# Predicting long-term wildfire effects across complex landscapes

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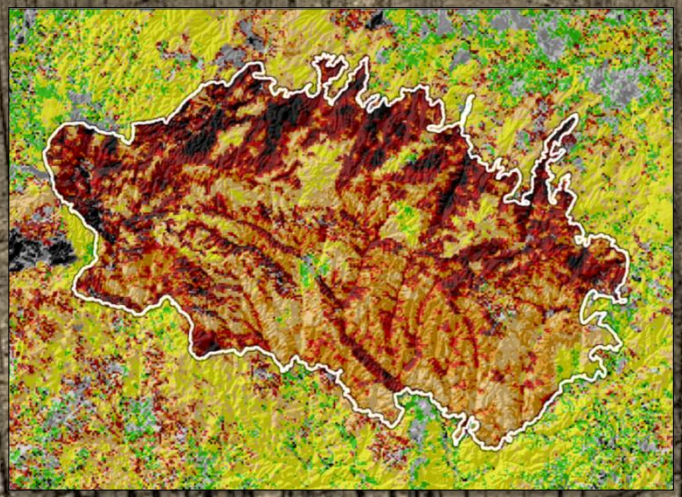
William W. Hargrove, Danny C. Lee, William M. Christie
Joseph P. Spruce



October 29, 2013
US Forest Service Research and Development
Landscape Science Webinar

# Outline

**PART I—**Our wildland fire and management crisis

**PART II—**Efficient coarse-filter landscape monitoring

**PART III—**Predicting long-term fire effects

# Outline

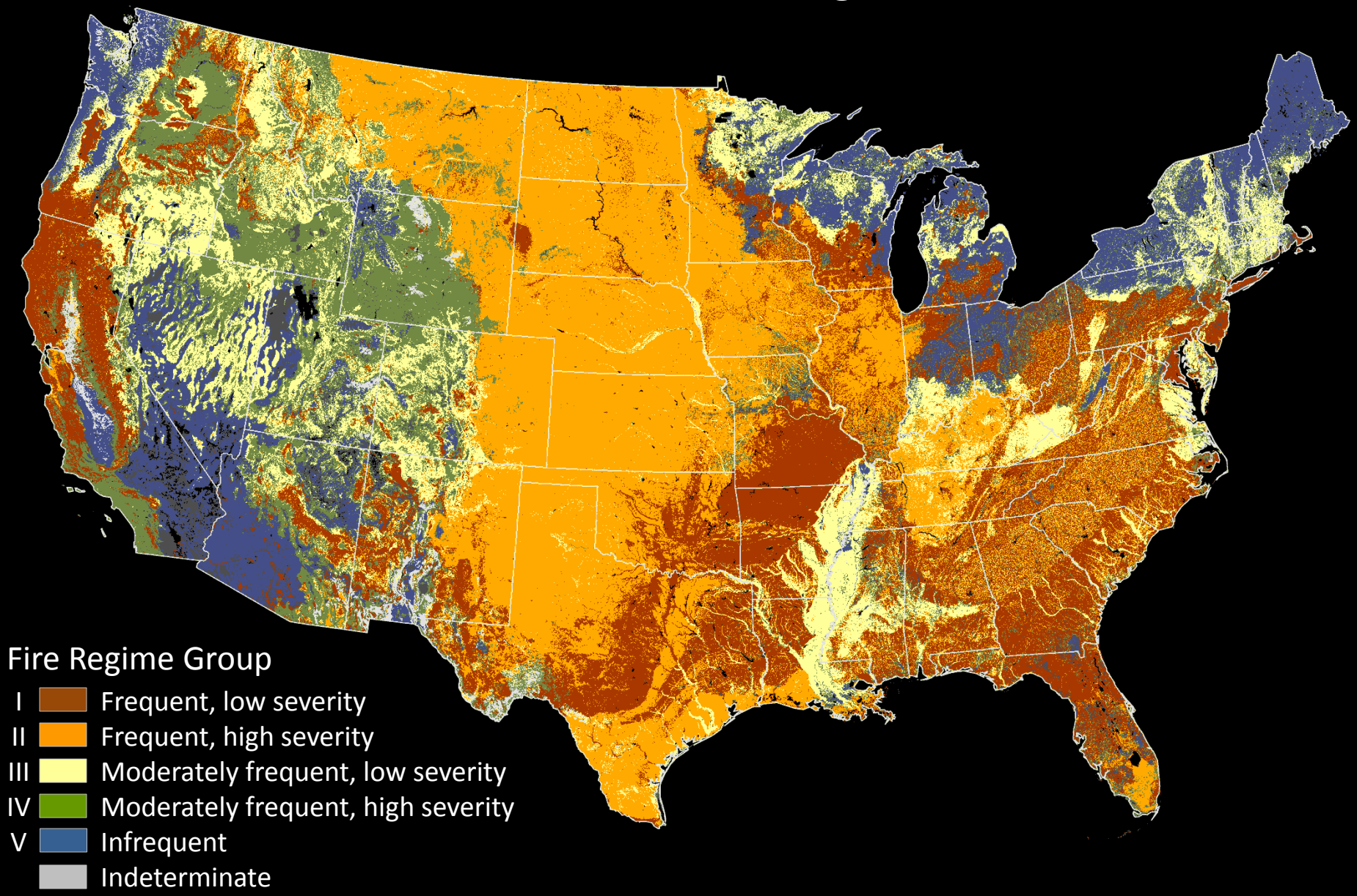
**PART I—**Our wildland fire and management crisis

The entangling effects of past management decisions, conflicting values, ecological need, and a changing environment

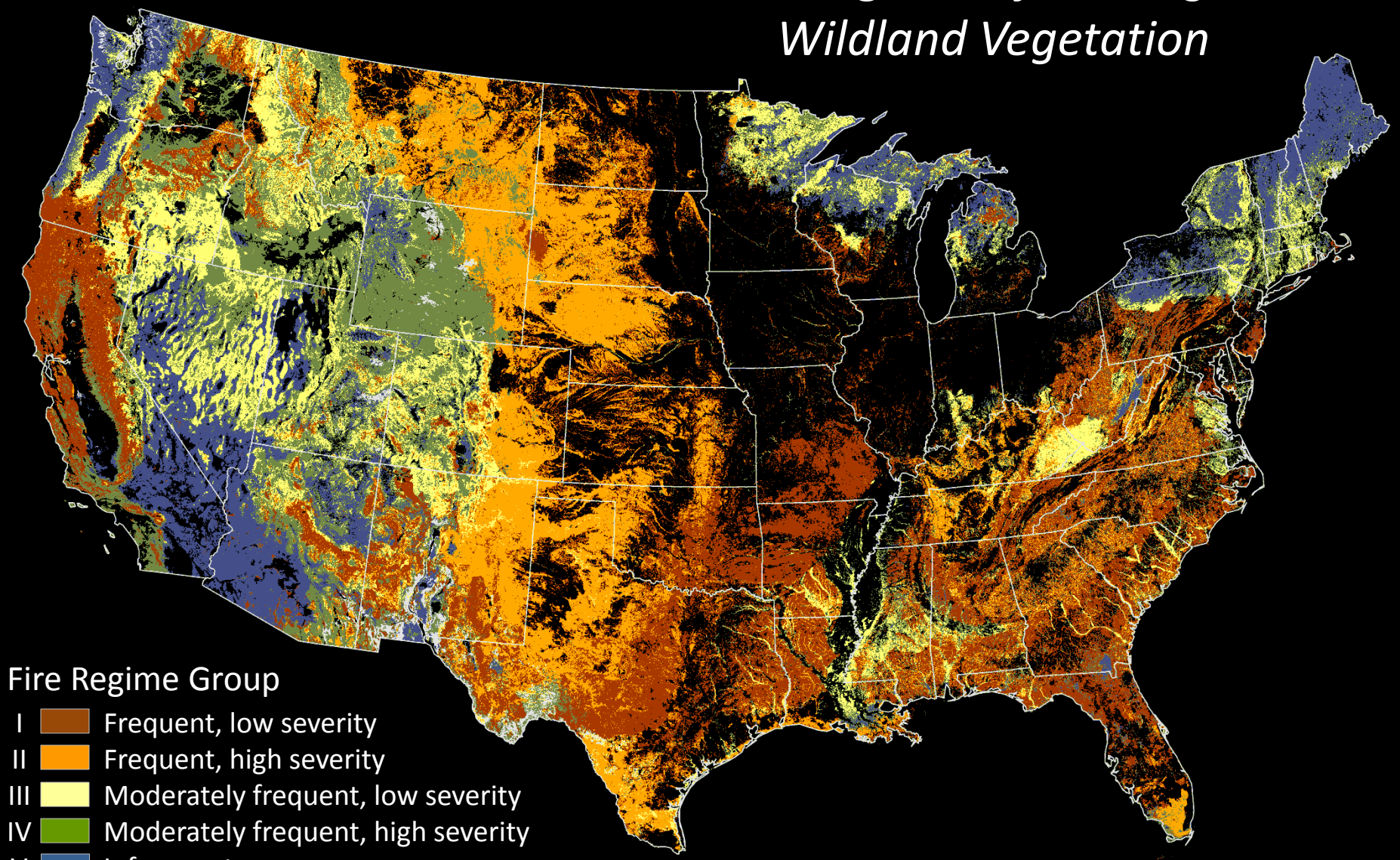
**PART II—**Efficient coarse-filter landscape monitoring

**PART III—**Predicting long-term fire effects

# Historical Fire Regimes



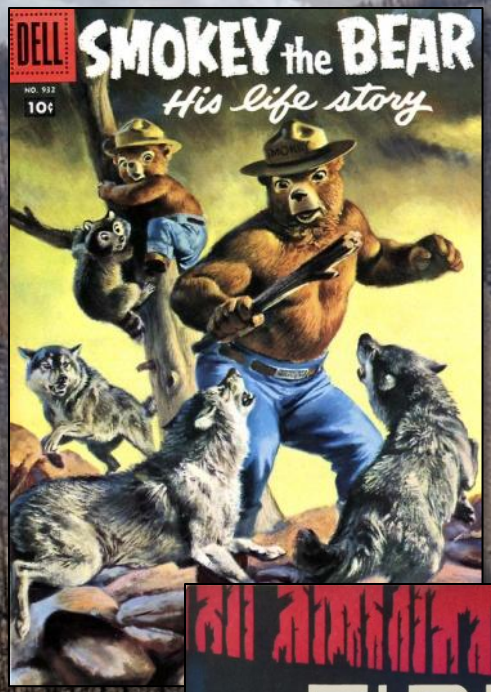
# Historical Fire Regimes *of Existing Wildland Vegetation*

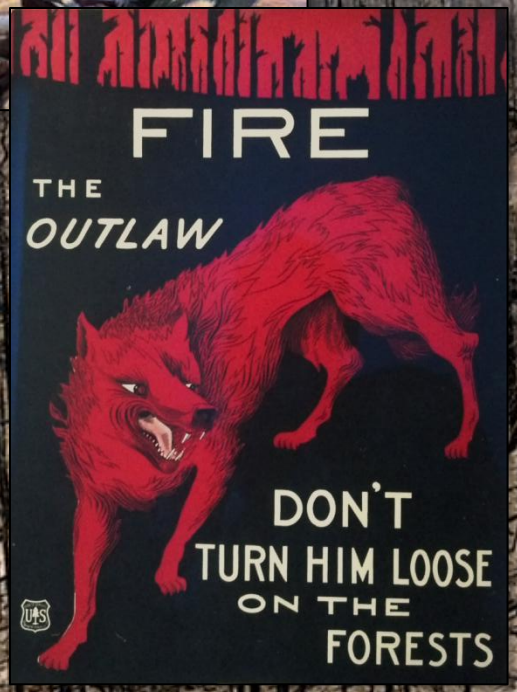


Fire Regime Group

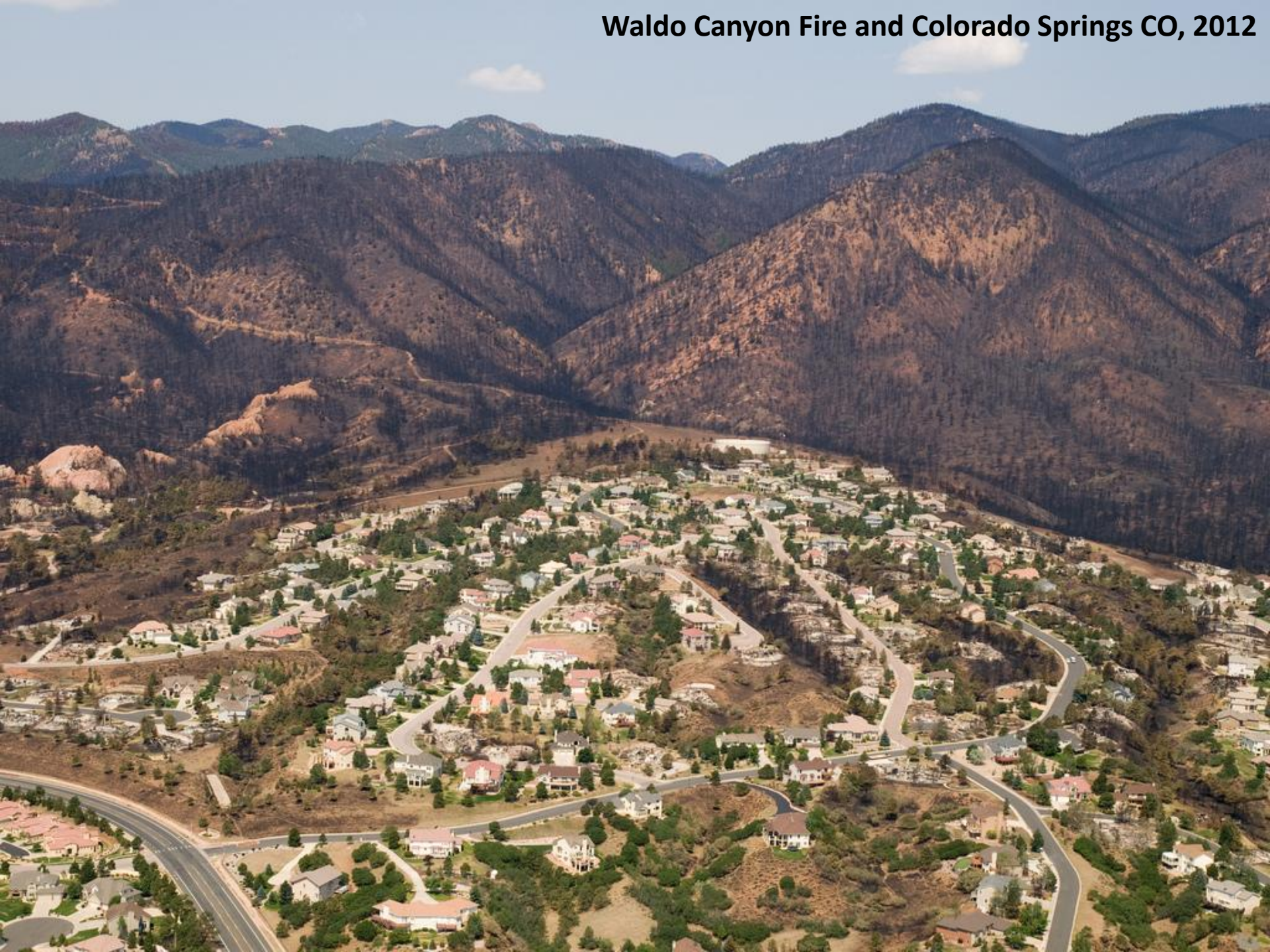
- I — Frequent, low severity
- II — Frequent, high severity
- III — Moderately frequent, low severity
- IV — Moderately frequent, high severity
- V — Infrequent
- Indeterminate

Wallow Fire AZ, 2011

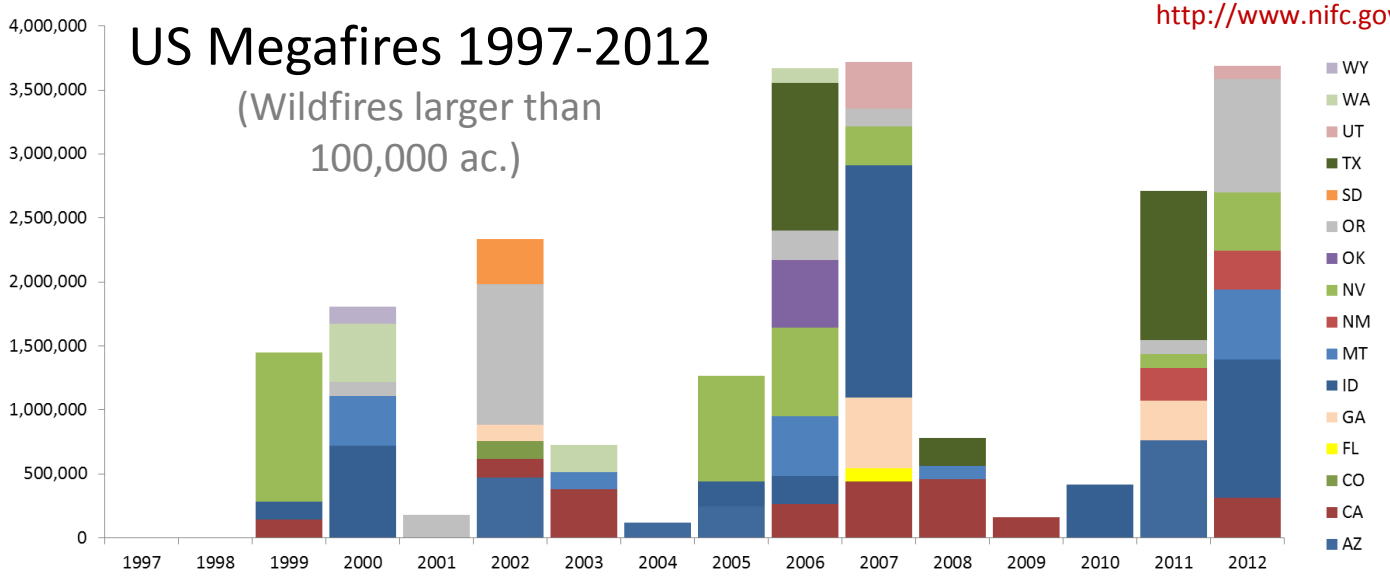

DELL
SMOKEY the BEAR
His life story
NO. 932
10¢

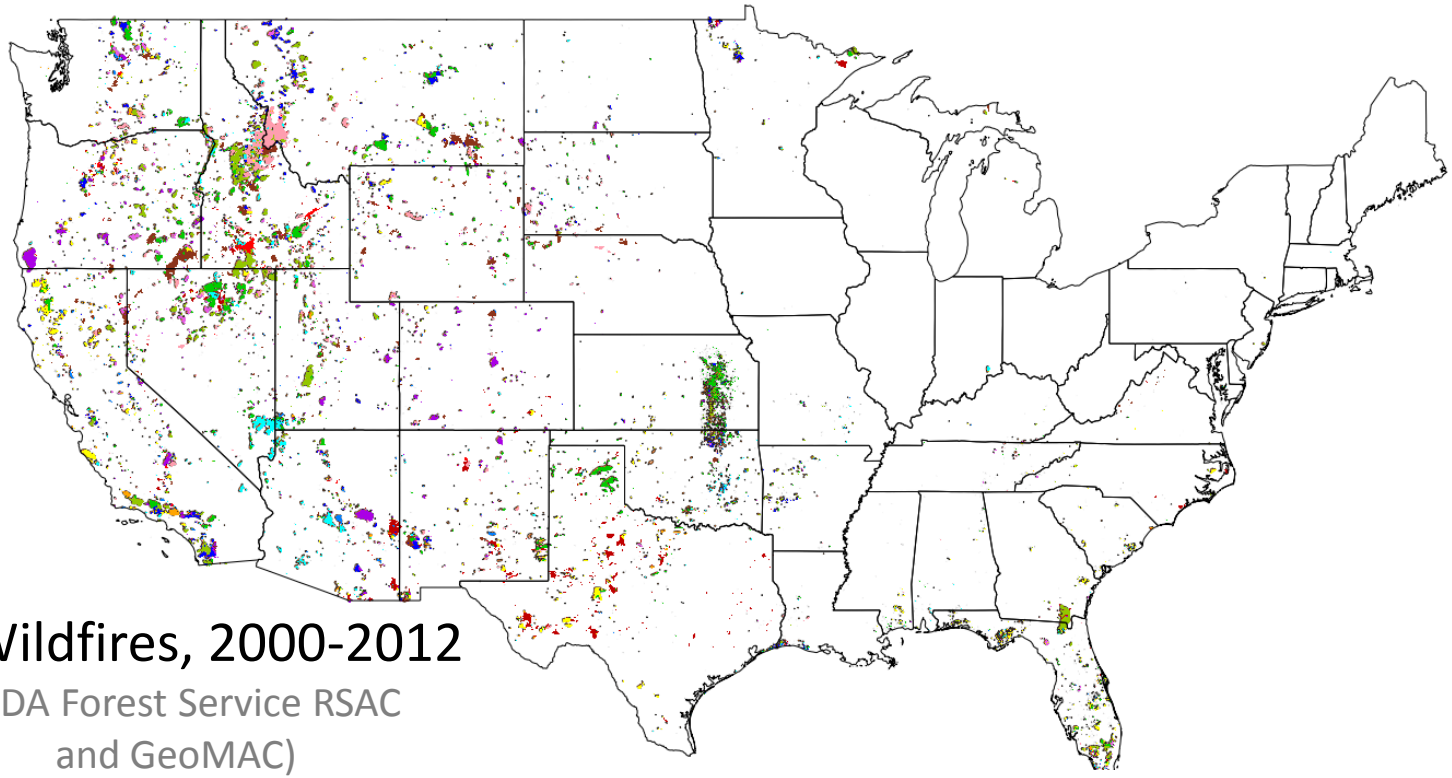

FIRE
THE
OUTLAW
DON'T
TURN HIM LOOSE
ON THE
FORESTS
U.S.

Waldo Canyon Fire and Colorado Springs CO, 2012



http://www.nifc.gov



US Wildfires, 2000-2012

(USDA Forest Service RSAC and GeoMAC)

**Complex disturbance interactions (drainage, logging, hurricanes, repeated fires) in the Great Dismal Swamp NWR, Virginia**

Buffelgrass

Cheatgrass

Cogongrass

Tamarisk/Salt cedar

# Complex disturbance interactions (beetle kill, drought, wildfire) in the Interior West

Little Bear Fire, Lincoln National Forest NM, 2012
Showing resilient fire effects in natural areas

# Outline

**PART I—**Our wildland fire and management crisis

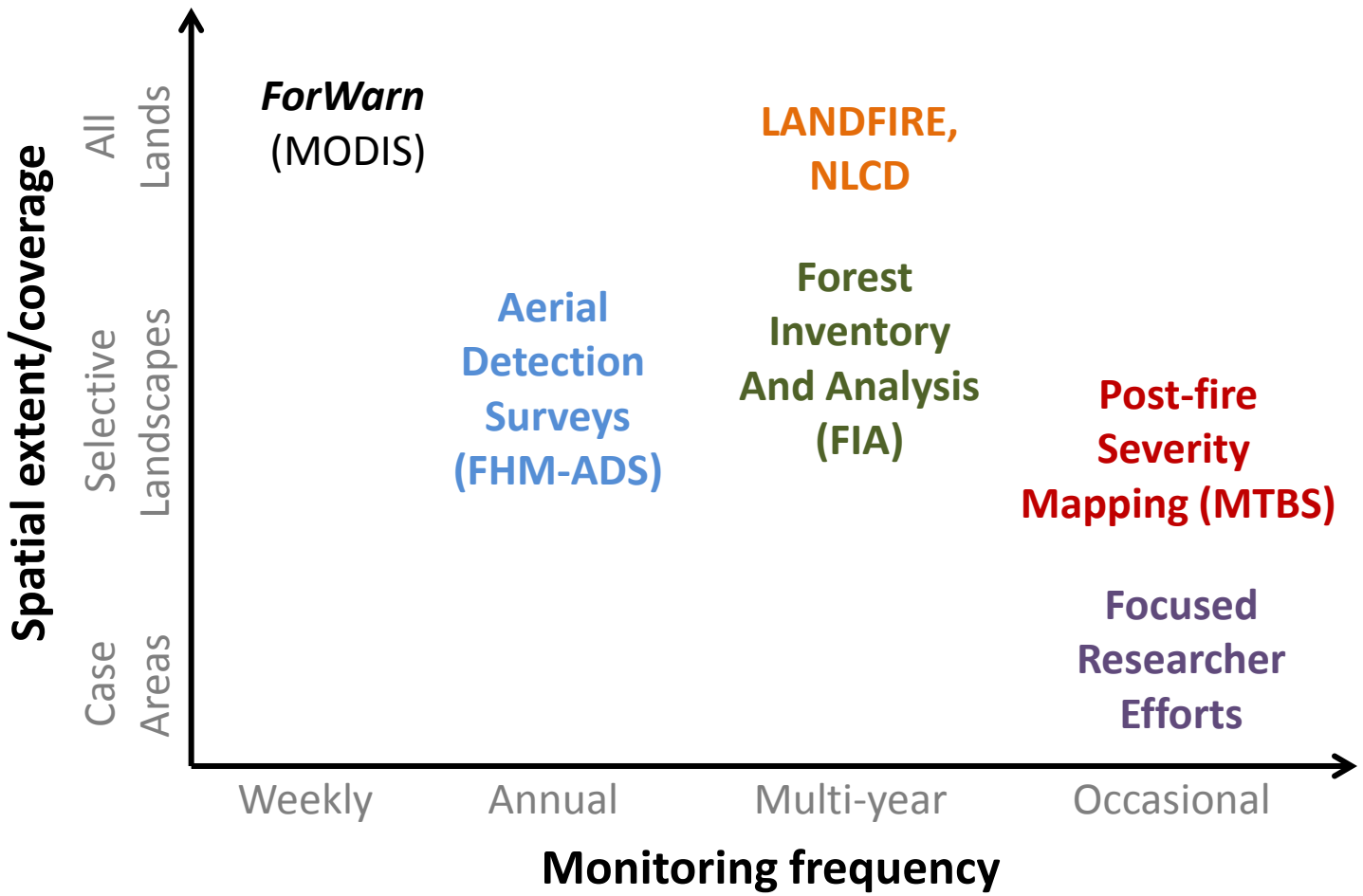
**PART II—**Efficient coarse-filter landscape monitoring

Of what *has* burned, *will* likely burn, and *needs to* burn to maintain or recover landscape resiliency.

