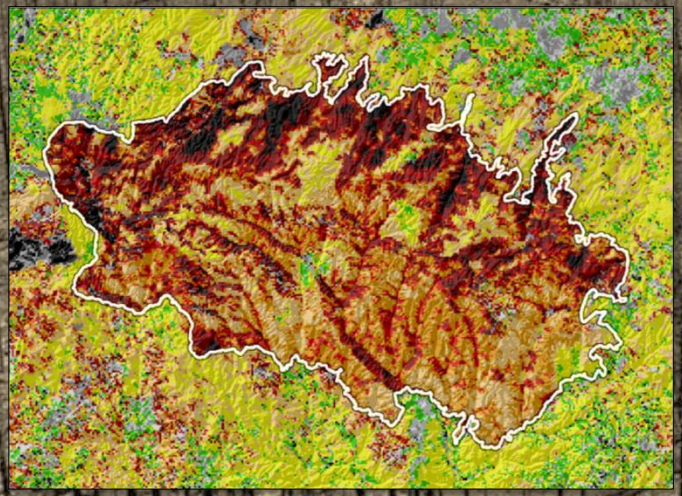
Predicting long-term wildfire effects across complex landscapes

Steven P. Norman
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

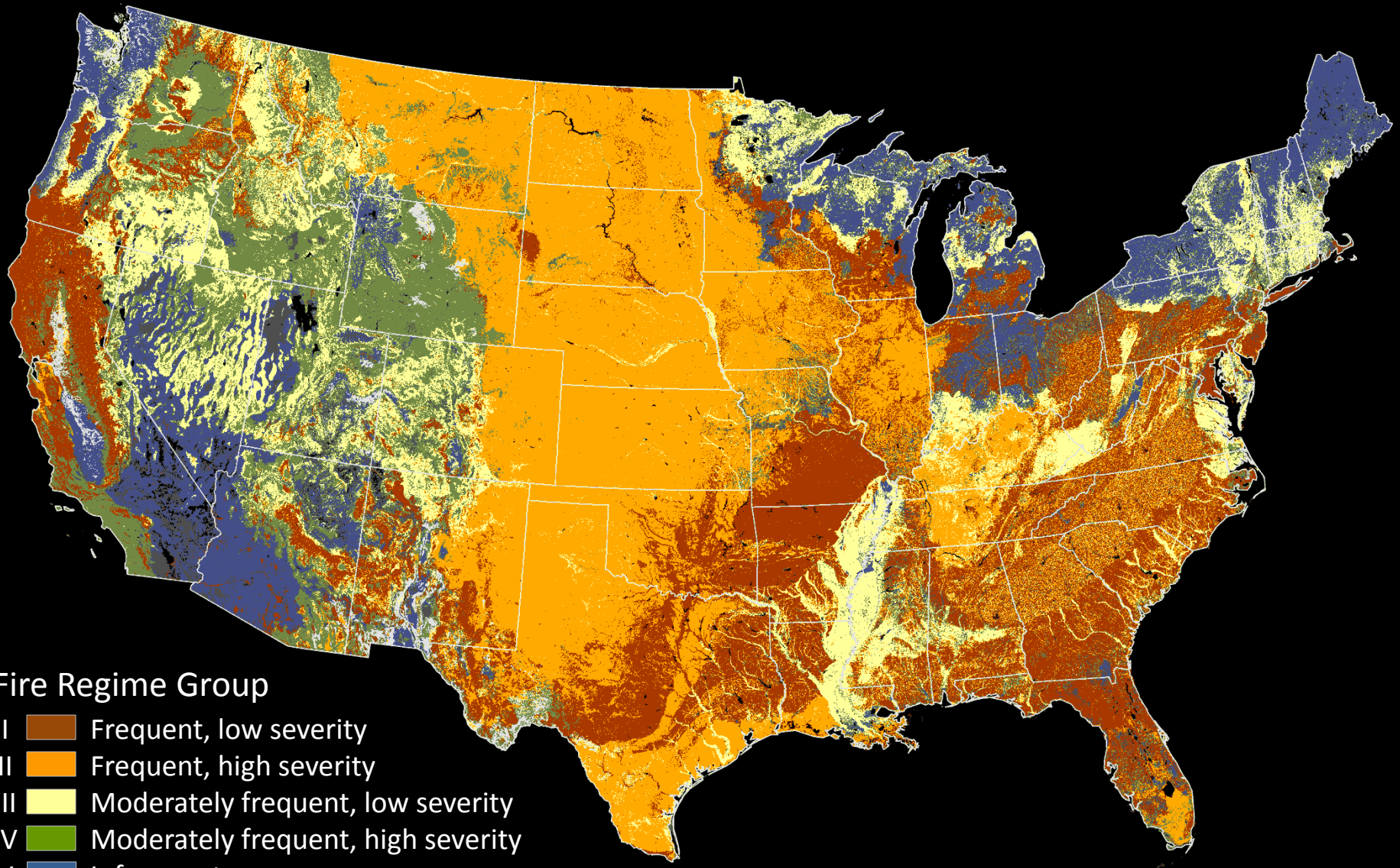
PART I—Our wildland fire and management crisis

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

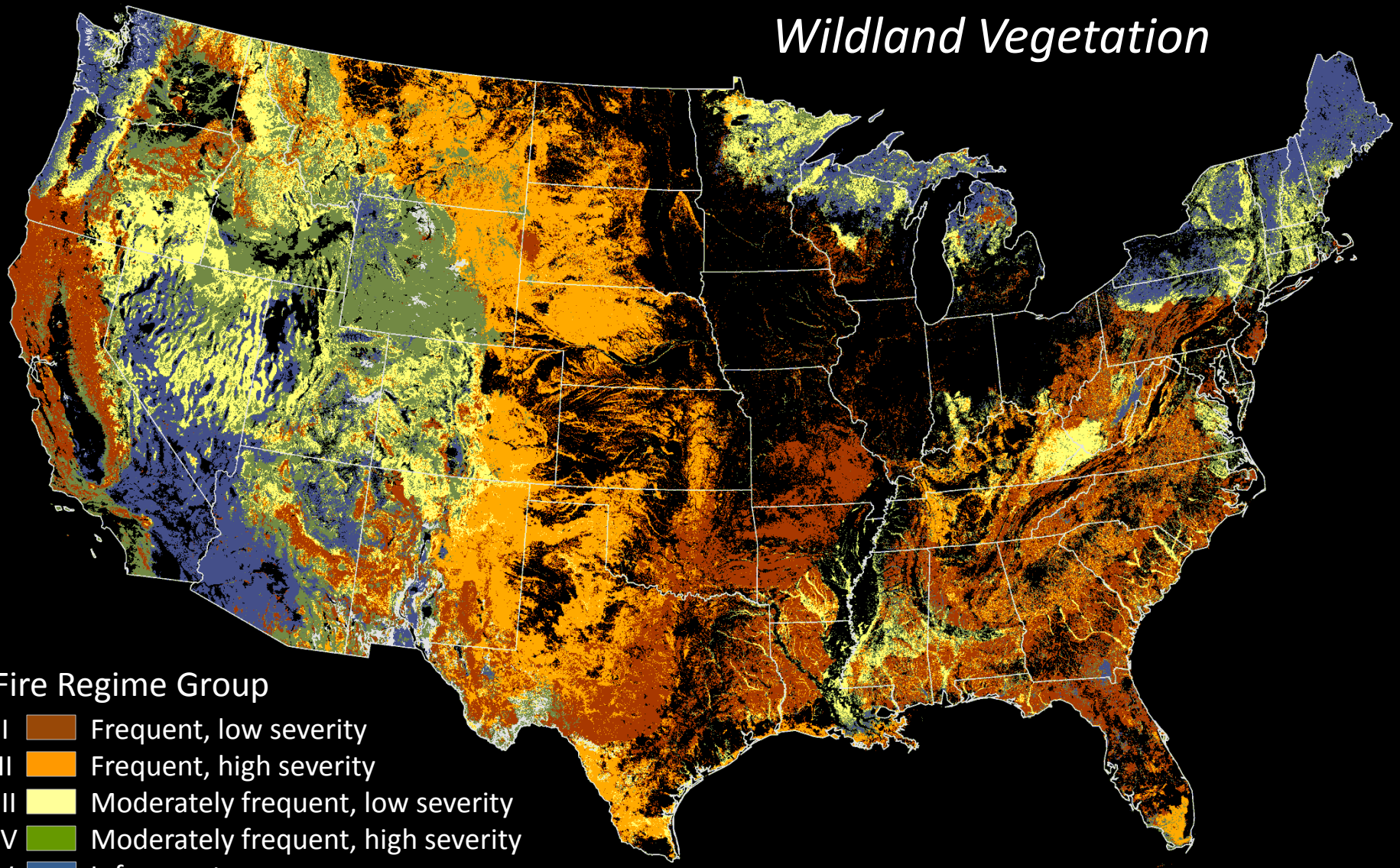
PART II—Efficient coarse-filter landscape monitoring

