Implementation

- Model results drive treatment location and amounts:
  - ◆ Seeding
  - ◆ Straw Mulching



# Sensors Used

Landsat 5 and 7 SLC-Off

ASTER

SPOT 4 and 5

AWiFS

NASA Ikhana

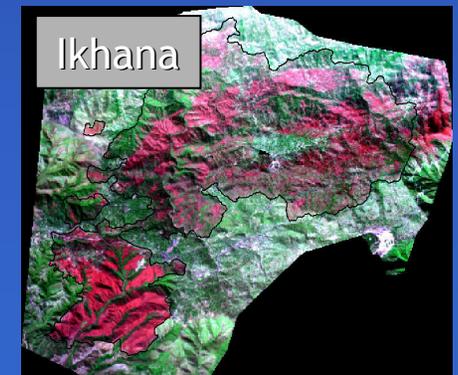
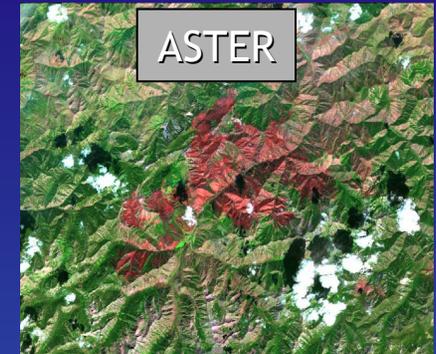
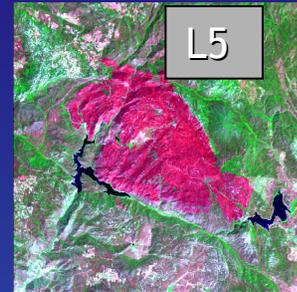
Disaster Monitoring Constellation (DMC)

MODIS

MASTER

IKONOS

Quickbird



# Fire Support Statistics

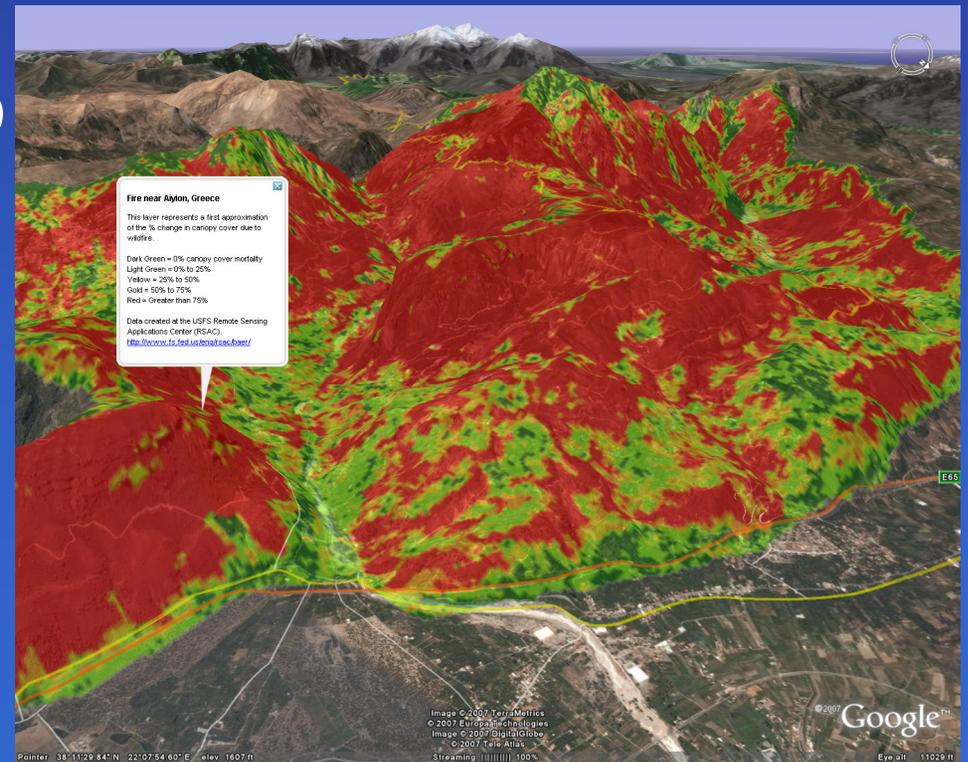
Year	USGS-EROS		USFS-RSAC		Sum	
	Fires	Acres	Fires	Acres	Fires	Acres
2001	5	N/A	15	310,500	20	310,500
2002	10	500,000	73	2,710,599	83	3,210,599
2003	17	307,034	54	1,637,471	71	1,944,505
2004	24	5,000,000	25	471,102	49	5,471,102
2005	23	800,000	46	734,559	69	1,534,559
2006	61	2,532,907	115	2,470,856	176	5,003,763
2007	48	2,422,130	106	3,508,407	154	5,930,537
<b>Sum</b>	<b>188</b>	<b>11,562,071</b>	<b>434</b>	<b>11,841,324</b>	<b>622</b>	<b>23,405,565</b>