**PART III—**Predicting long-term fire effects

# **PART II**—Efficient coarse-filter landscape monitoring

Key existing approaches and datasets

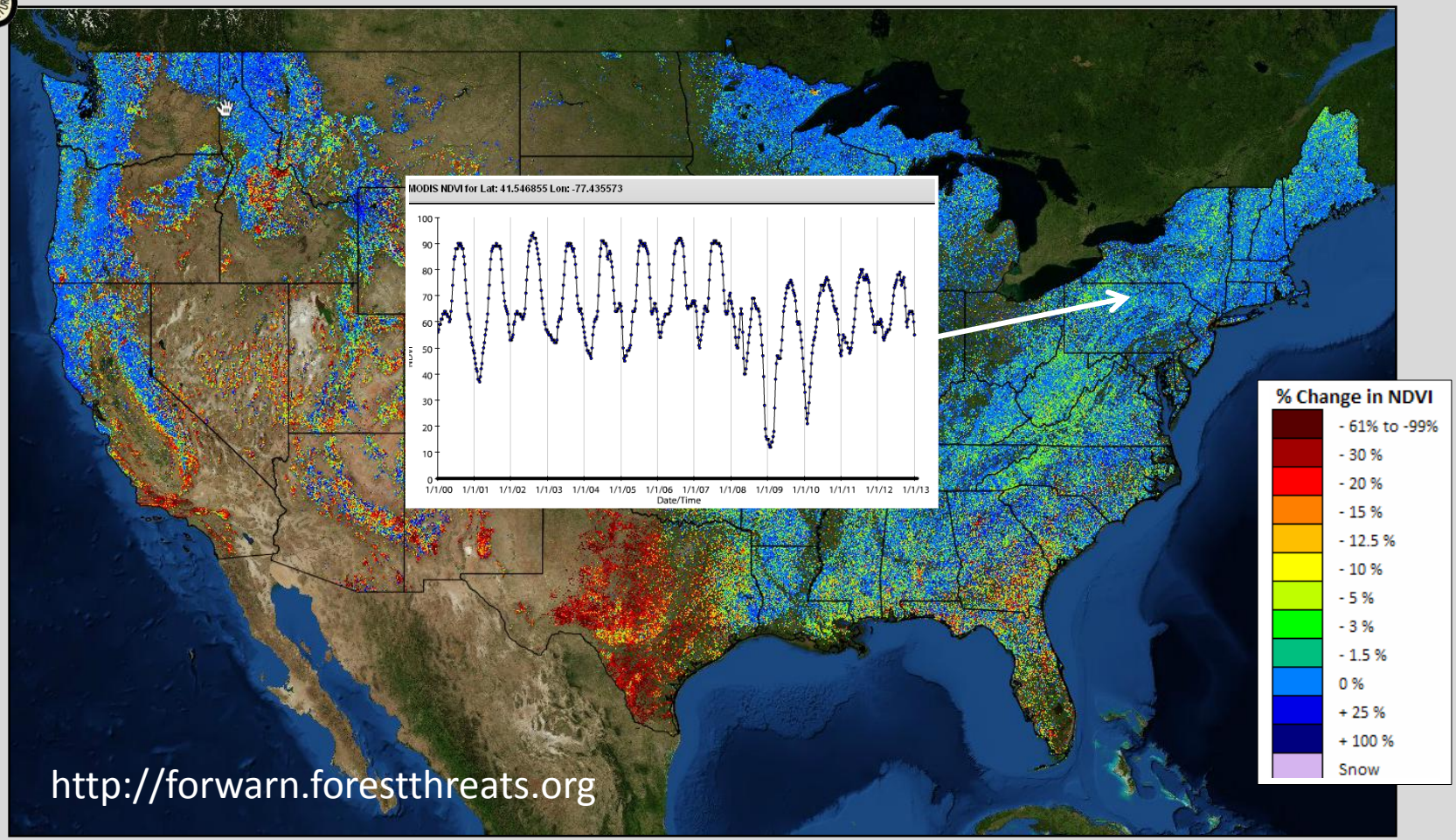


"Praemonitus Praemunitus"

# ForWarn

Satellite-Based Change Recognition and Tracking

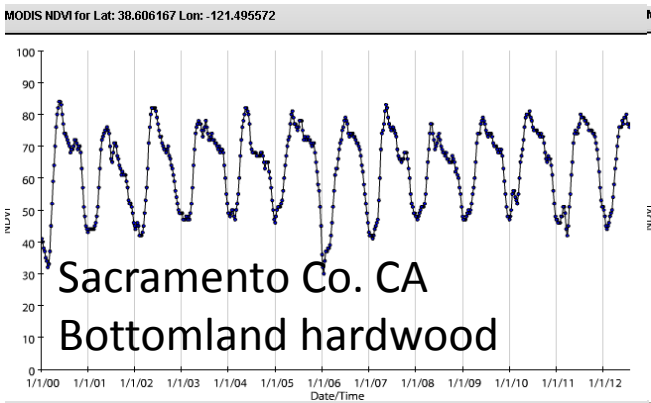
- Normalized Difference Vegetation Index (NDVI) from daily MODIS stream
- 232 meter resolution
- 46 periods per year (8-day intervals)
- 2000 to present historical database
- Includes NDVI time series and change maps

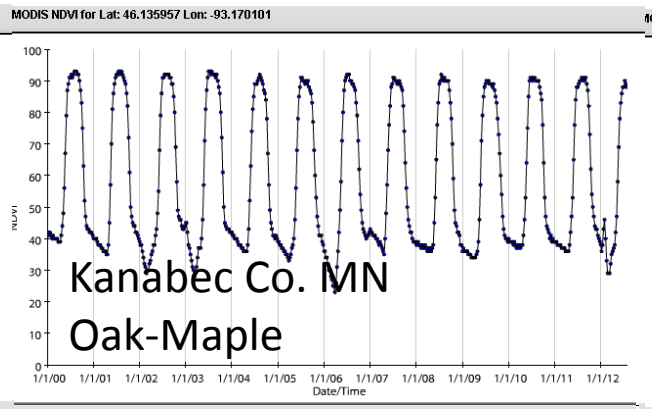


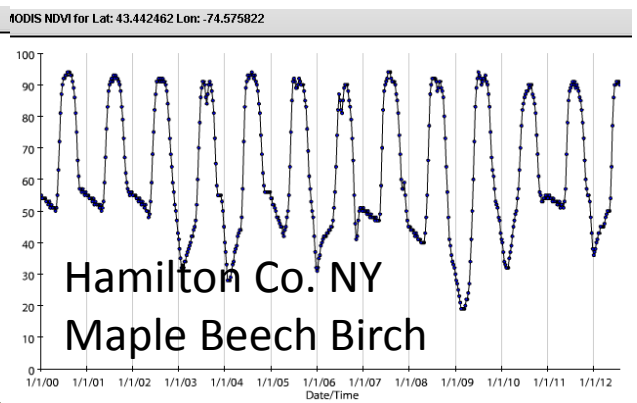

http://forwarn.forestthreats.org

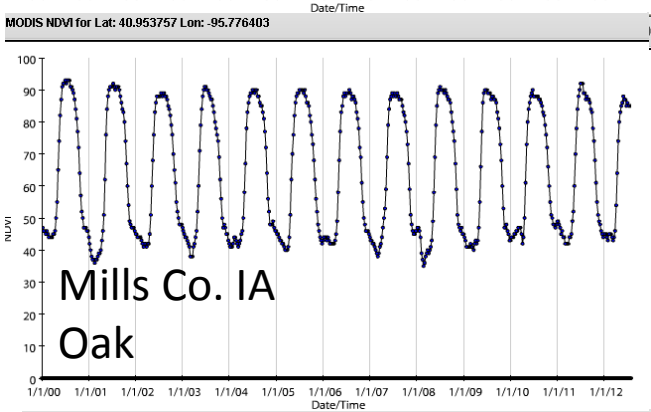
# **PART II—**Efficient coarse-filter landscape monitoring

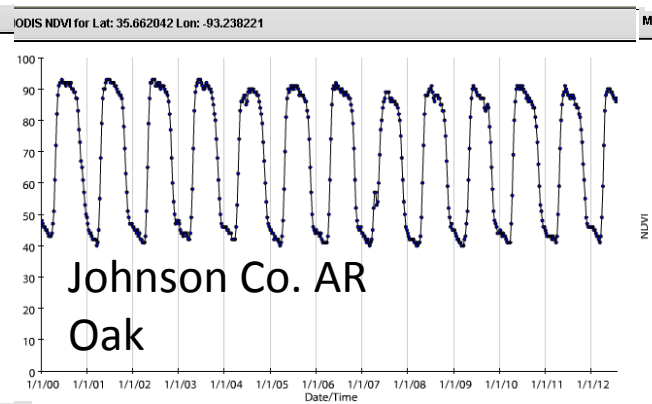
## Phenological signatures of **deciduous forest** dominated pixels

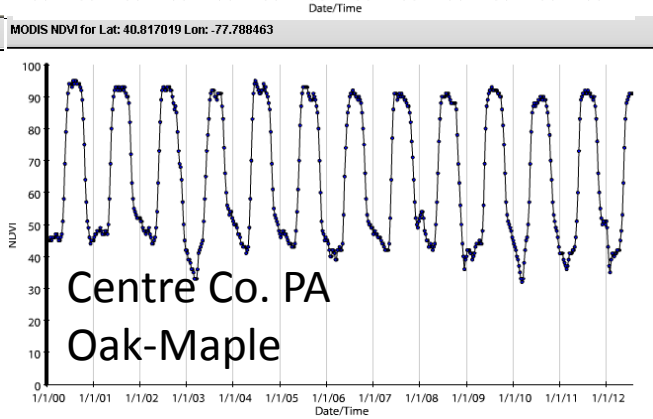


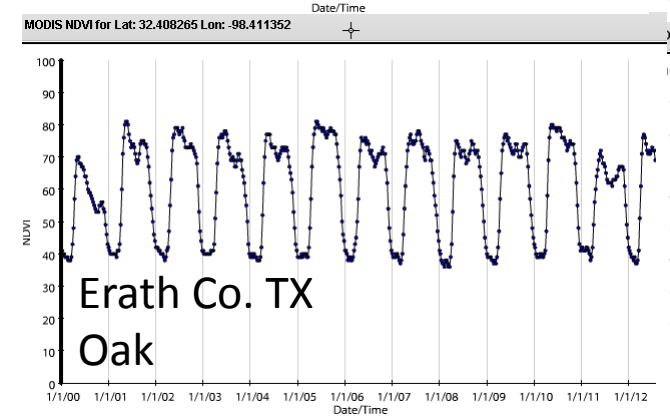



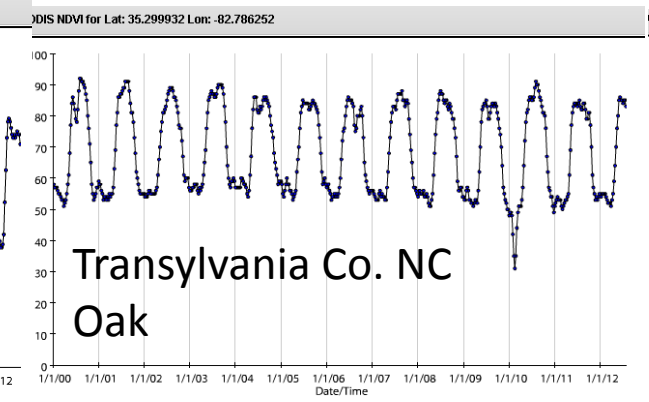



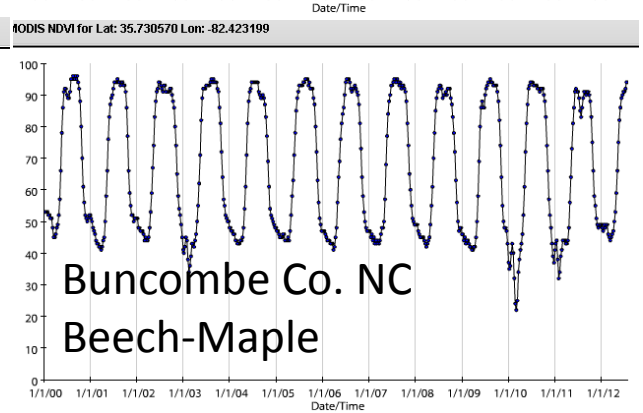



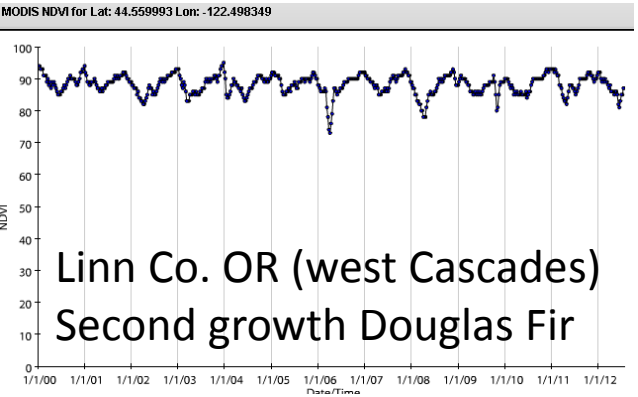



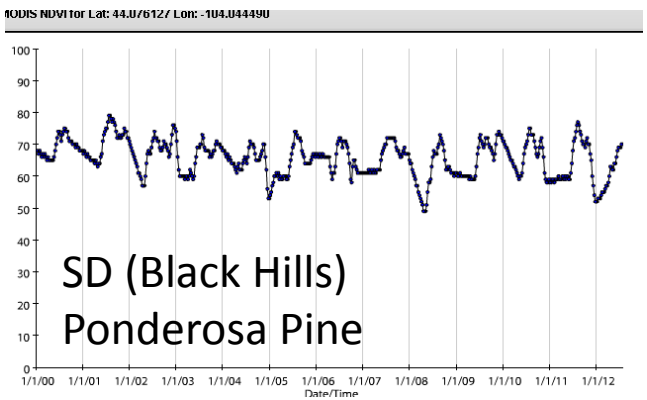



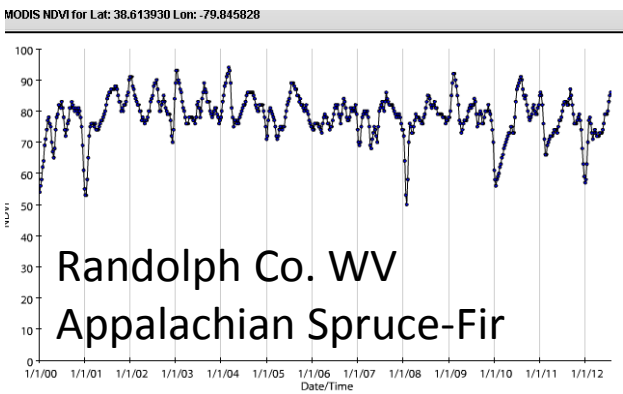



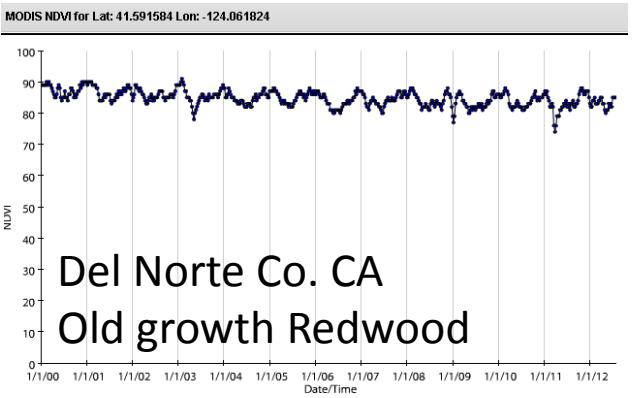
# **PART II—**Efficient coarse-filter landscape monitoring

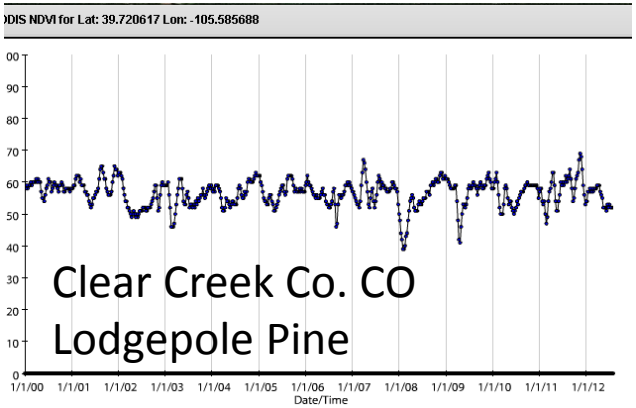
## Phenological signatures of **conifer forest** dominated pixels

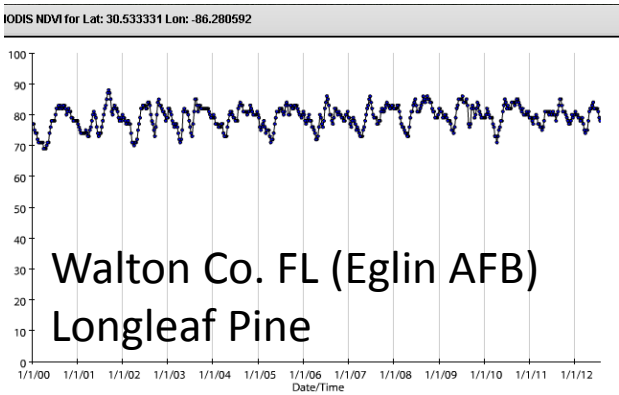


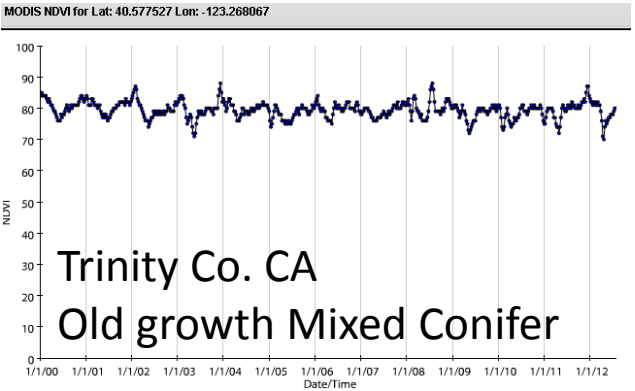



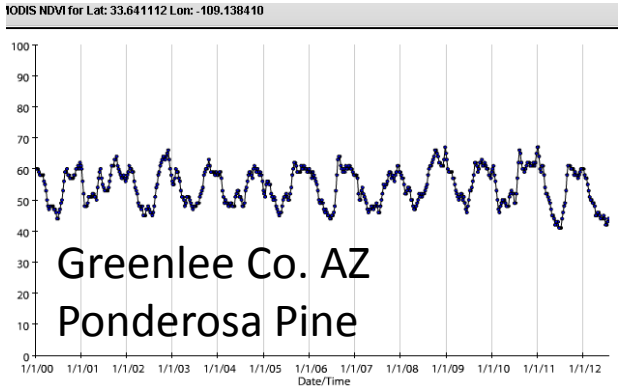



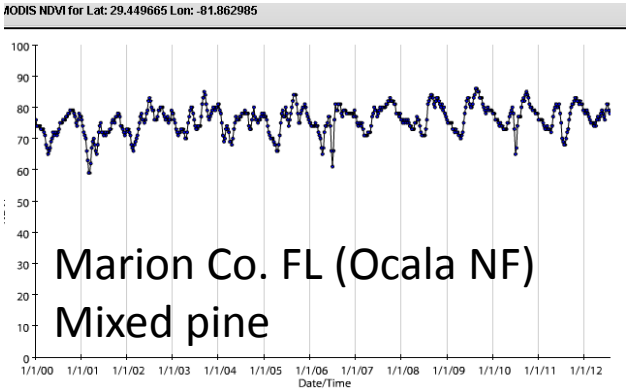



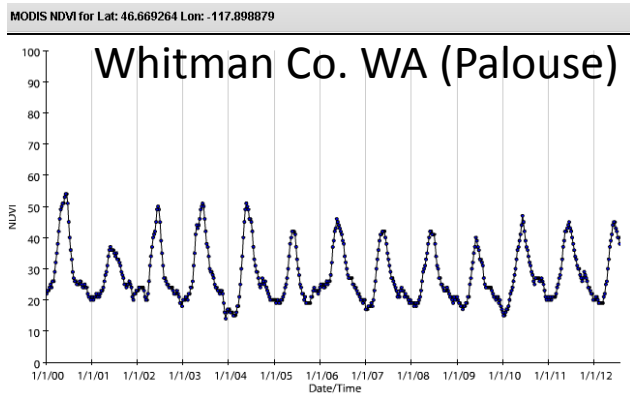



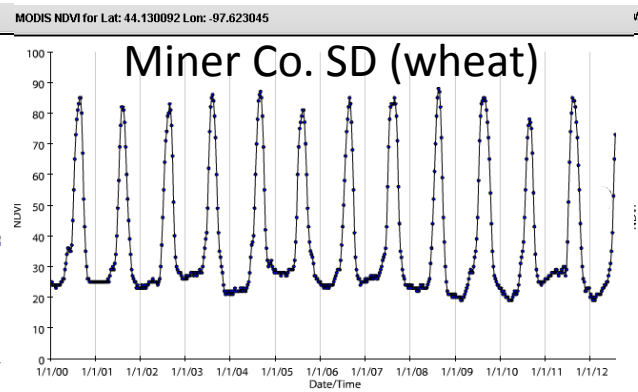



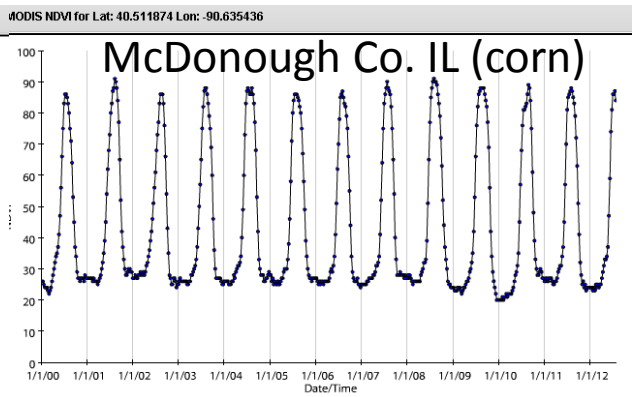



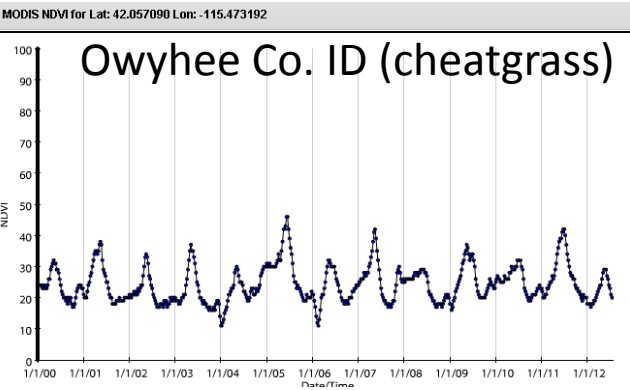
# **PART II—**Efficient coarse-filter landscape monitoring

