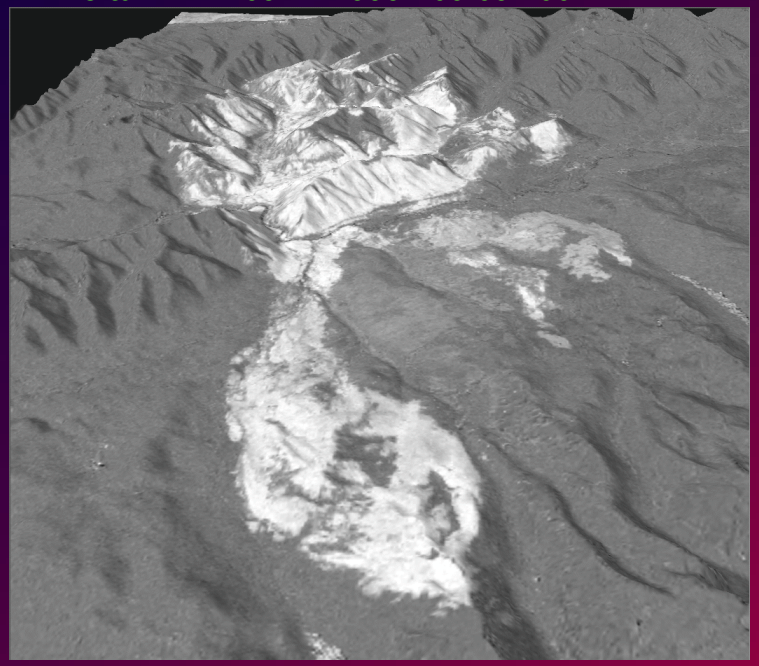
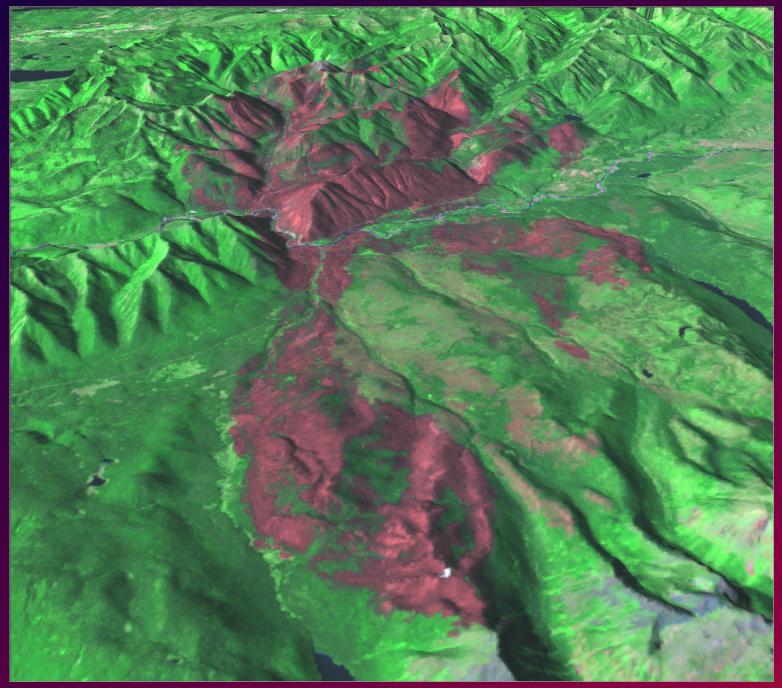
The Normalized Burn Ratio and relationships to burn severity: ecology, remote sensing and implementation.

Carl Key, USGS Northern Rocky Mtn Sci Cent
Nate Benson, National Park Service
Donald Ohlen, USGS EROS Data Center
Stephen Howard, USGS EROS Data Center
Zhiliang Zhu, USGS EROS Data Center

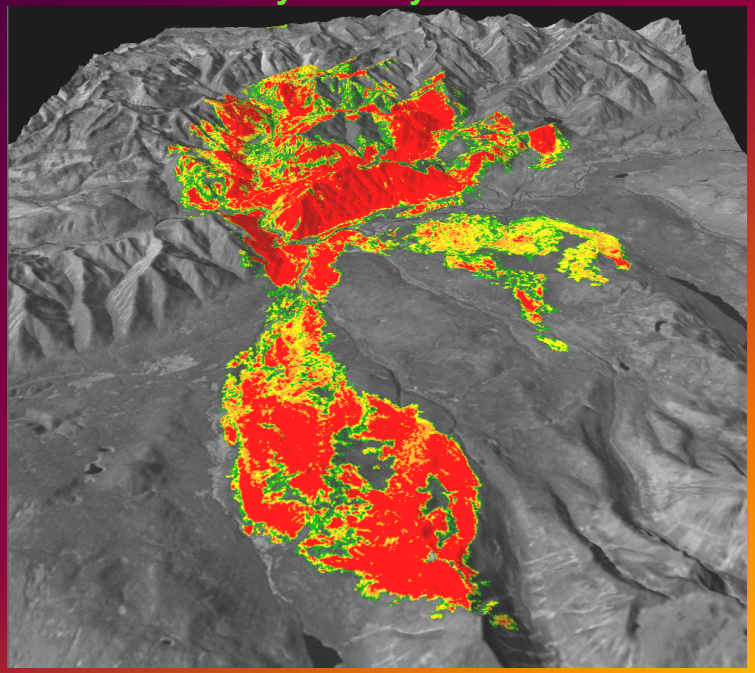
Delta NBR: 09/12/1999 - 09/09/2001

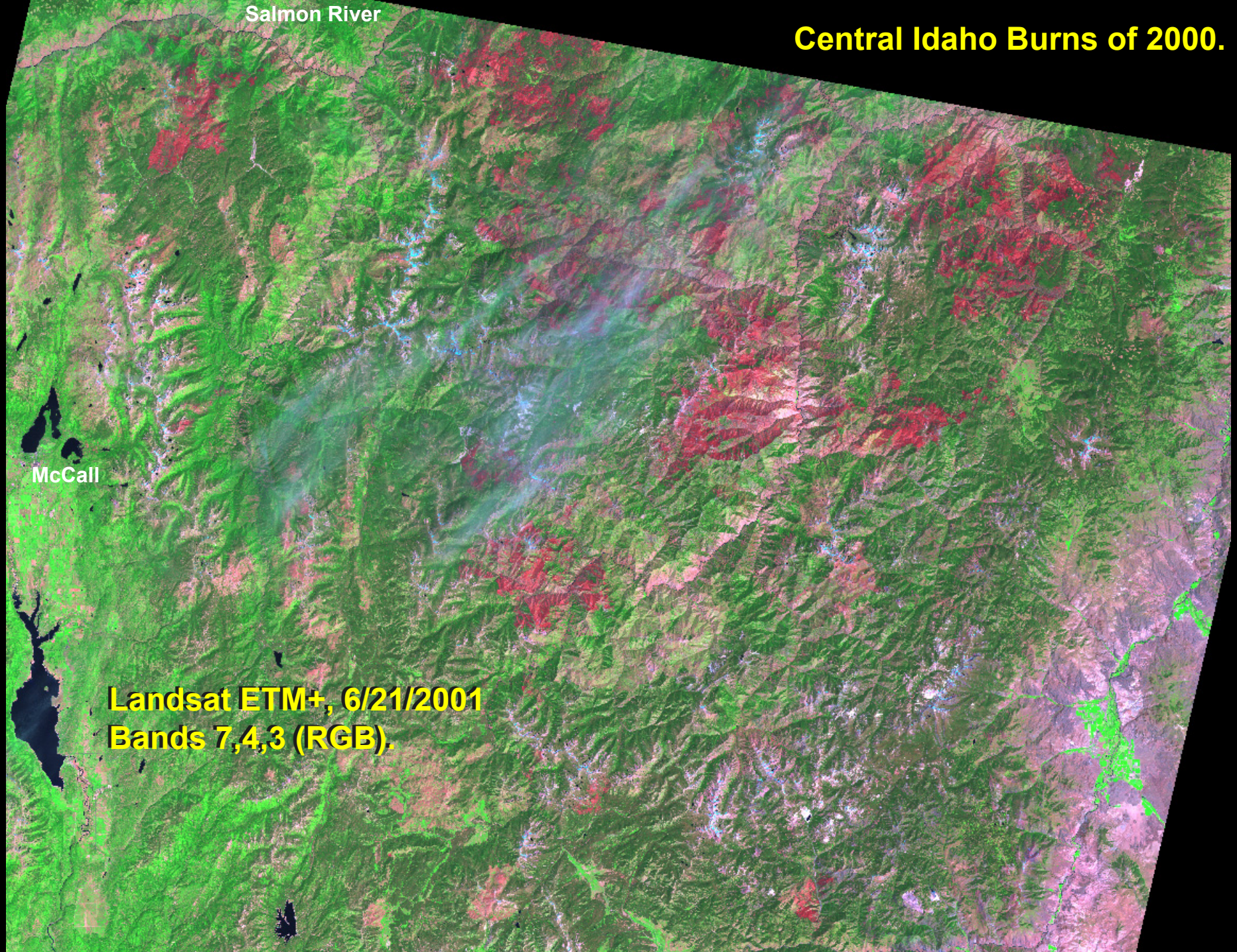


Initial Assessment 2001 Moose Burn
ETM+ 09/09/2001



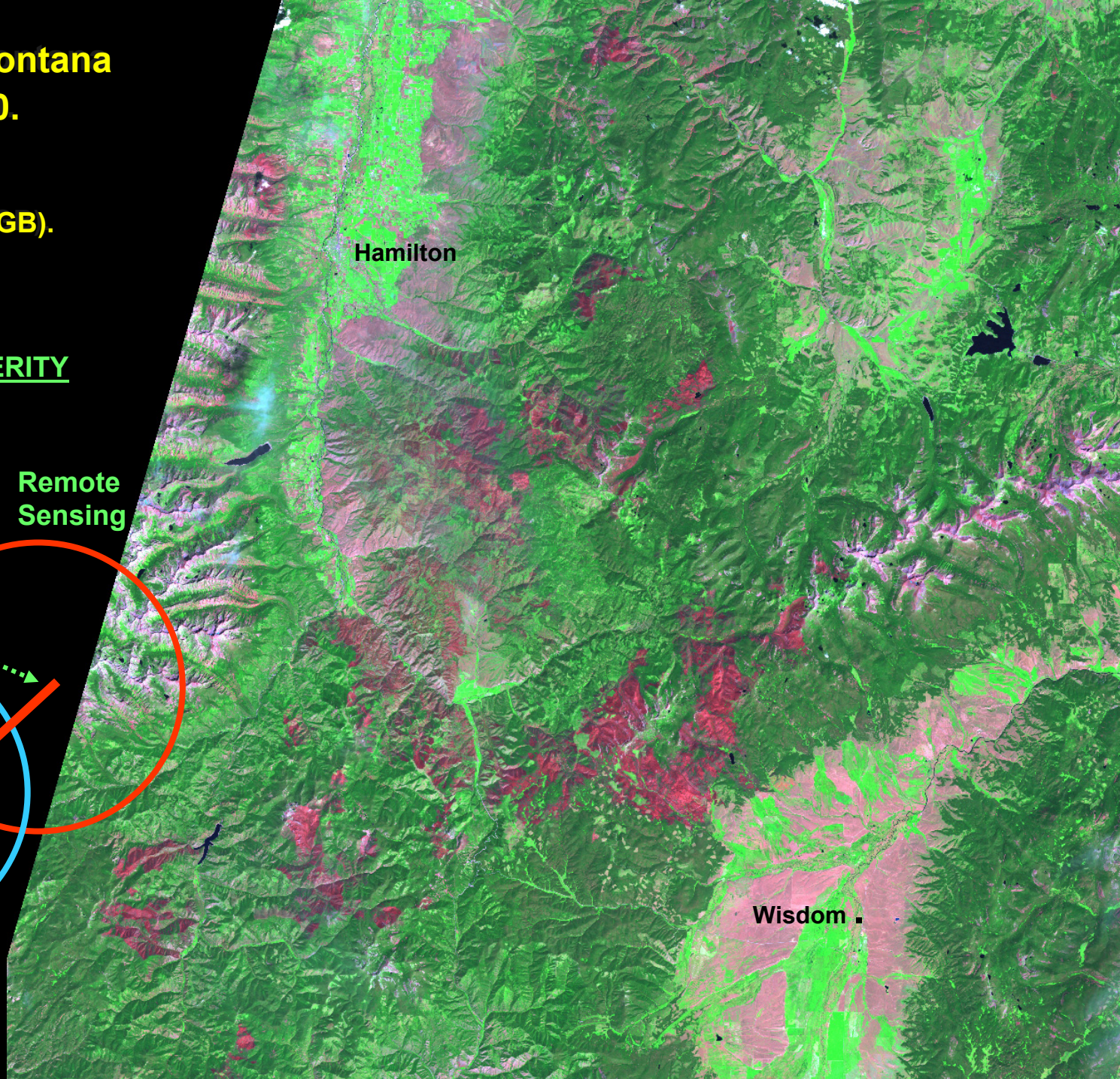
Preliminary Severity Levels



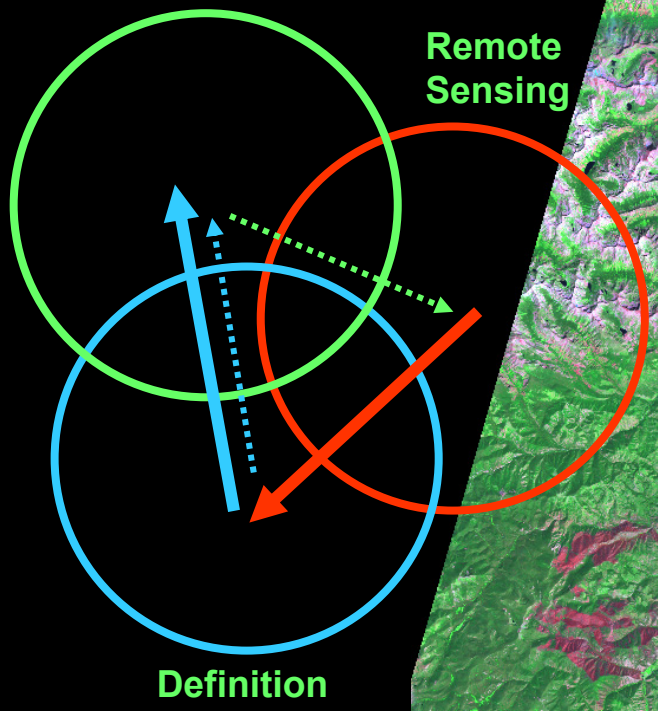

Salmon River
Central Idaho Burns of 2000.
McCall
Landsat ETM+, 6/21/2001
Bands 7,4,3 (RGB).

Southwest Montana Burns of 2000.