PART III—Predicting long-term fire effects

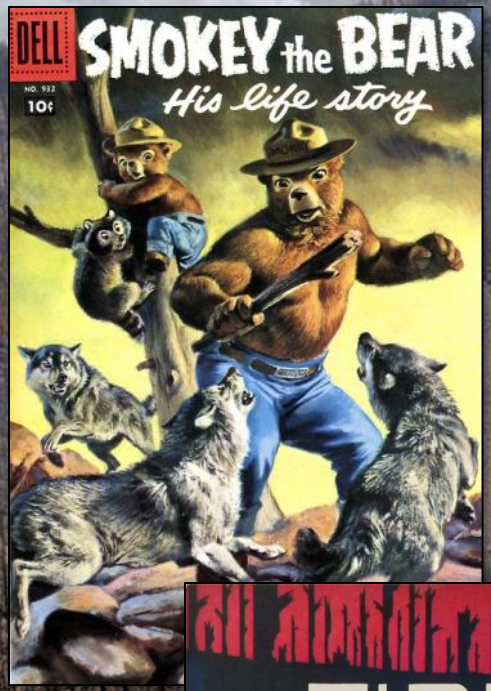
Historical Fire Regimes

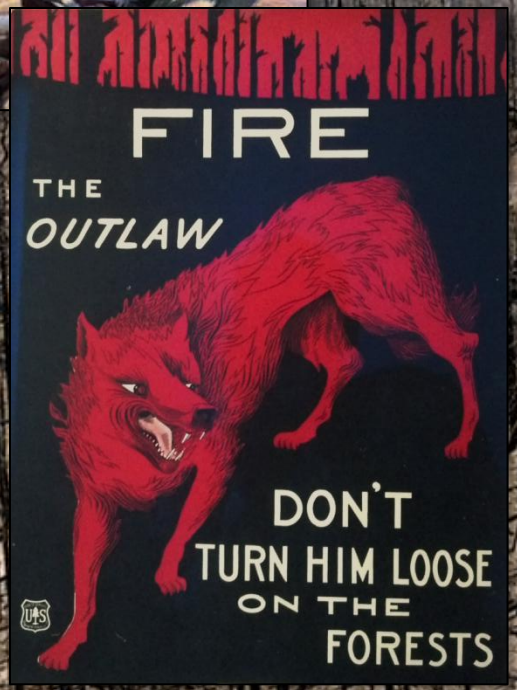


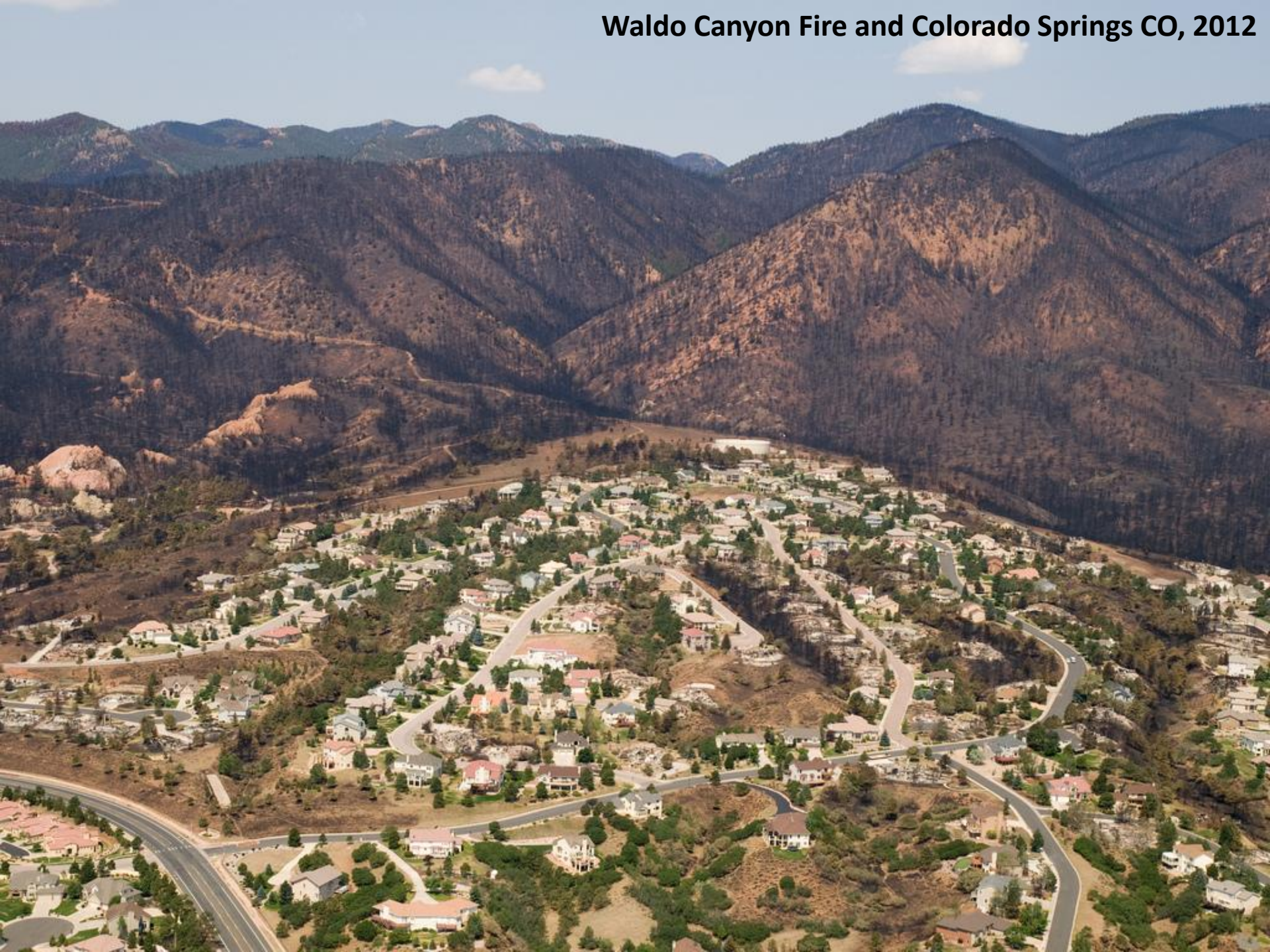
Historical Fire Regimes *of Existing Wildland Vegetation*




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.

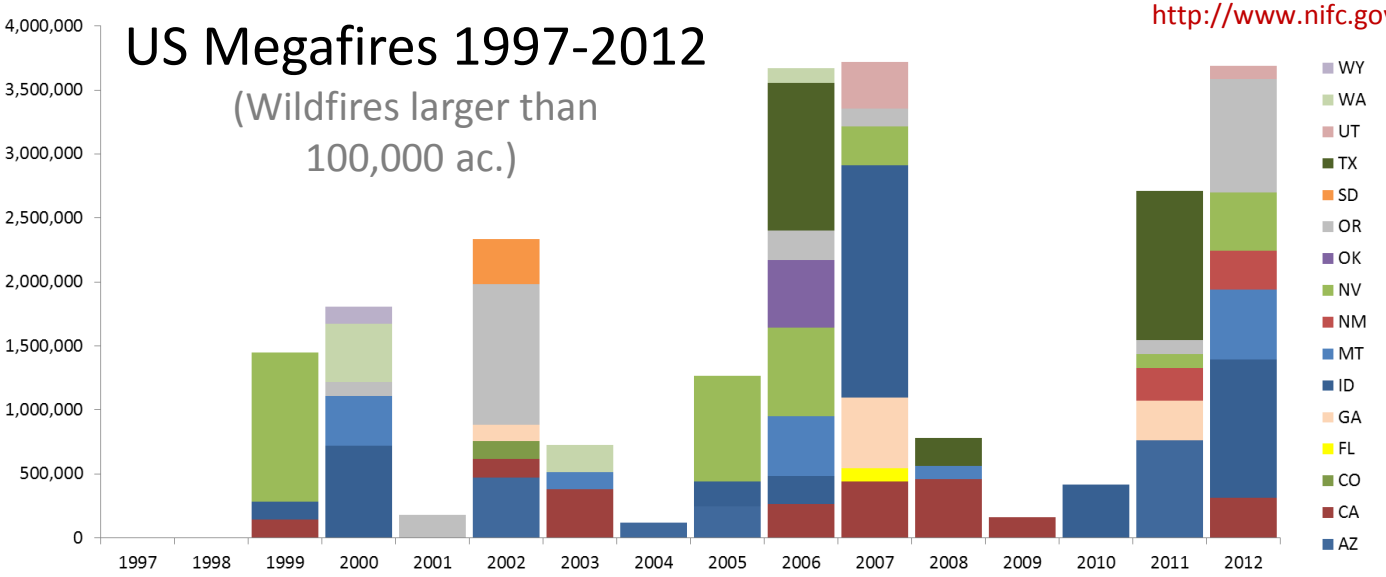


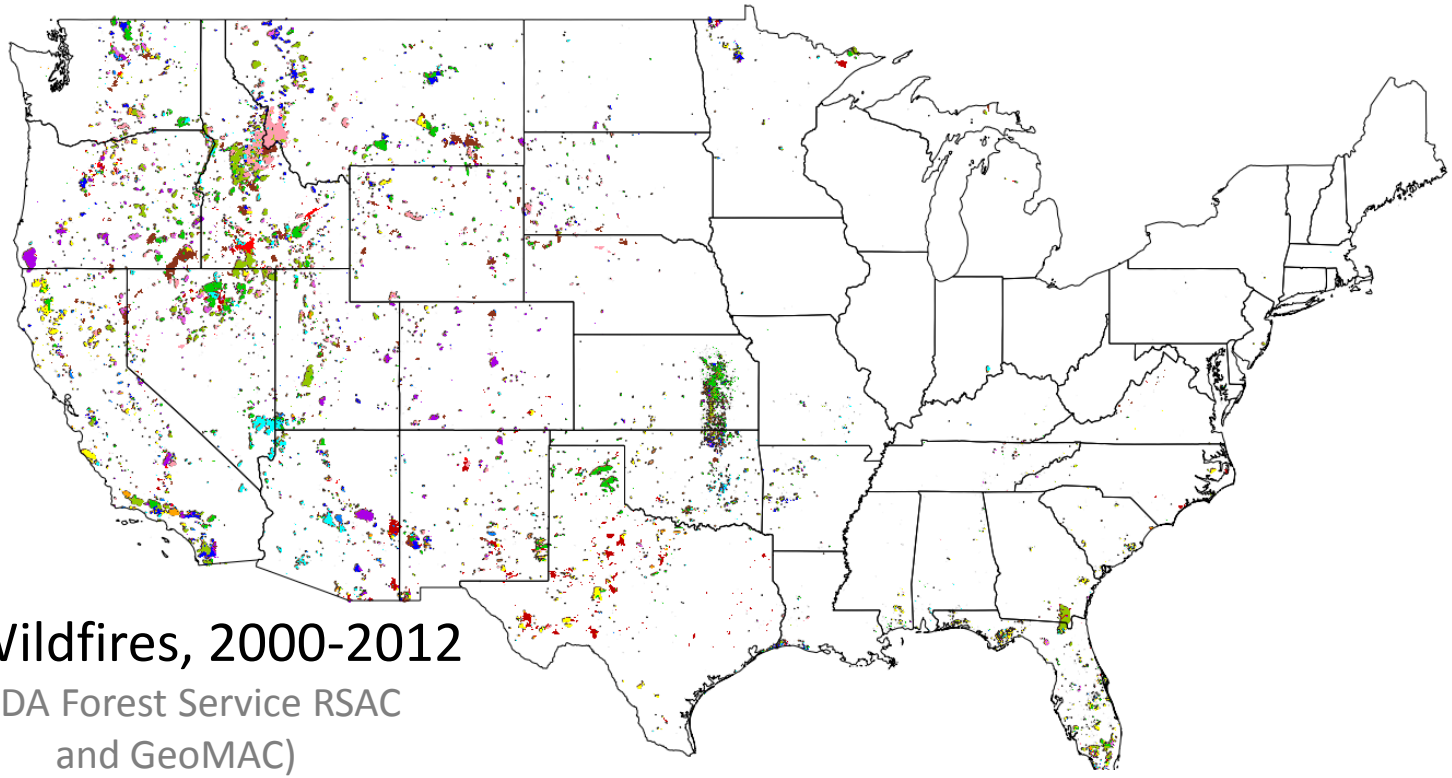
Waldo Canyon Fire and Colorado Springs CO, 2012