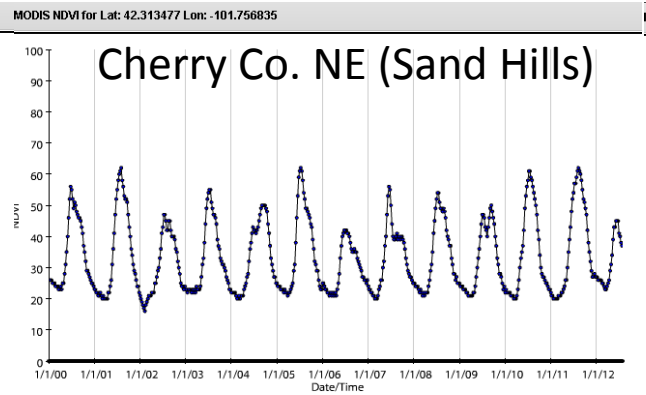
## Phenological signatures of **grass** dominated pixels

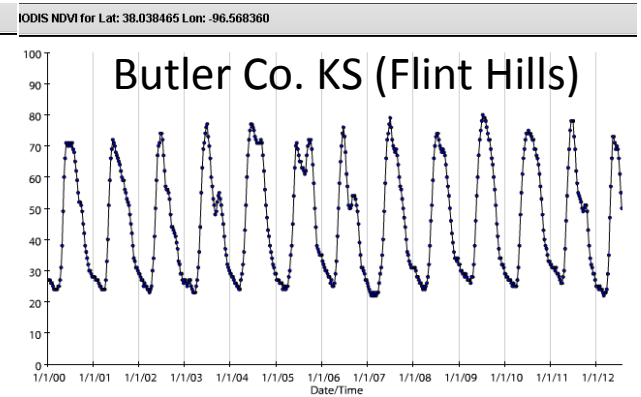


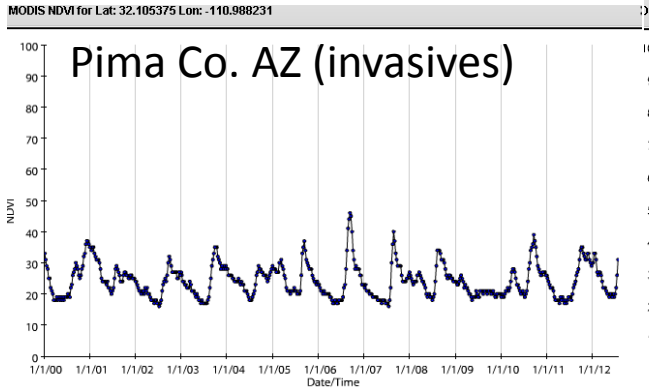



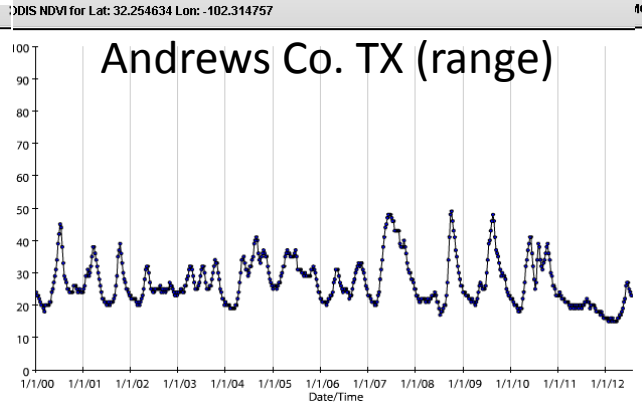



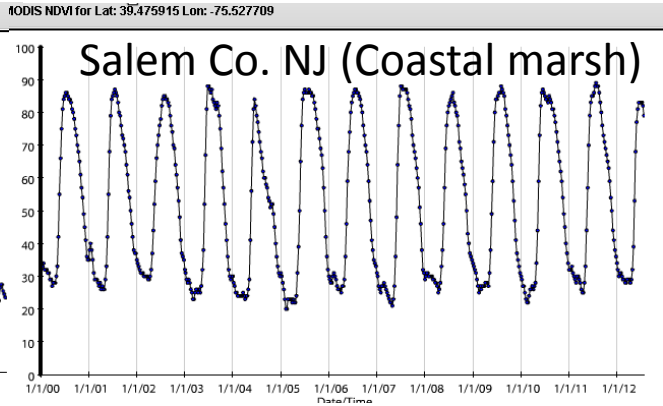



# **PART II**—Efficient coarse-filter landscape monitoring

## Potential measures of fire effects and desired vegetation

*Maximum NDVI*
*Minimum NDVI*
*Mean NDVI*
*Median NDVI*

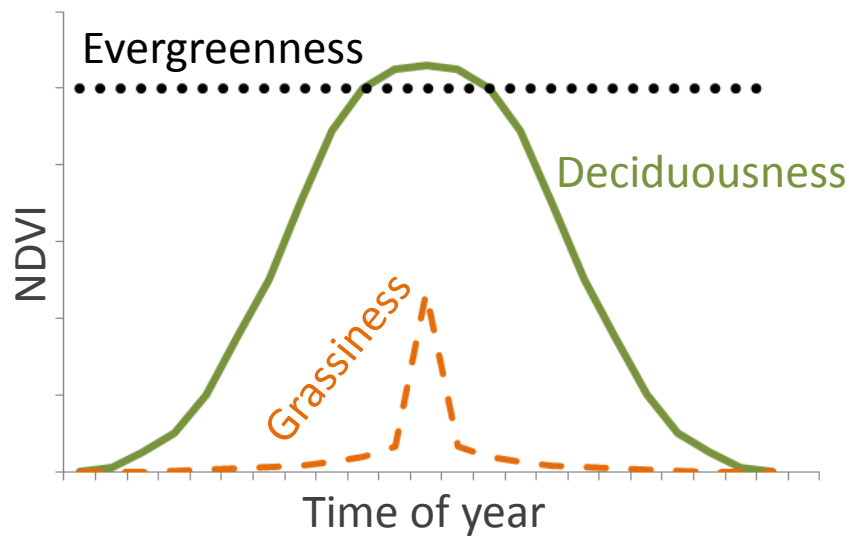
*Percentiles of the annual distribution*
*Amplitude of NDVI (of extremes)*
*NDVI difference (between thresholds)*
*Duration above some threshold*
*Area under the growing season curve*

**Key measures for vegetation change associated with wildland fire:**

**(1) LIVING BIOMASS**
(median NDVI or 50th %ile)

**(2) EVERGREEN FRACTION**
(~25th %ile of annual distribution)

**(3) GRASS FRACTION**
(peakedness of uppermost distribution)



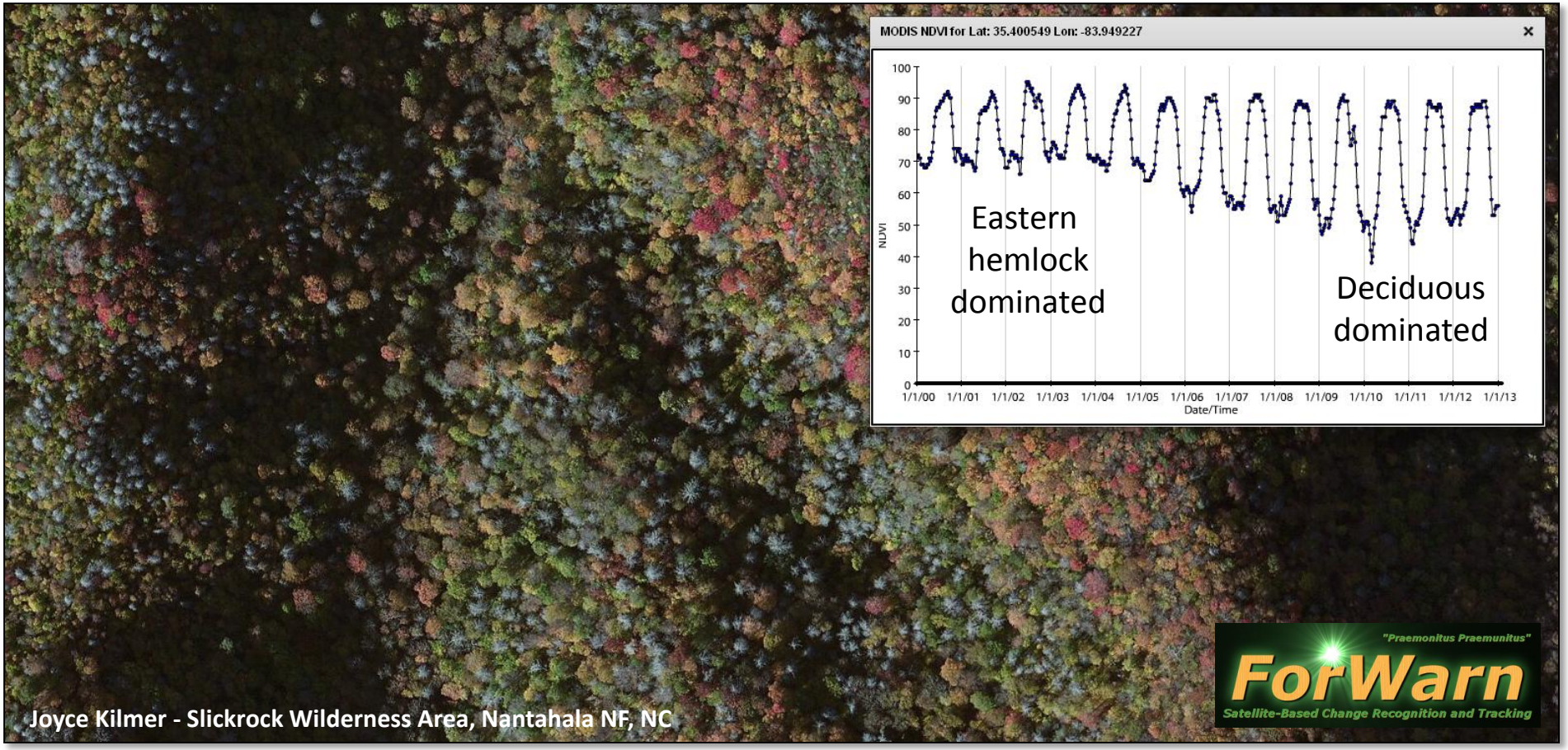
# **PART II**—Efficient coarse-filter landscape monitoring

## Shifts in annual phenology profiles track changes in vegetation

The NDVI values of evergreen (conifer) annual percentiles are similar year round

(Note decline of the lower (winter) percentiles)

Deciduous forest percentiles have high amplitude and a more diverse distribution of NDVI values.

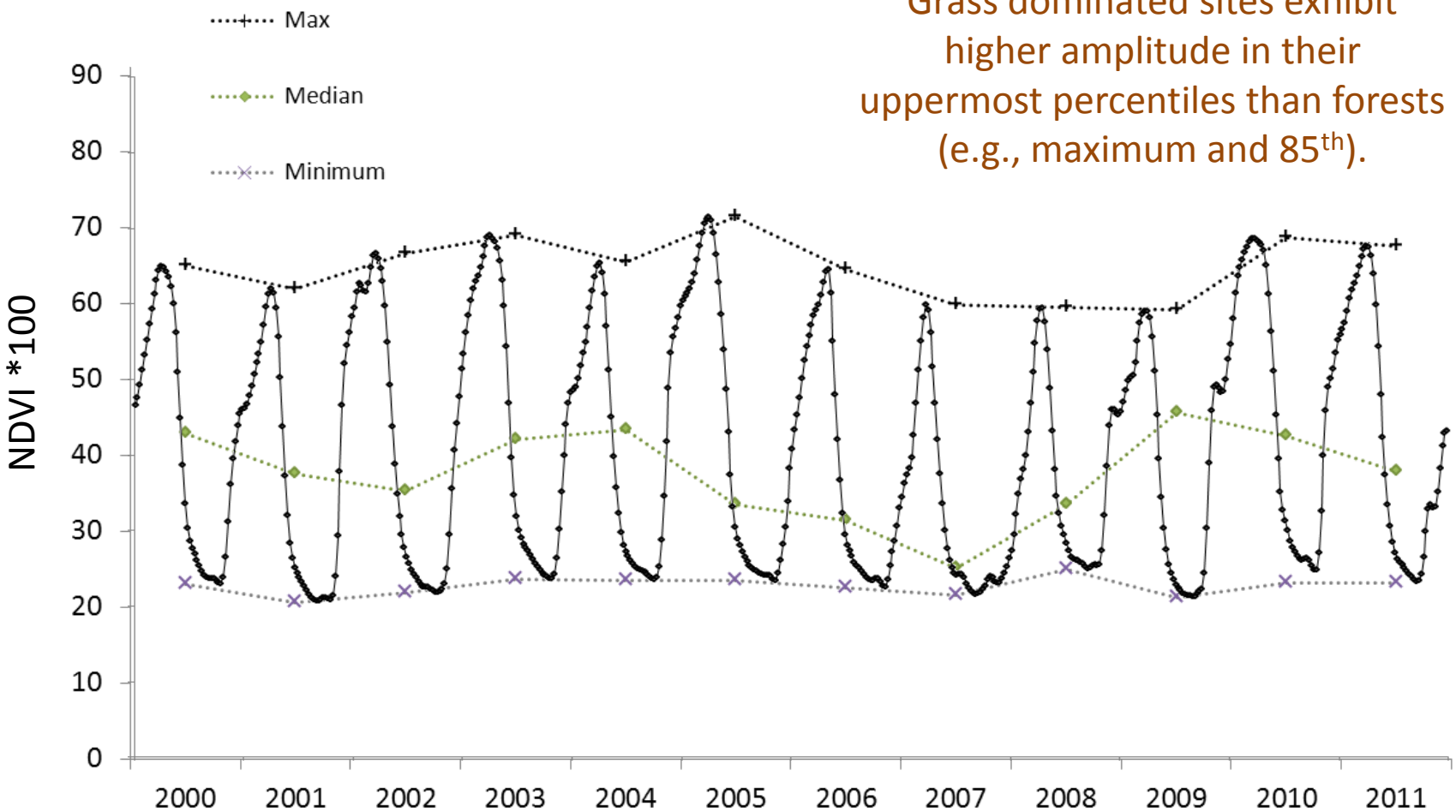


# **PART II—**Efficient coarse-filter landscape monitoring

## The max., median and min. NDVI for Willows CA non-native grasslands

(The landscape mean of 9,345 MODIS pixels)

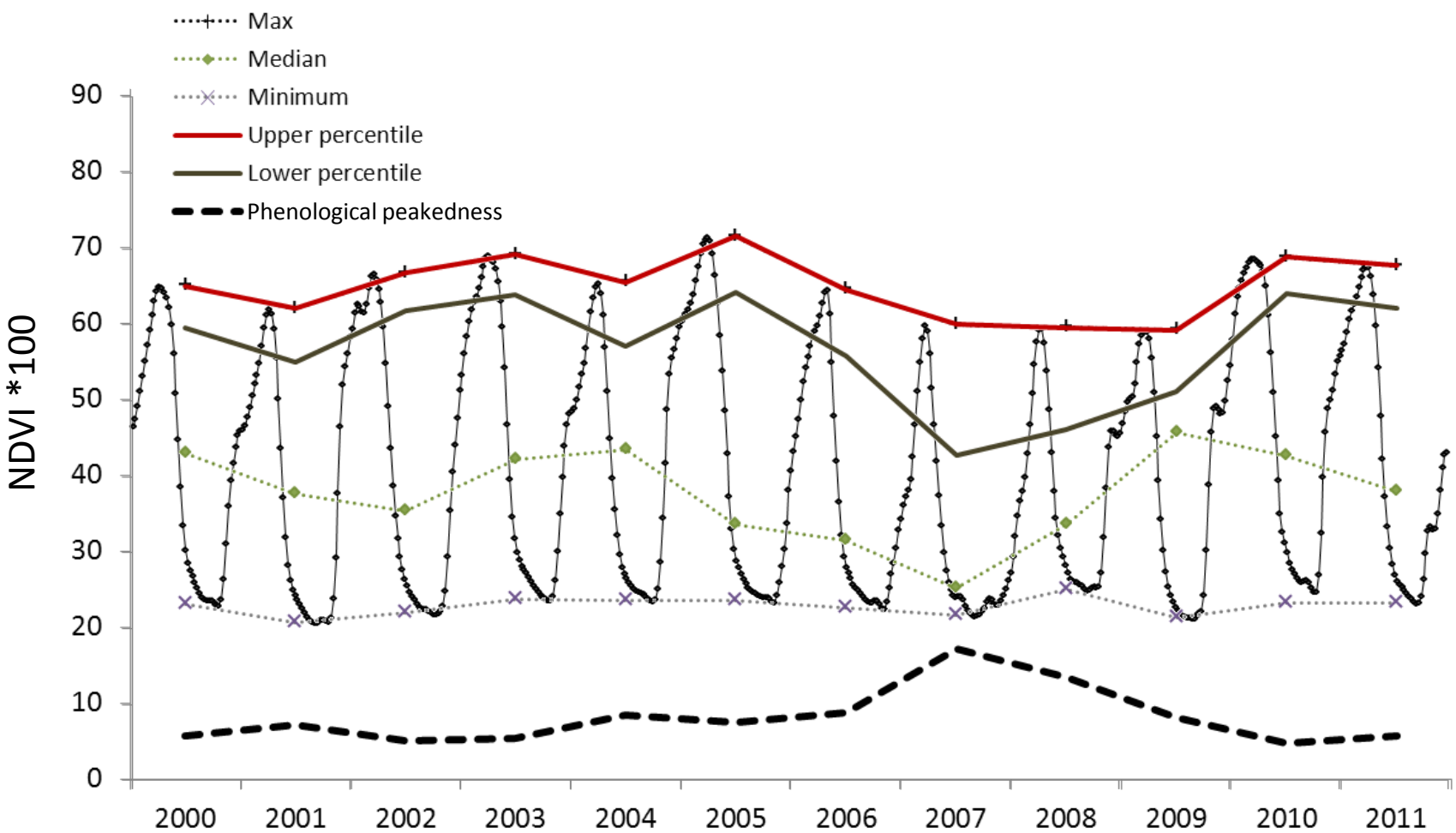
Grass dominated sites exhibit higher amplitude in their uppermost percentiles than forests (e.g., maximum and 85th).




*Note the inter-annual volatility of this measure typically caused by climate variation*

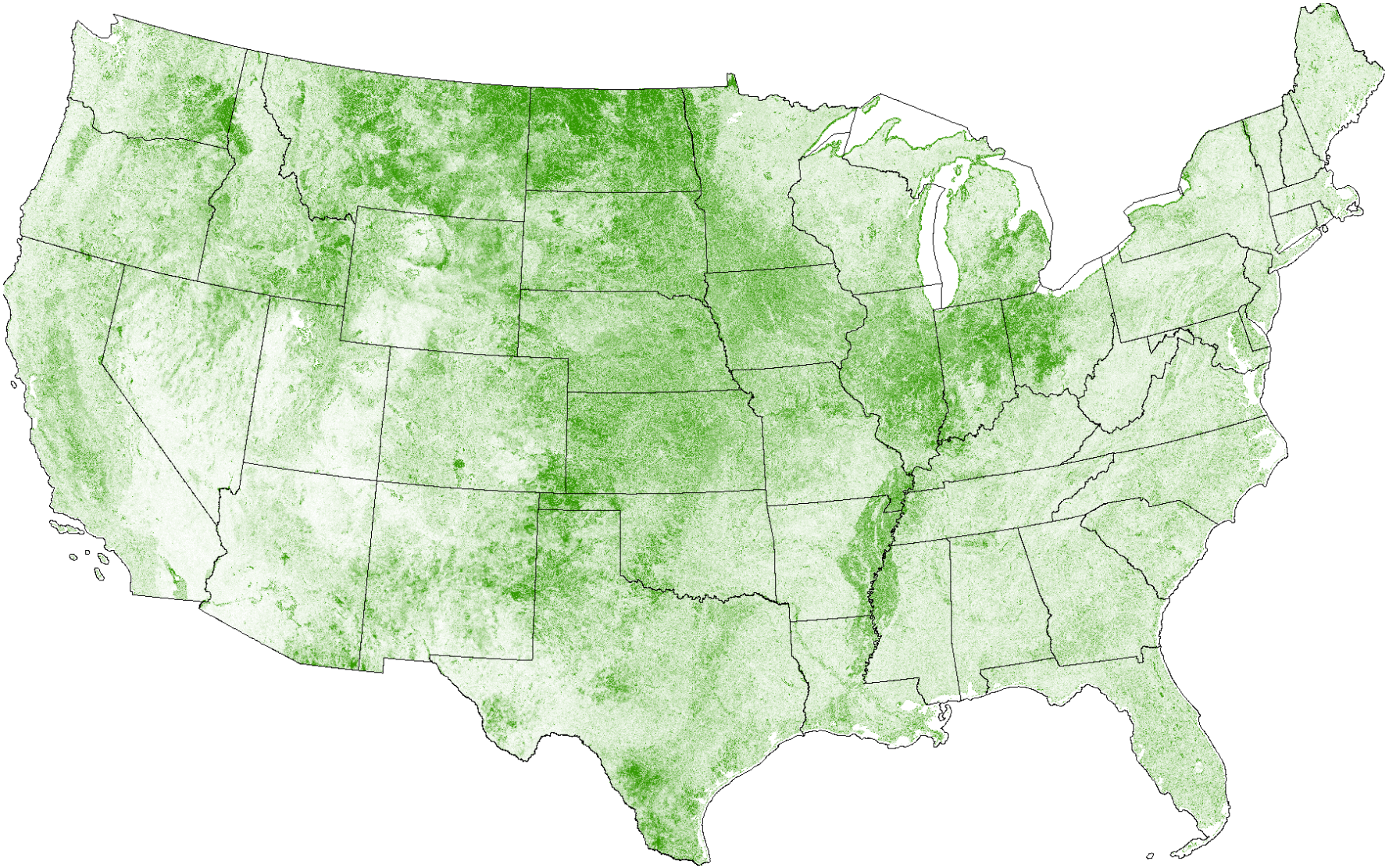
# **PART II**—Efficient coarse-filter landscape monitoring

*Phenological peakedness* as the difference between the **Max** and **80th** percentile of the calendar year distribution