Landsat ETM+
8/1/2001
Bands 7,4,3 (RGB).



BURN SEVERITY



BURN SEVERITY

The degree of environmental change caused by fire.

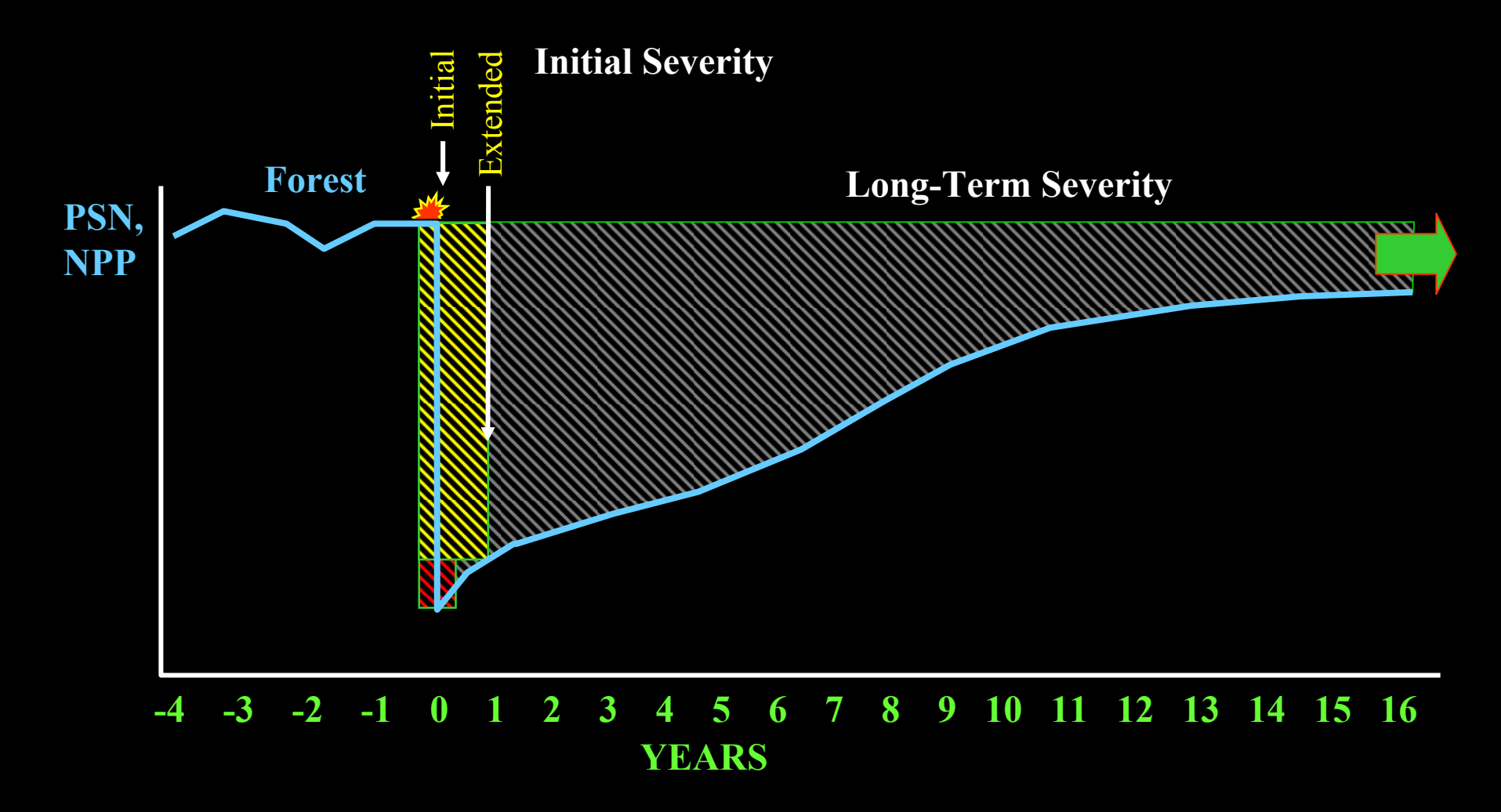
How much has fire affected the established community?

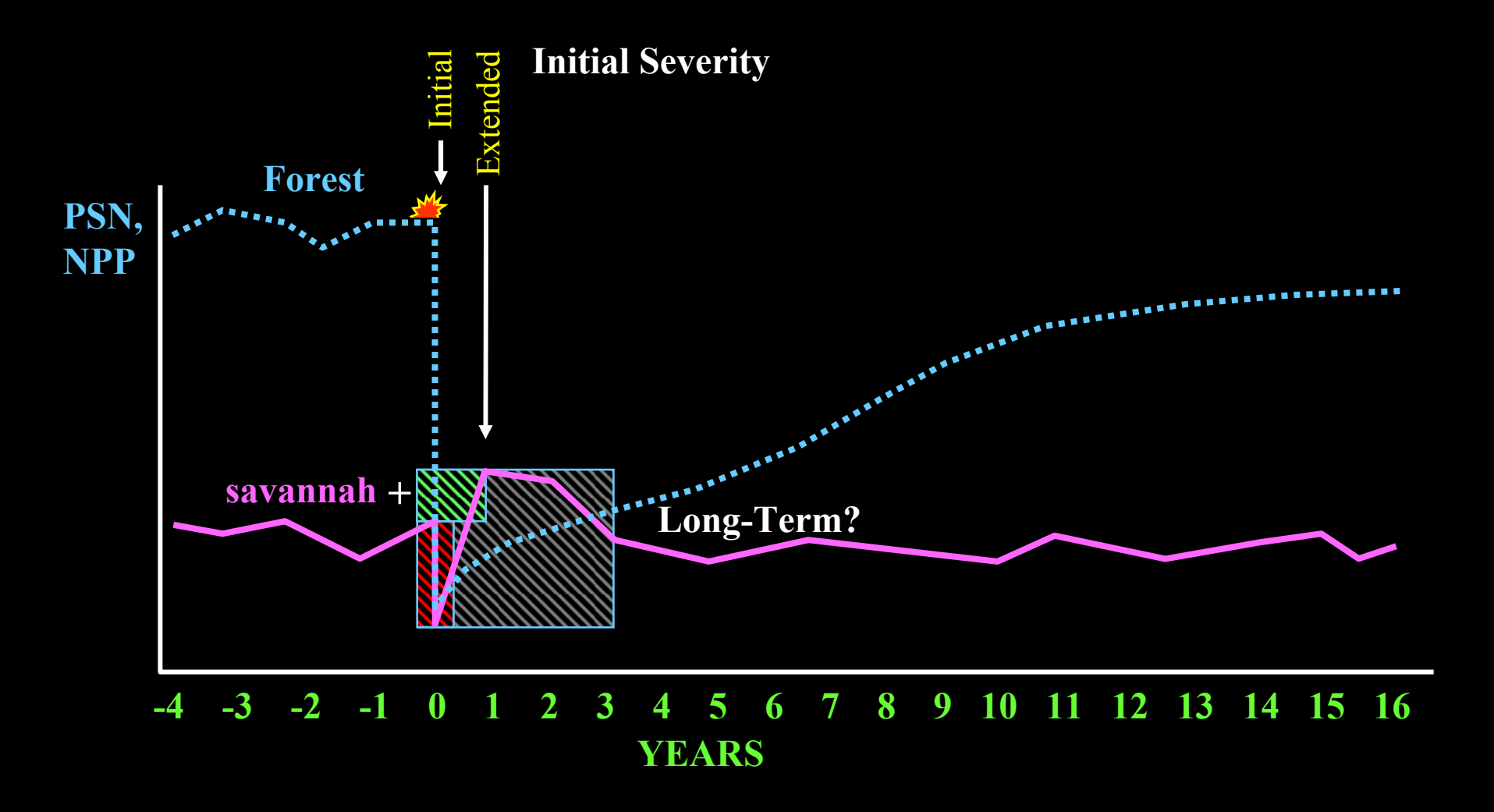
In the broad sense, short and long-term consequences.

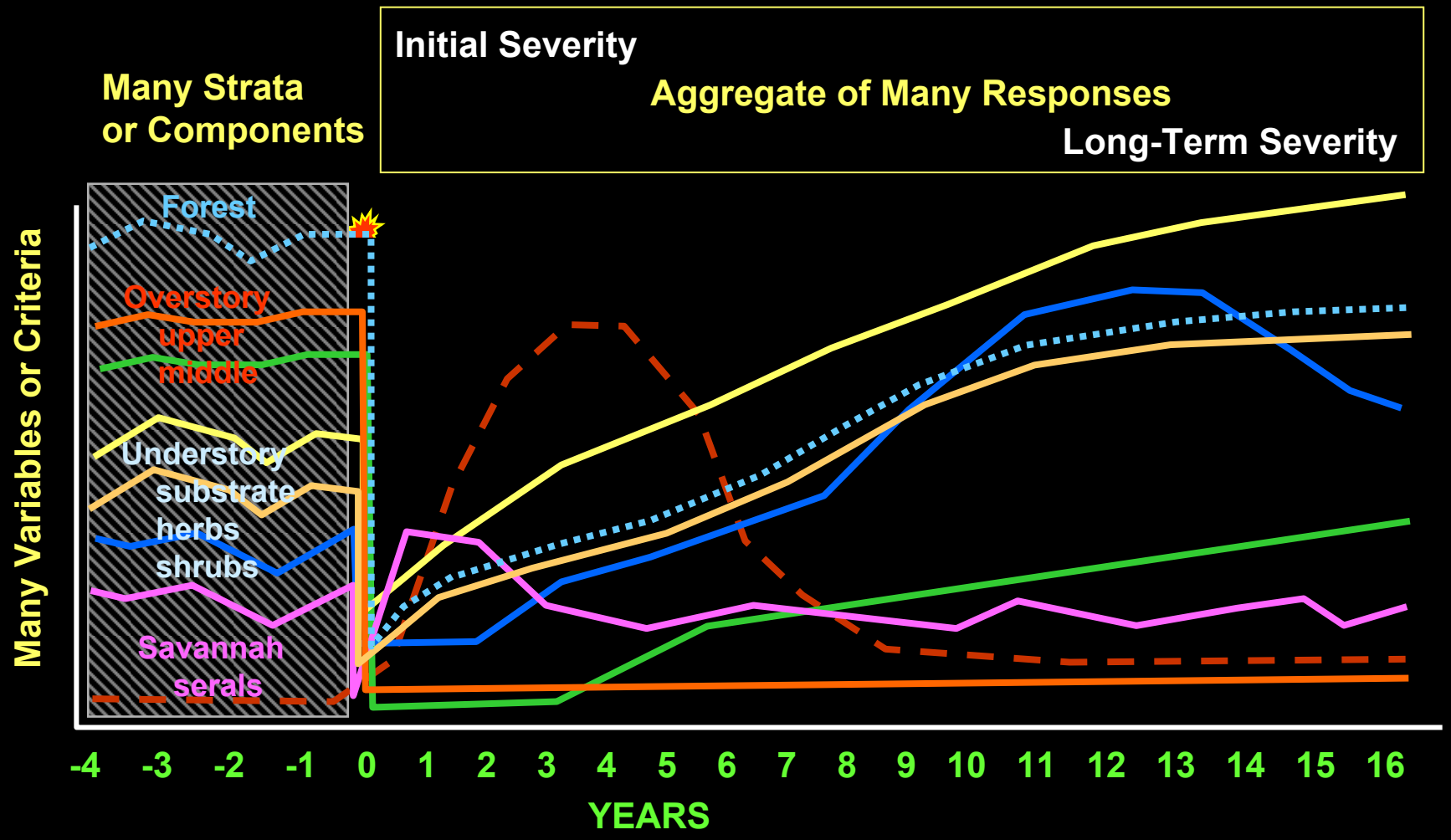
A. Initial changes to pre-established communities:
   1. Fire effects by downward and upward heat transfer.
   2. Potential for vegetative recovery next growing season.

B. Time-dependent responses over long term, involving many biophysical factors:
   1. Seedbank species and proximity to post-fire seed sources.
   2. Localized site characteristics and successional pathways.
   3. Subsequent climate.
   4. Secondary effects from erosion, mass wasting, etc.

USGS
science for a changing world

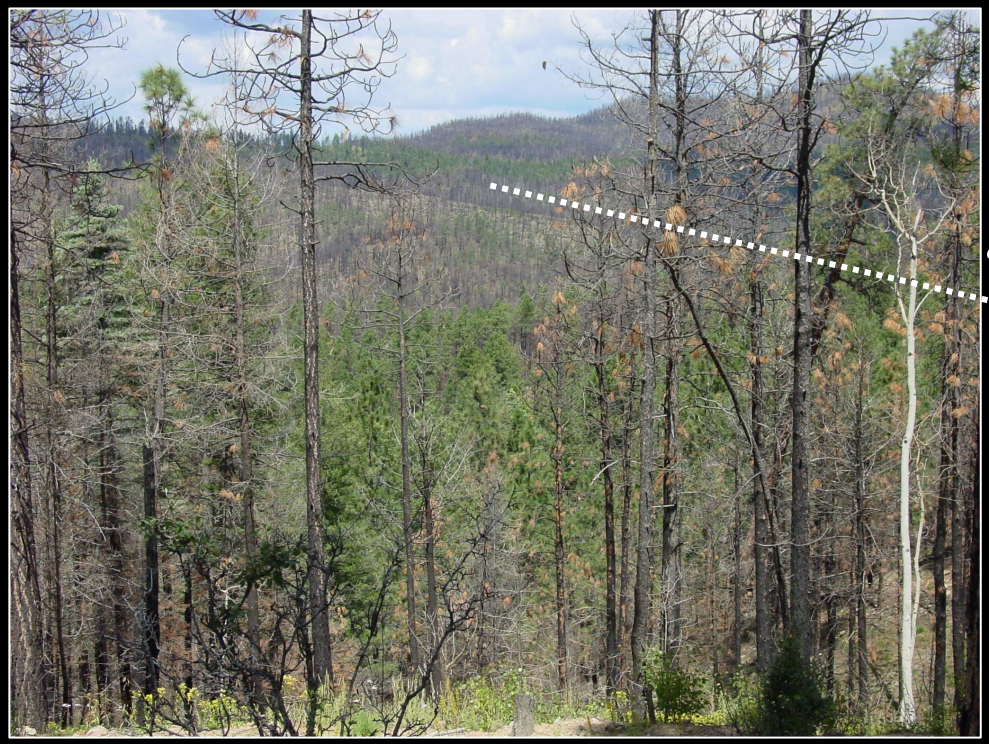

Initial Severity
Initial
Extended
Forest
Long-Term Severity
PSN,
NPP
-4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
YEARS


Initial Severity
Initial
Extended
Forest
PSN,
NPP
savannah +
Long-Term?
-4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
YEARS