http://www.nifc.gov

US Megafires 1997-2012

(Wildfires larger than 100,000 ac.)





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

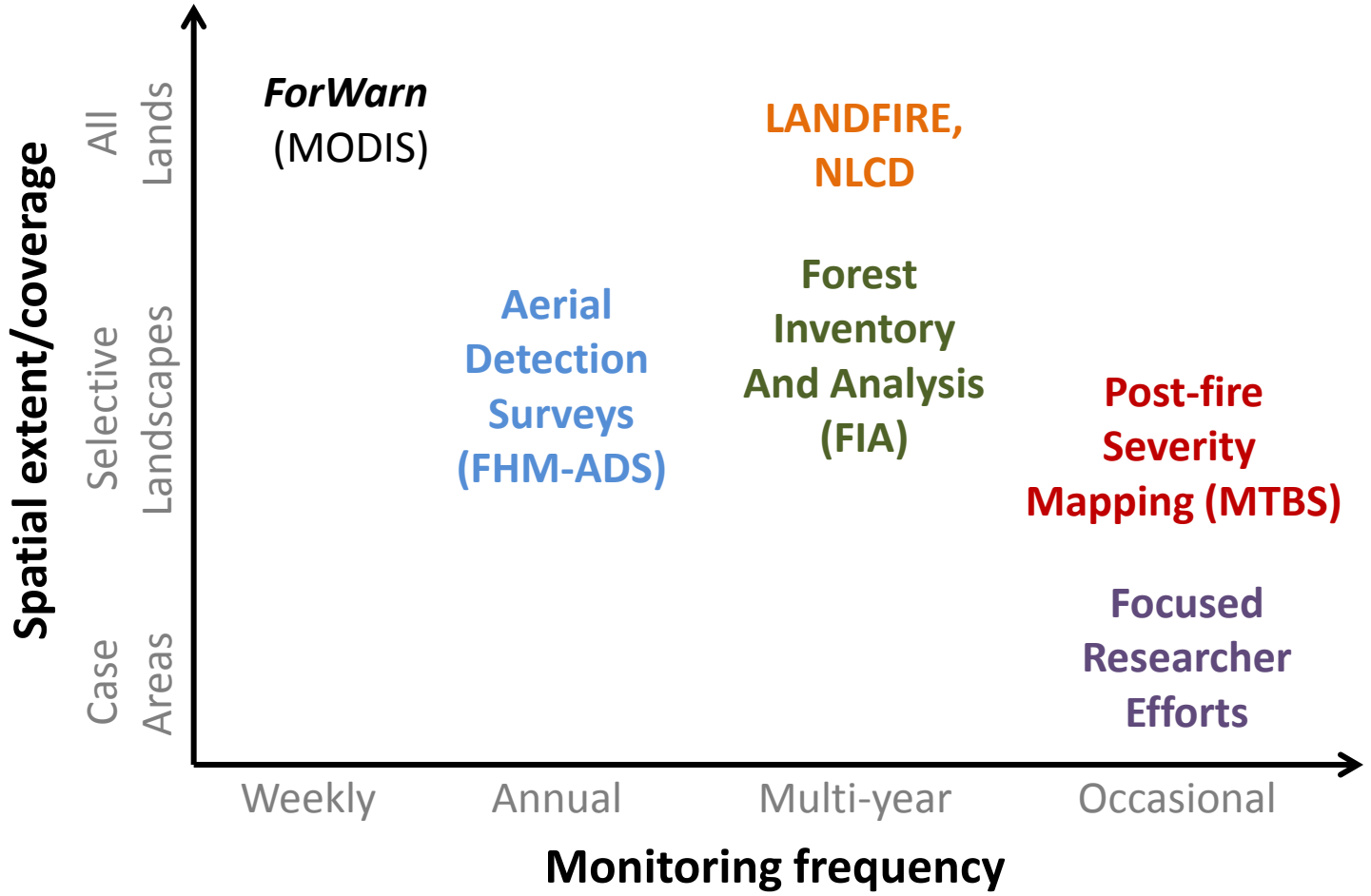
PART II—Efficient coarse-filter landscape monitoring

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

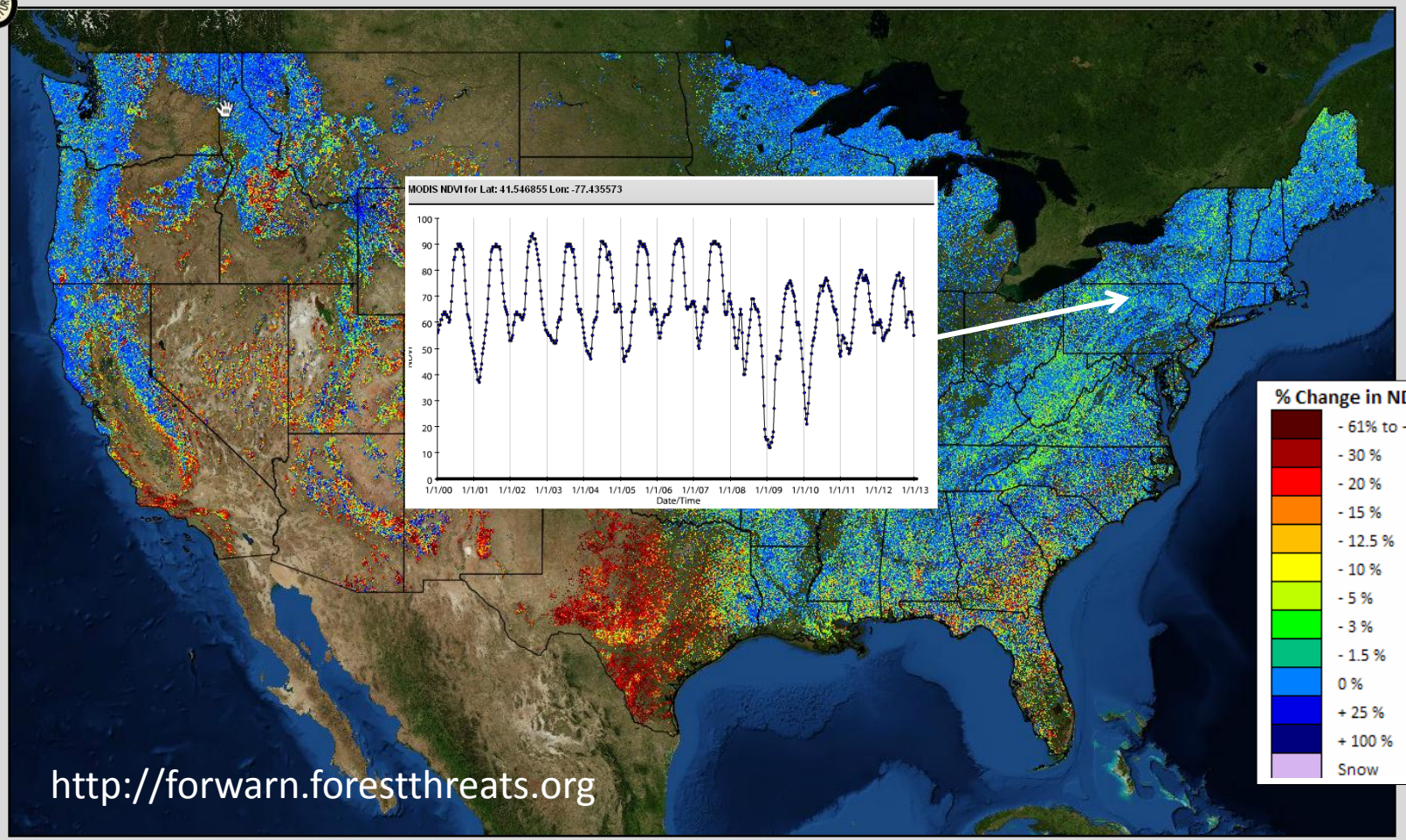


"Praemonitus Praemunitus"