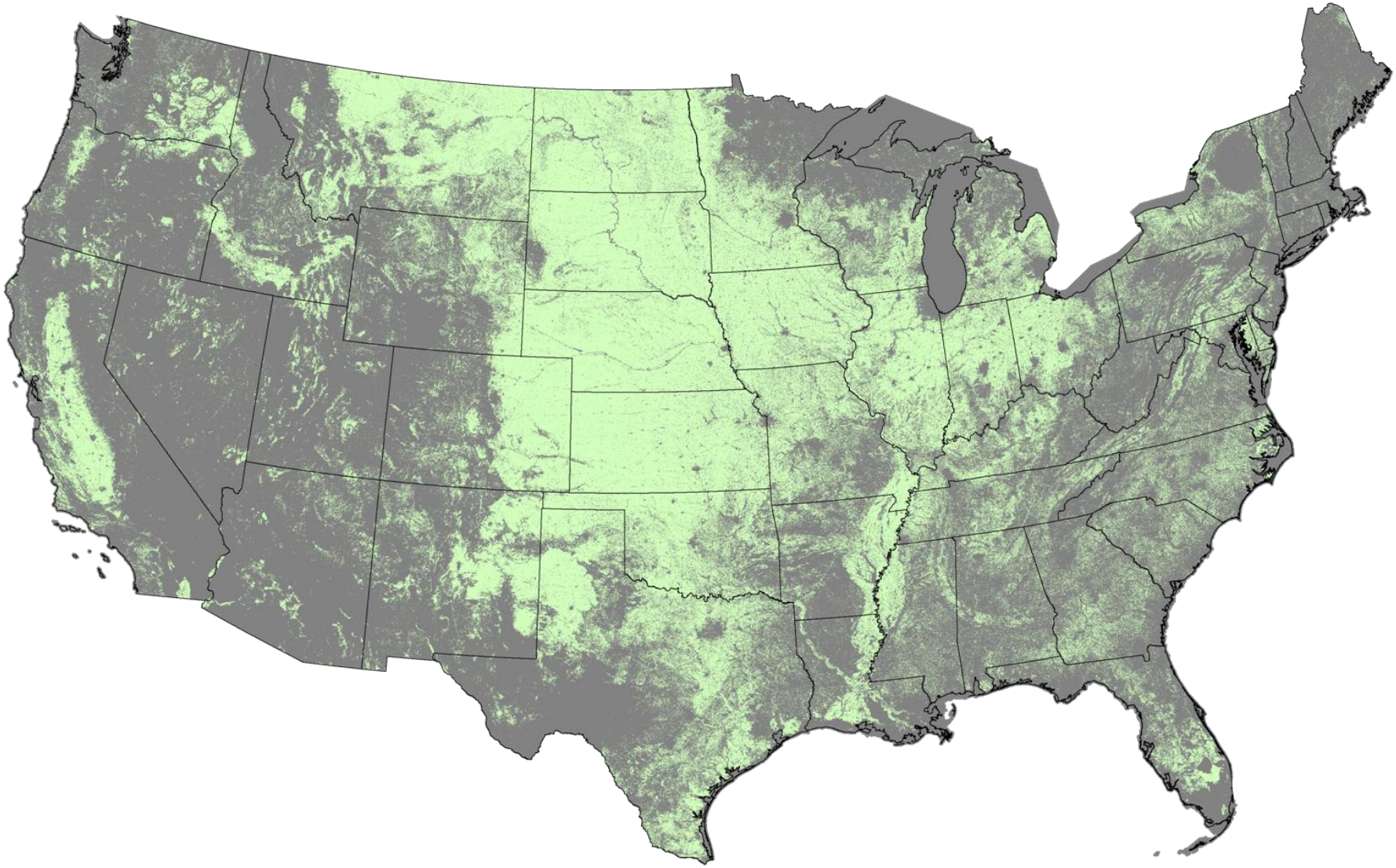
# **PART II—**Efficient coarse-filter landscape monitoring

*Phenological peakedness* as the difference between the **Max** and **85th** percentile of the **2002** fiscal year distribution



# **PART II—**Efficient coarse-filter landscape monitoring

National Land Cover Dataset (NLCD 2006): grassland/herbaceous, pasture/hay, cultivated crops



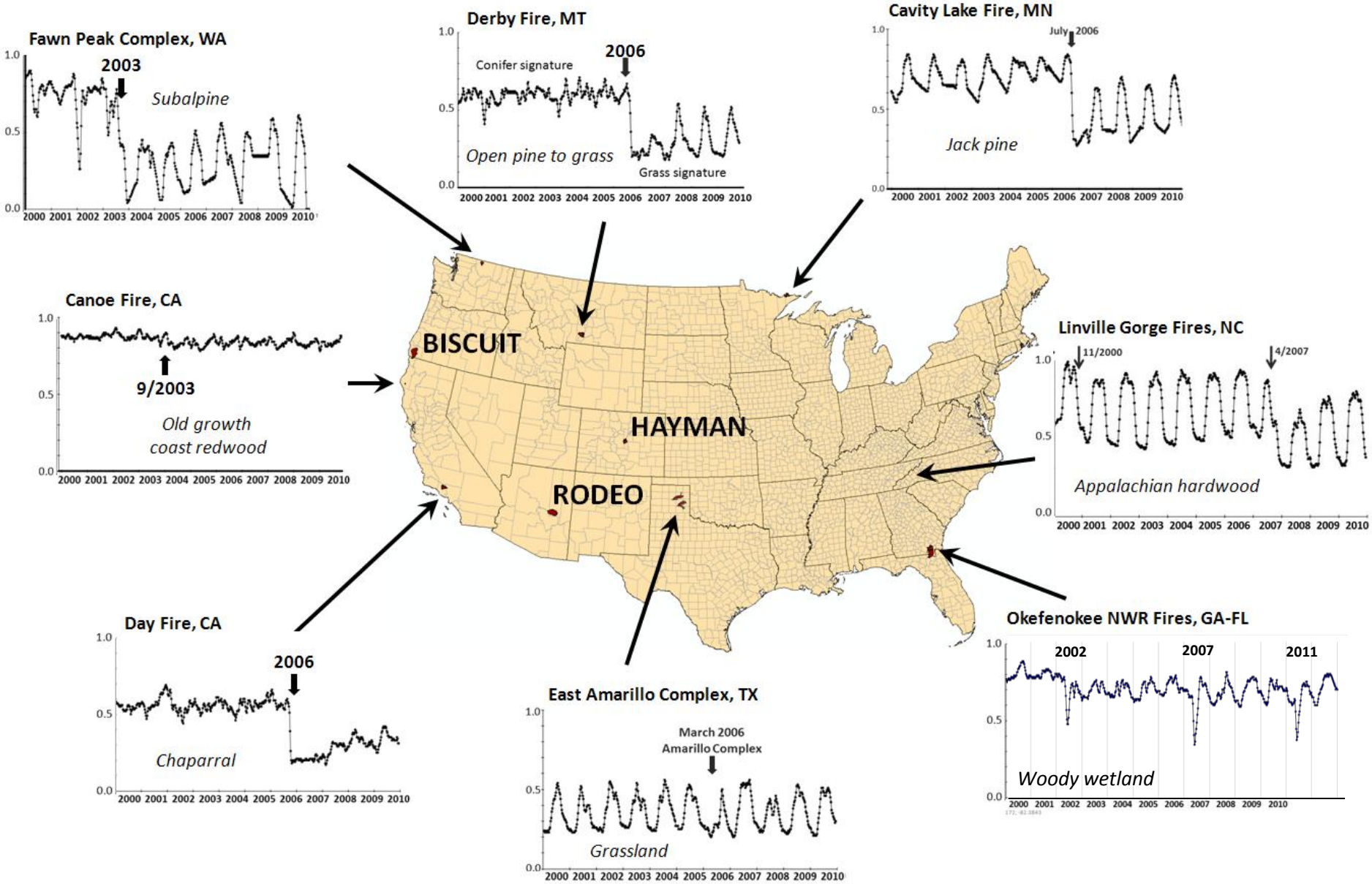
# Outline

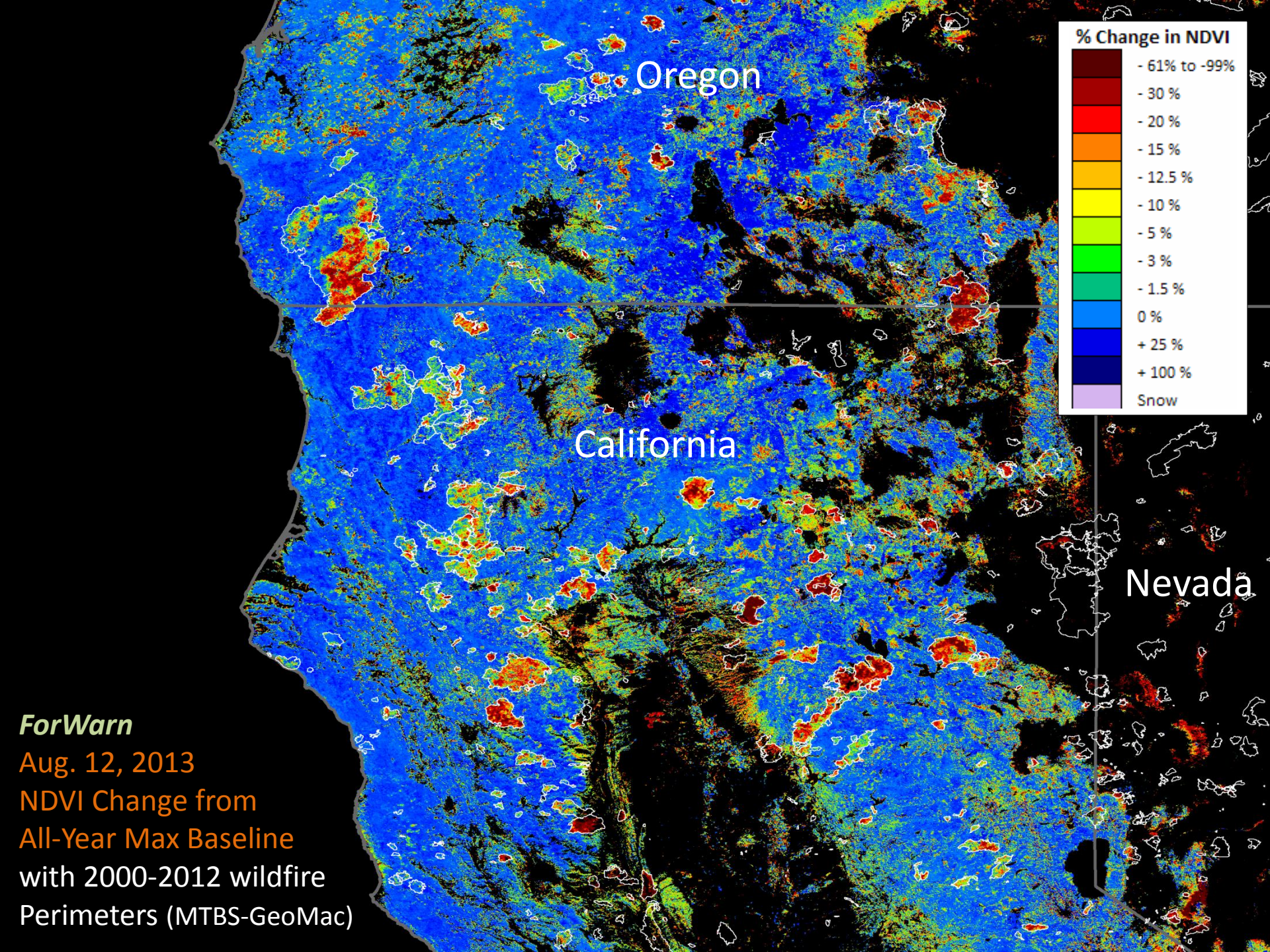
**PART I—**Our wildland fire and management crisis

**PART II—**Efficient coarse-filter landscape monitoring

**PART III—**Predicting long-term wildfire effects
with respect to specifiable *Desired Future Conditions*.

# **PART III**—Predicting long-term fire effects

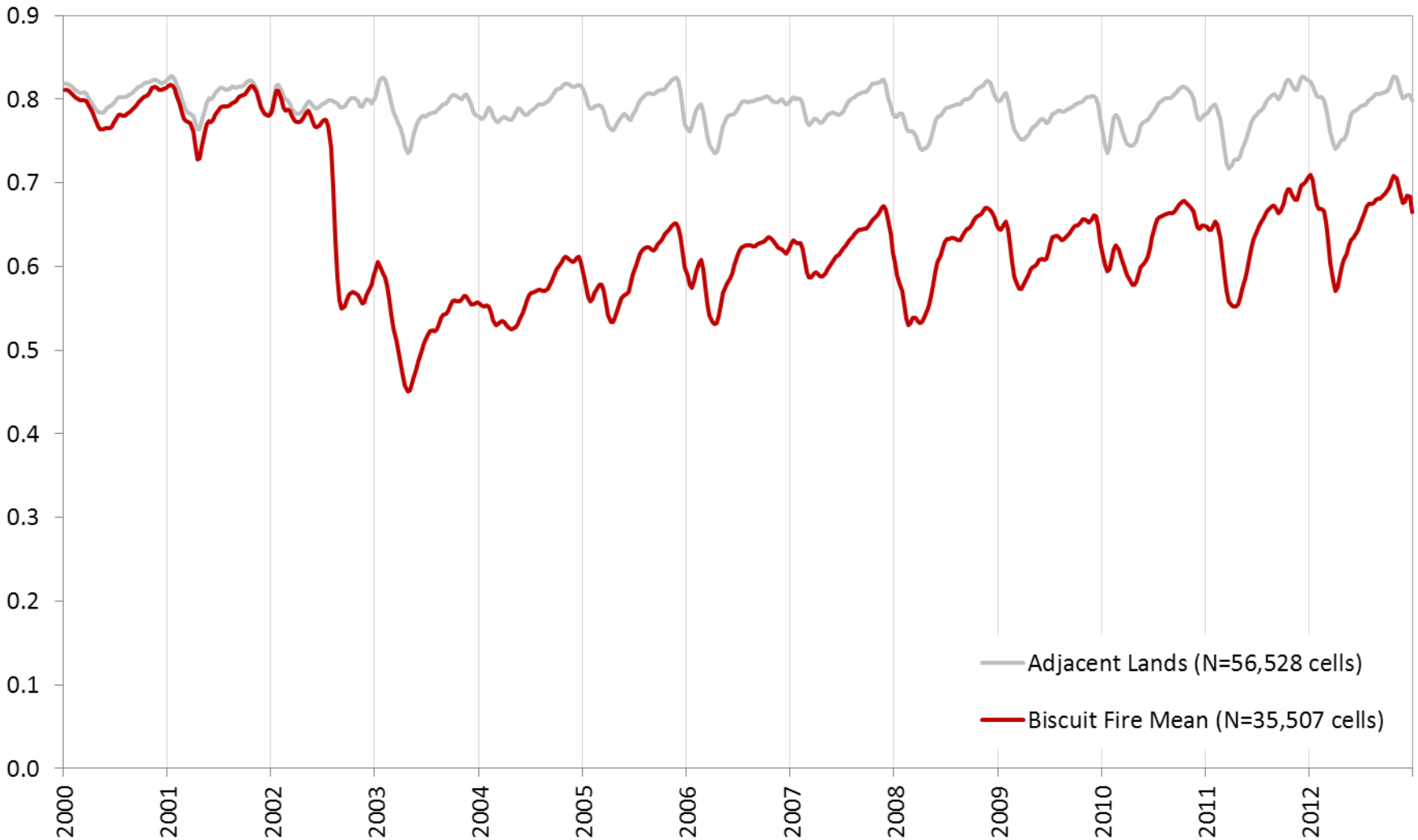





***ForWarn***
Aug. 12, 2013
NDVI Change from
All-Year Max Baseline
with 2000-2012 wildfire
Perimeters (MTBS-GeoMac)

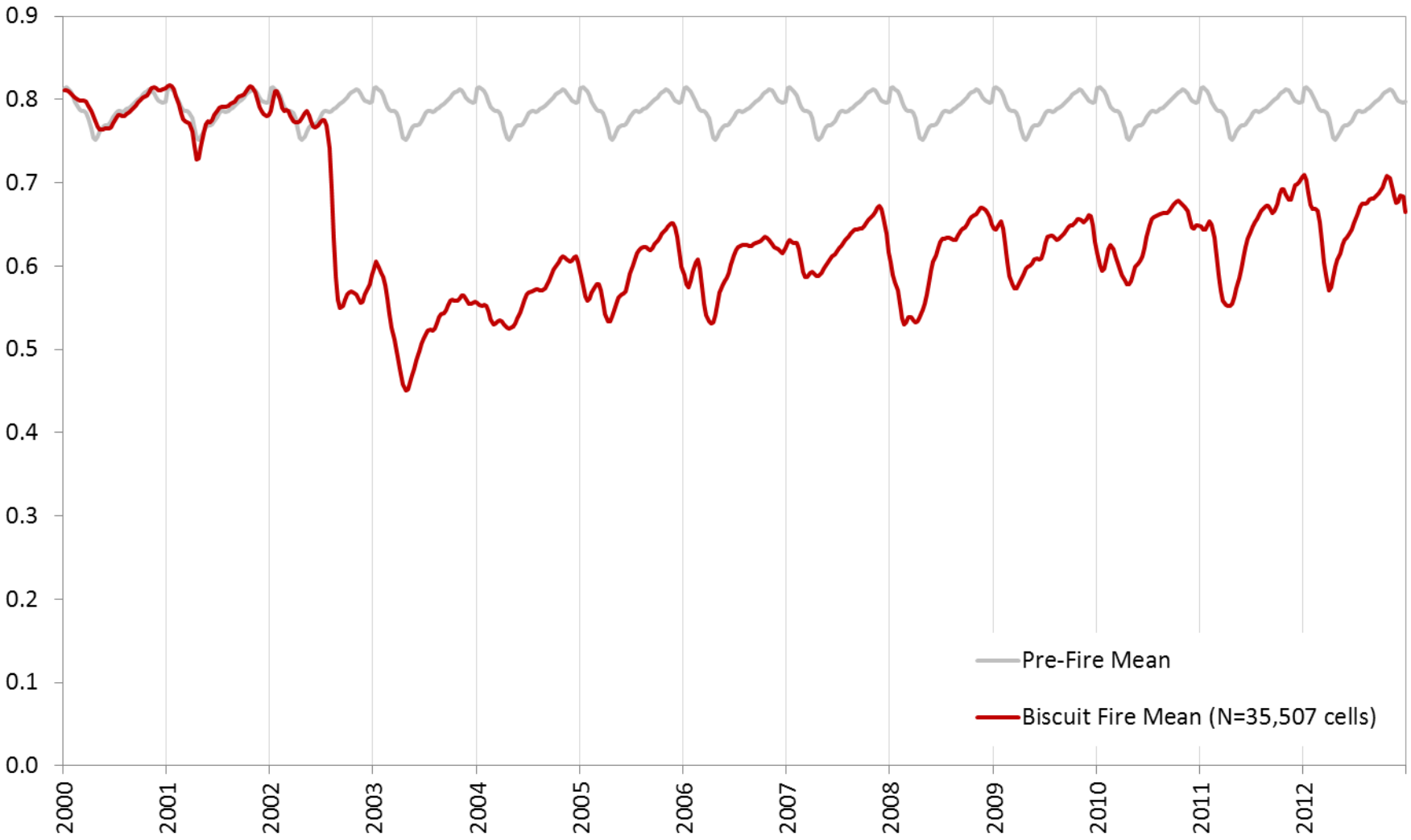
# PART III—Biscuit Fire

Reference conditions as phenology of adjacent unburned area



# PART III—Biscuit Fire

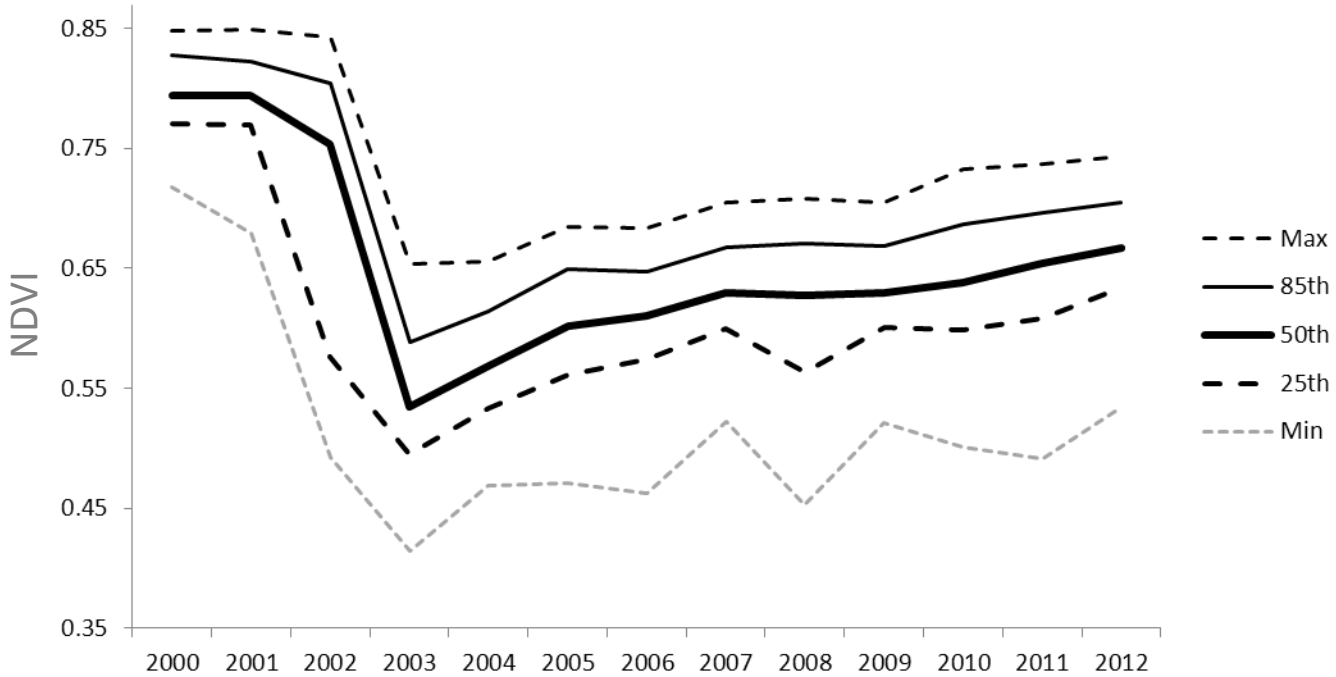
Reference conditions as phenology of pre-fire mean