Initial Severity
Aggregate of Many Responses
Long-Term Severity
Many Strata
or Components
Forest
Overstory
upper
middle
Understory
substrate
herbs
shrubs
Savannah
serals
Many Variables or Criteria
-4 -3 -2 -1 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16
YEARS

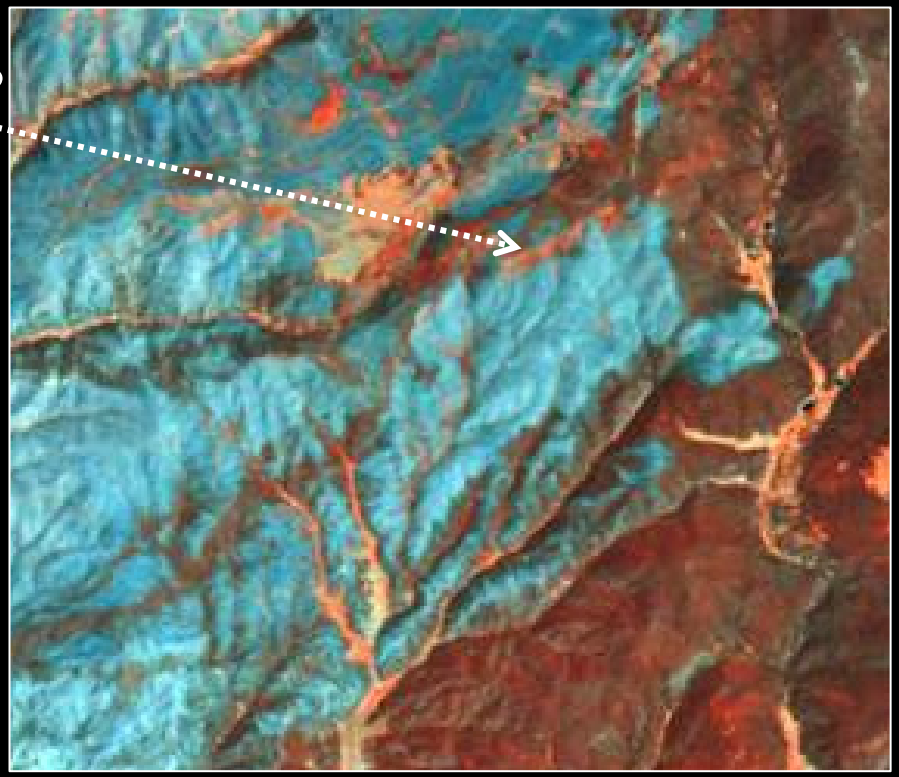
How do severity concepts relate to Landsat data signal properties?

Signals:
Spectrally integrate all strata w/in 30x30 meters.
Respond individually per bandwidth after fire.
Vary temporally by season and time since fire.



?

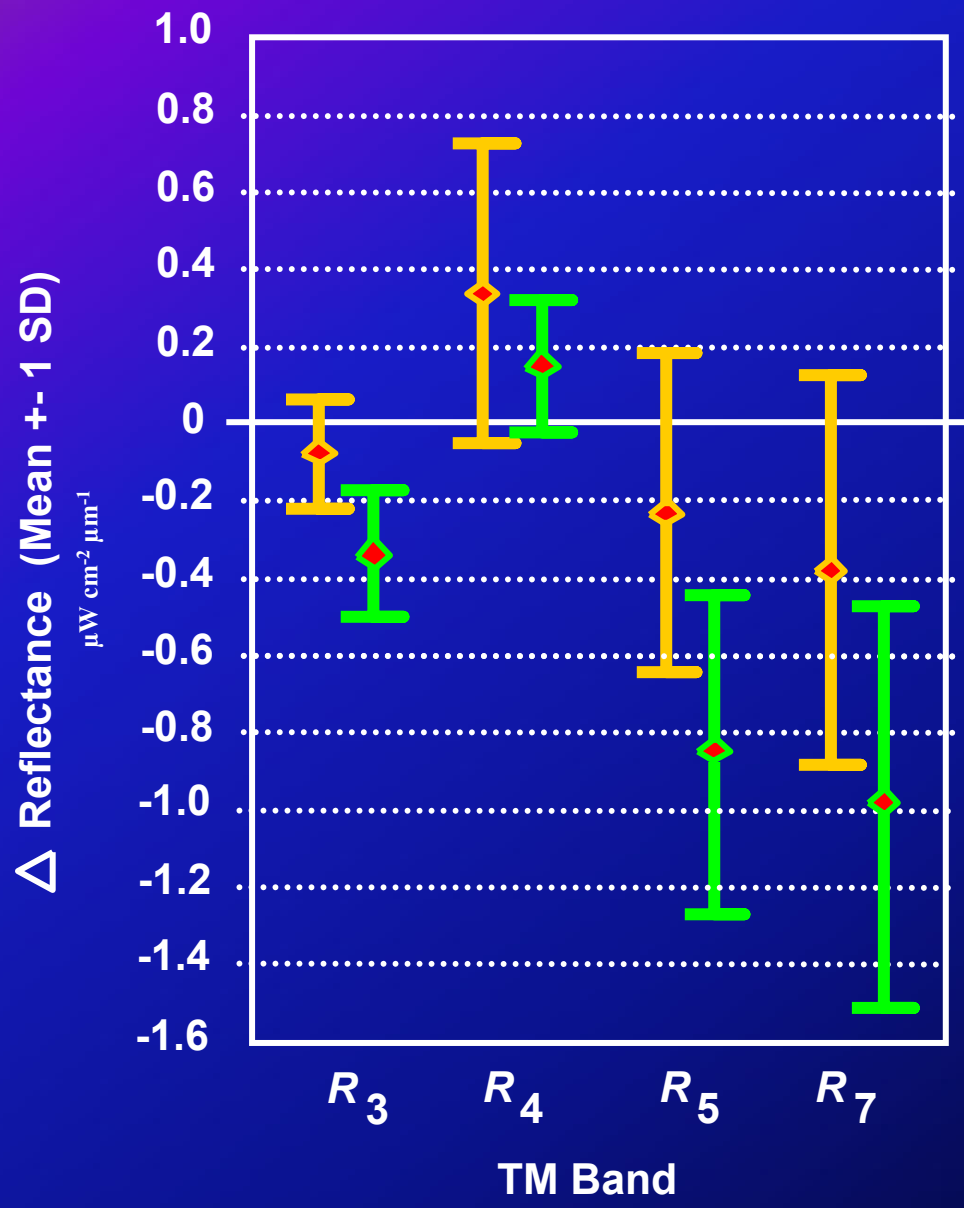
Band 4,5,7 RGB



30 m data efficient, relatively inexpensive for large-area coverage
Bandwidths that register fire effects
Continual repetitive coverage, archived for ~20 yrs:
- Pre and post fire information
- Recent burn history

These and other factors enable implementation on a national level.

TM Band Response to Burning - Change in Reflectance,



Prefire – Postfire.

Positive = Prefire > Postfire
Burn *decreases R* in that band.

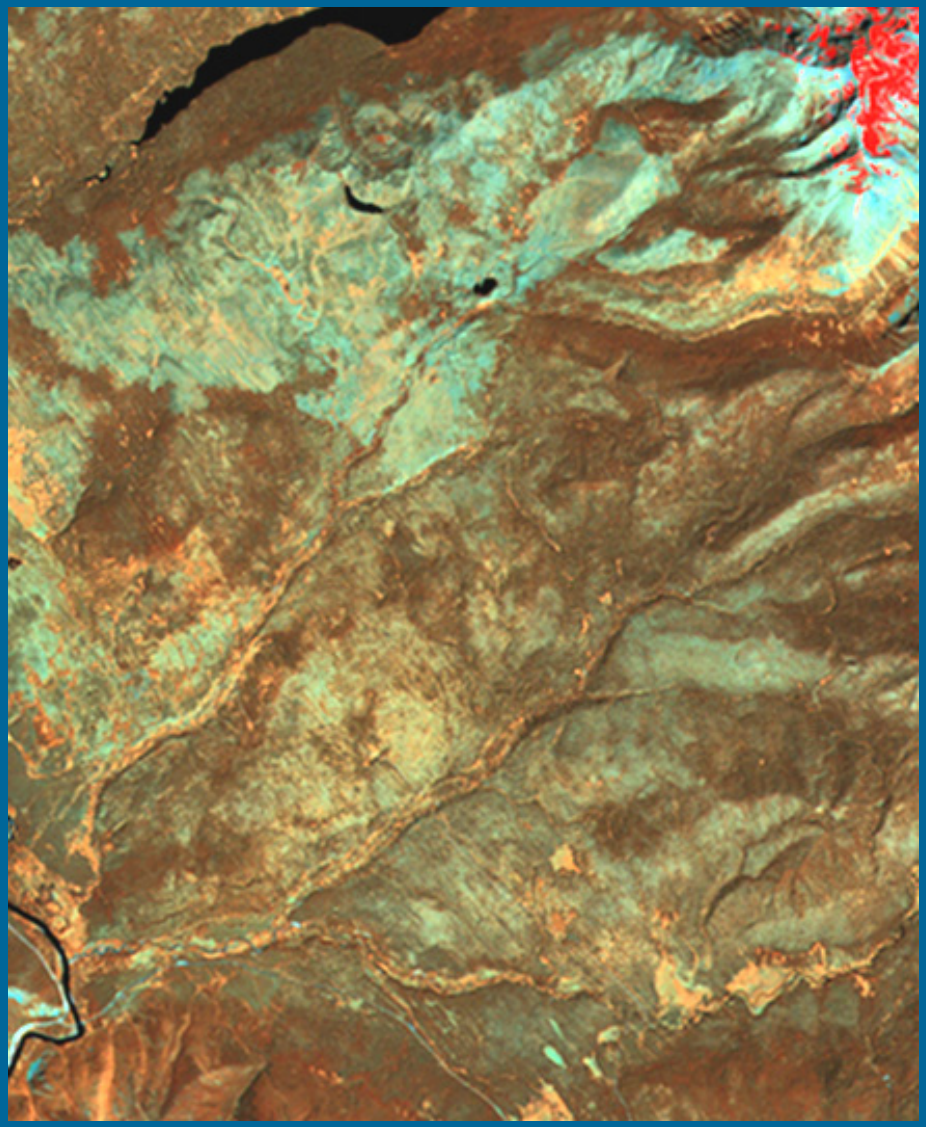
Negative = Postfire > Prefire
Burn *increases R* in that band.

N.W. Montana, Late Summer
Prefire 08/13/94 - Postfire 09/01/95
N=1000

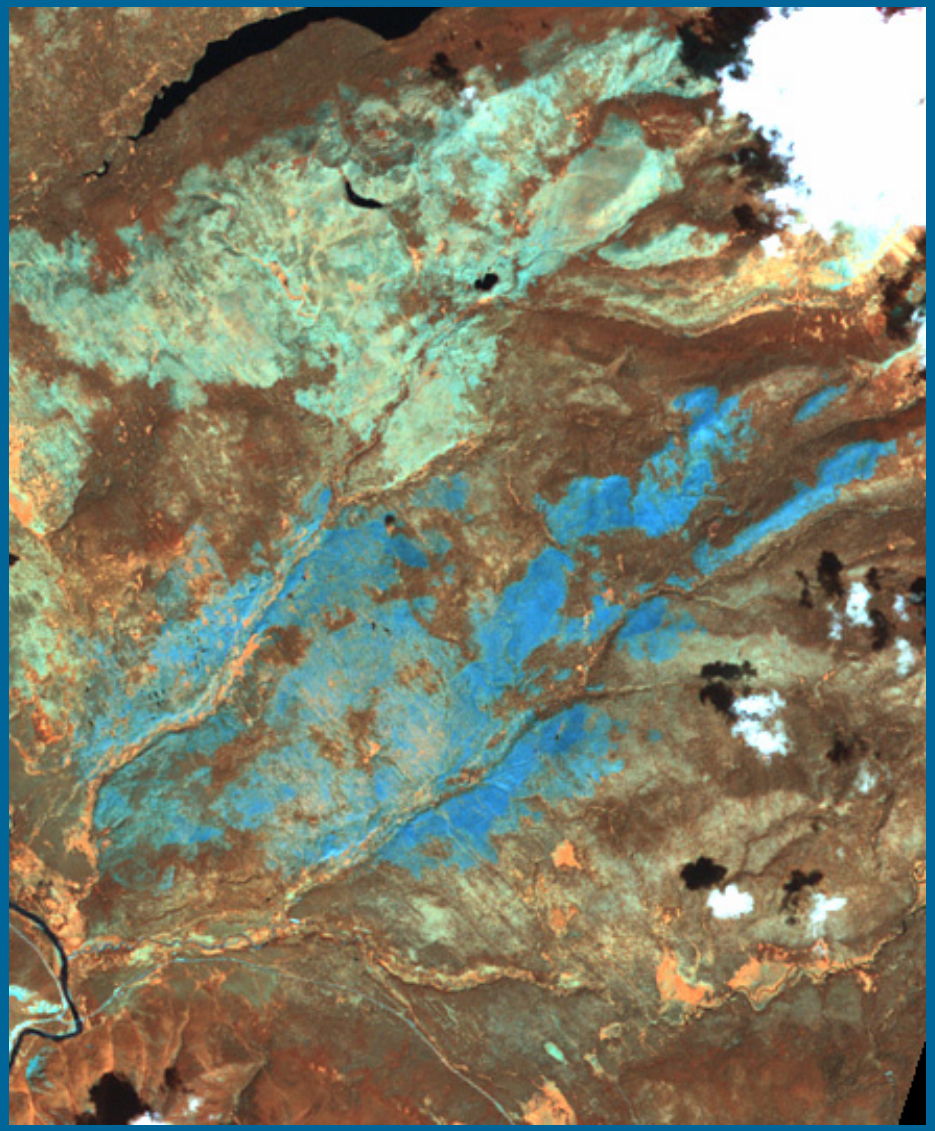
N. New Mexico, Early Summer
Prefire 06/07/99 - Postfire 06/04/01
N=2000

Pre- and Post-Fire False Color Composites, Bands 4,5,7 (RGB)

TM 7/10/1999



ETM 6/25/2000



"Normalized Burn Ratio".