ForWarn

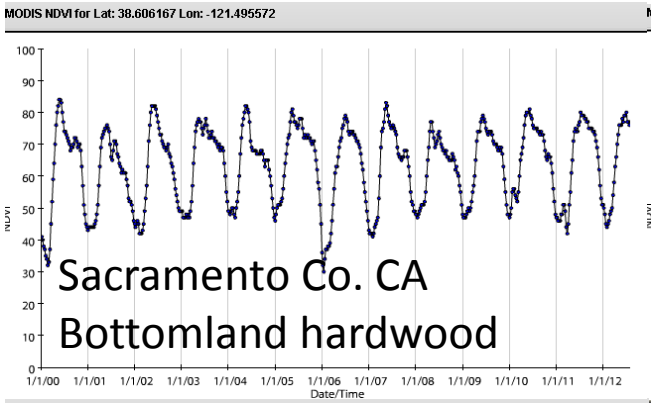
Satellite-Based Change Recognition and Tracking

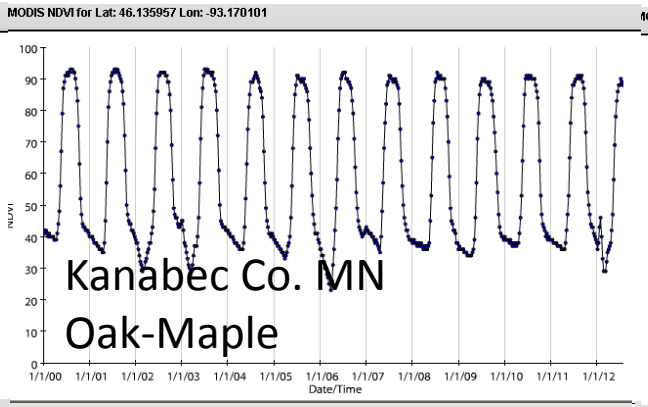
- Normalized Difference Vegetation Index (NDVI) from daily MODIS stream
- 232 meter resolution
- 46 periods per year (8-day intervals)
- 2000 to present historical database
- Includes NDVI time series and change maps

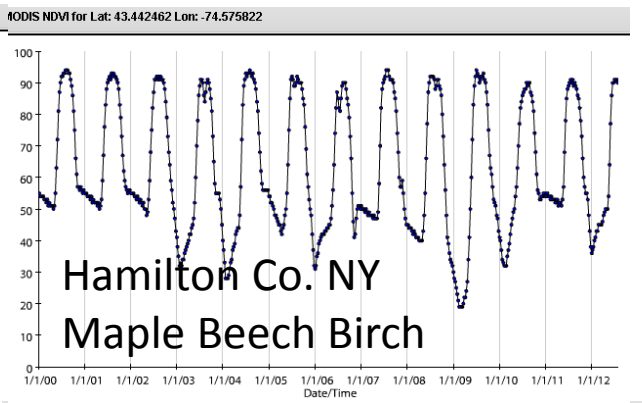


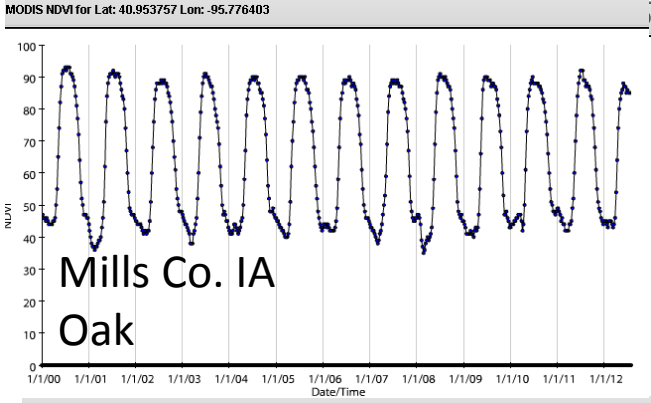
PART II—Efficient coarse-filter landscape monitoring

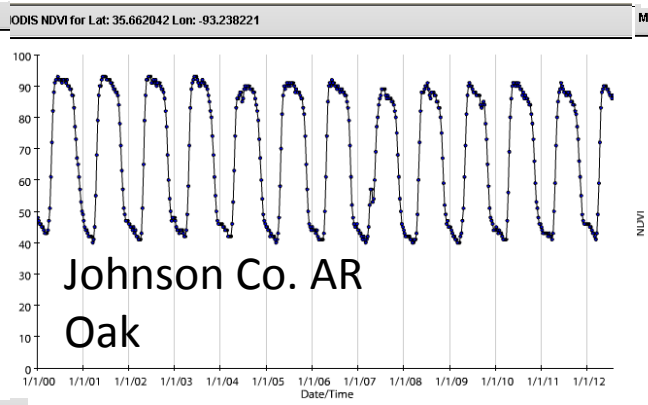
Phenological signatures of **deciduous forest** dominated pixels