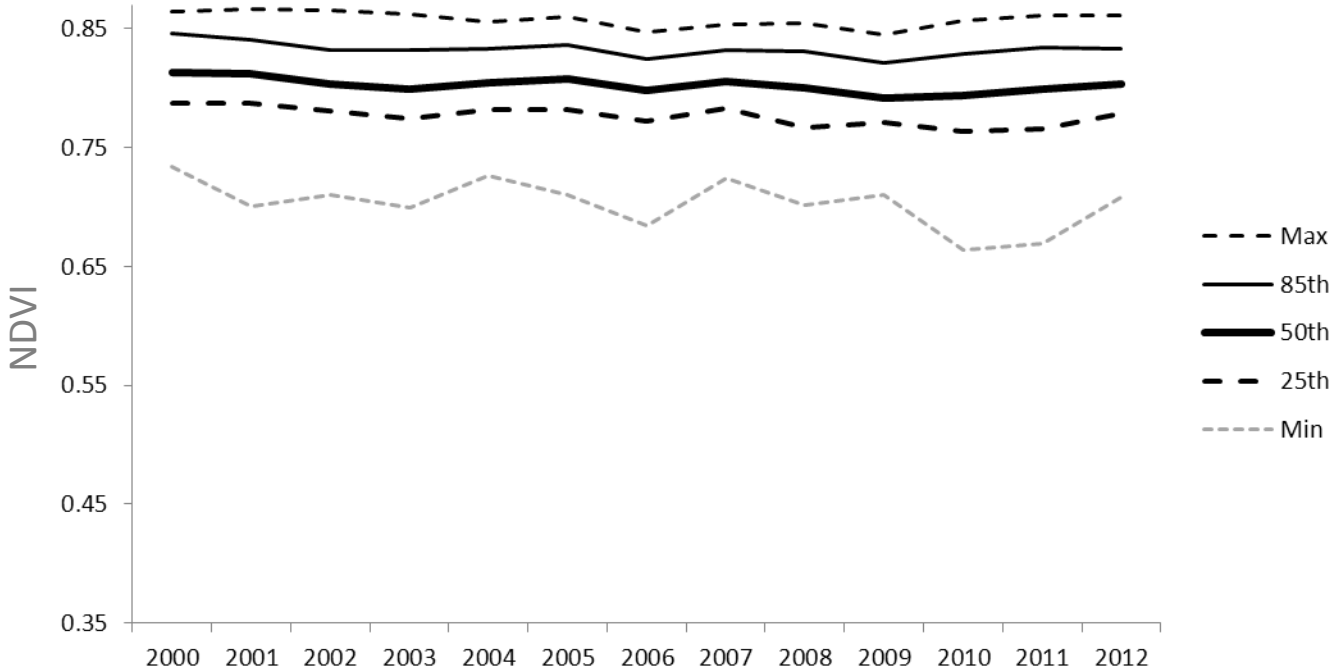
# PART III—
# Biscuit Fire

Change in annual percentiles over time

**Burned**:



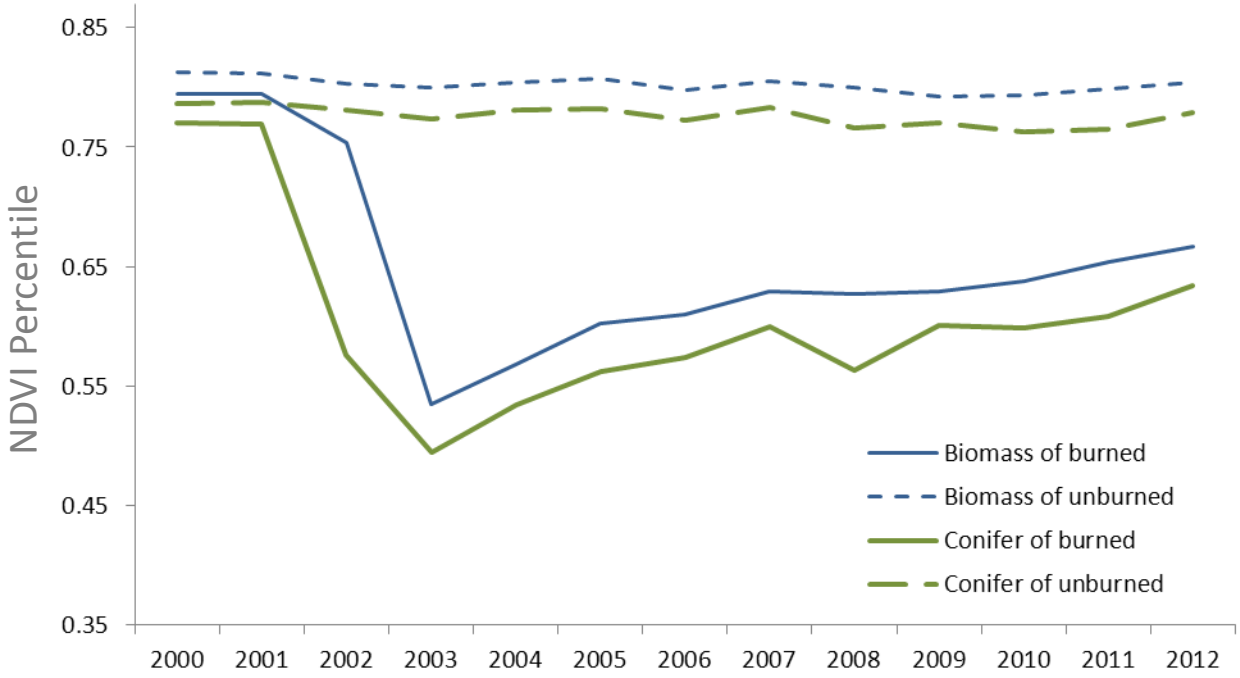

**Unburned**:



# PART III—
# Biscuit Fire

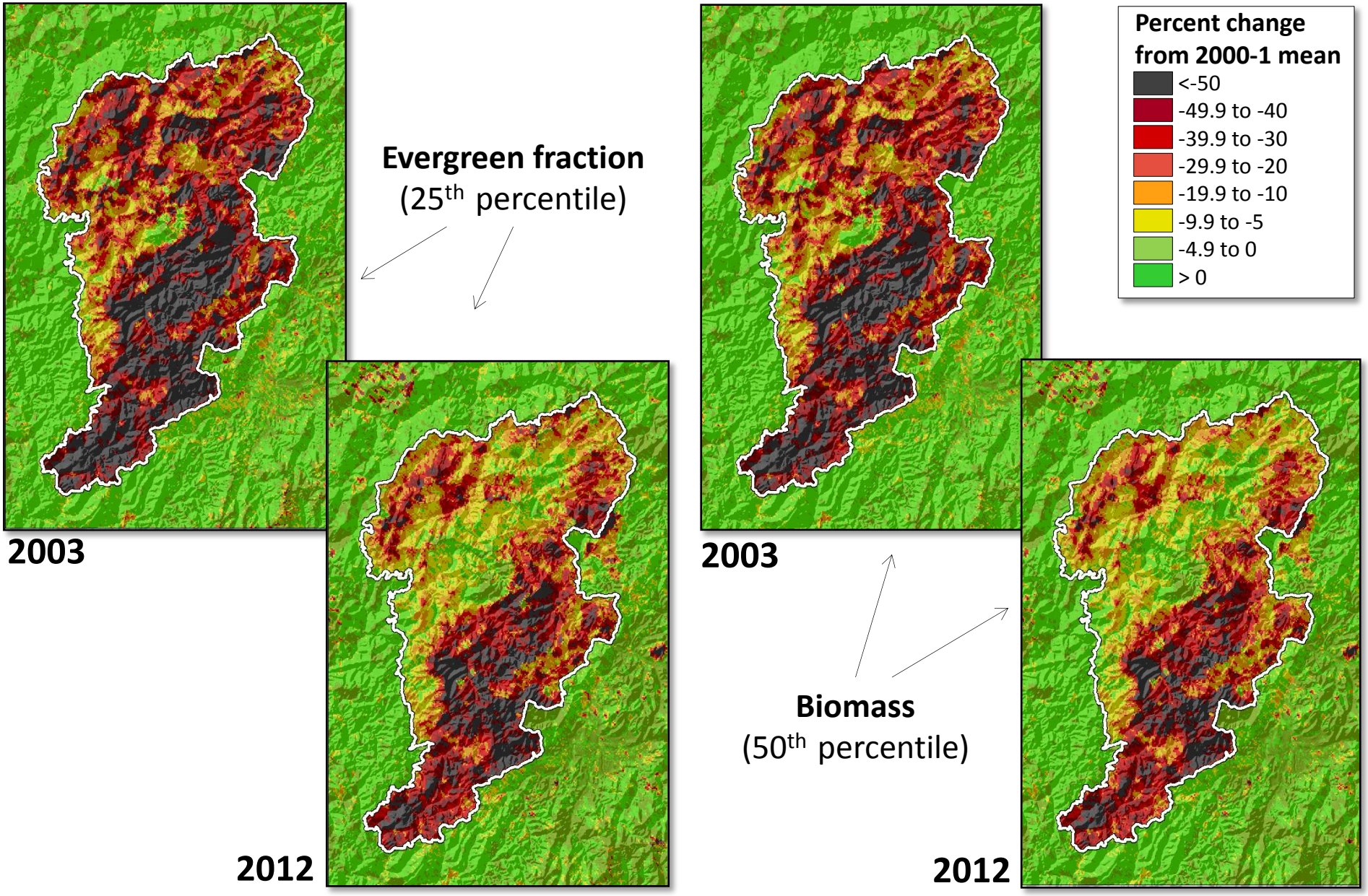
Change in fire and succession sensitive measures

**Biomass and evergreen measures:**




**Grassiness measure:**

# **PART III—**Predicting long-term effects from the **Biscuit Fire**

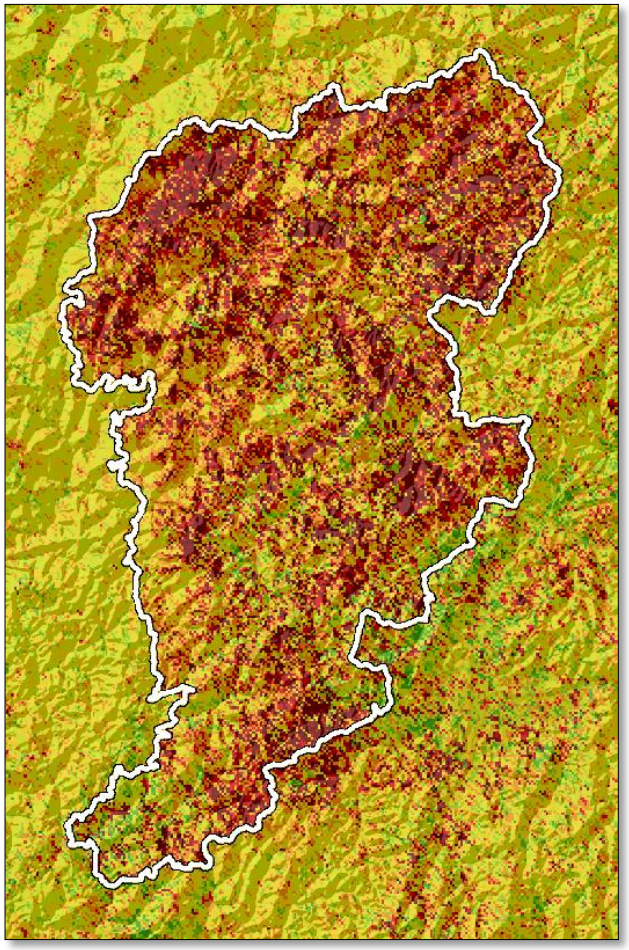


# **PART III**—Predicting long-term effects

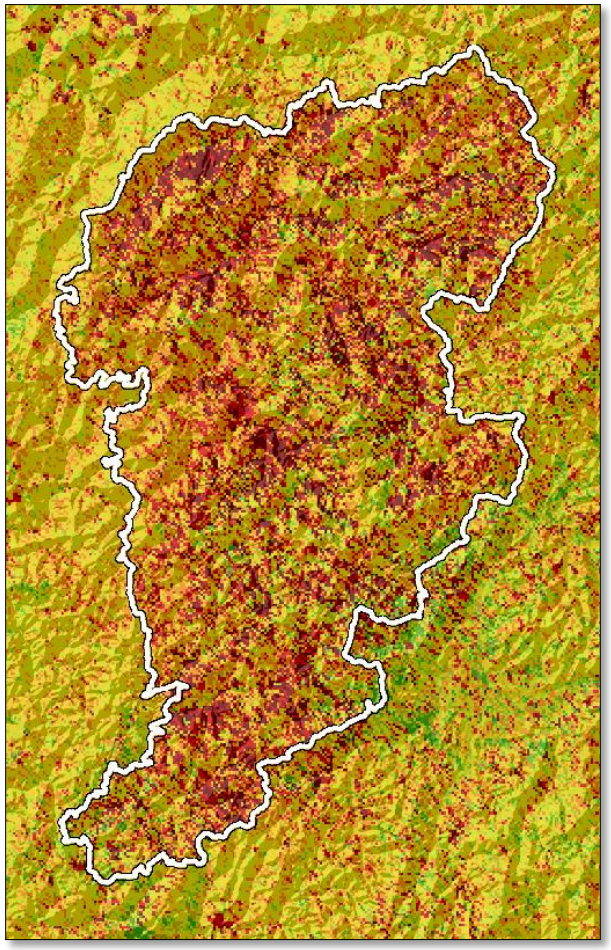
Change in peakedness/grassiness (difference between max and 85th %iles)

More peaked
> 3
2.1 to 3
1.1 to 2
0.1 to 1
-0.9 to 0
-1.9 to -1
-2.9 to -2
< -3
Less peaked

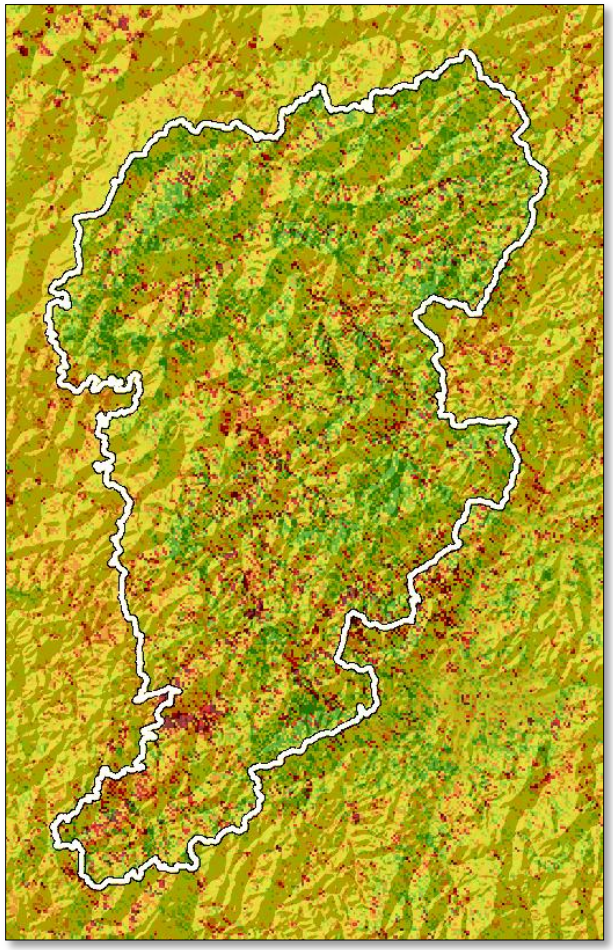
**Pre-fire to 2003-7 mean**



**Pre-fire to 2008-12 mean**

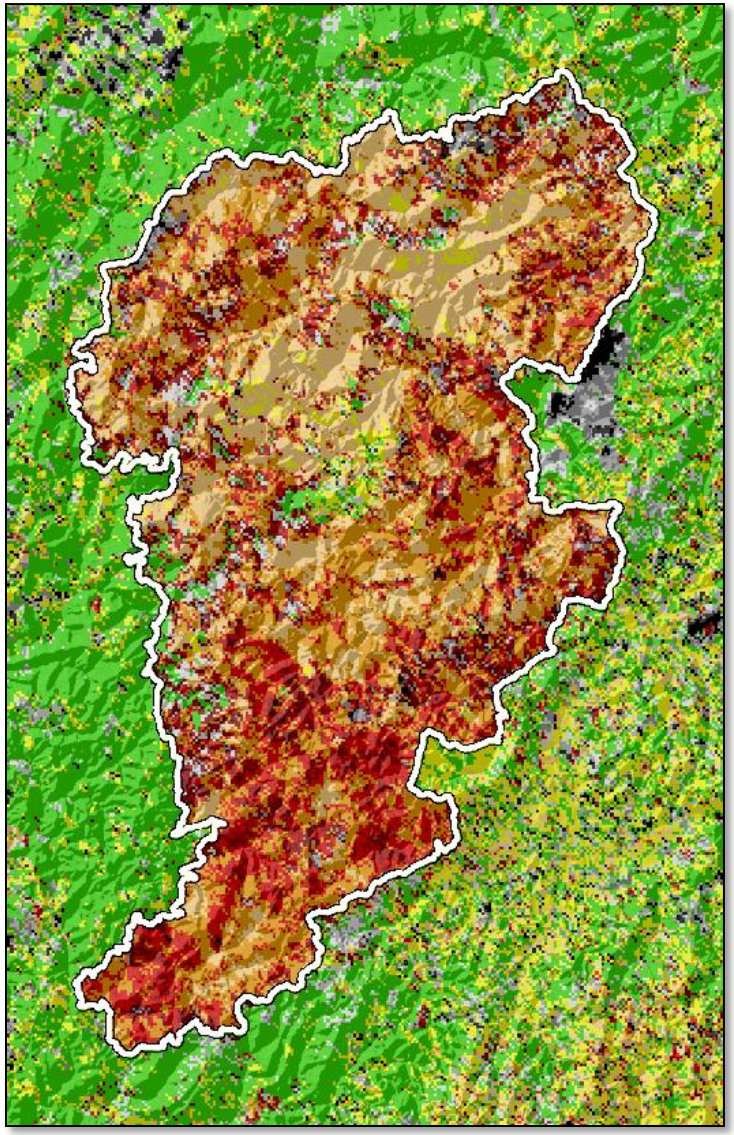


**2003-7 to 2008-12 mean**

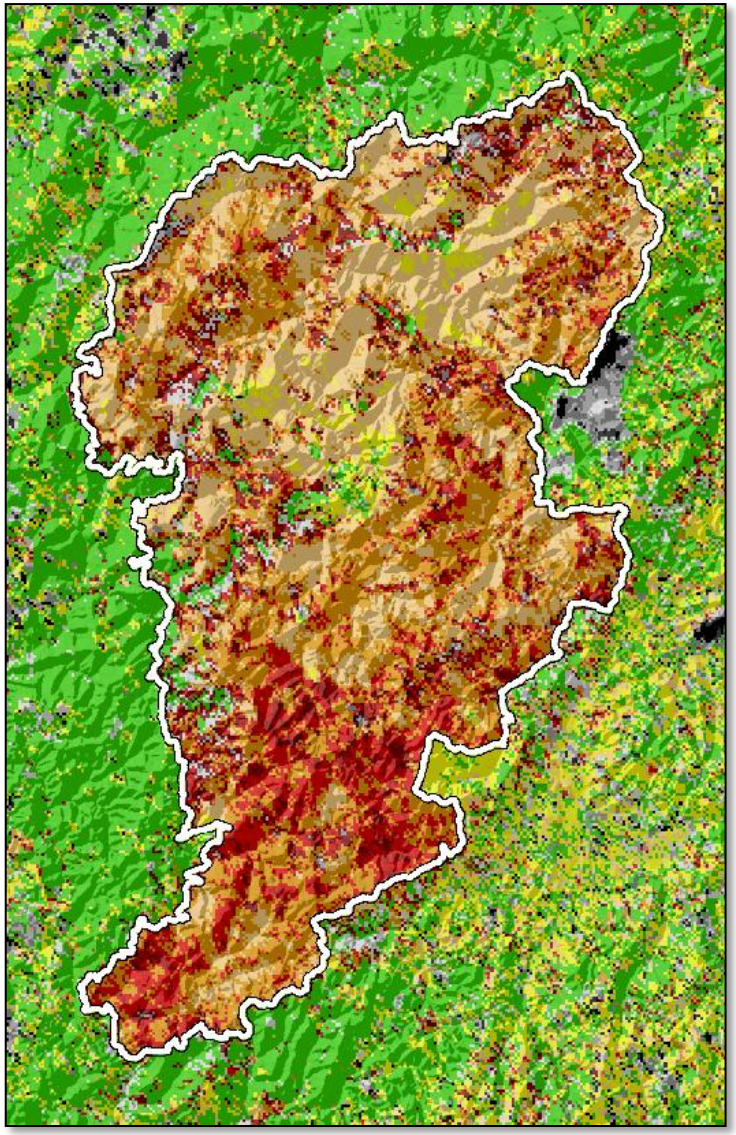


# **PART III**—Predicting long-term effects

**Time to recovery of evergreen fraction (25th %ile)**



**Time to recovery of biomass (50th %ile)**

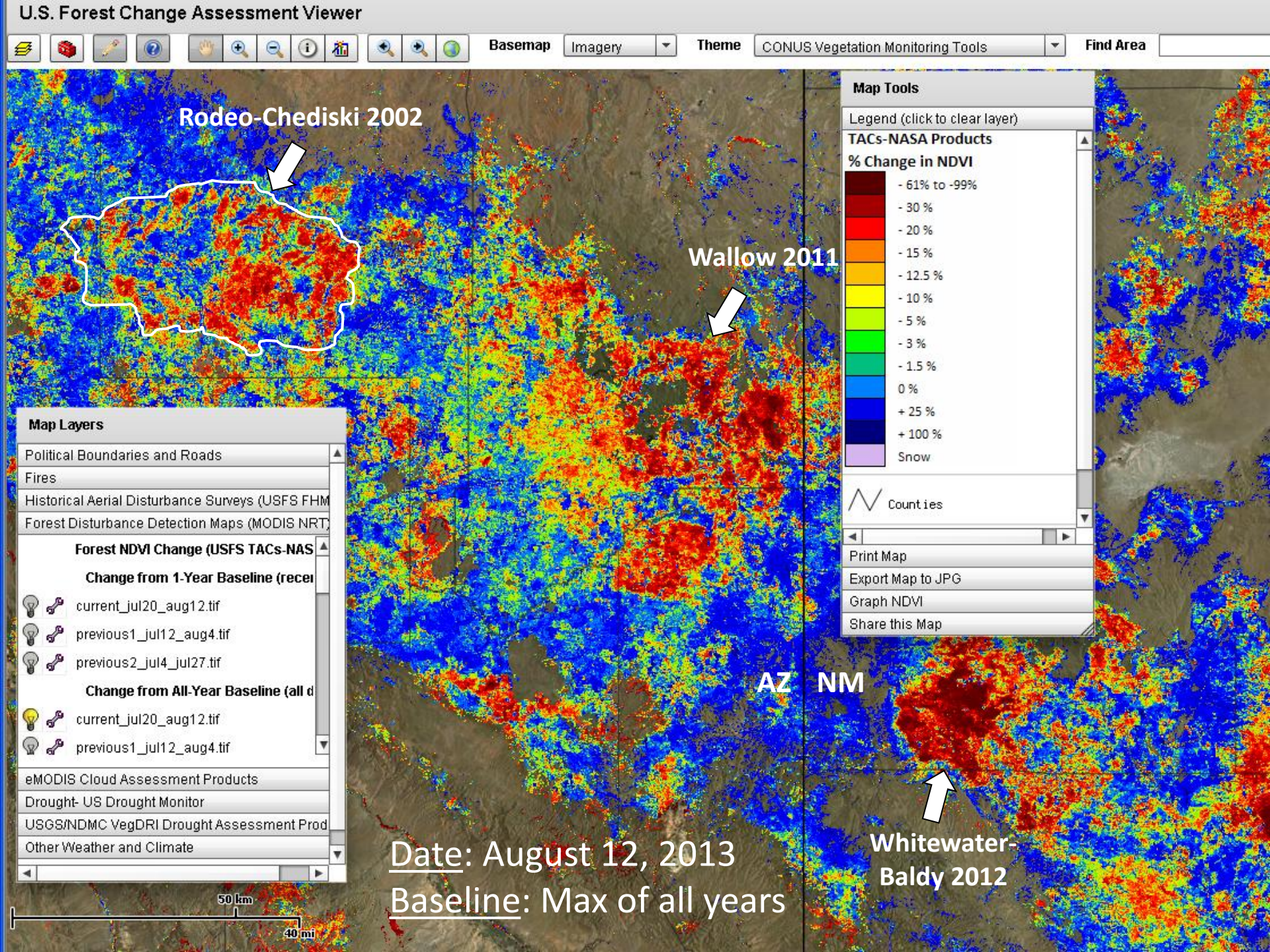


**Years to recovery**

- > 50
- 40.1 to 50
- 30.1 to 40
- 20.1 to 30
- 10.1 to 20
- 0 to 10

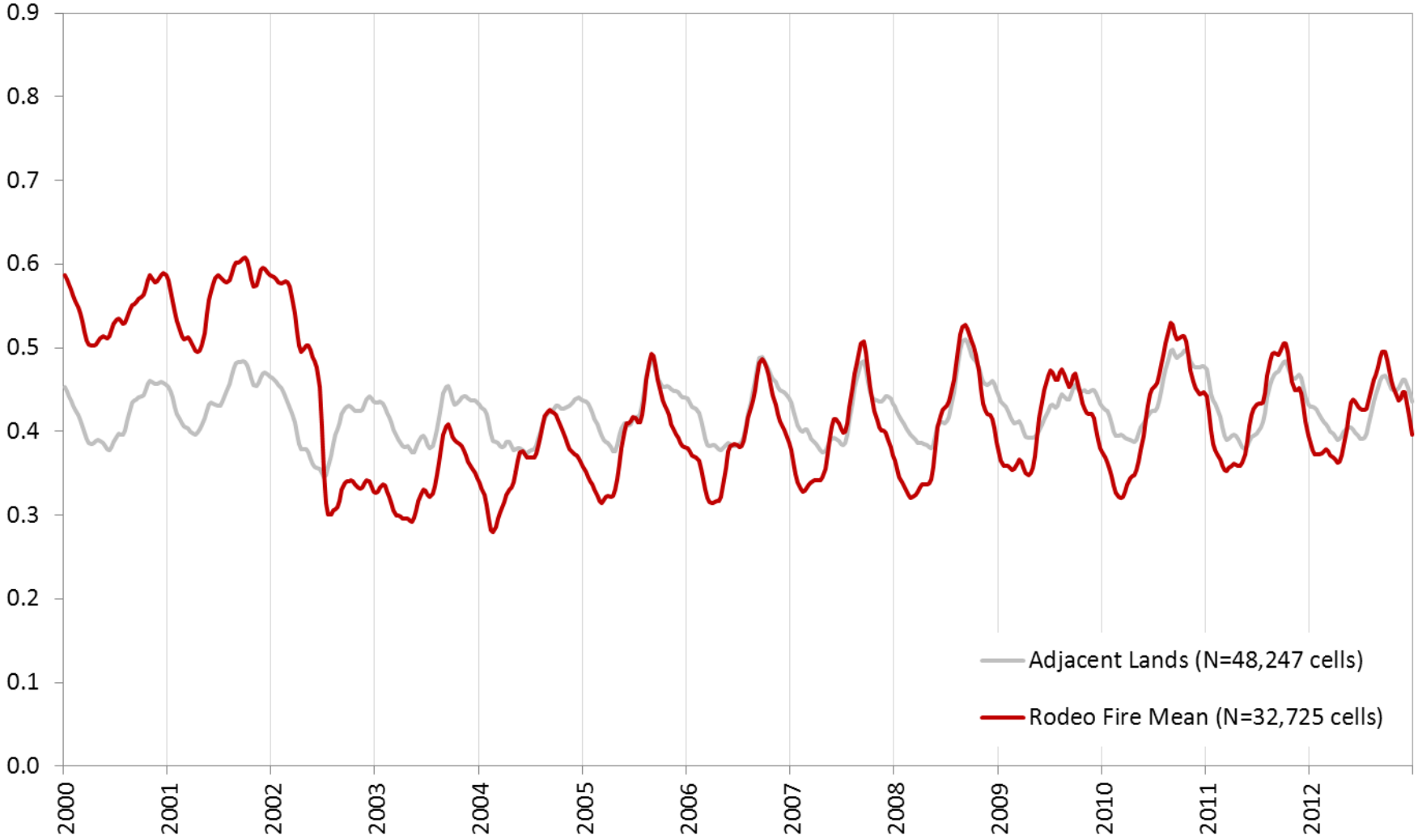
**No observed recovery (% decline in 2012)**