$$NBR = (R_4 - R_7) / (R_4 + R_7)$$

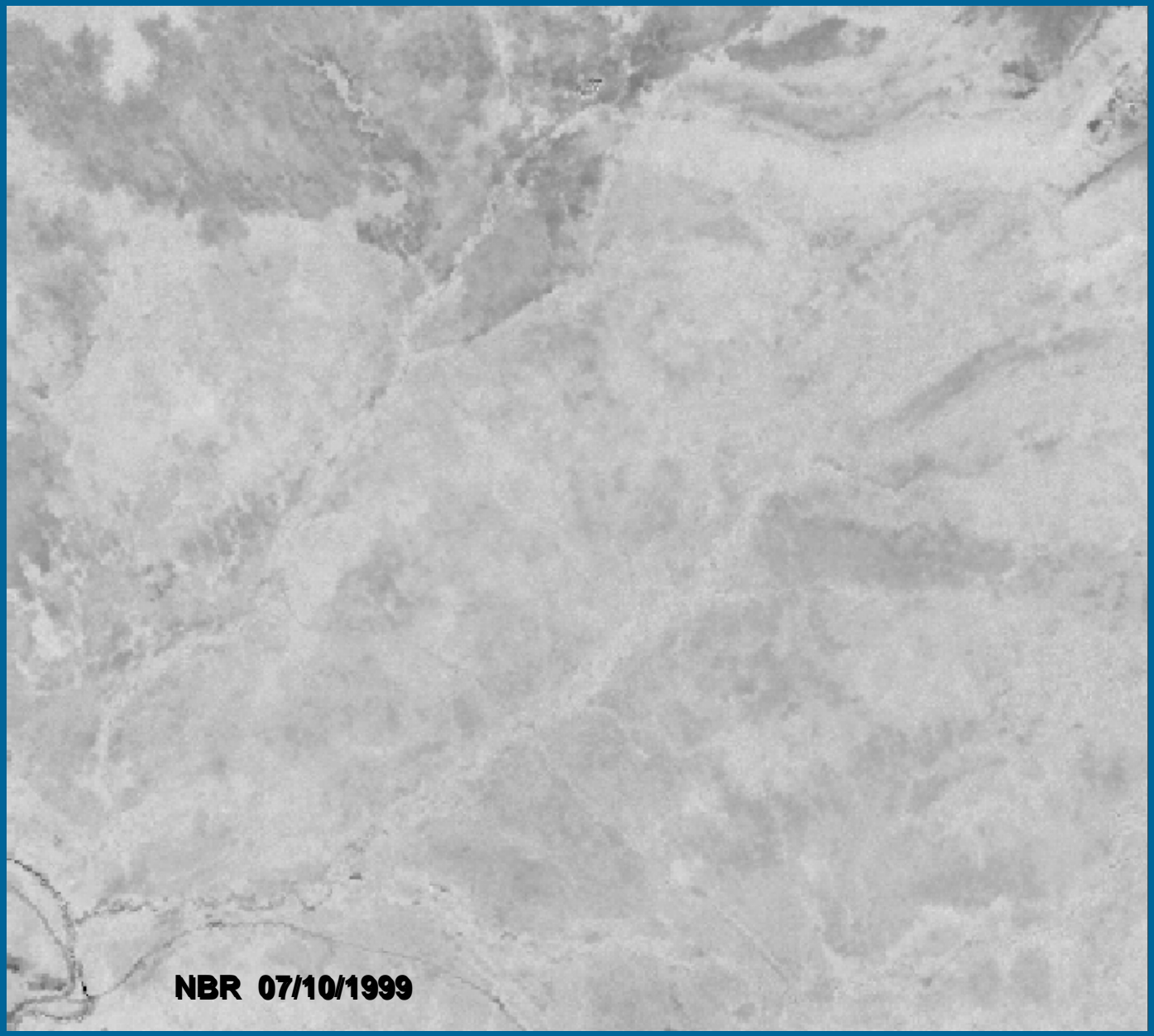
range: -1.0 to +1.0

TM 7/10/1999

ETM 6/25/2000

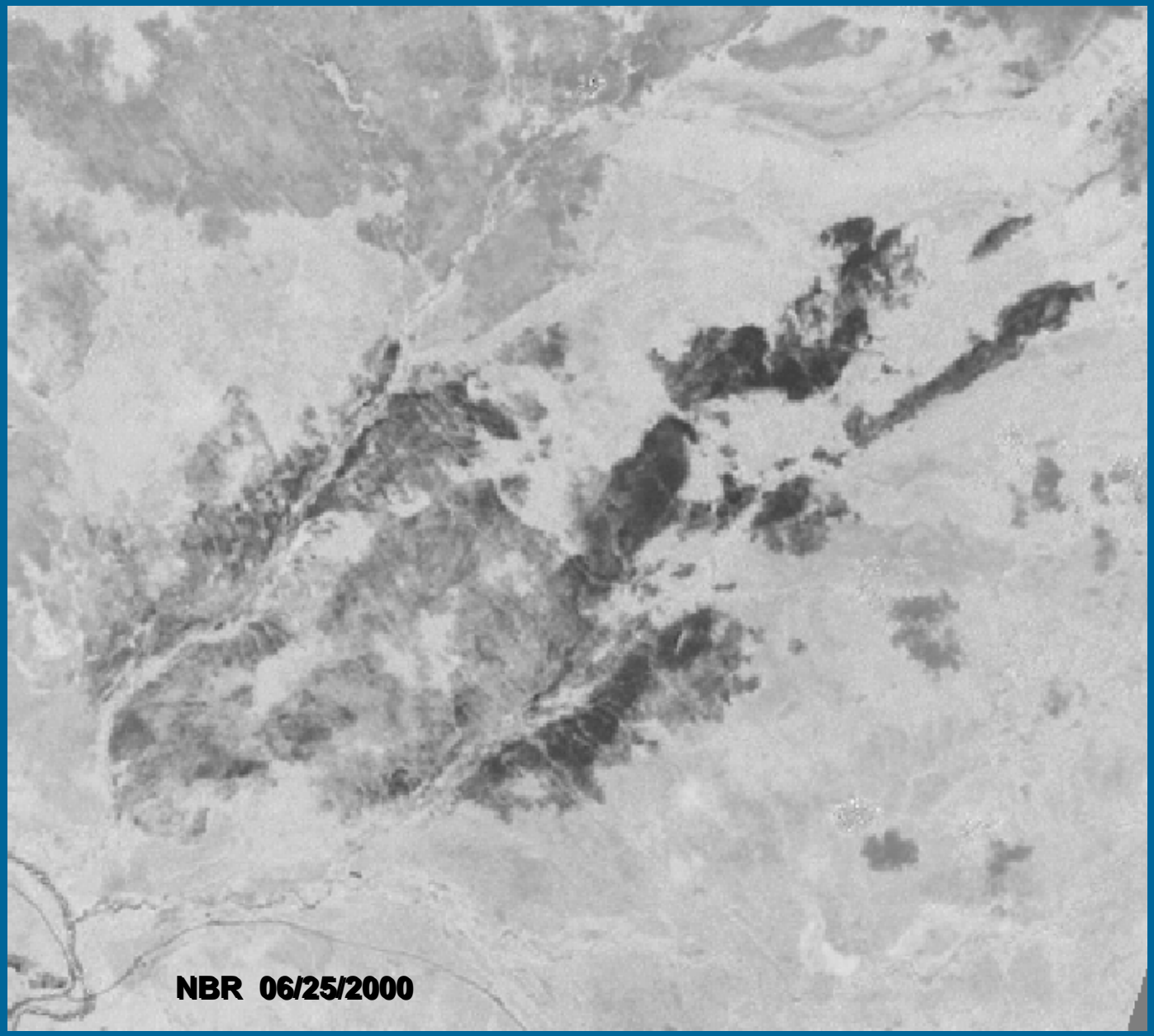
"Differenced or Delta NBR":

$$\Delta NBR = NBR_{pre} - NBR_{post}$$



"Differenced or Delta NBR":

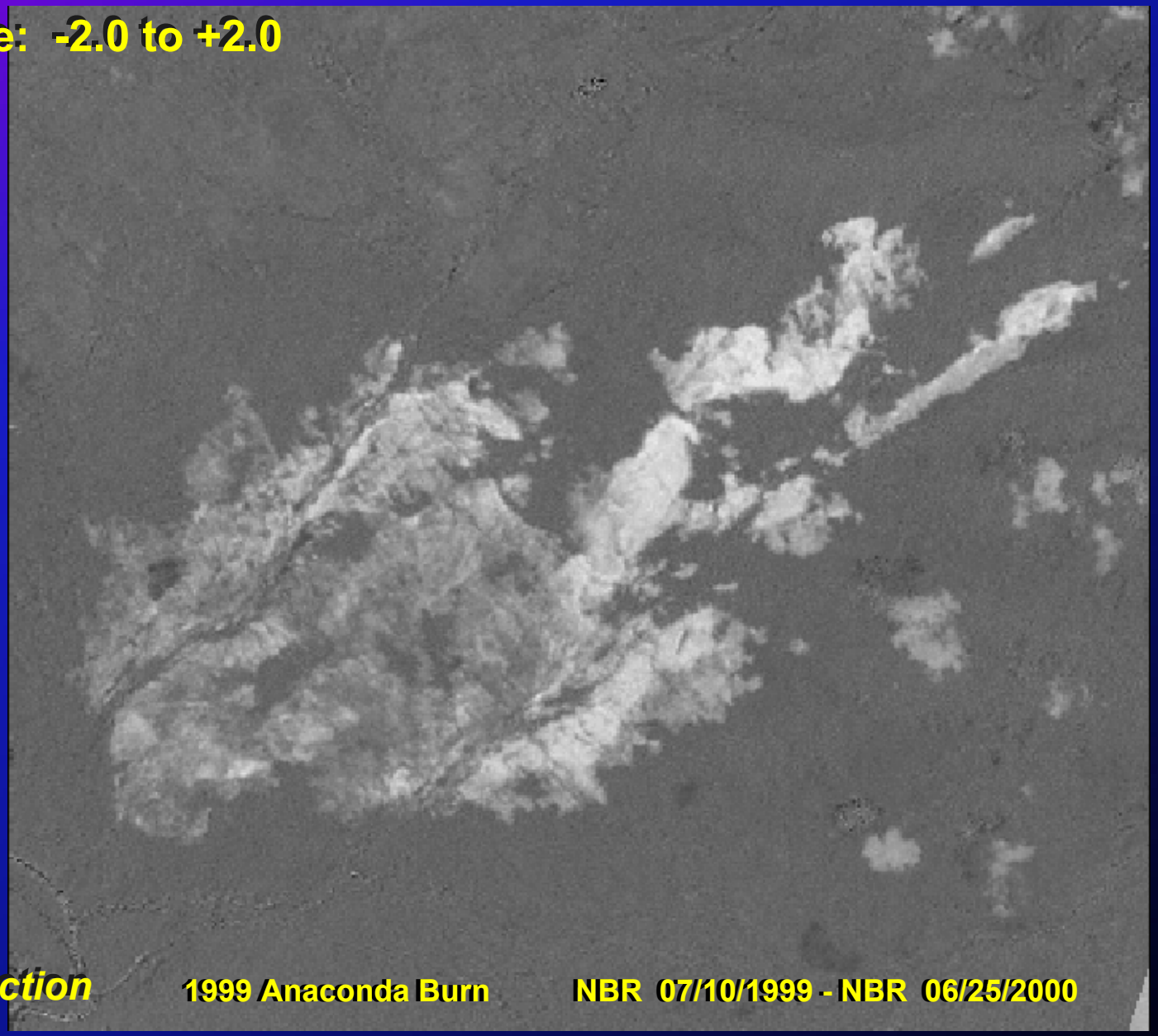
$$\Delta NBR = NBR_{pre} - NBR_{post}$$



"Differenced or Delta NBR":

Δ NBR = NBR_{pre} - NBR_{post}

Range: -2.0 to +2.0



Change Detection

1999 Anaconda Burn

NBR 07/10/1999 - NBR 06/25/2000

Scene Selection.

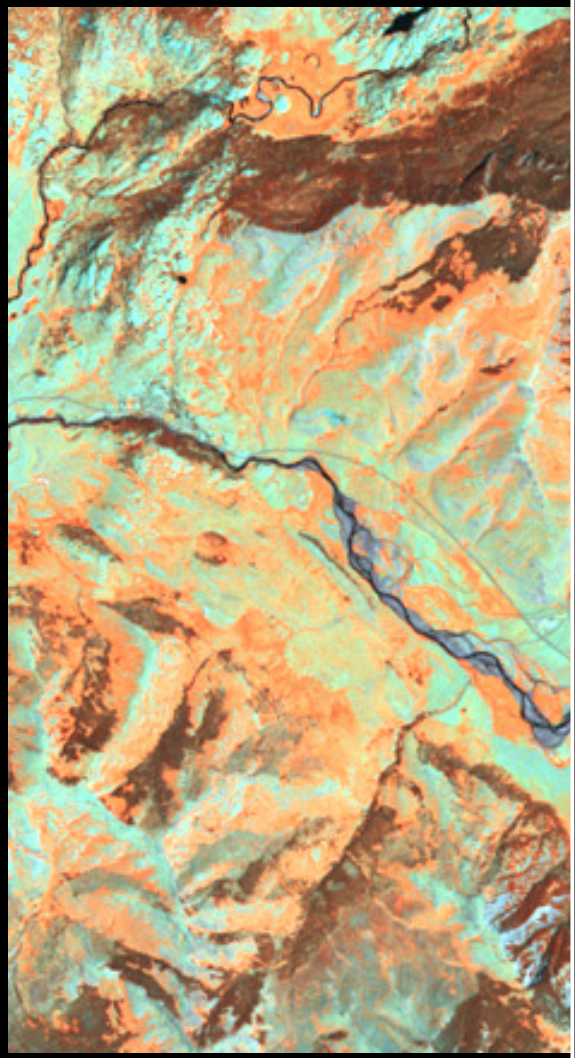
Scene Pairs should represent similar phenology and moisture.

The background/unburned landscape is not static.

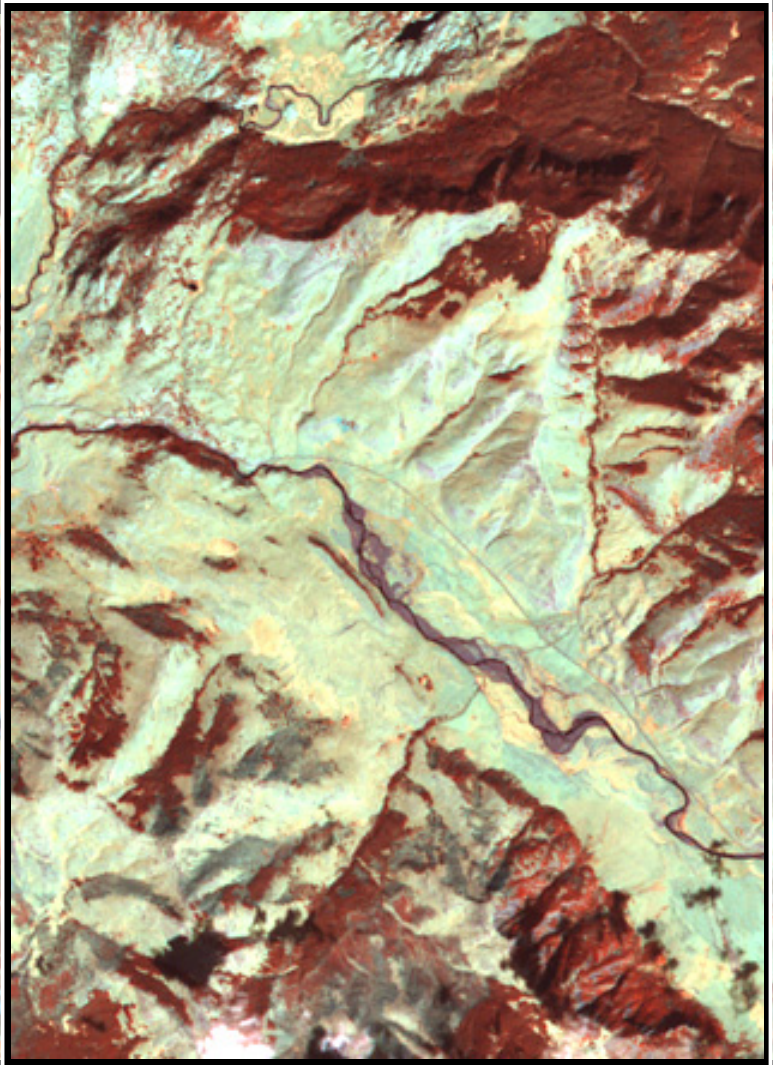
Seasonality varies by region and with elevation.