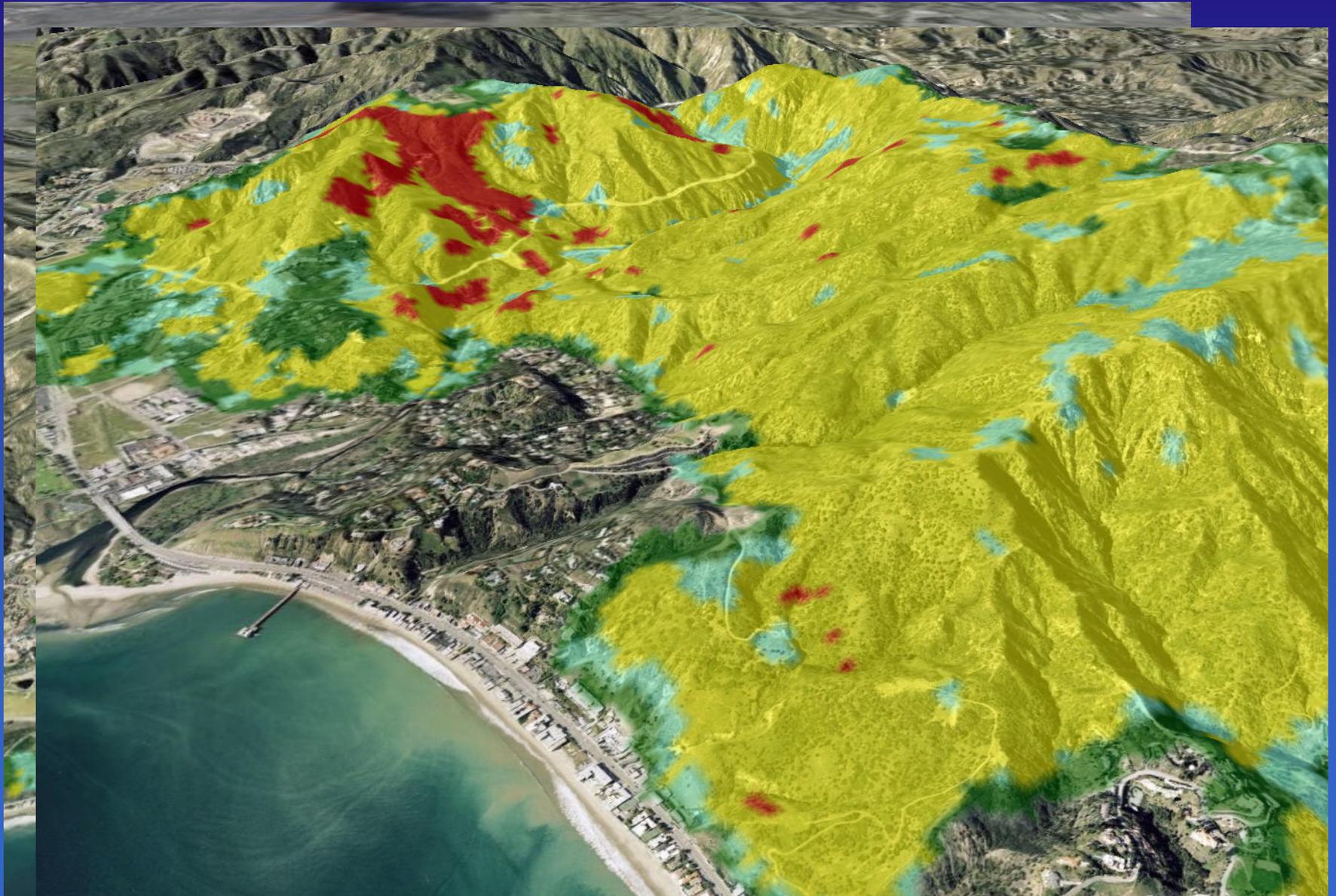
Collaborative effort between USFS-RSAC and USGS-EROS

# International Support – 2007

- RSAC supported 3 fires in Canada and 14 fires in Greece
  - 17 fires: 609,115 acres
  - Imagery and derived products shared in Google Earth
  - Partnership with USAID and Office of Foreign Disaster Assistance (OFDA)



# 3D Applications – Google Earth



## More Information

BAER Support Lead  
Jess Clark

Operations Program Leader  
Brian Schwind

801-975-3750  
[www.fs.fed.us/eng/rsac/baer](http://www.fs.fed.us/eng/rsac/baer)