- -4.9 to 0
- -9.9 to -5
- -24.9 to -10
- < -25


U.S. Forest Change Assessment Viewer
Basemap
Imagery
Theme
CONUS Vegetation Monitoring Tools
Find Area
Rodeo-Chediski 2002
Wallow 2011
Whitewater-Baldy 2012
AZ
NM
Map Tools
Legend (click to clear layer)
TACs-NASA Products
% Change in NDVI
- 61% to -99%
- 30 %
- 20 %
- 15 %
- 12.5 %
- 10 %
- 5 %
- 3 %
- 1.5 %
0 %
+ 25 %
+ 100 %
Snow
Counties
Print Map
Export Map to JPG
Graph NDVI
Share this Map
Map Layers
Political Boundaries and Roads
Fires
Historical Aerial Disturbance Surveys (USFS FHM
Forest Disturbance Detection Maps (MODIS NRT)
Forest NDVI Change (USFS TACs-NAS
Change from 1-Year Baseline (recei
current_jul20_aug12.tif
previous1_jul12_aug4.tif
previous2_jul4_jul27.tif
Change from All-Year Baseline (all d
current_jul20_aug12.tif
previous1_jul12_aug4.tif
eMODIS Cloud Assessment Products
Drought- US Drought Monitor
USGS/NDMC VegDRI Drought Assessment Prod
Other Weather and Climate
50 km
40 mi
Date: August 12, 2013
Baseline: Max of all years

# PART III—Rodeo Fire

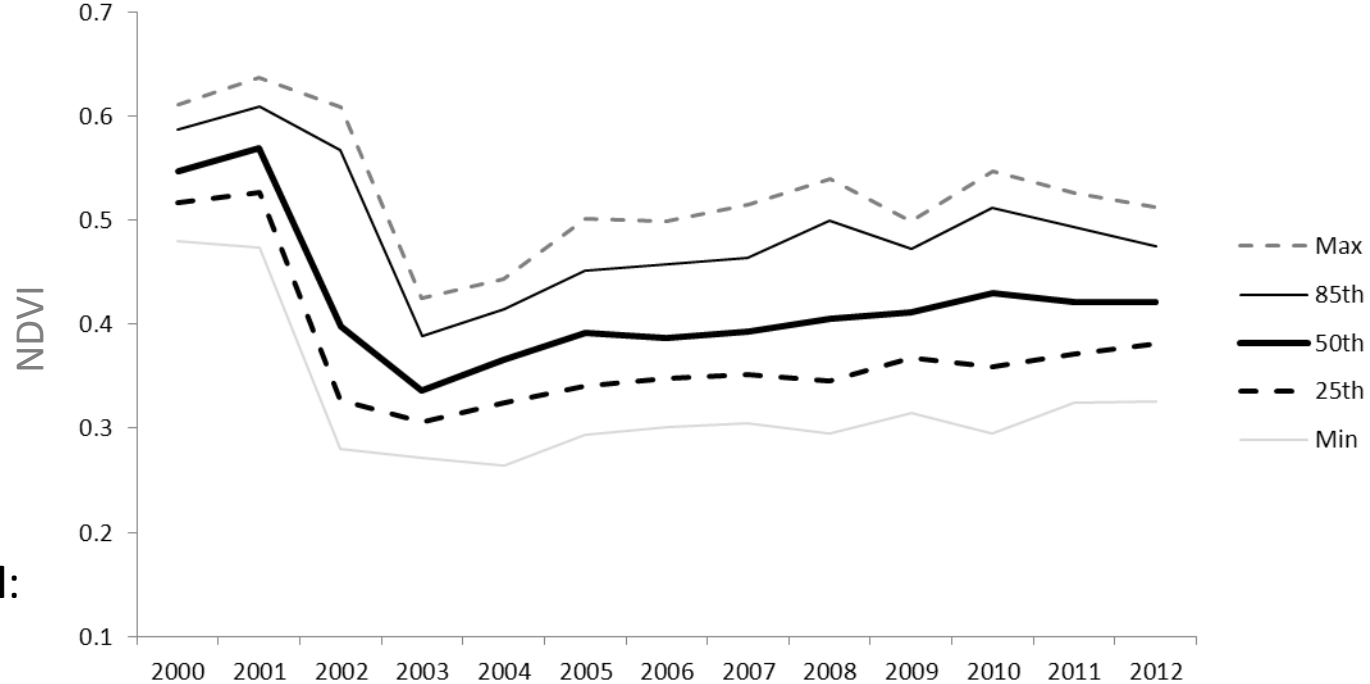
Reference conditions as phenology of adjacent unburned area



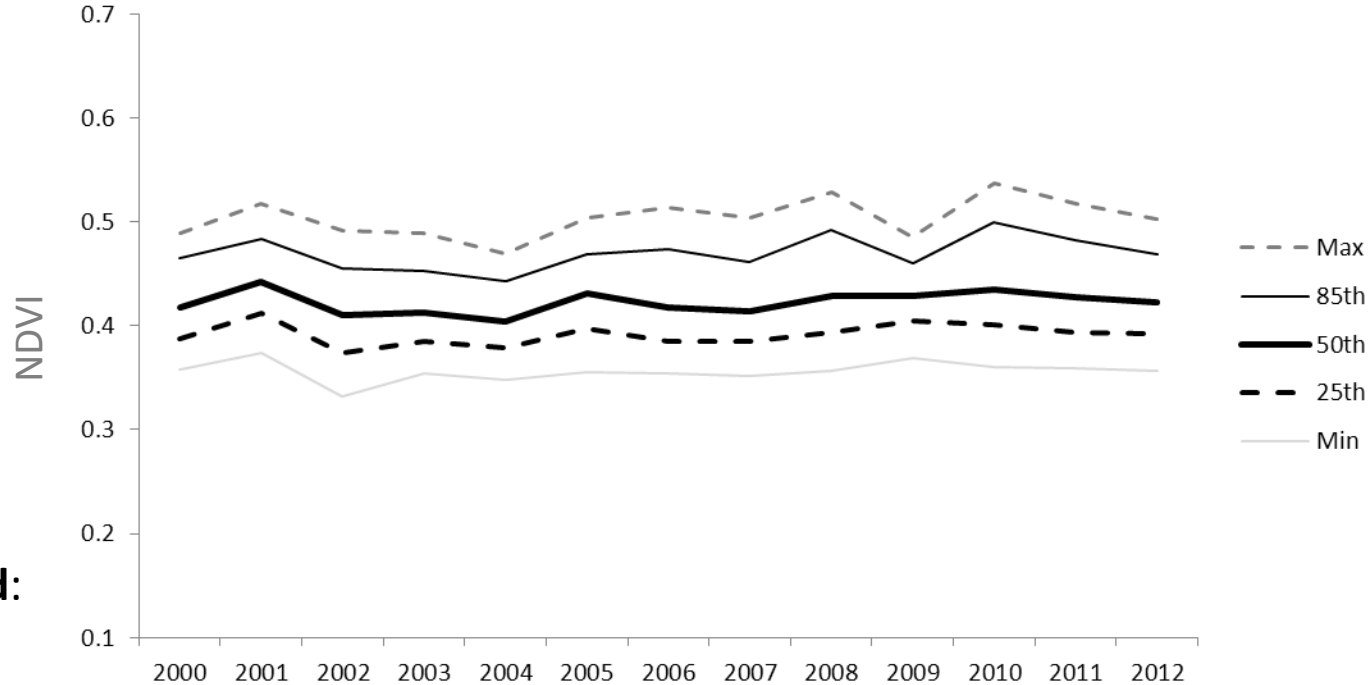
# PART III—
# Rodeo Fire

Change in annual percentiles over time

**Burned**:



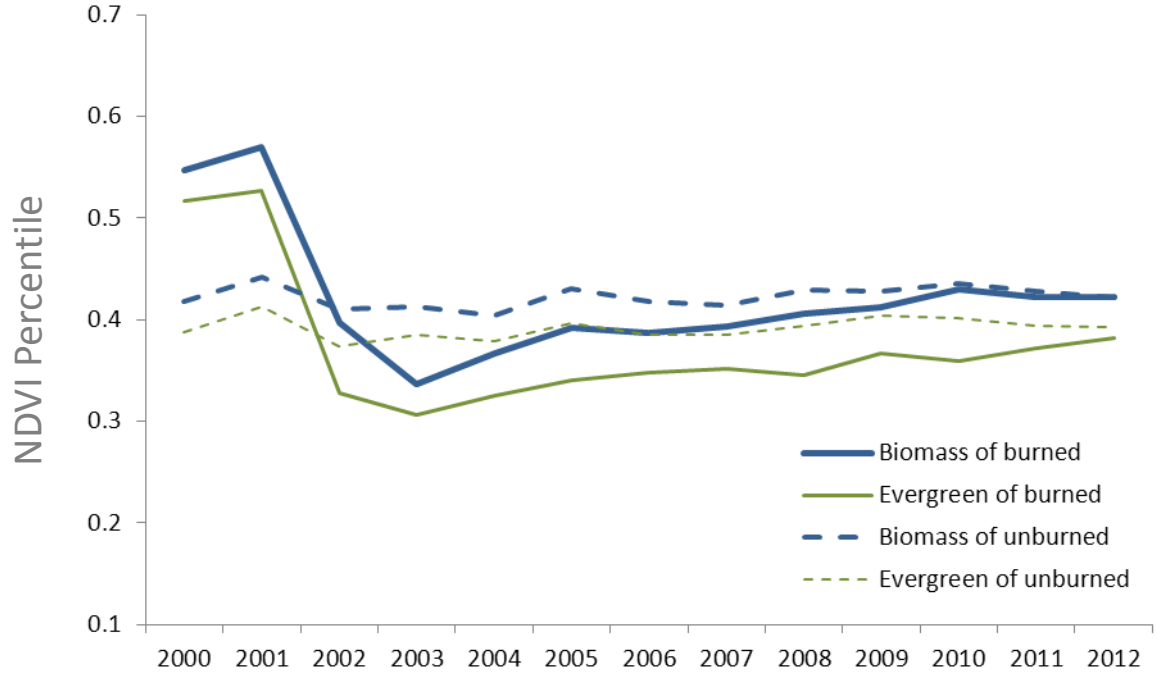

**Unburned**:



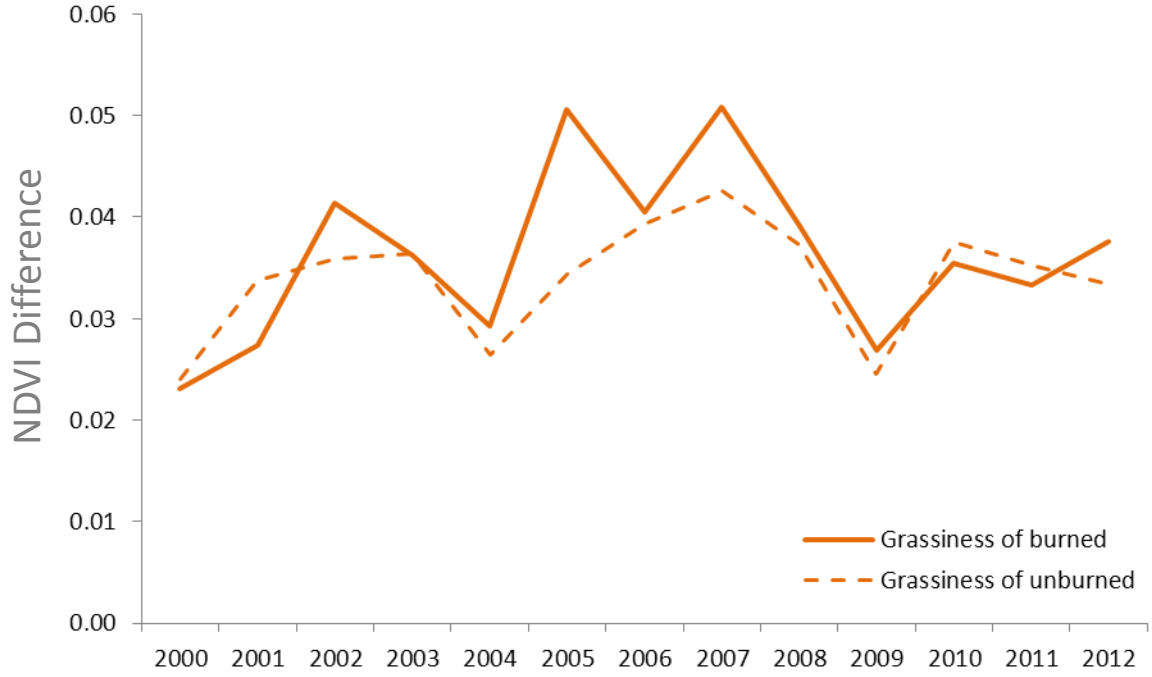
# PART III—
# Rodeo Fire

Change in fire and succession sensitive measures

**Biomass and evergreen measures:**




**Grassiness measure:**



# **PART III—**Predicting long-term effects from the **Rodeo Fire**

**Percent change from 2000-1 mean**

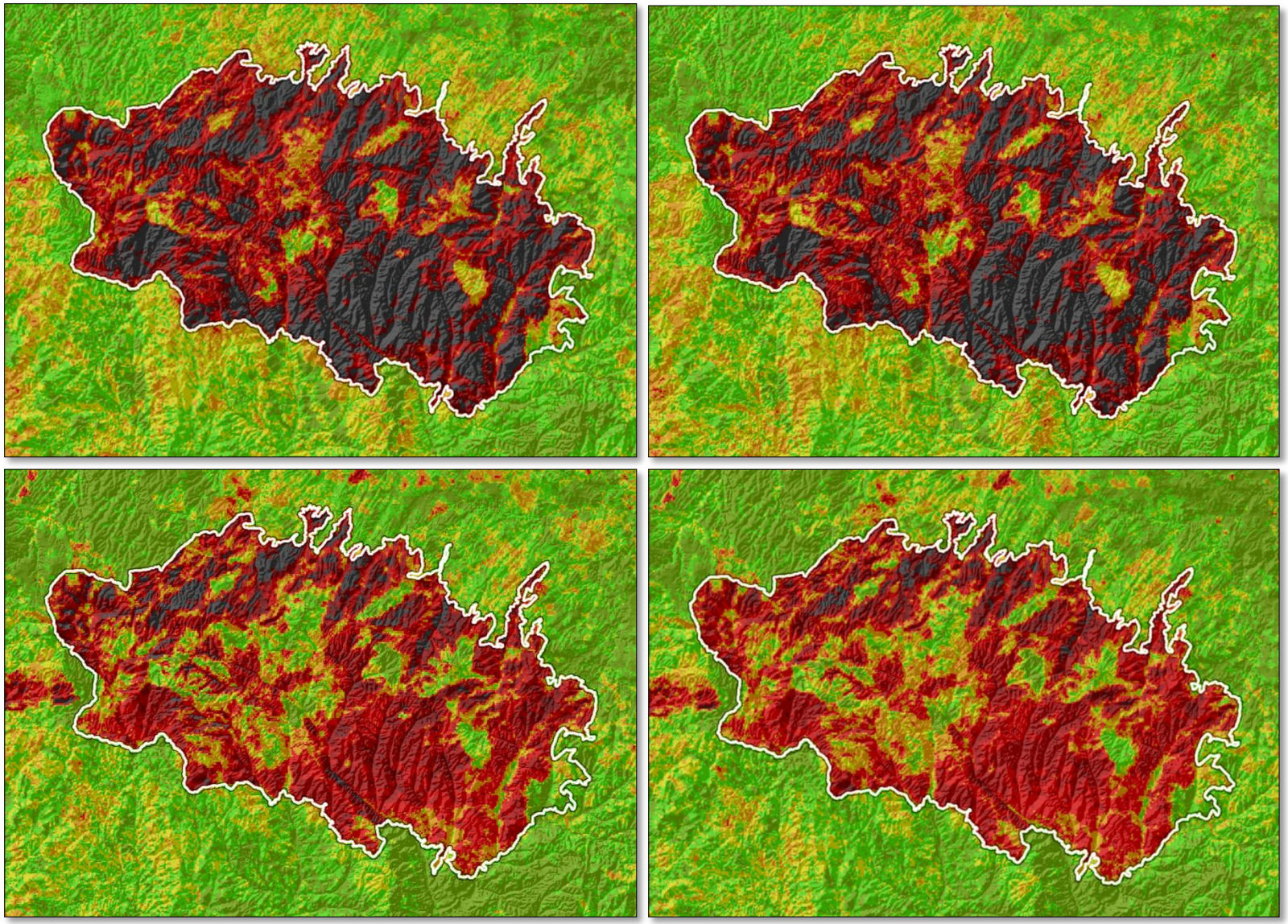
- <-50
- -49.9 to -40
- -39.9 to -30
- -29.9 to -20
- -19.9 to -10
- -9.9 to -5
- -4.9 to 0
- > 0

**Evergreen fraction**
(25th percentile)

**Biomass**
(50th percentile)

**2003**

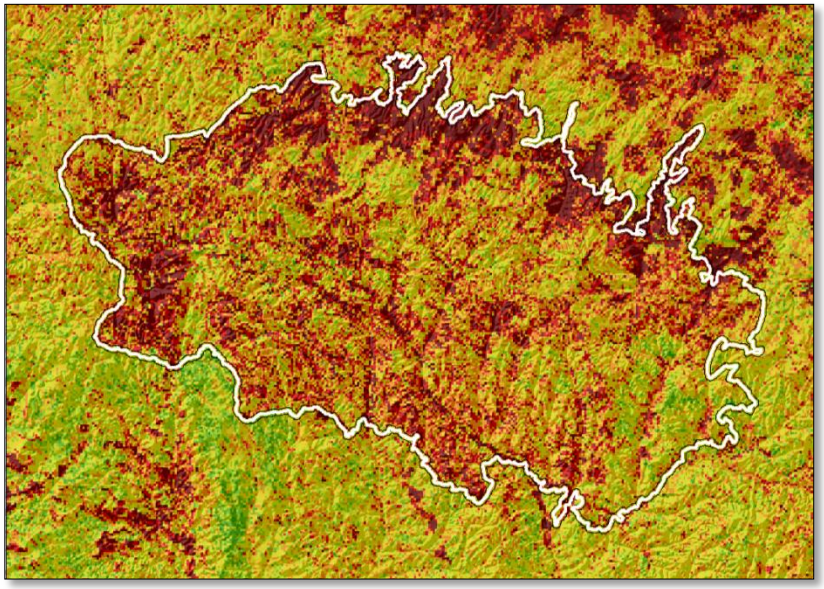
**2012**



# **PART III**—Predicting long-term fire effects

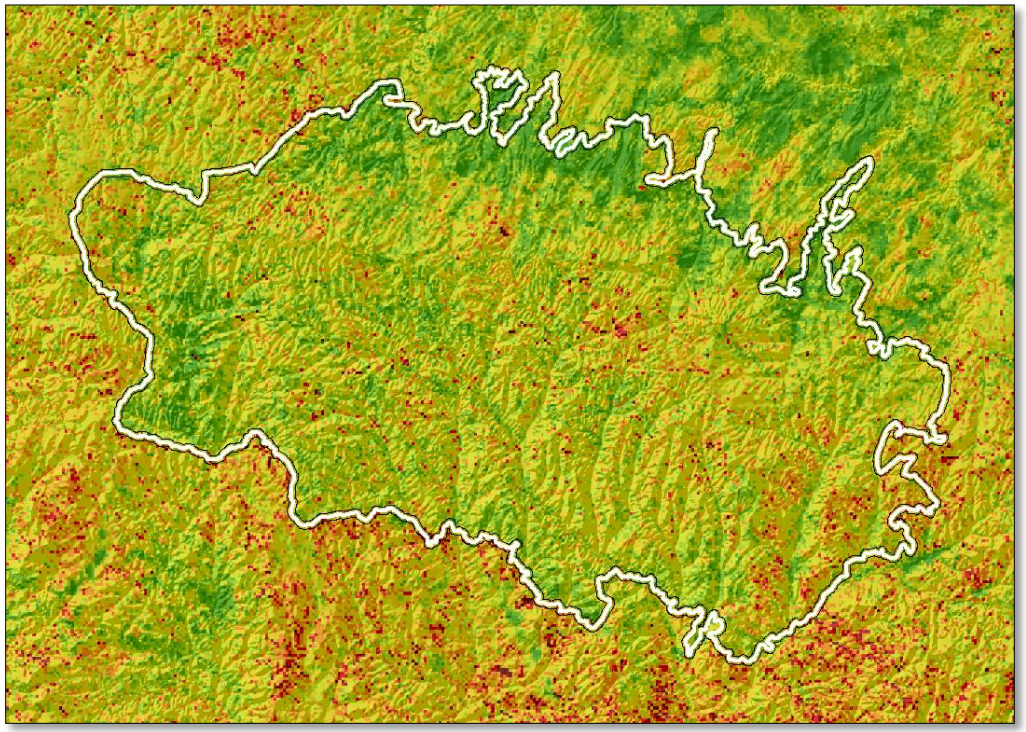
Change in peakedness/grassiness (difference between 100th and 85th %iles)

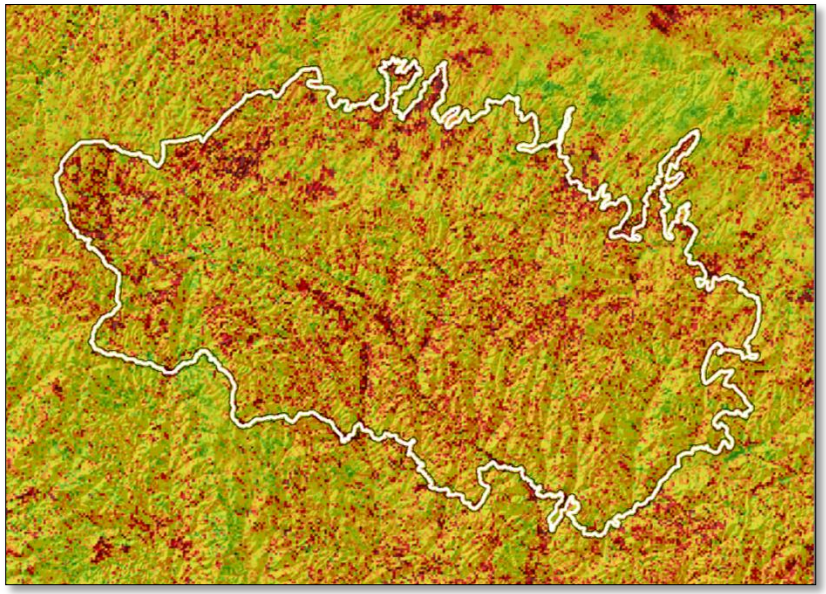
More peaked
> 3
2.1 to 3
1.1 to 2
0.1 to 1
-0.9 to 0
-1.9 to -1
-2.9 to -2
< -3
Less peaked