Lamar River, Yellowstone

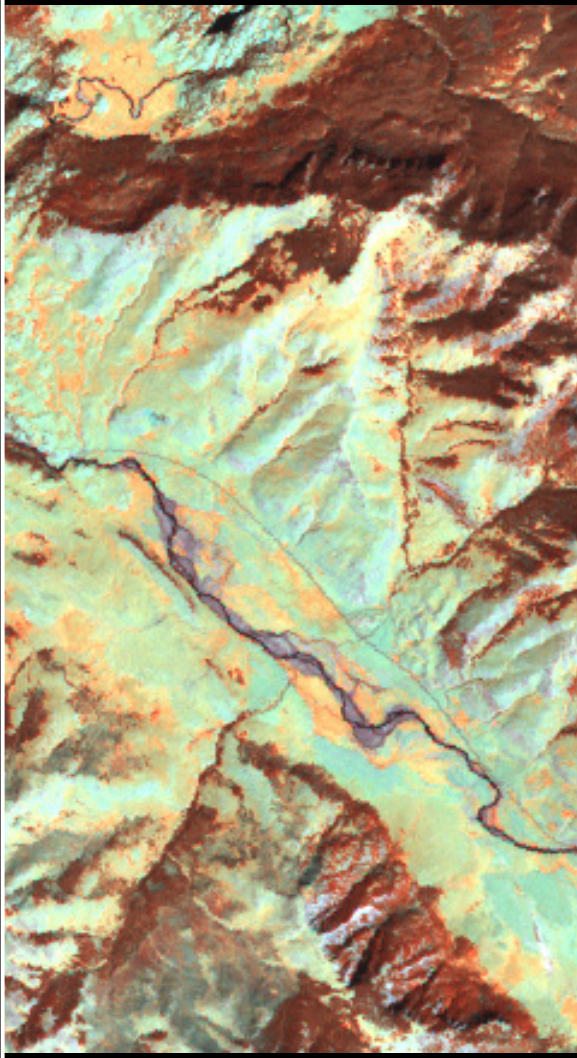
7/15/2000



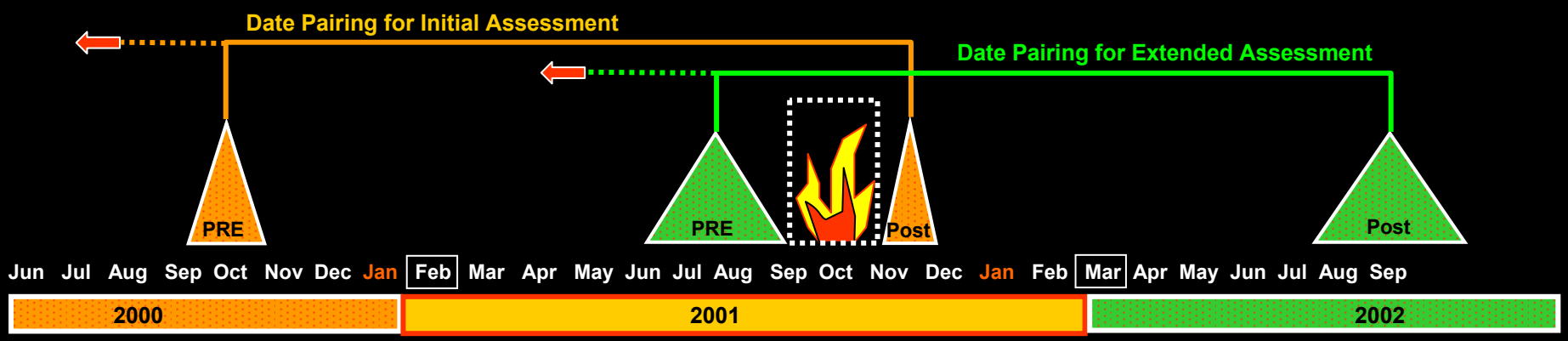
10/3/2000



9/15/1999



TWO SCENARIOS, Relative to Time Since Fire.



A) Initial Assessment - Good definition of areas burned and perimeter. Clouds, sun angle and dryness can be problems.

Post-fire scene from soon after burning (e.g. Aug-Oct)
Pre-fire scene from the year before (e.g. Aug-Oct)

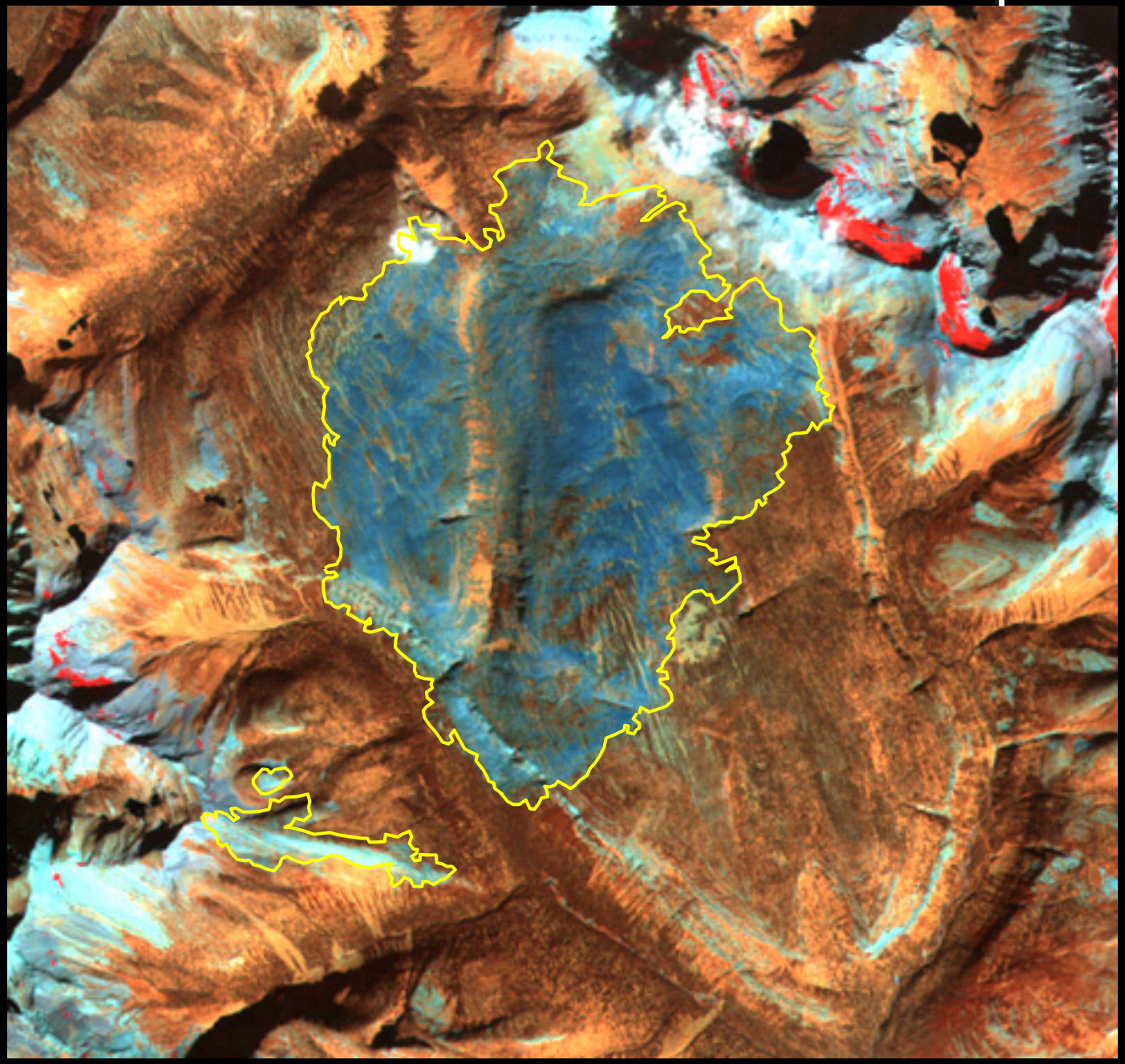
B) Extended Assessment - "Best" index of severity, good definition of burned areas and perimeter. More latitude selecting comparable scenes.

Pre-fire scene from year of the fire (e.g. May-July)
Post-fire scene from next growing season (e.g. May-July)