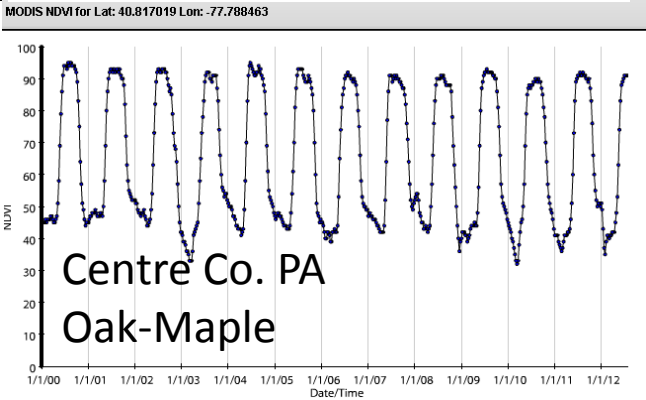


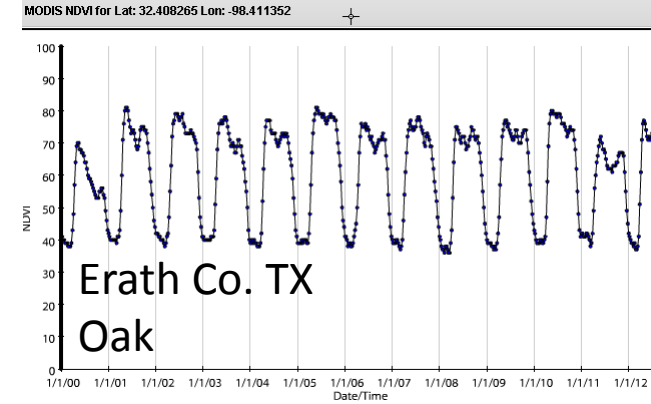


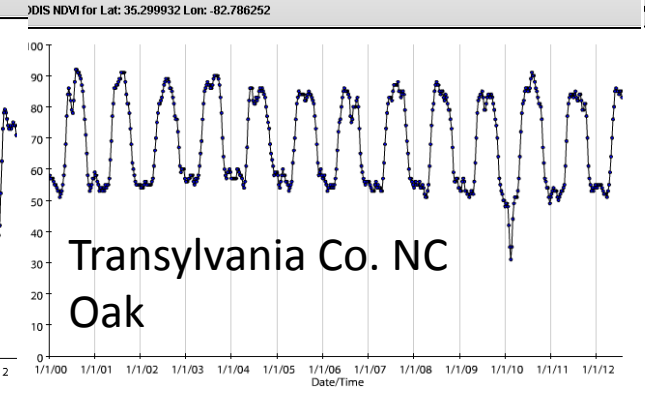


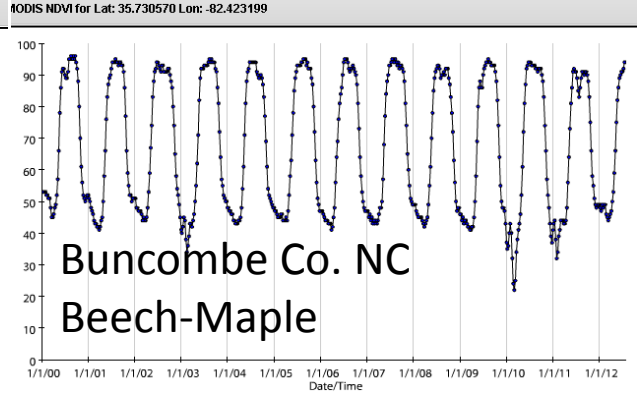






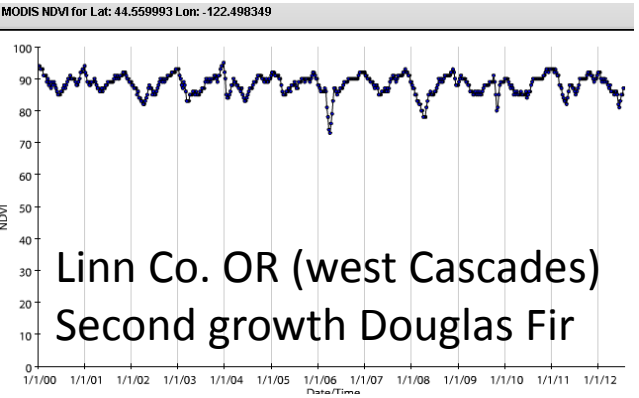


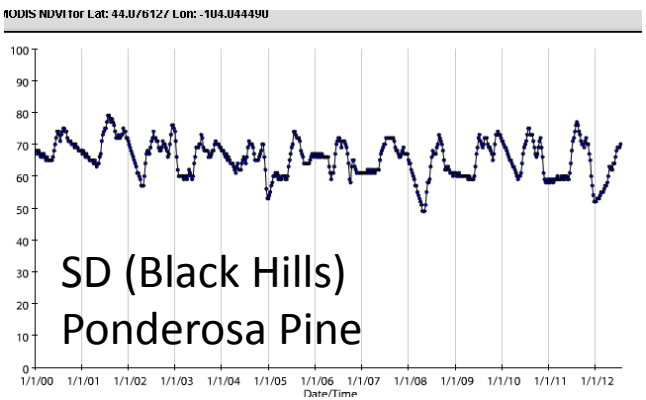


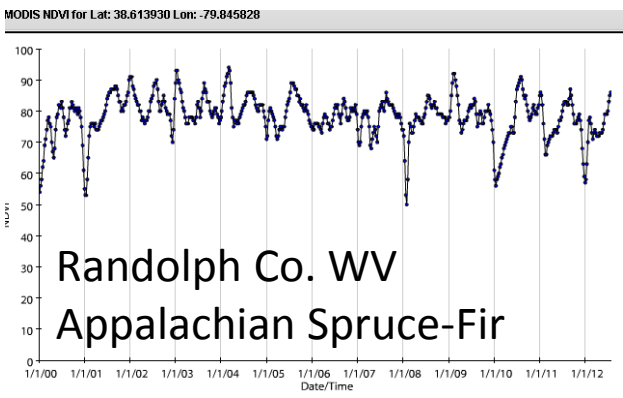


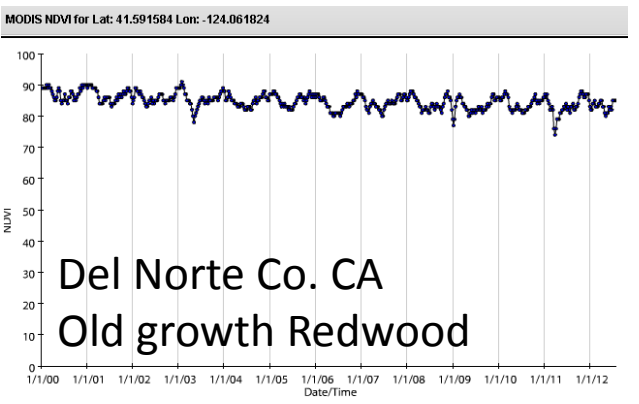
PART II—Efficient coarse-filter landscape monitoring

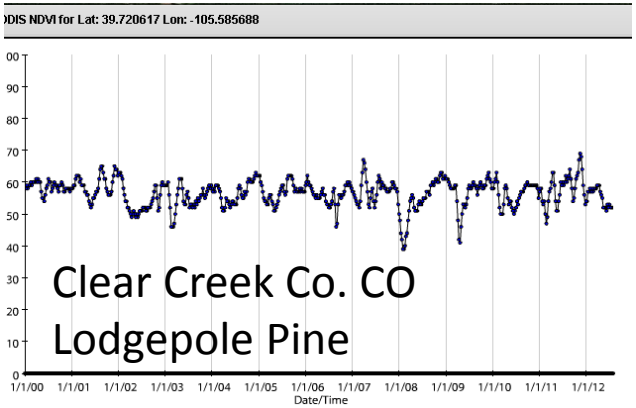
Phenological signatures of **conifer forest** dominated pixels

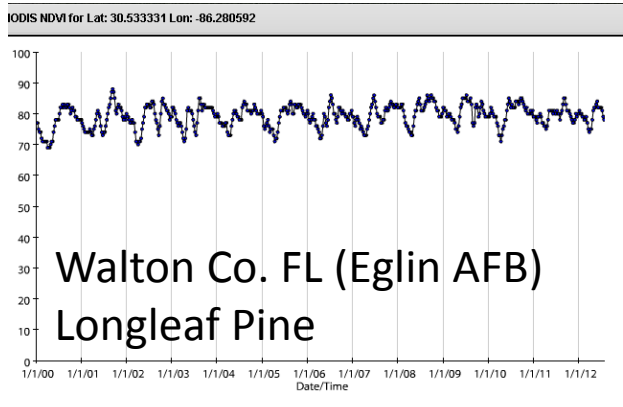


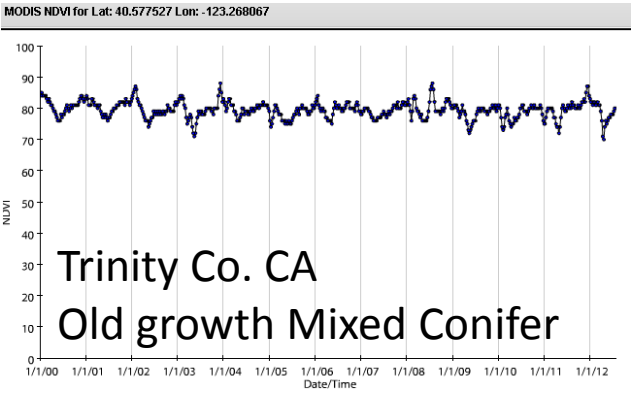


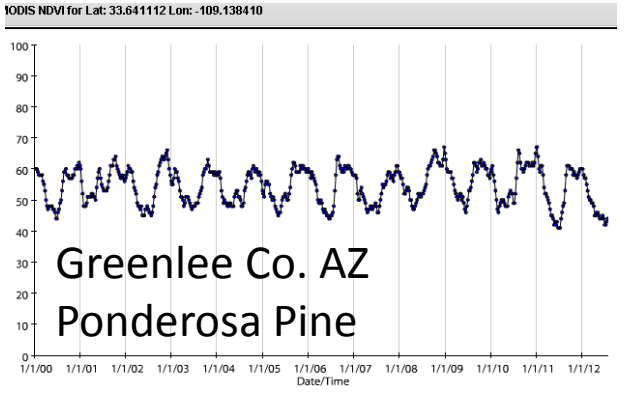


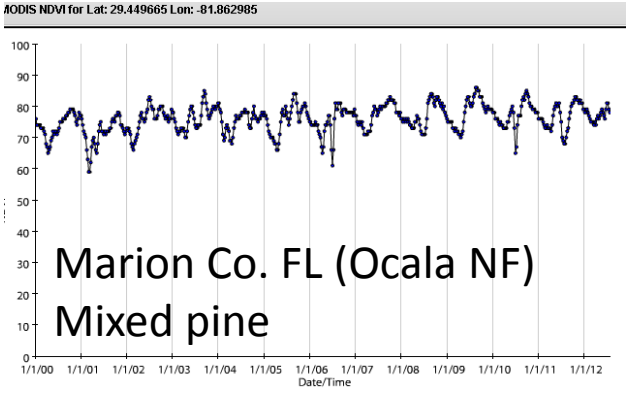






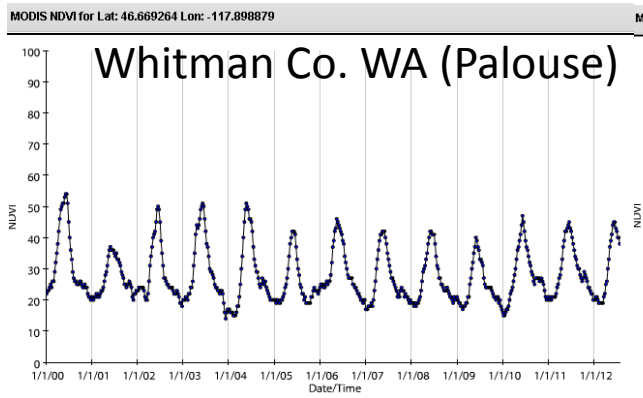


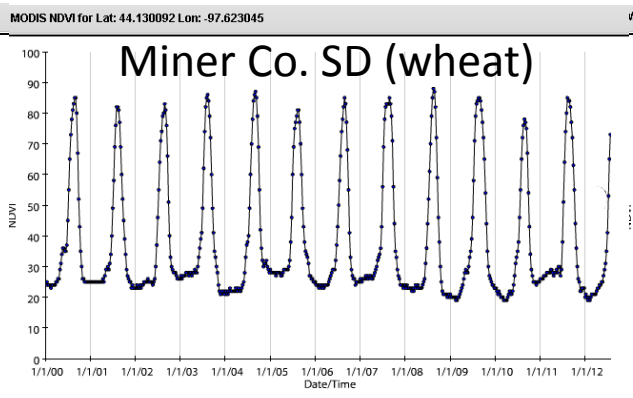


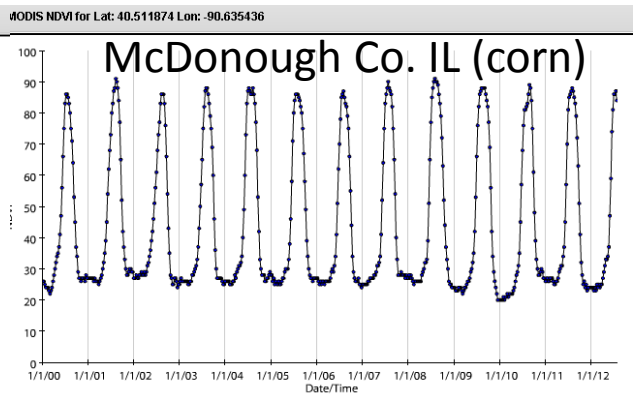


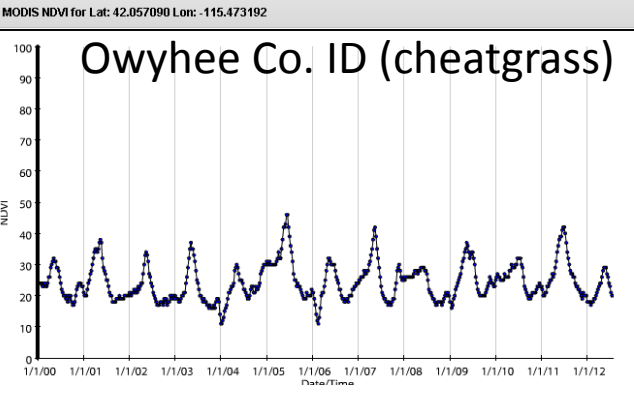
PART II—Efficient coarse-filter landscape monitoring