**Pre-fire to 2003-7 mean**

**2003-7 to 2008-12 mean**

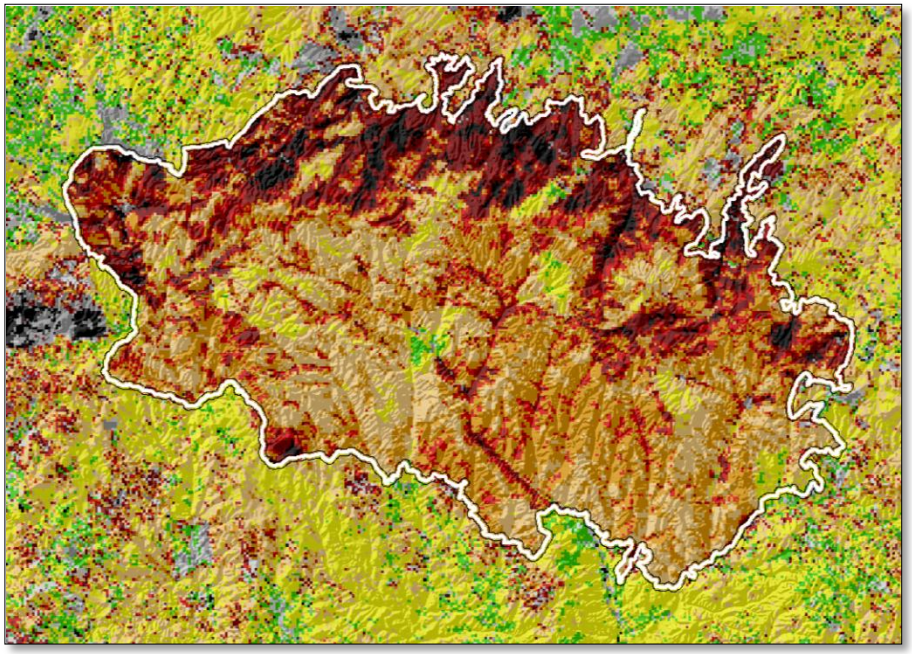




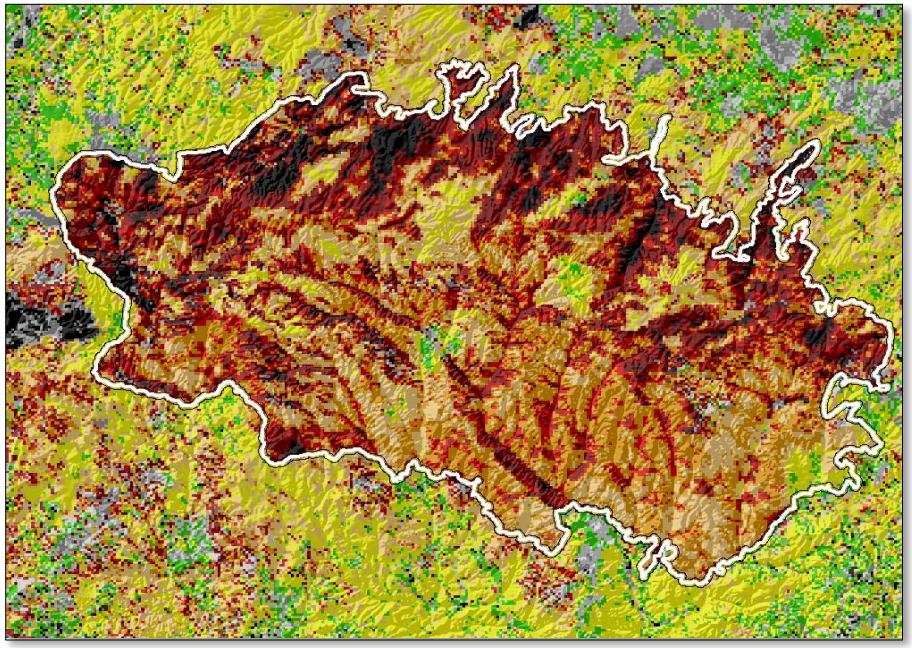
**Pre-fire to 2008-12 mean**

# **PART III—**Predicting long-term effects from the **Rodeo Fire**

**Time to recovery of evergreen fraction (25th %ile)**



**Time to recovery of biomass (50th %ile)**

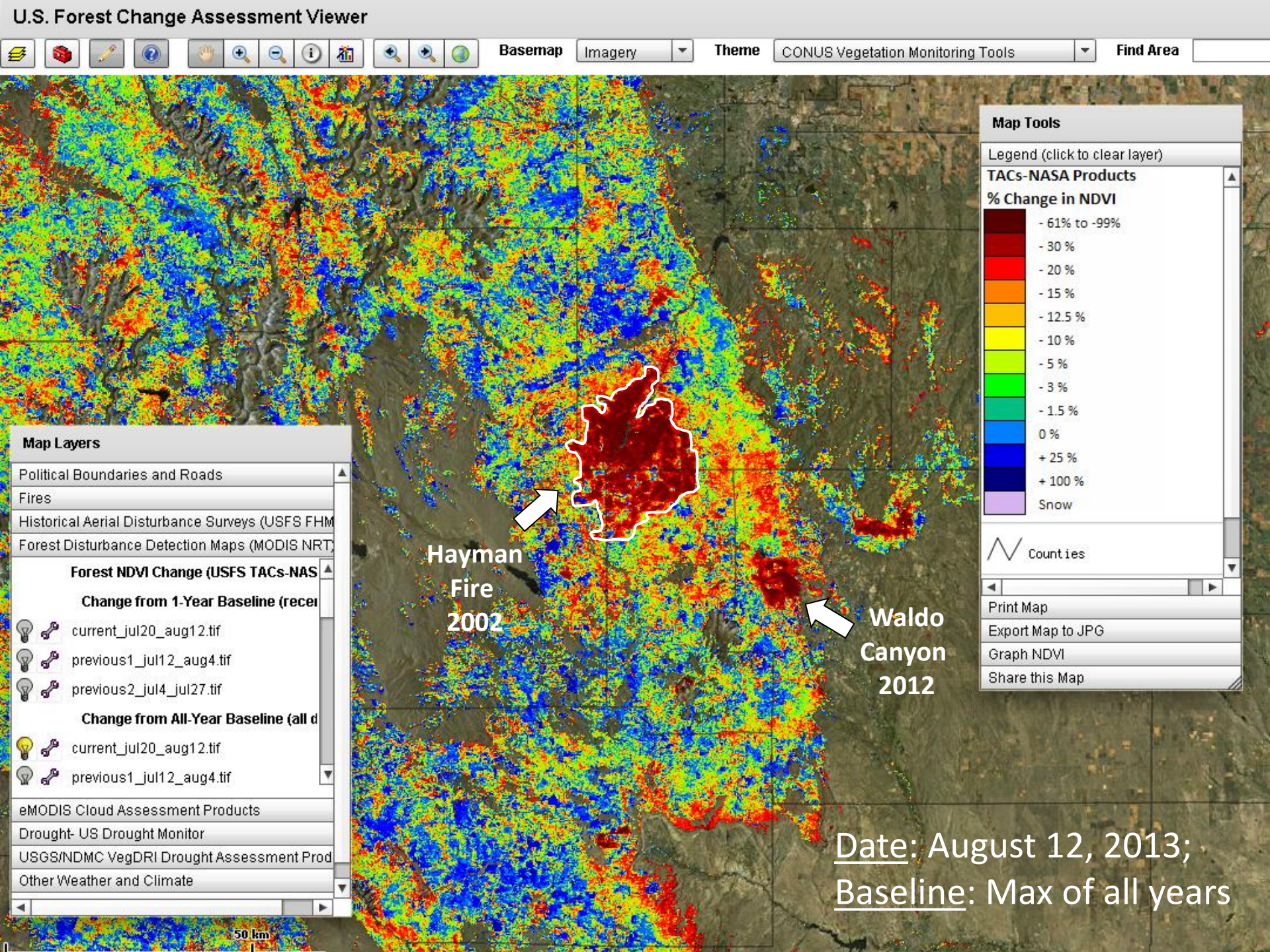


**Years to recovery**

- > 50
- 40.1 to 50
- 30.1 to 40
- 20.1 to 30
- 10.1 to 20
- 0 to 10

**No observed recovery (% decline in 2012)**

- -4.9 to 0
- -9.9 to -5
- -24.9 to -10
- < -25


U.S. Forest Change Assessment Viewer
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TACs-NASA Products
% Change in NDVI
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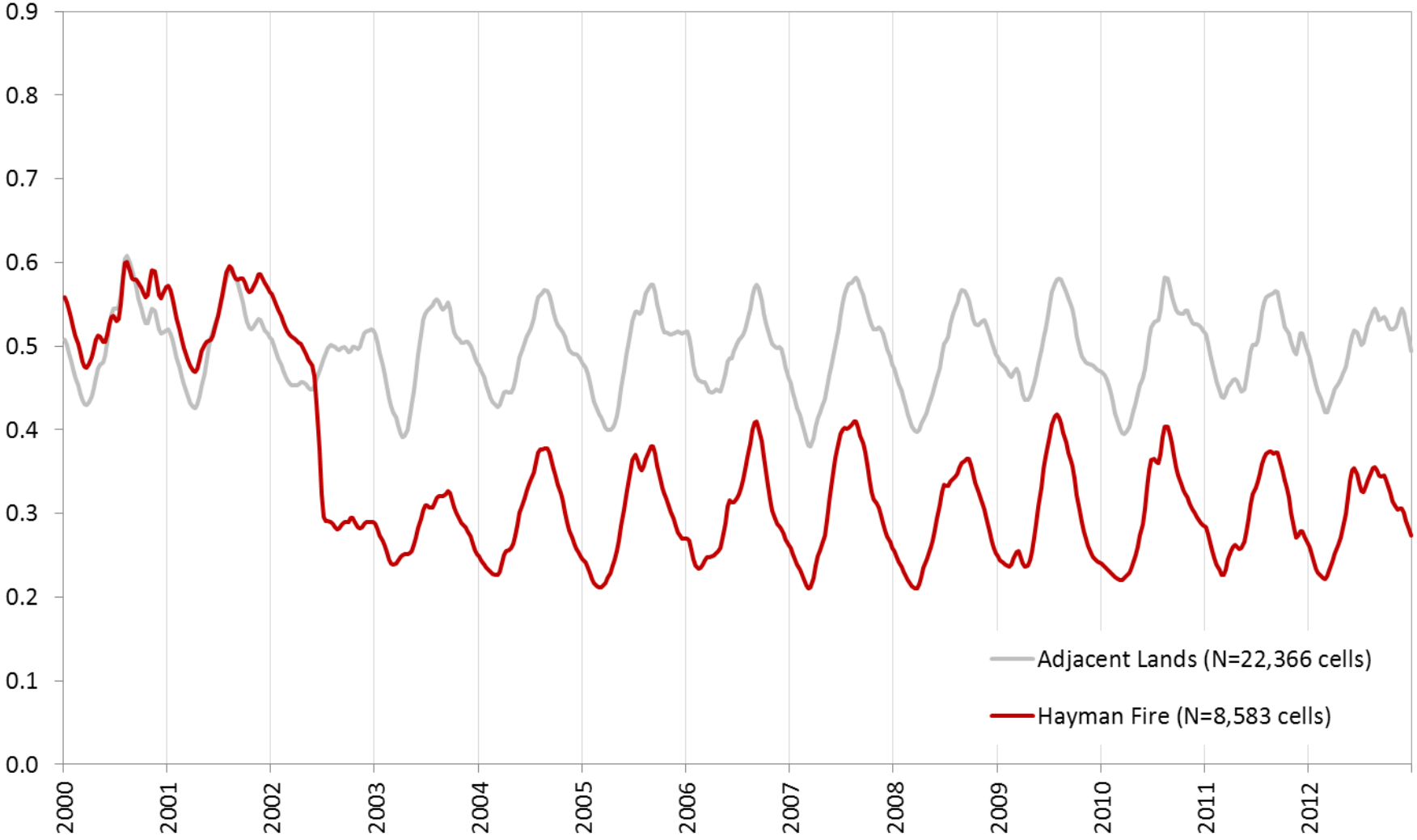
- 5 %
- 3 %
- 1.5 %
0 %
+ 25 %
+ 100 %
Snow
Counties
Print Map
Export Map to JPG
Graph NDVI
Share this Map
Map Layers
Political Boundaries and Roads
Fires
Historical Aerial Disturbance Surveys (USFS FHM
Forest Disturbance Detection Maps (MODIS NRT)
Forest NDVI Change (USFS TACs-NAS
Change from 1-Year Baseline (recei
current_jul20_aug12.tif
previous1_jul12_aug4.tif
previous2_jul4_jul27.tif
Change from All-Year Baseline (all d
current_jul20_aug12.tif
previous1_jul12_aug4.tif
eMODIS Cloud Assessment Products
Drought- US Drought Monitor
USGS/NDMC VegDRI Drought Assessment Prod
Other Weather and Climate
Hayman Fire 2002
Waldo Canyon 2012
50 km
Date: August 12, 2013;
Baseline: Max of all years

# PART III—Hayman Fire

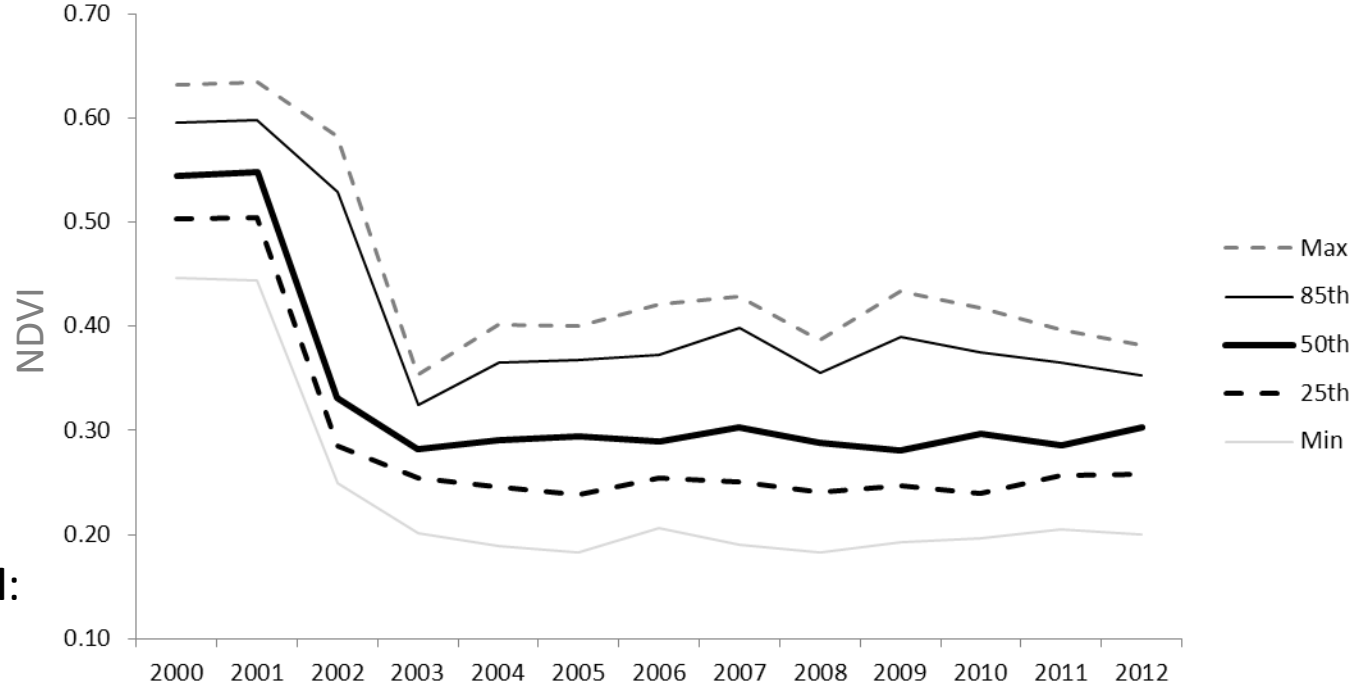
Reference conditions as phenology of adjacent unburned area