1998 Kootenai Complex

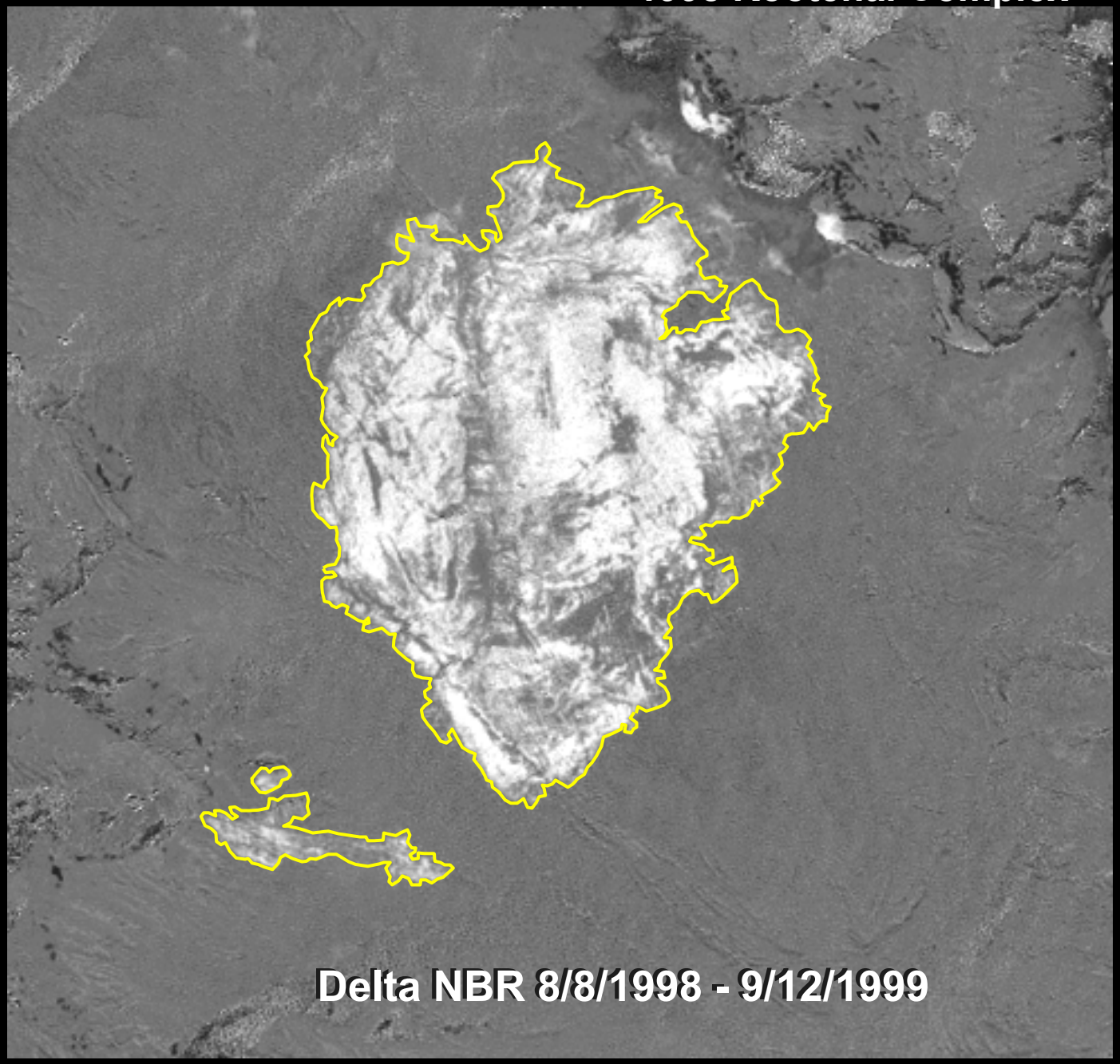
Extended Assessment

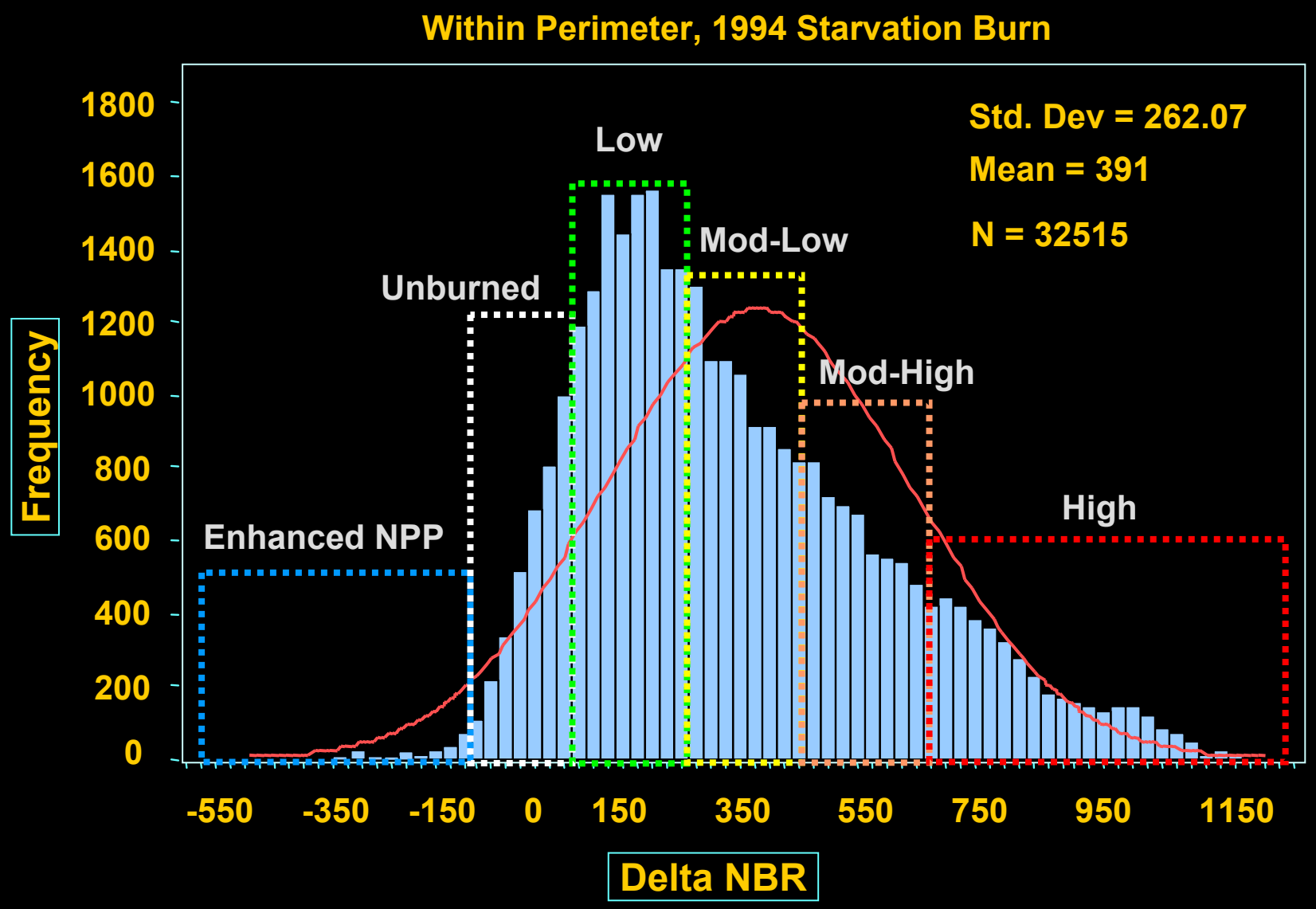
Landsat 9/12/1999



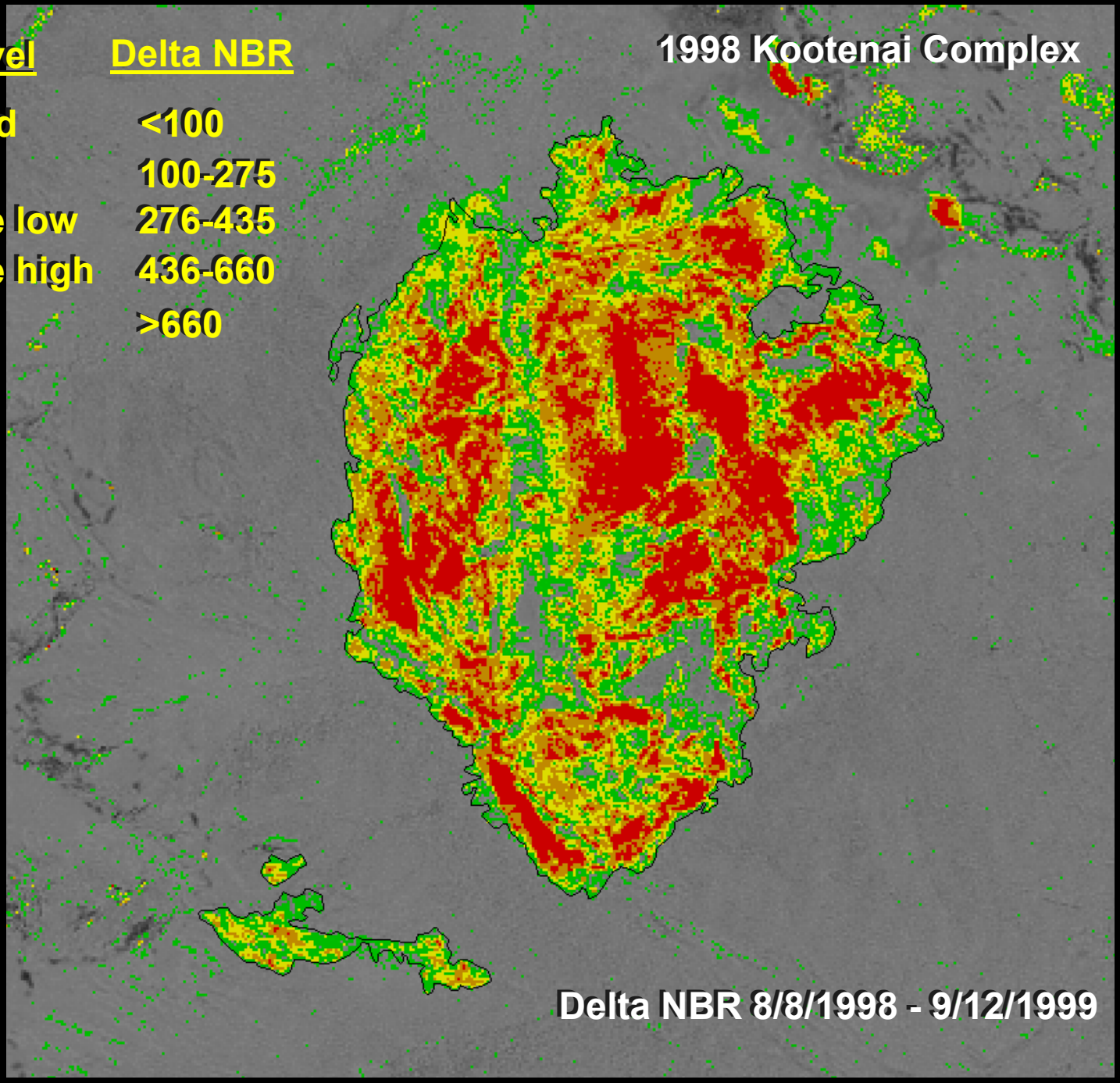
Extended Assessment

1998 Kootenai Complex



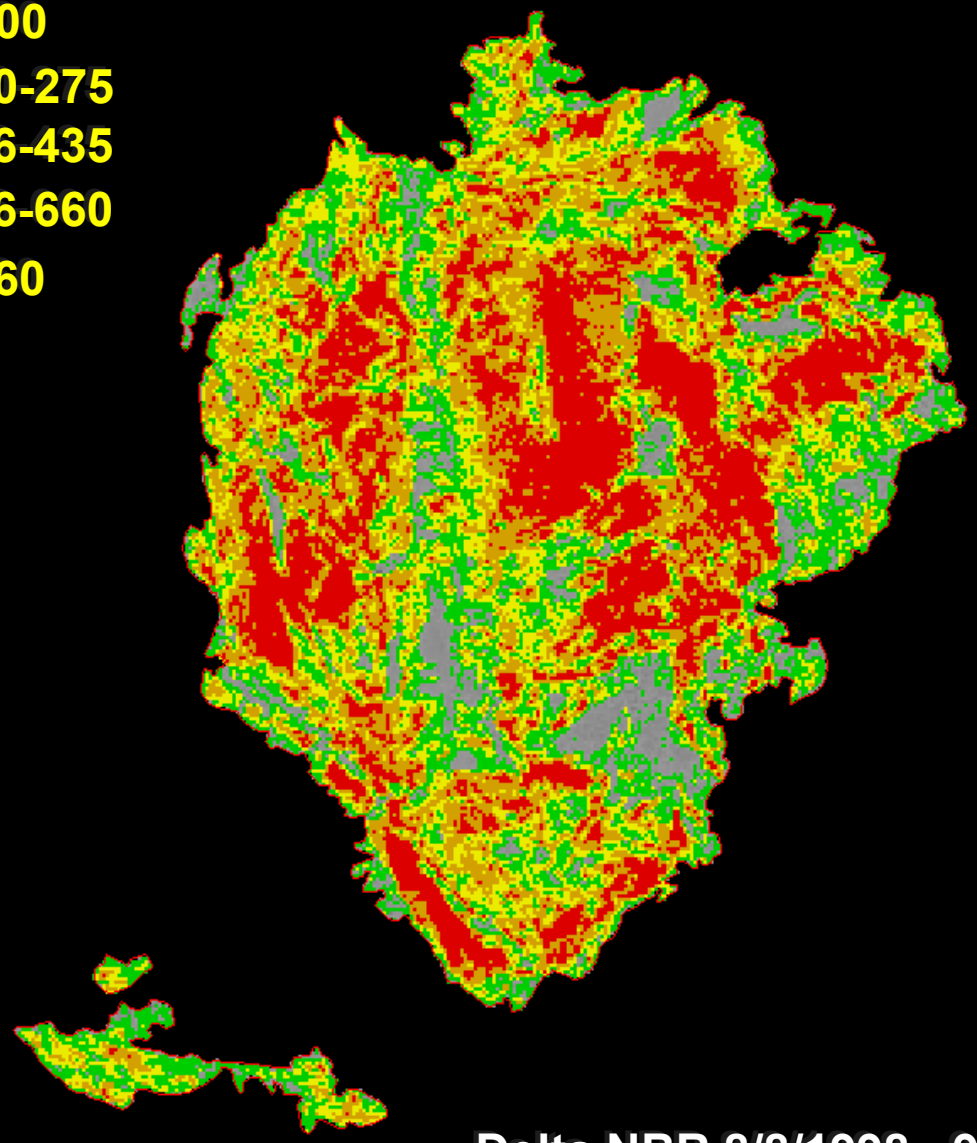

Within Perimeter, 1994 Starvation Burn
Std. Dev = 262.07
Mean = 391
N = 32515
Low
Mod-Low
Unburned
Mod-High
High
Enhanced NPP
Frequency
1800
1600
1400
1200
1000
800
600
400
200
0
-550
-350
-150
0
150
350
550
750
950
1150
Delta NBR

Severity Level	Delta NBR
Unburned	<100
Low	100-275
Moderate low	276-435
Moderate high	436-660
High	>660



1998 Kootenai Complex

Severity Level	Delta NBR
Unburned	<100
Low	100-275
Moderate low	276-435
Moderate high	436-660
High	>660