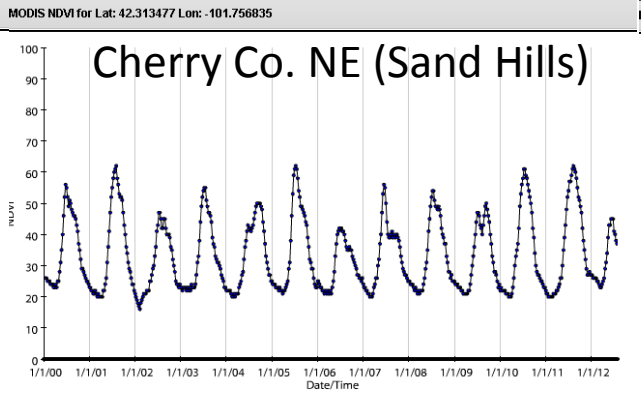
Phenological signatures of **grass** dominated pixels

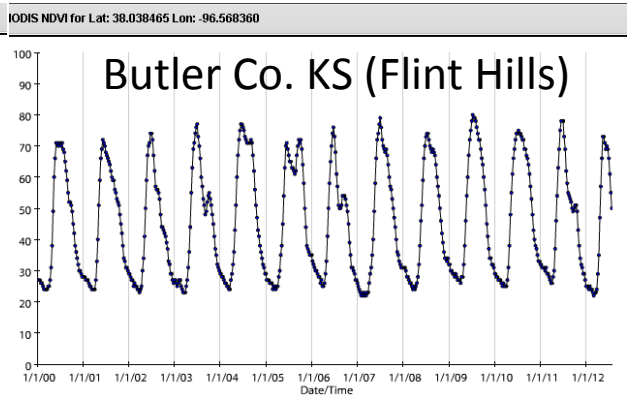


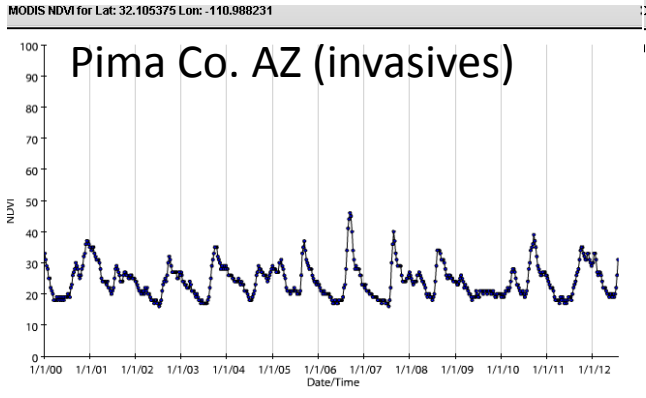


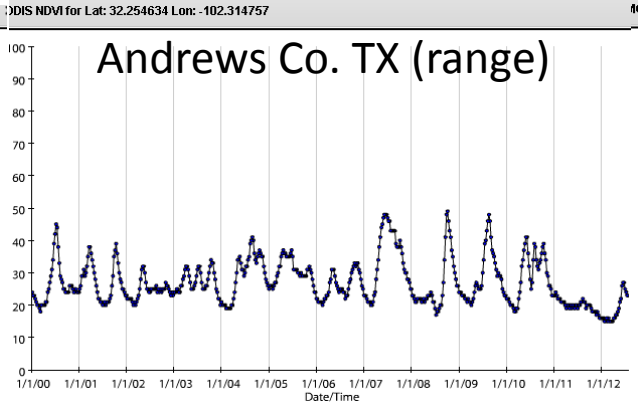


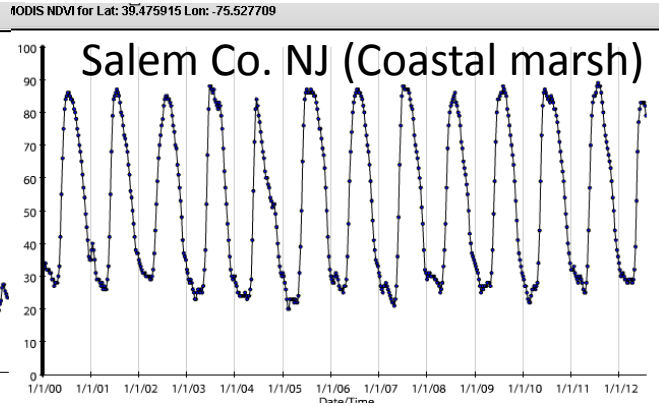












PART II—Efficient coarse-filter landscape monitoring

Potential measures of fire effects and desired vegetation

Maximum NDVI
Minimum NDVI
Mean NDVI
Median NDVI

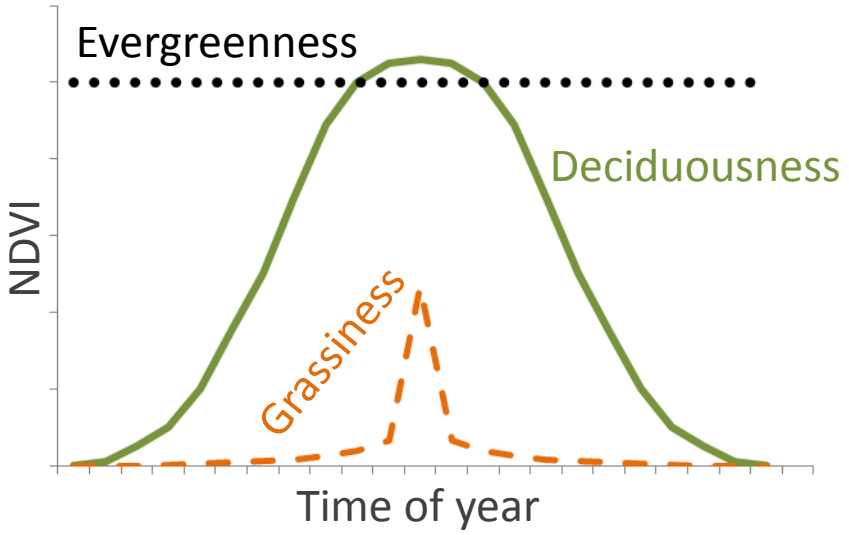
Percentiles of the annual distribution
Amplitude of NDVI (of extremes)
NDVI difference (between thresholds)
Duration above some threshold
Area under the growing season curve

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)



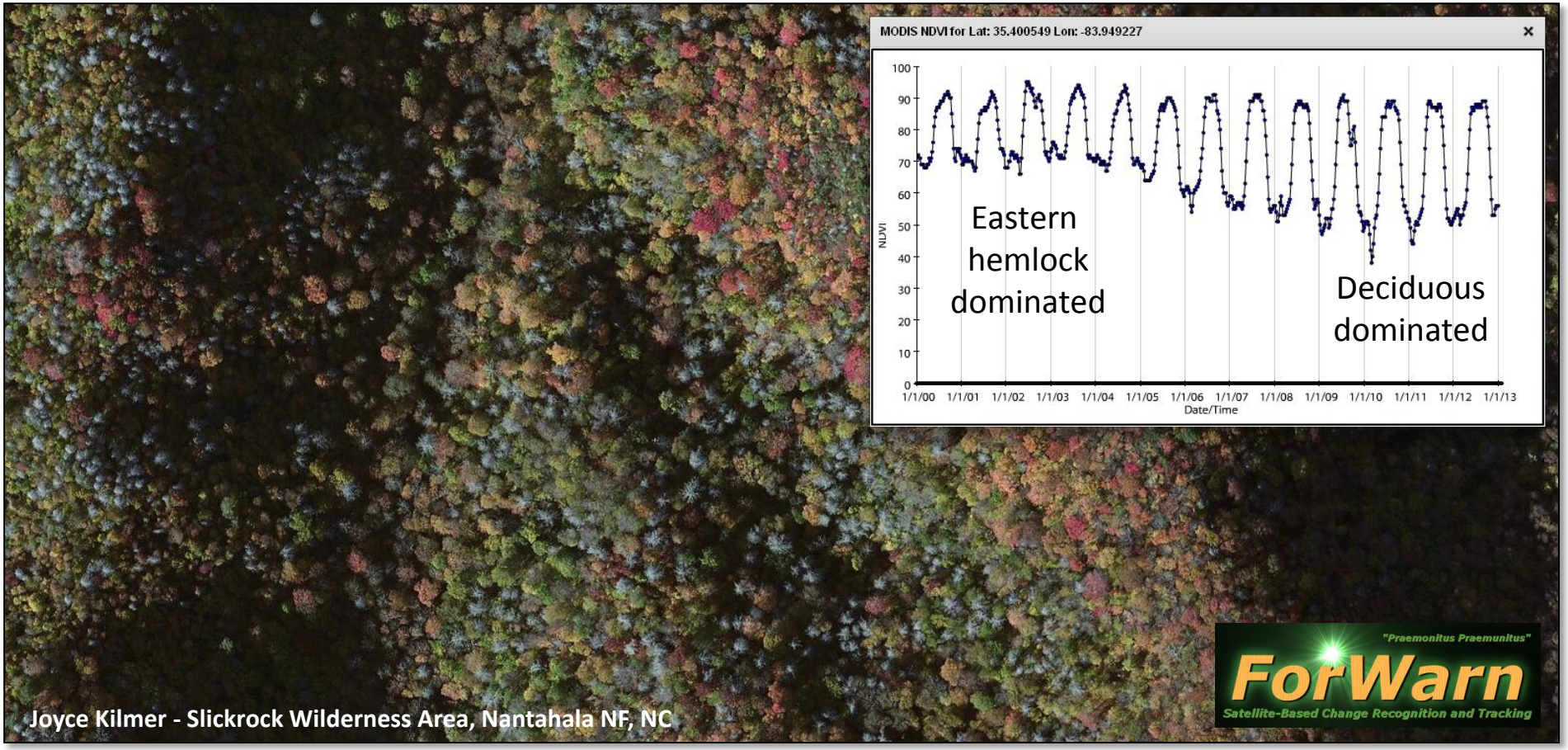
PART II—Efficient coarse-filter landscape monitoring

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.