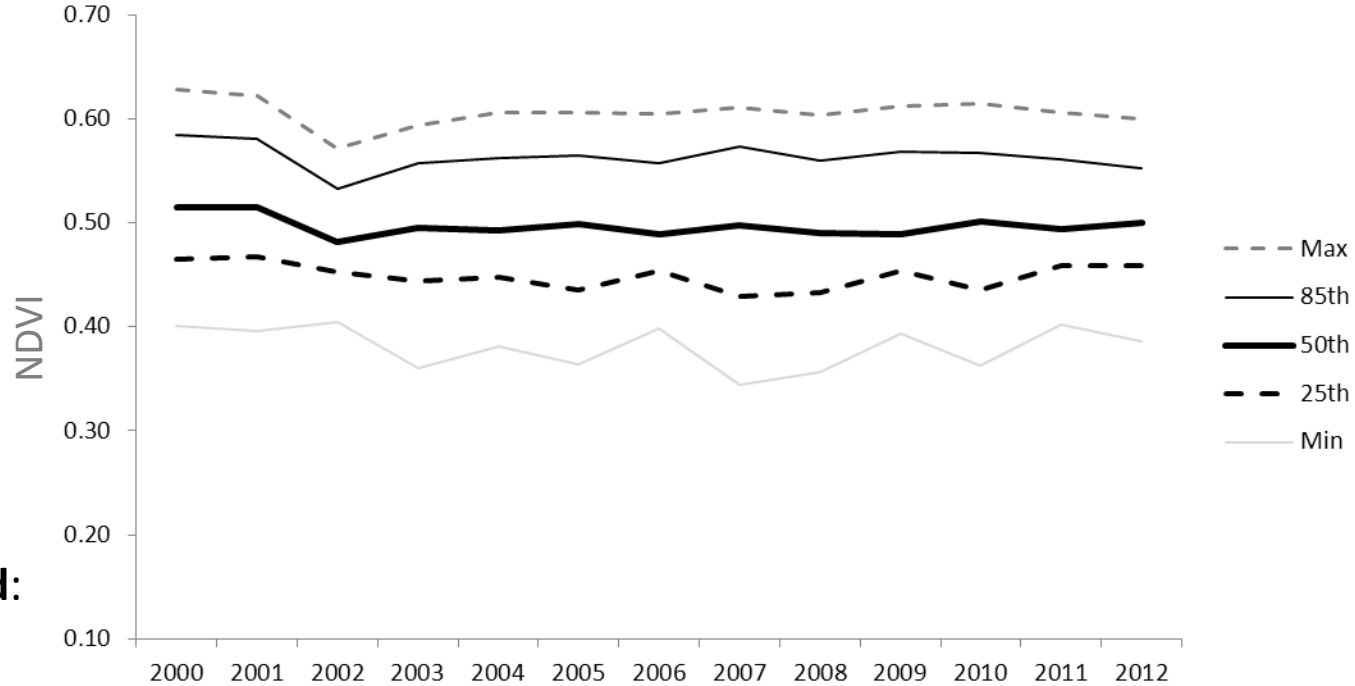
# PART III—Hayman Fire

Change in annual percentiles over time

**Burned**:



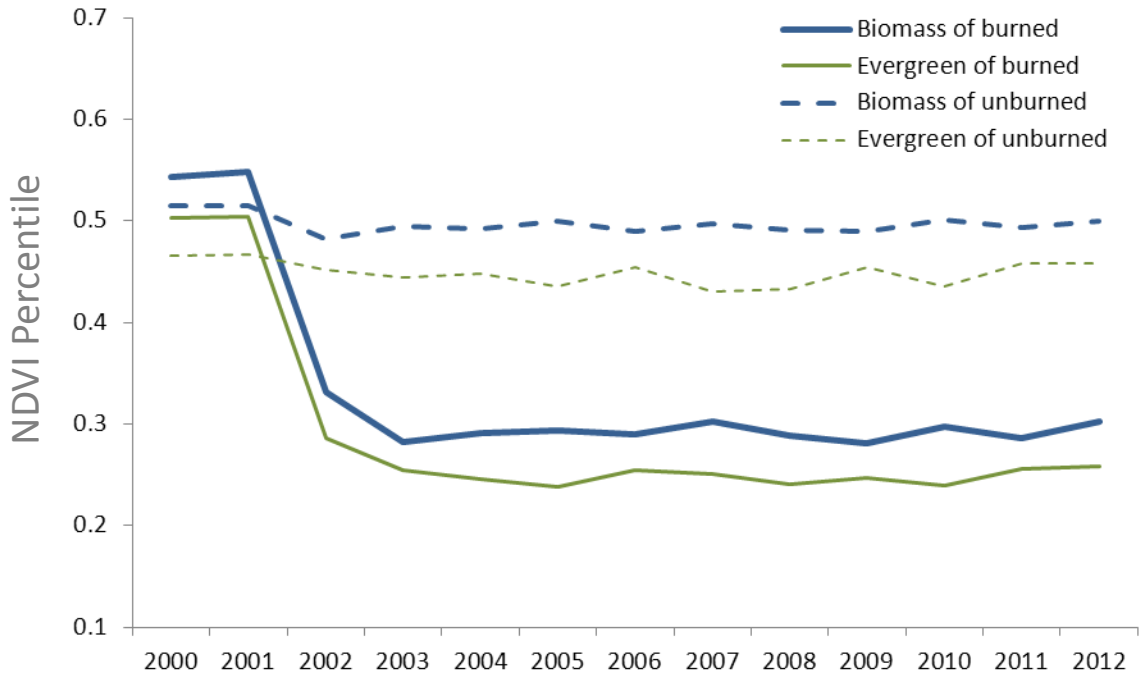

**Unburned**:



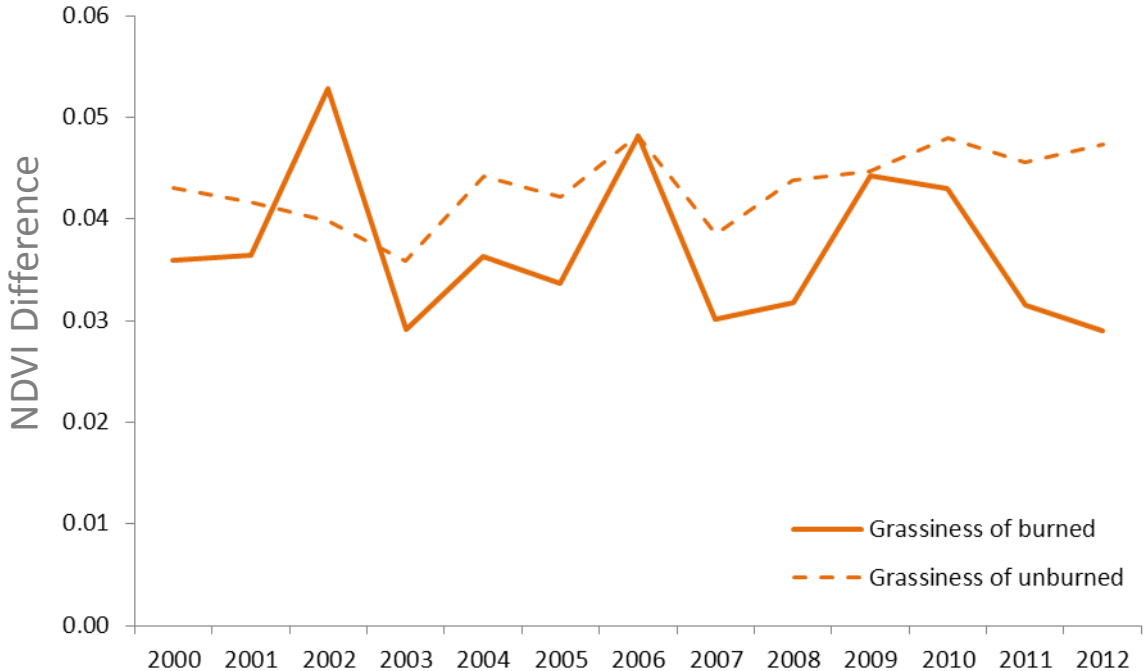
# PART III—
# Hayman Fire

Change in fire and succession sensitive measures

**Biomass and evergreen measures:**



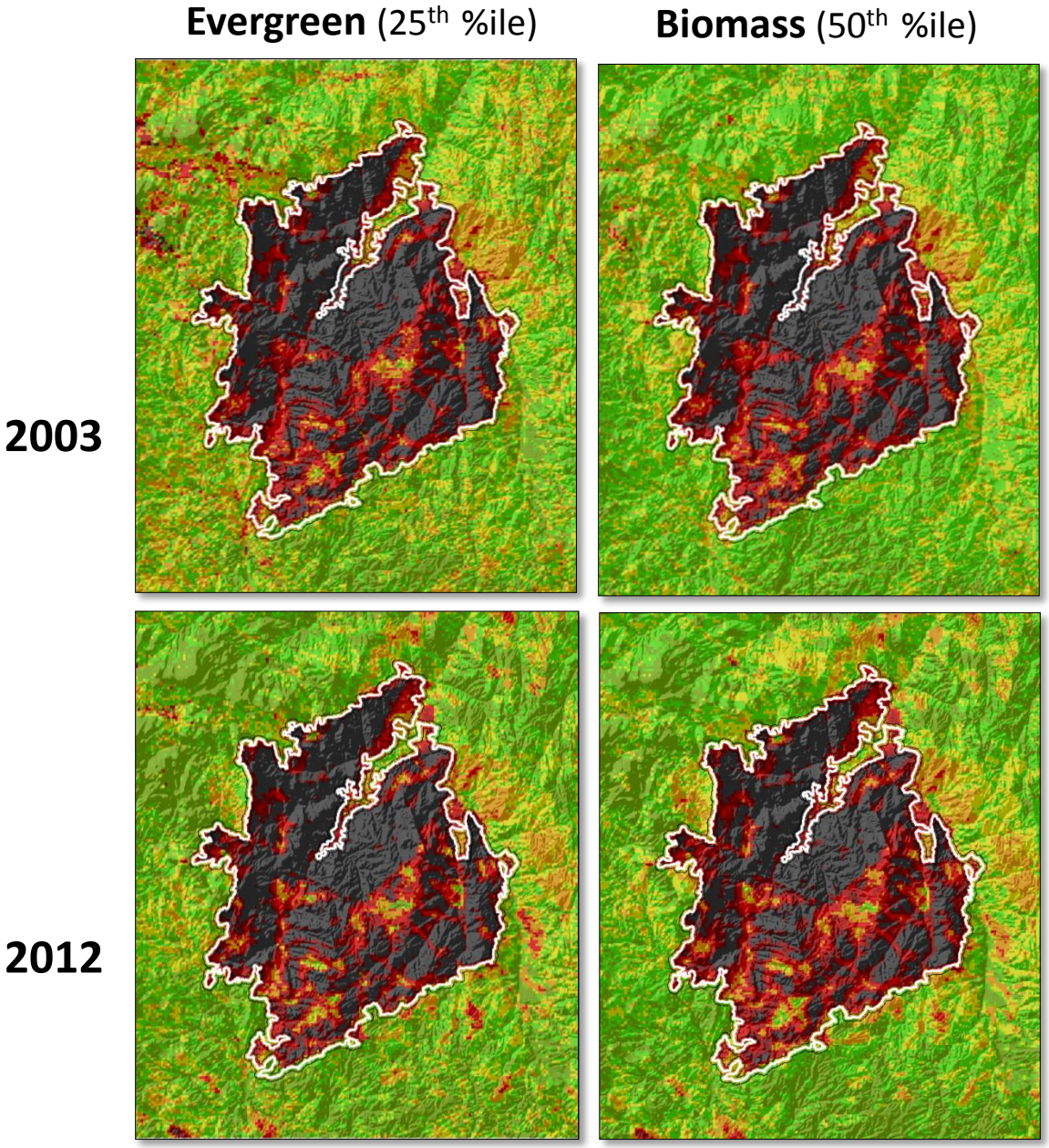

**Grassiness measure:**



# **PART III—**Predicting long-term effects from the **Hayman Fire**

**Percent change from 2000-1 mean**

- <-50
- -49.9 to -40
- -39.9 to -30
- -29.9 to -20
- -19.9 to -10
- -9.9 to -5
- -4.9 to 0
- > 0

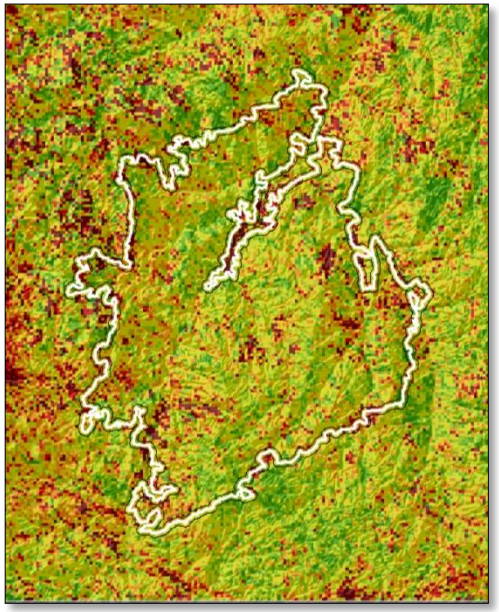


# **PART III**—Predicting long-term fire effects

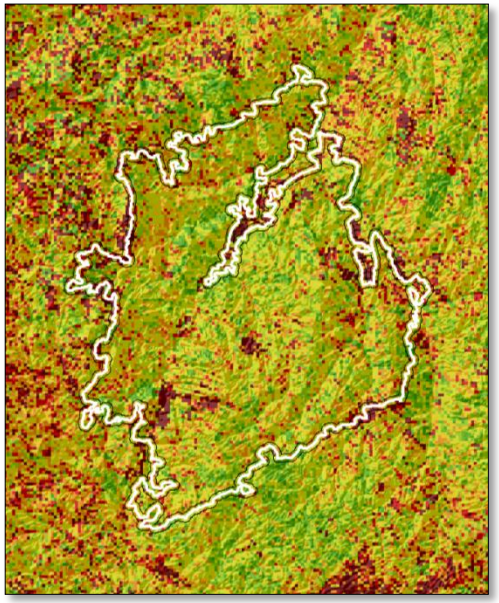
Change in peakedness/grassiness (Difference between 100th and 85th %iles)

More peaked
> 3
2.1 to 3
1.1 to 2
0.1 to 1
-0.9 to 0
-1.9 to -1
-2.9 to -2
< -3
Less peaked

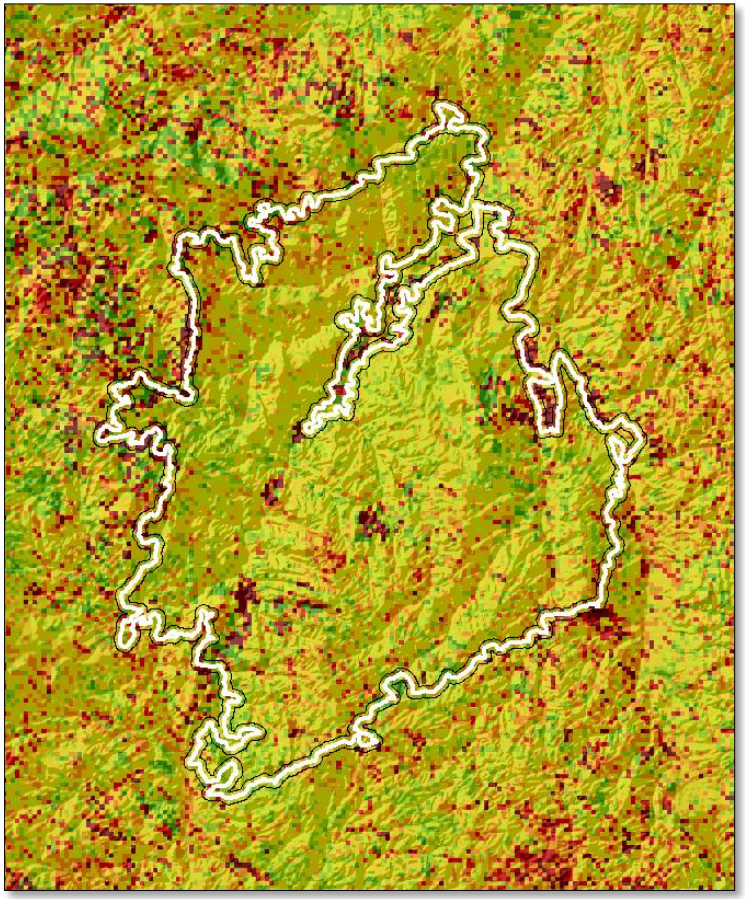
**Pre-fire to 2003-7 mean**



**Pre-fire to 2008-12 mean**

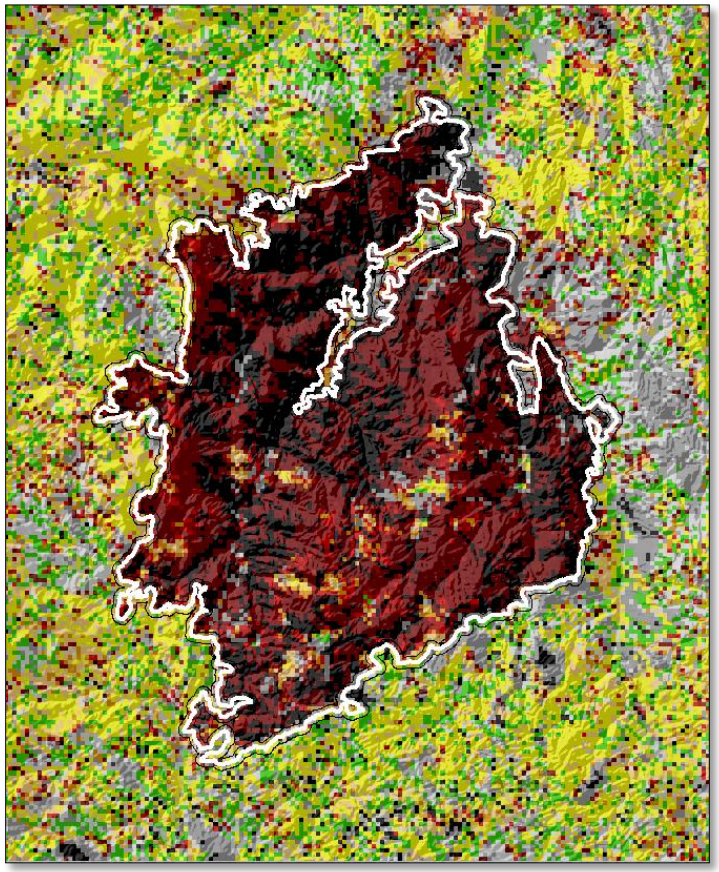


**2003-7 to 2008-12 mean**

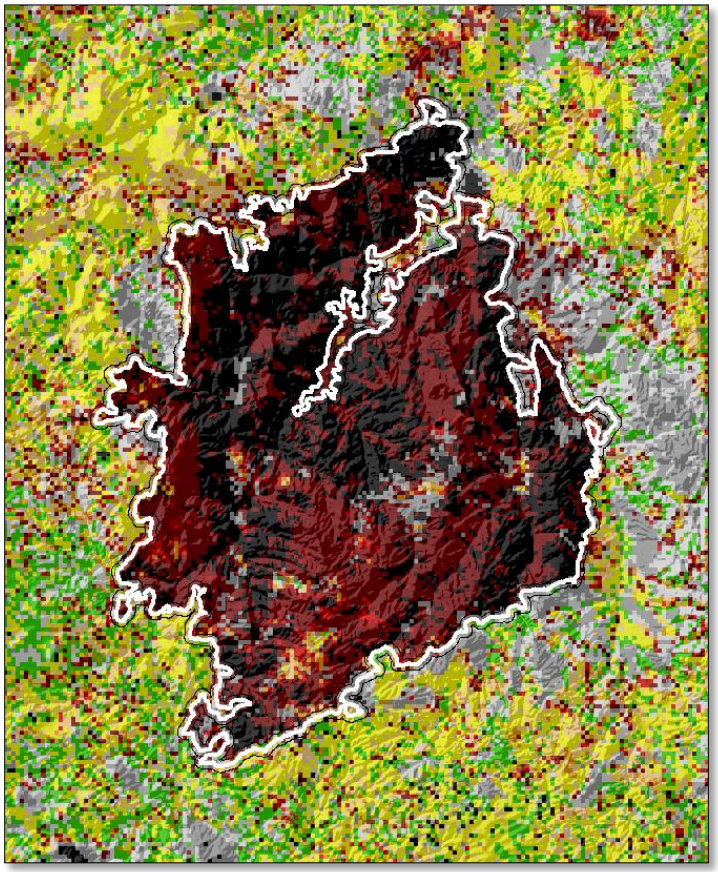


# **PART III—**Predicting long-term effects

**Time to recovery of evergreen fraction (25th %ile)**



**Time to recovery of biomass (50th %ile)**



**Years to recovery**

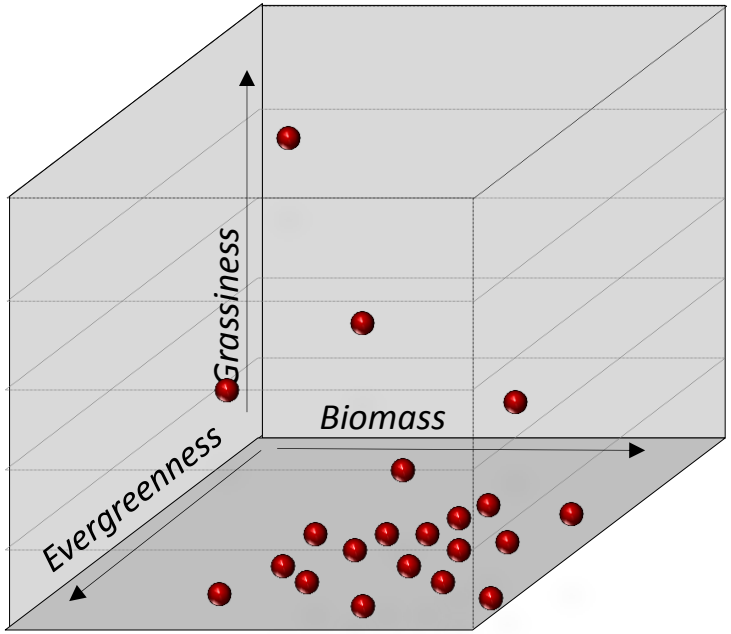
- > 50
- 40.1 to 50
- 30.1 to 40
- 20.1 to 30
- 10.1 to 20
- 0 to 10

**No observed recovery (% decline in 2012)**

- -4.9 to 0
- -9.9 to -5
- -24.9 to -10
- < -25

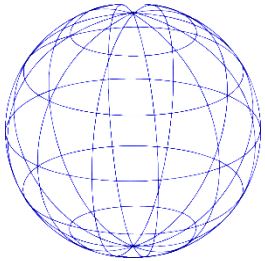
# **PART III—**Predicting long-term fire effects

Monitoring existing, post-disturbance or post-treatment change with respect to desired conditions




A location's attributes

Desired conditions



"Praemonitus Praemunitus"

ForWarn

Satellite-Based Change Recognition and Tracking

## *Summary*

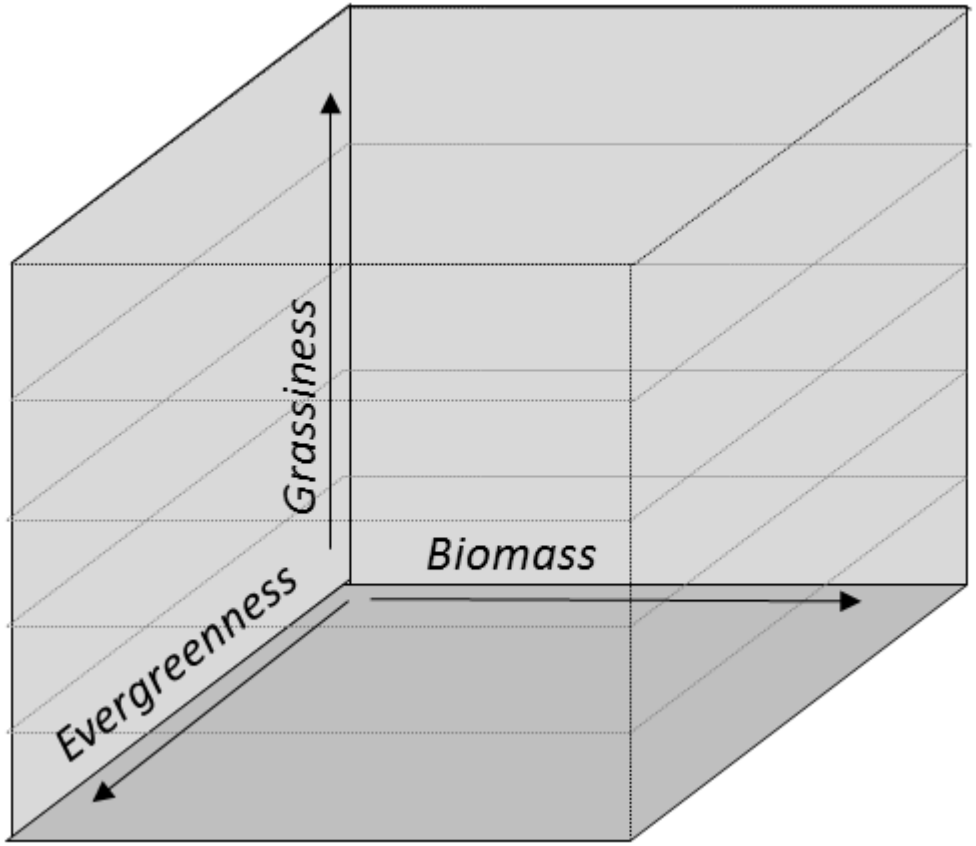
(1) High frequency, moderate resolution MODIS NDVI provides insights into *short* and *long-term* fire effects.

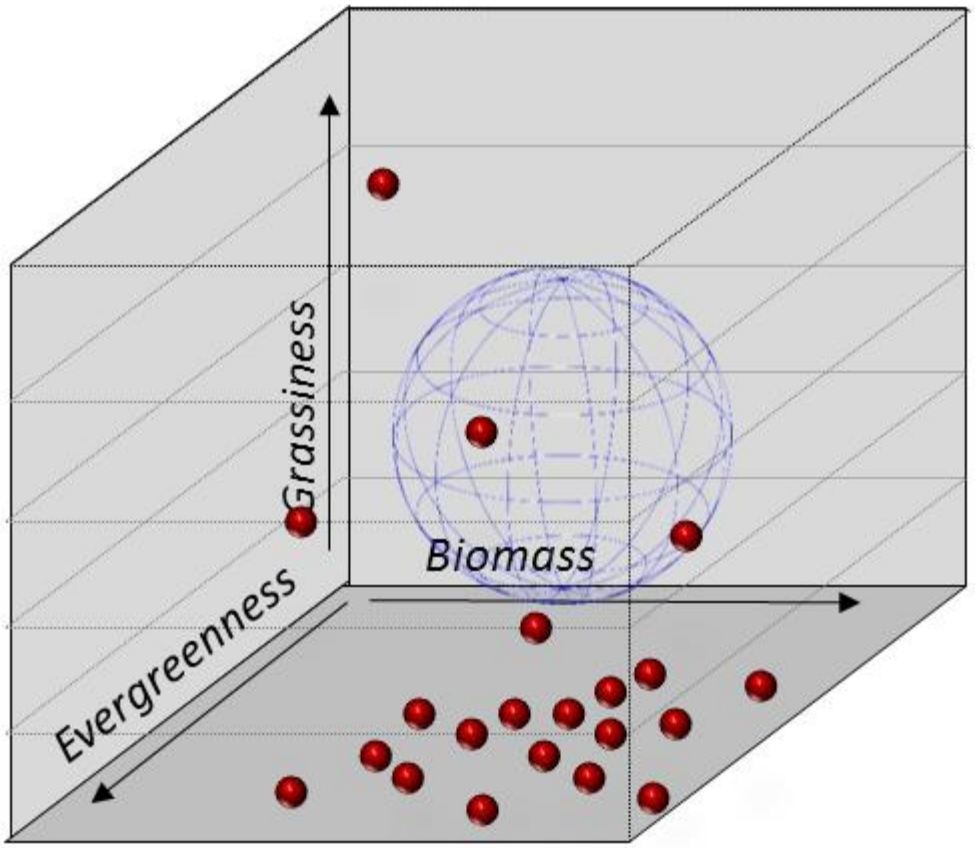
(2) Recovery to pre-fire or progress toward *desired conditions* can be *predicted*.

(3) This approach also provides a uniform coarse filter mechanism for *ecological process* monitoring.

(4) This functions for many other disturbances, and therefore for coarse aspects of disturbance interactions including cumulative effects from causes, both indigenous and novel.

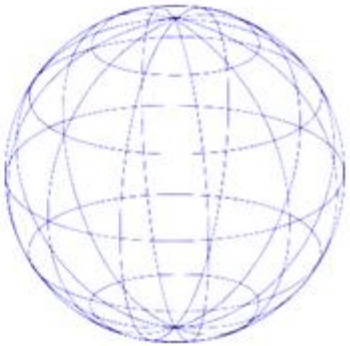
http://forwarn.forestthreats.org

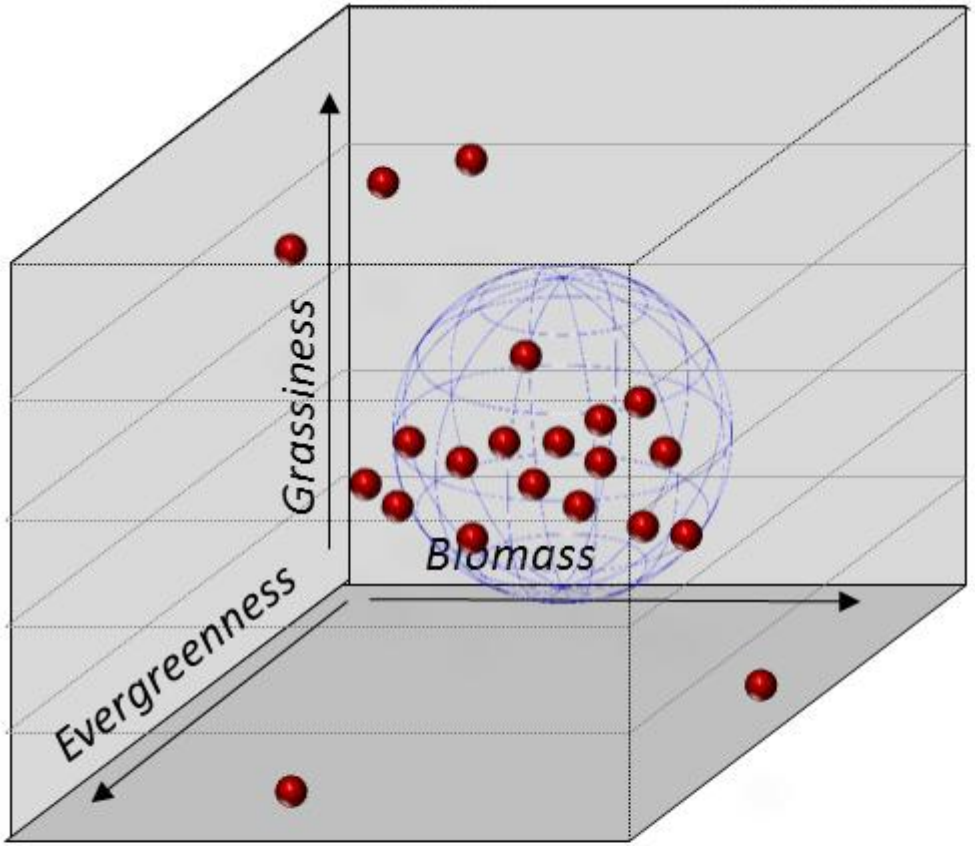

Grassiness
Biomass
Evergreenness

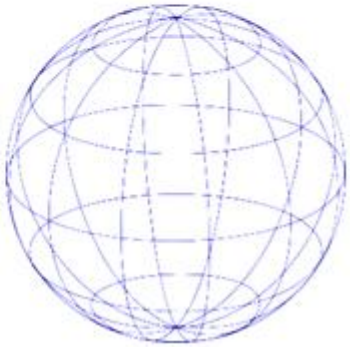



A location's attributes

Desired conditions






A location's attributes

Desired conditions