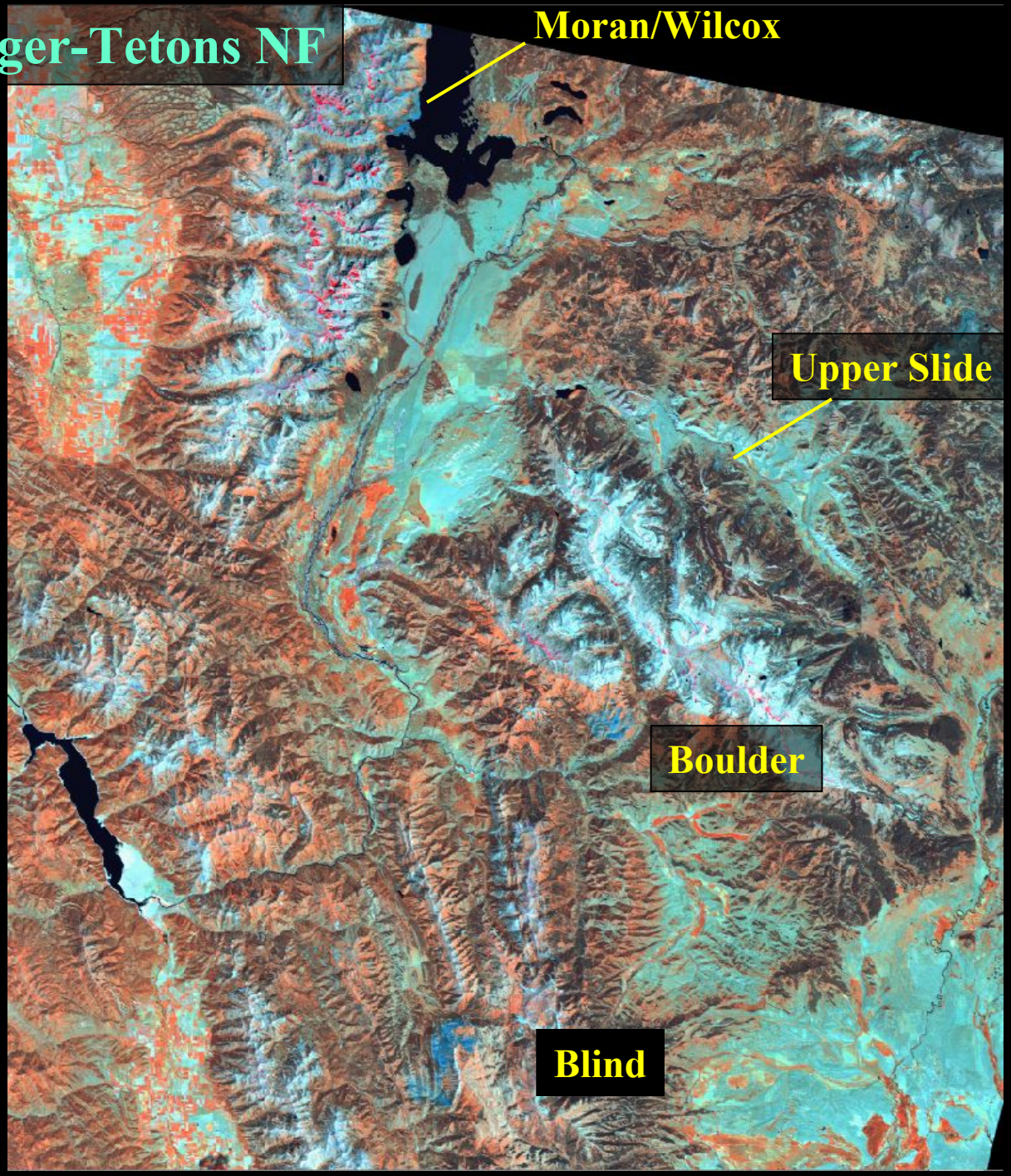
Delta NBR 8/8/1998 - 9/12/1999

USGS/NPS Burn Severity Project Sites

Grand Teton NP, Bridger-Tetons NF

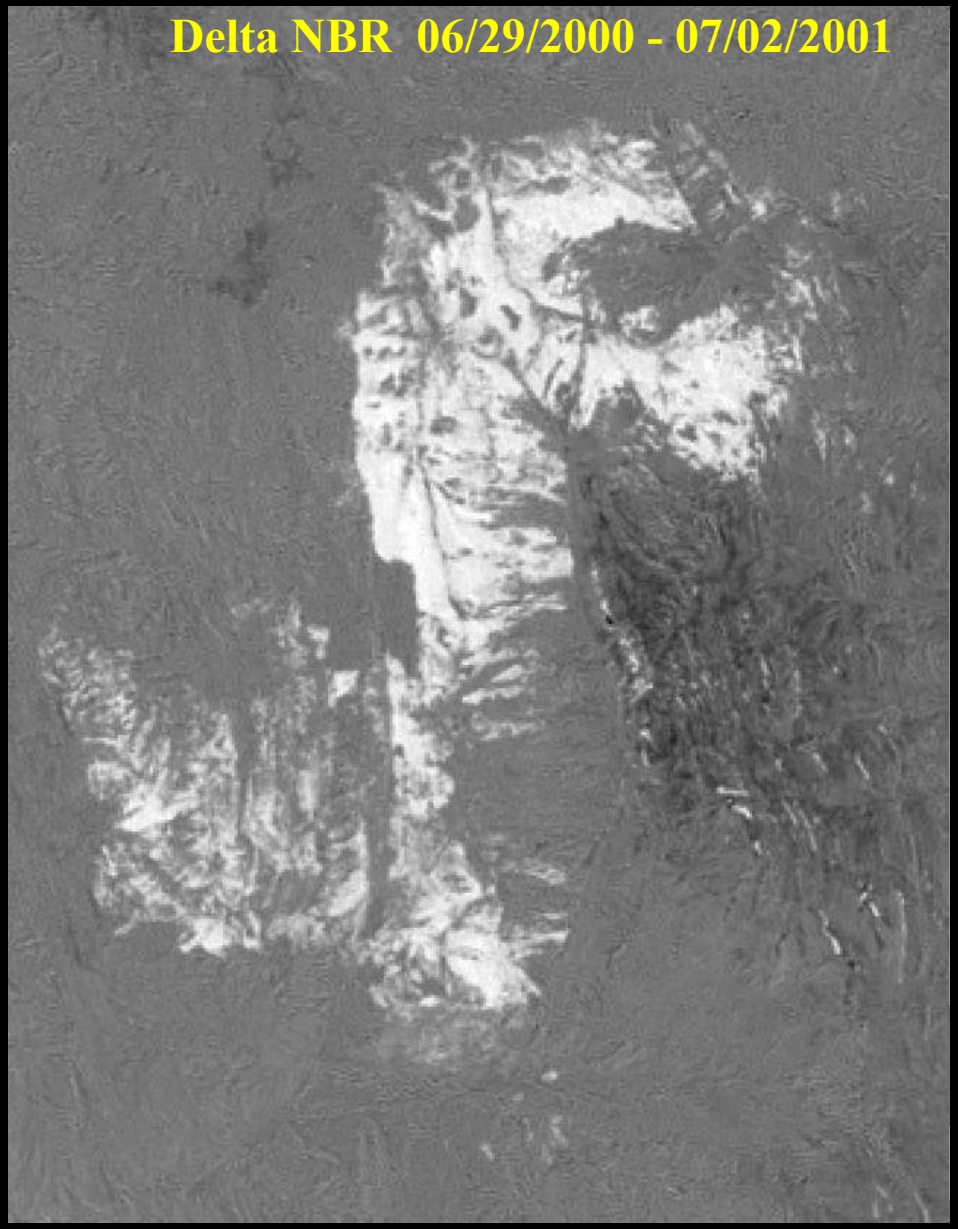
August 2000 Fire Starts

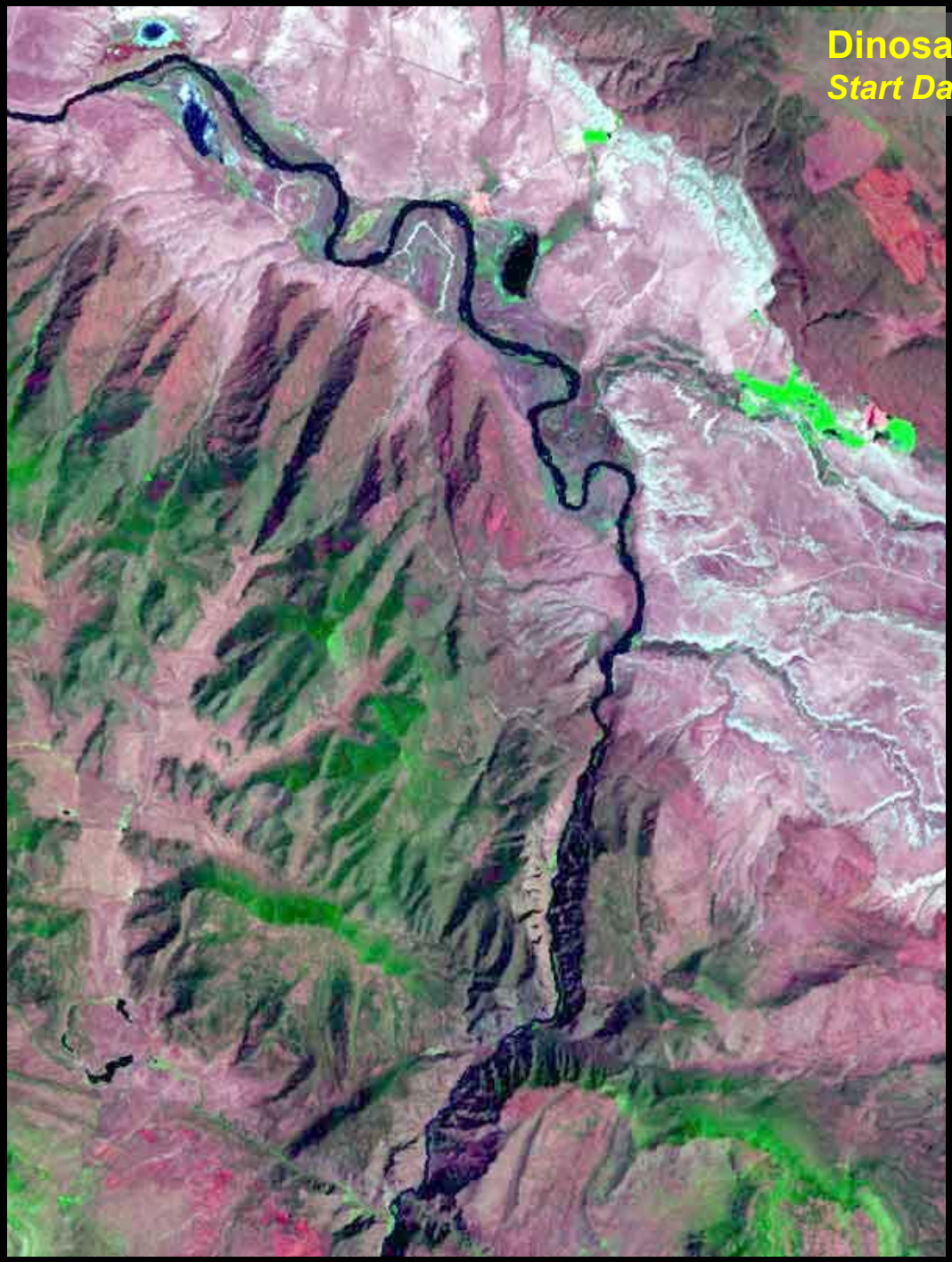
ETM+ 07/02/2001



Blind Burn 2000 – Bridger Teton N.F., WY – Landsat P38/R30

Blind Burn 2000 – Bridger Teton N.F., WY – Landsat P38/R30

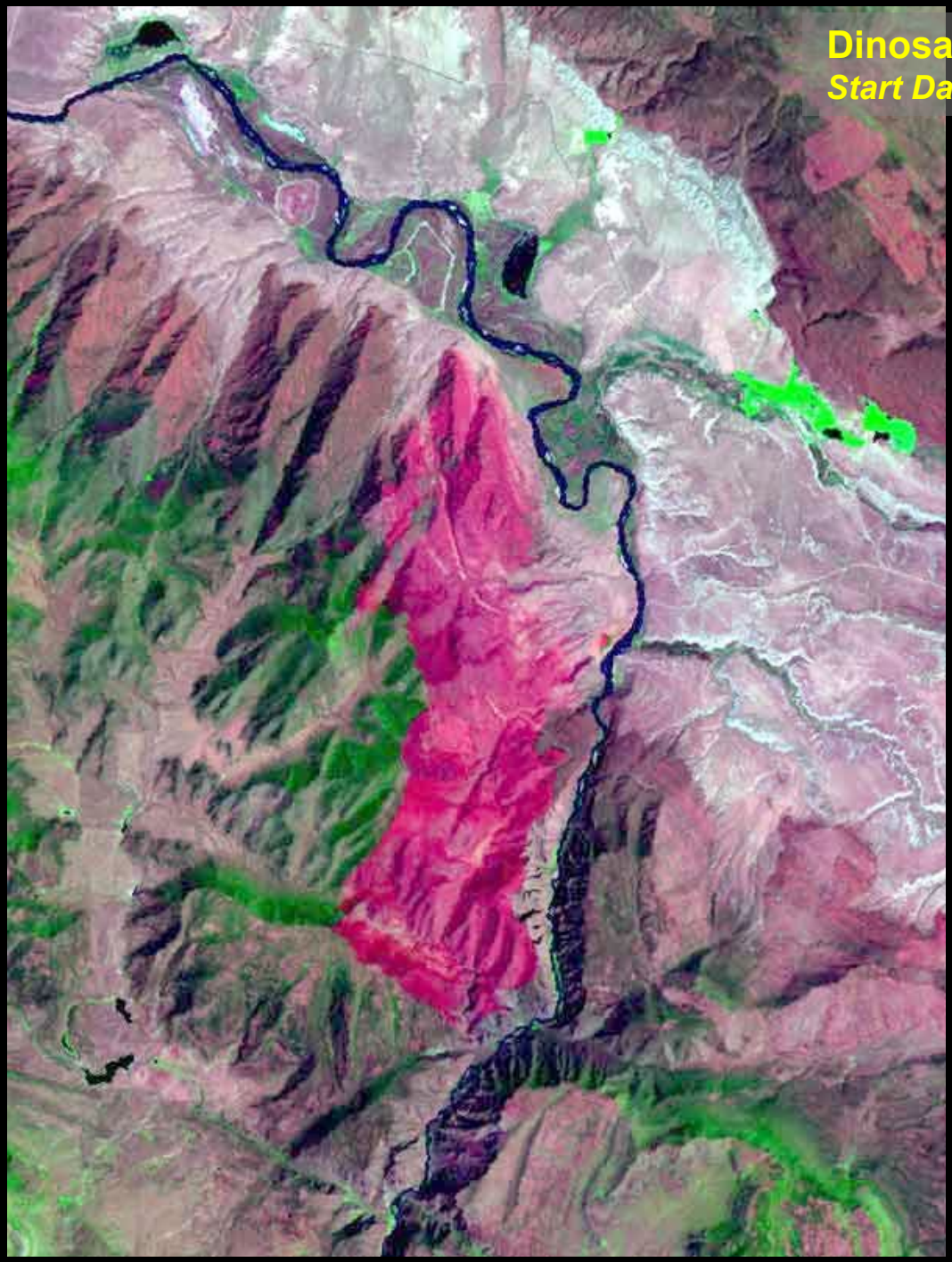




Dinosaur National Park: Buster Flat Burn

Start Date:* 07/03/2000 *Extended Assessment

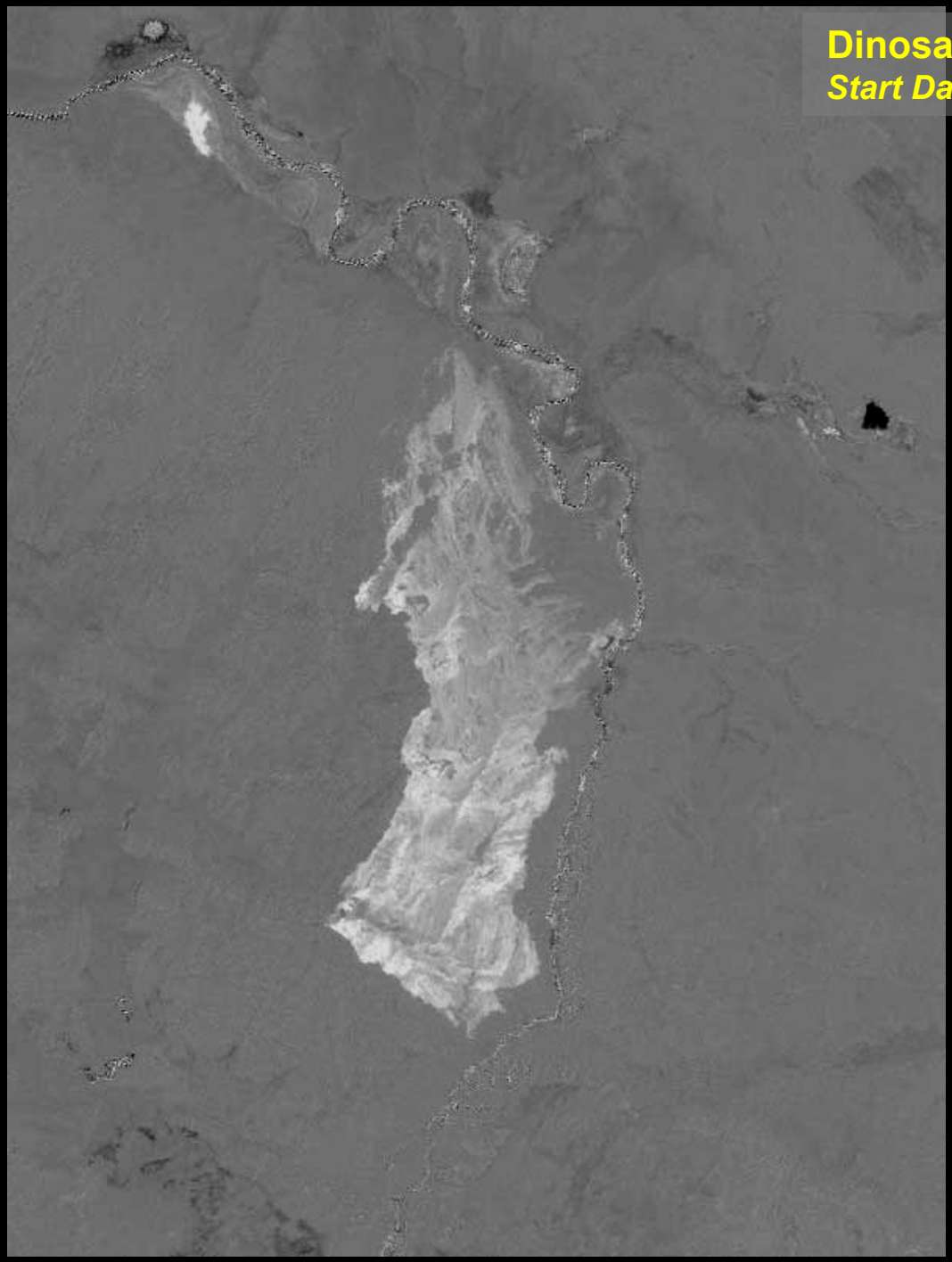
Pre Fire: L7: 05/25/00



Dinosaur National Park: Buster Flat Burn

Start Date:* 07/03/2000 *Extended Assessment

Post Fire: L5: 06/05/01



Dinosaur National Park: Buster Flat Burn

Start Date: **07/03/2000** ***Extended Assessment***

Delta NBR: L7-05/25/00 - L5-06/05/01

Status Code (code description): **302**

Incident-Reported Size: **11,055 ac.**

Delta NBR Size: **8,439 ac.**

Latitude: **40:40:29**

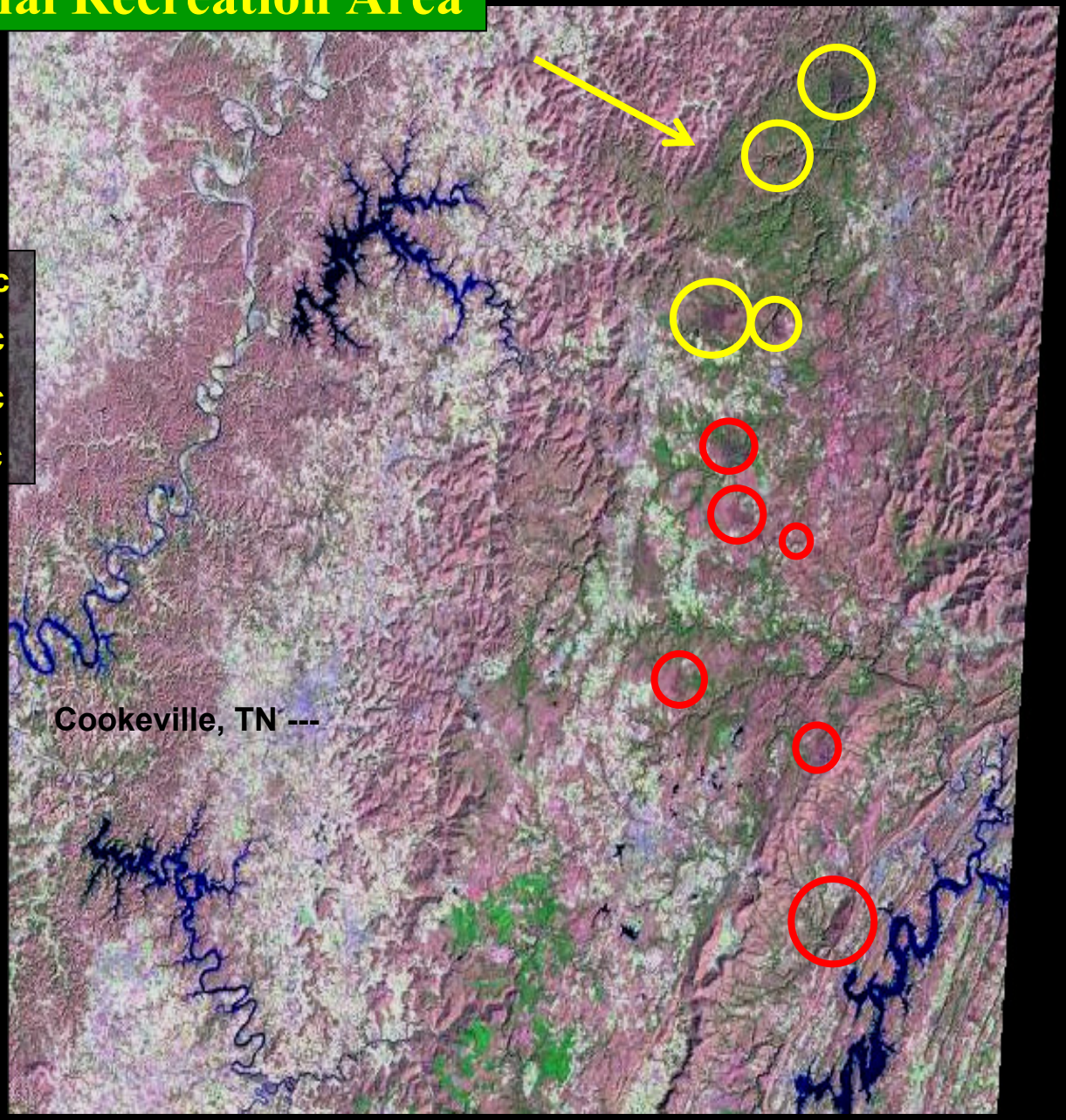
Longitude: **108:55:07**

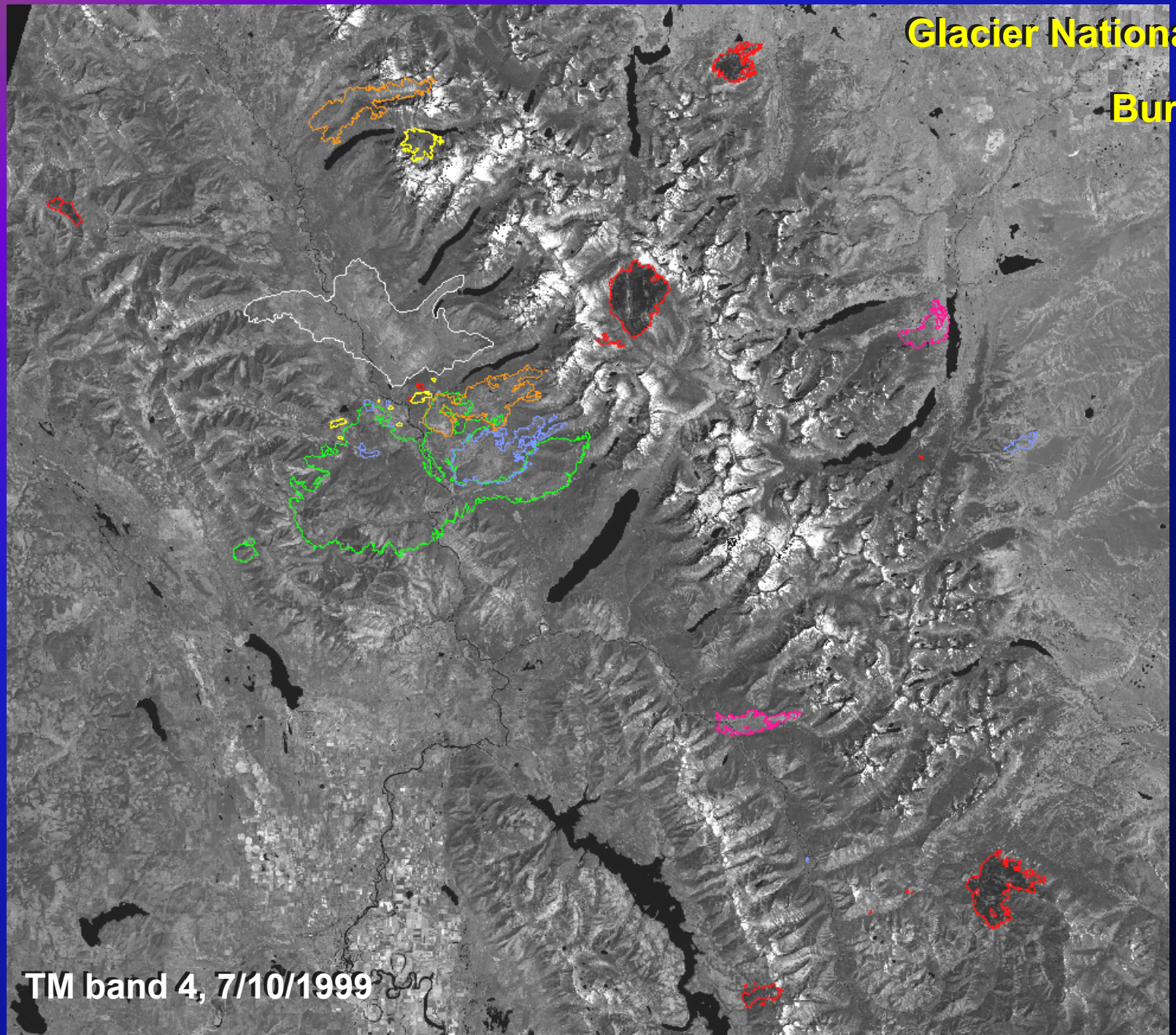
Landsat Path/Row: **36/32**

Big South Fork National Recreation Area

ETM+ 20/35
02/26/2001

School House	10/30/2000	2079 ac
Camp Branch	11/01/2000	1088 ac
Darrow Ridge	11/01/2000	3398 ac
Poplar	10/30/2000	800 ac




Glacier National Park
Burn Series
1984
1988
1994
1998