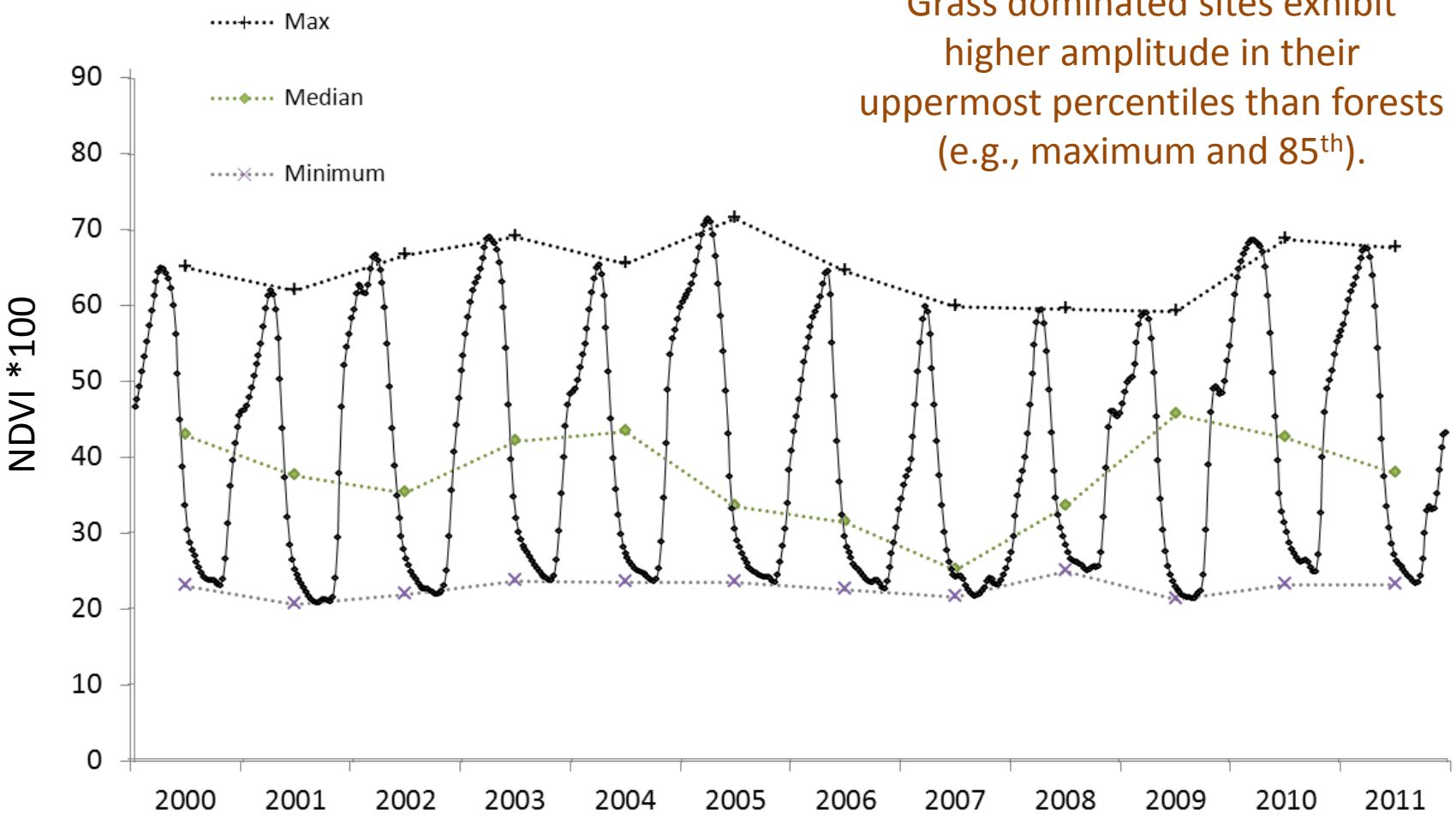


PART II—Efficient coarse-filter landscape monitoring

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

(The landscape mean of 9,345 MODIS pixels)

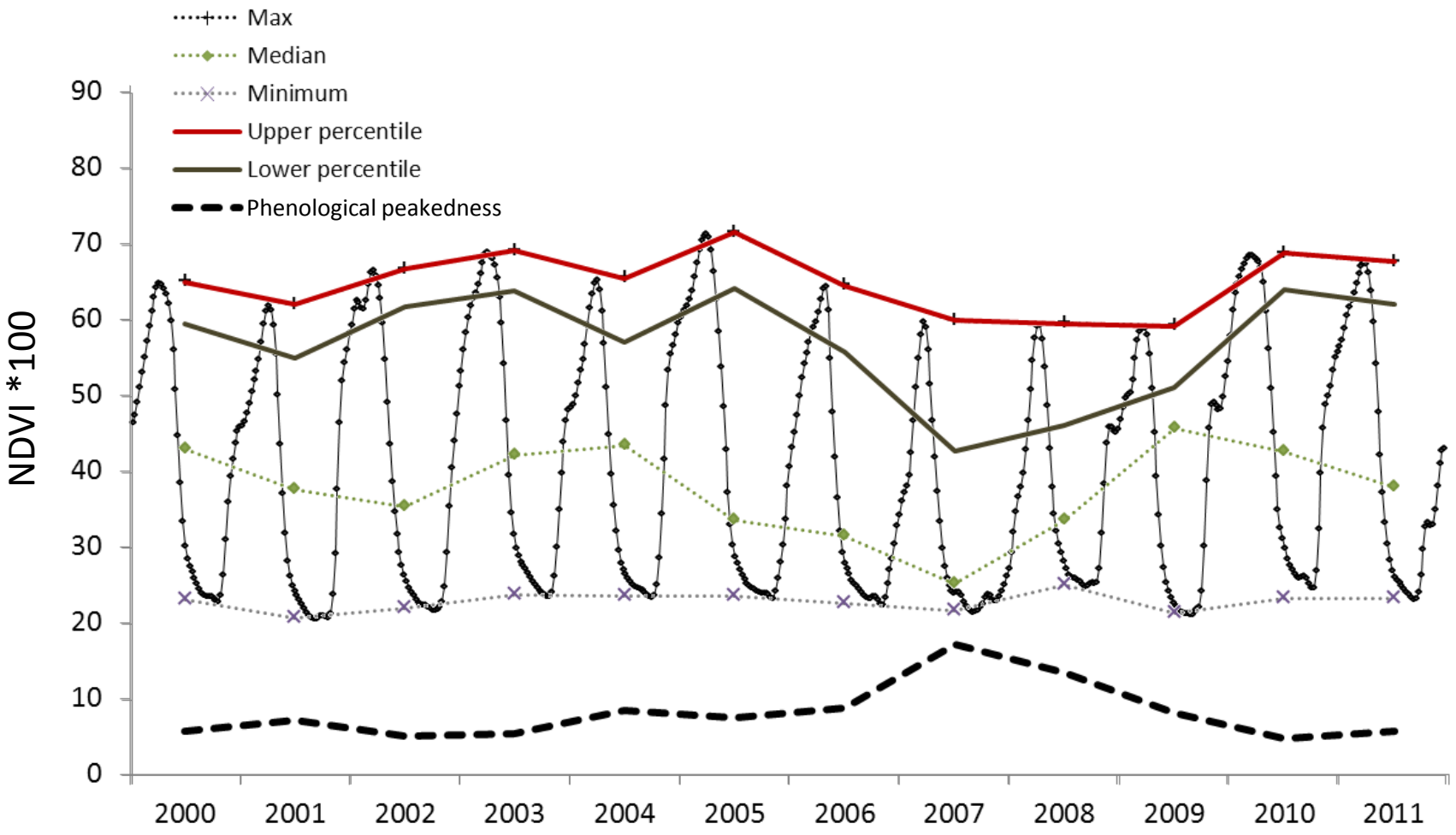
Grass dominated sites exhibit higher amplitude in their uppermost percentiles than forests (e.g., maximum and 85th).