1999
2000
2001
TM band 4, 7/10/1999

Fire Data - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Search Favorites History

Address http://edcw2ks15.cr.usgs.gov/lccp/fire_burn/show_fire.asp?intID=9 Go Links

USGS

LCCP | Overview | Global | National | Urban | Trends | Applications | Publications

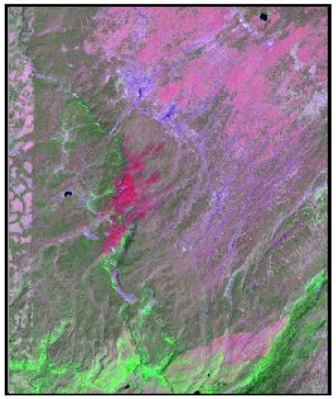
Fire Name: Plateau

Park Name: Yellowstone

Start Date:	8/16/2000
Assessment Type:	**Extended**
Status Code (code description):	**312**
Latitude:	44 18 26
Longitude:	111 02 40
Landsat Path/Row:	38/29
Image Dates:	L7-07/15/00 L7-07/02/01
Delta NBR Size (ac):	**2605**

Contact Point: ohlen@usgs.gov

PostFire False Color Subset



Links To Data:

Metadata (product projection information, image calibration parameters)

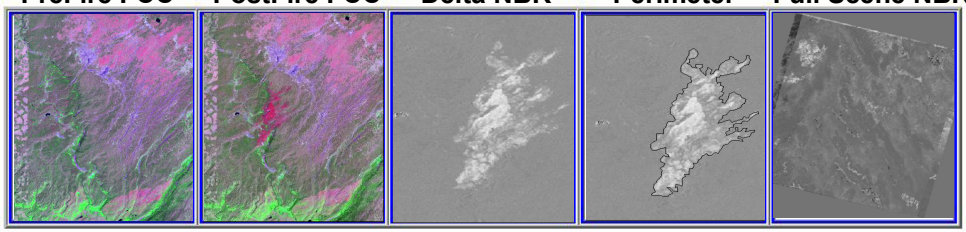
Fire Perimeter (shape file)
Pre-Fire Image subset (3-band Geo-TIFF)
Post-Fire Image subset (3-band Geo-TIFF)

Differenced NBR subset(s) (initial response, one-year if available)
Full Scene DNBR (large file >75MB)

Downloadable Image Gallery:

Click Images To Enlarge

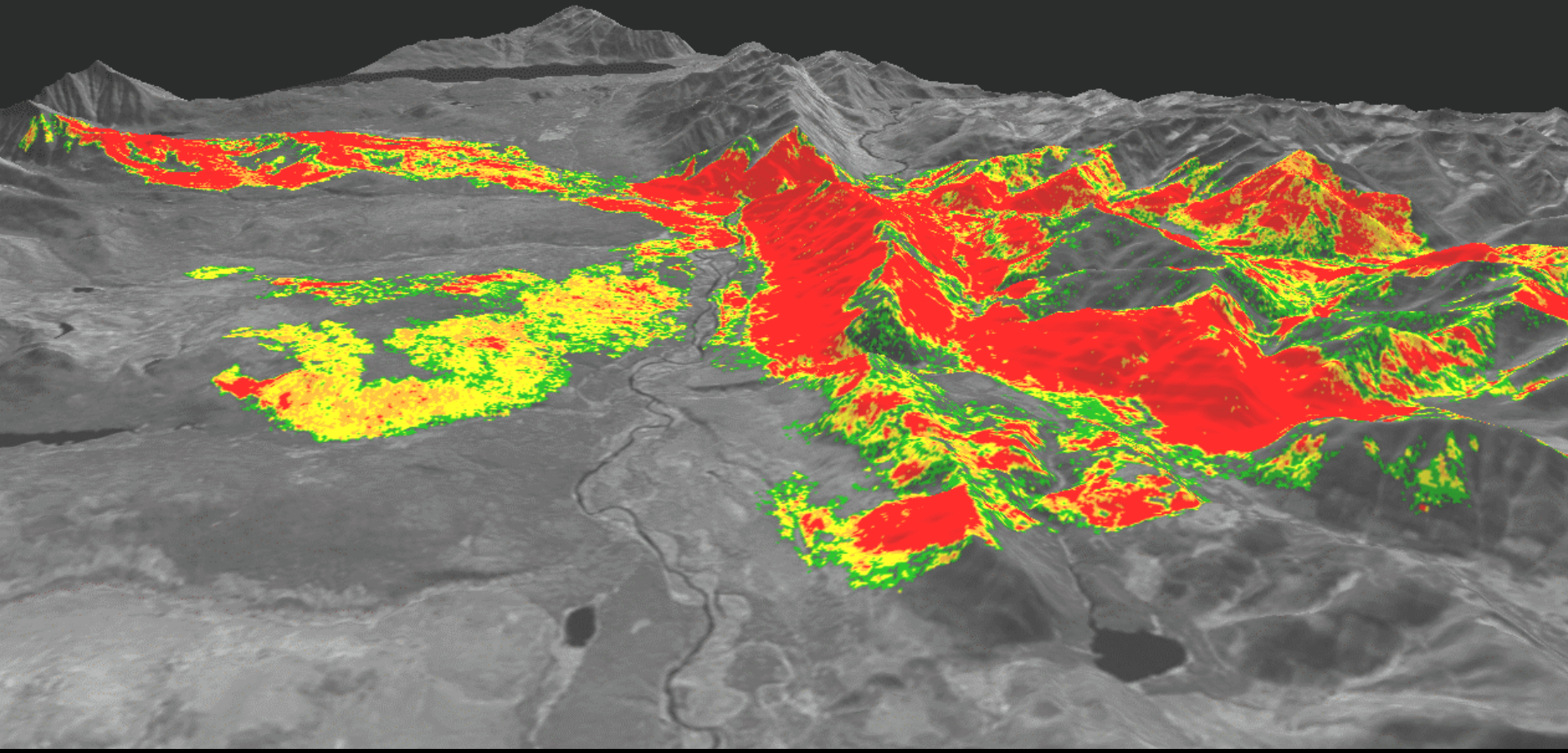
PreFire FCC **PostFire FCC** **Delta NBR** **Perimeter** **Full Scene NBR**



The End

See www.fire.org/firemon Updated Version 2 Now Available.

Link to Landscape Assessment (LA), then to LA Methods



2001 Moose Burn, Preliminary Severity Levels