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

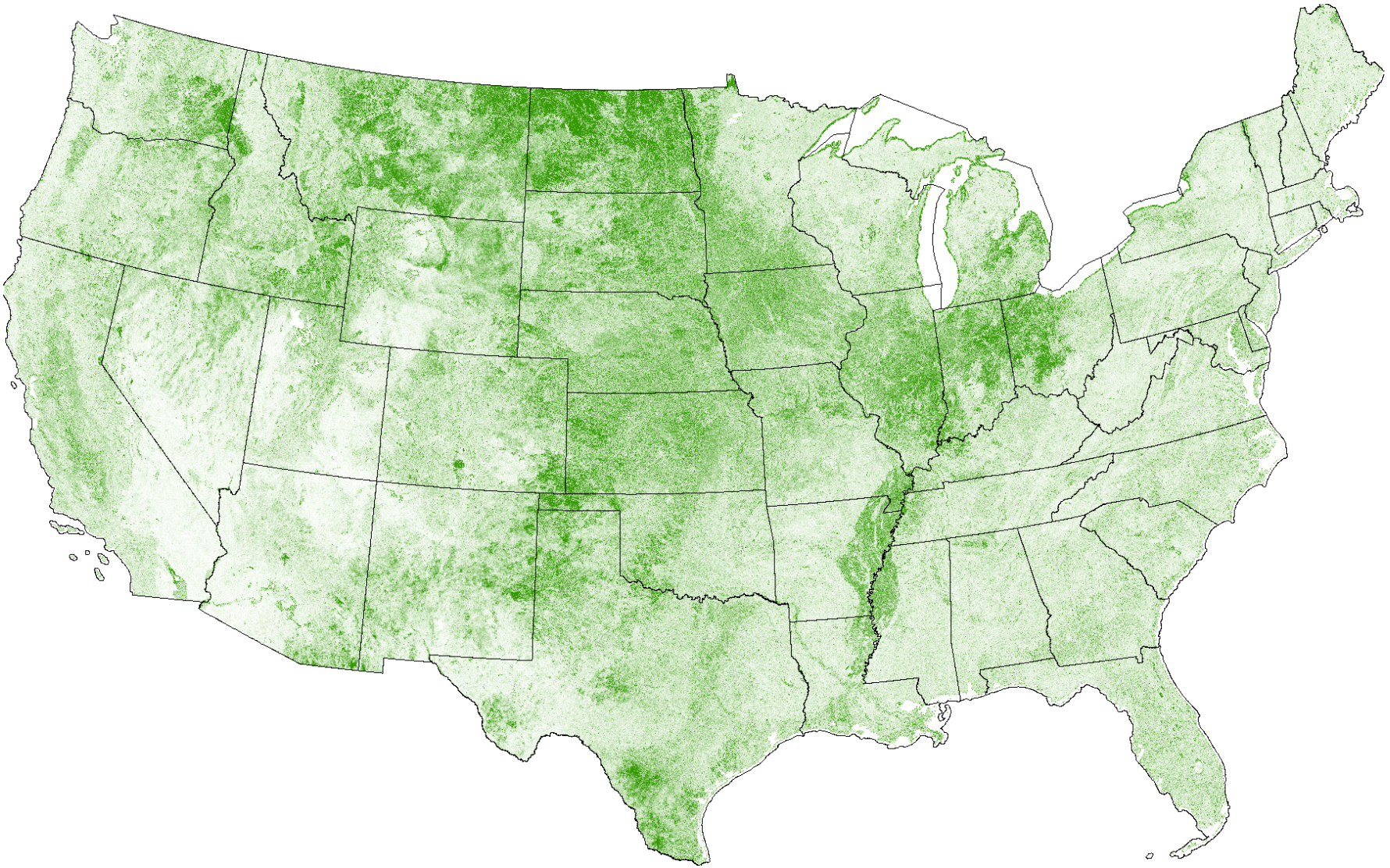
PART II—Efficient coarse-filter landscape monitoring

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



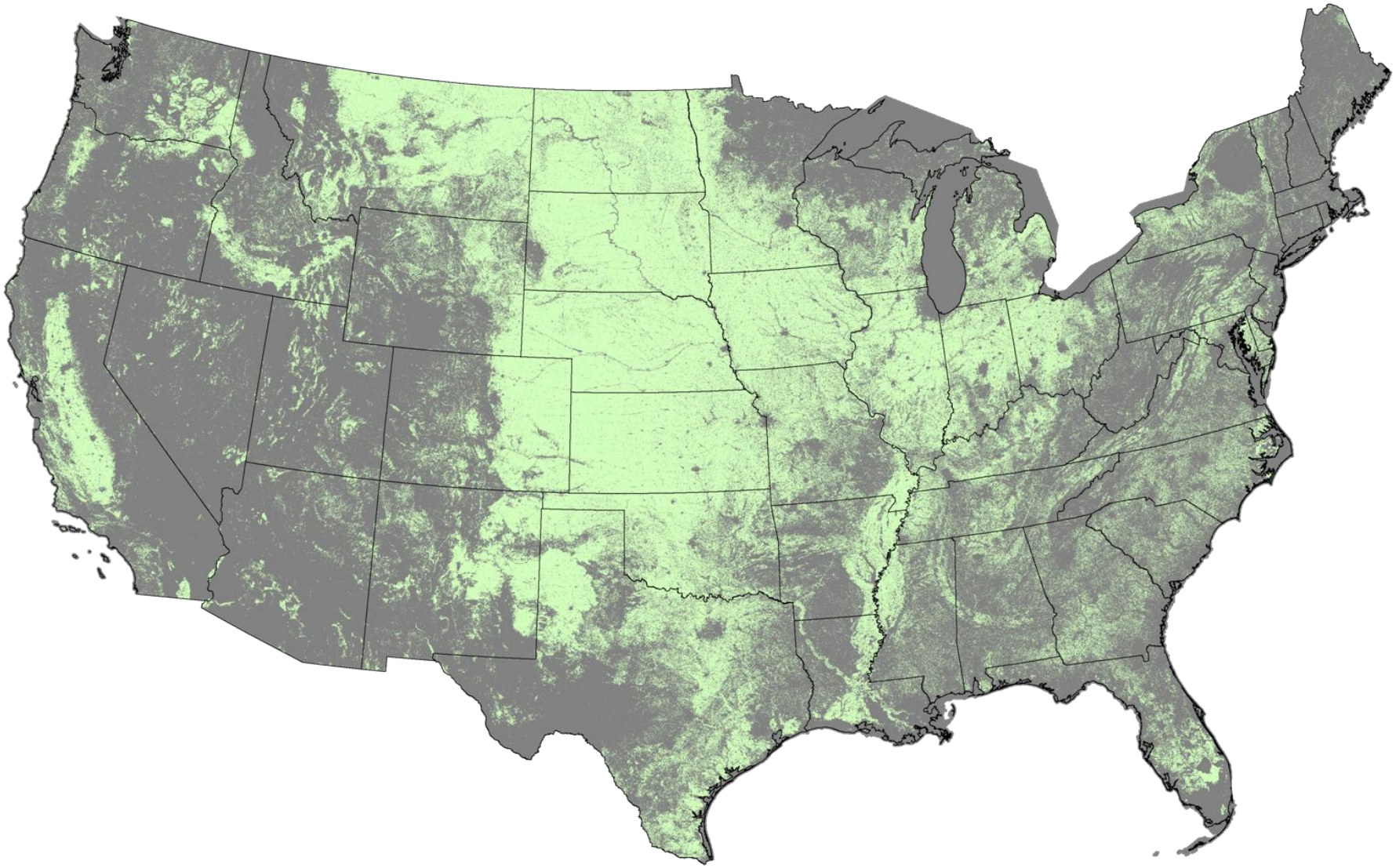
PART II—Efficient coarse-filter landscape monitoring

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

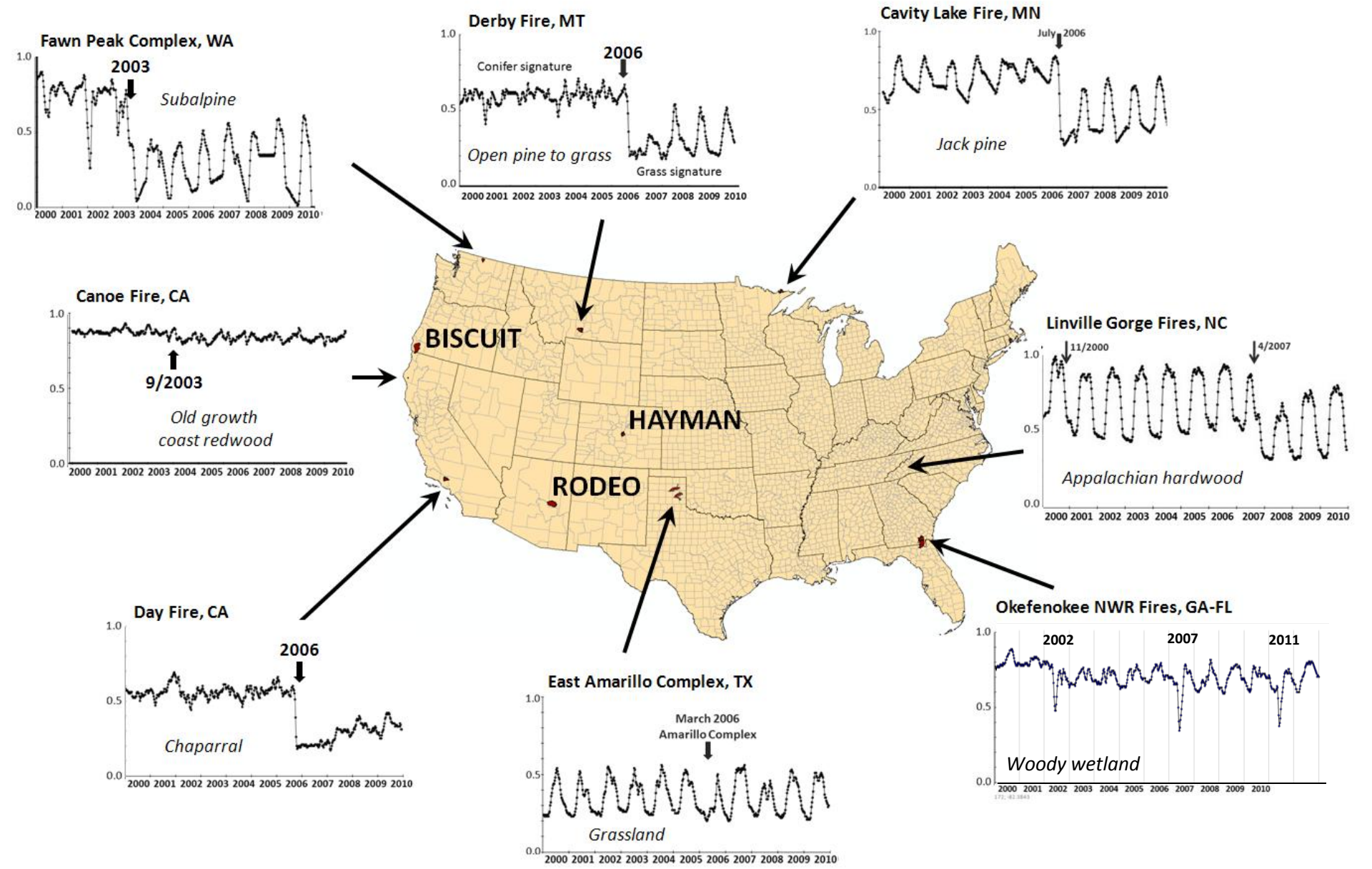
PART I—Our wildland fire and management crisis

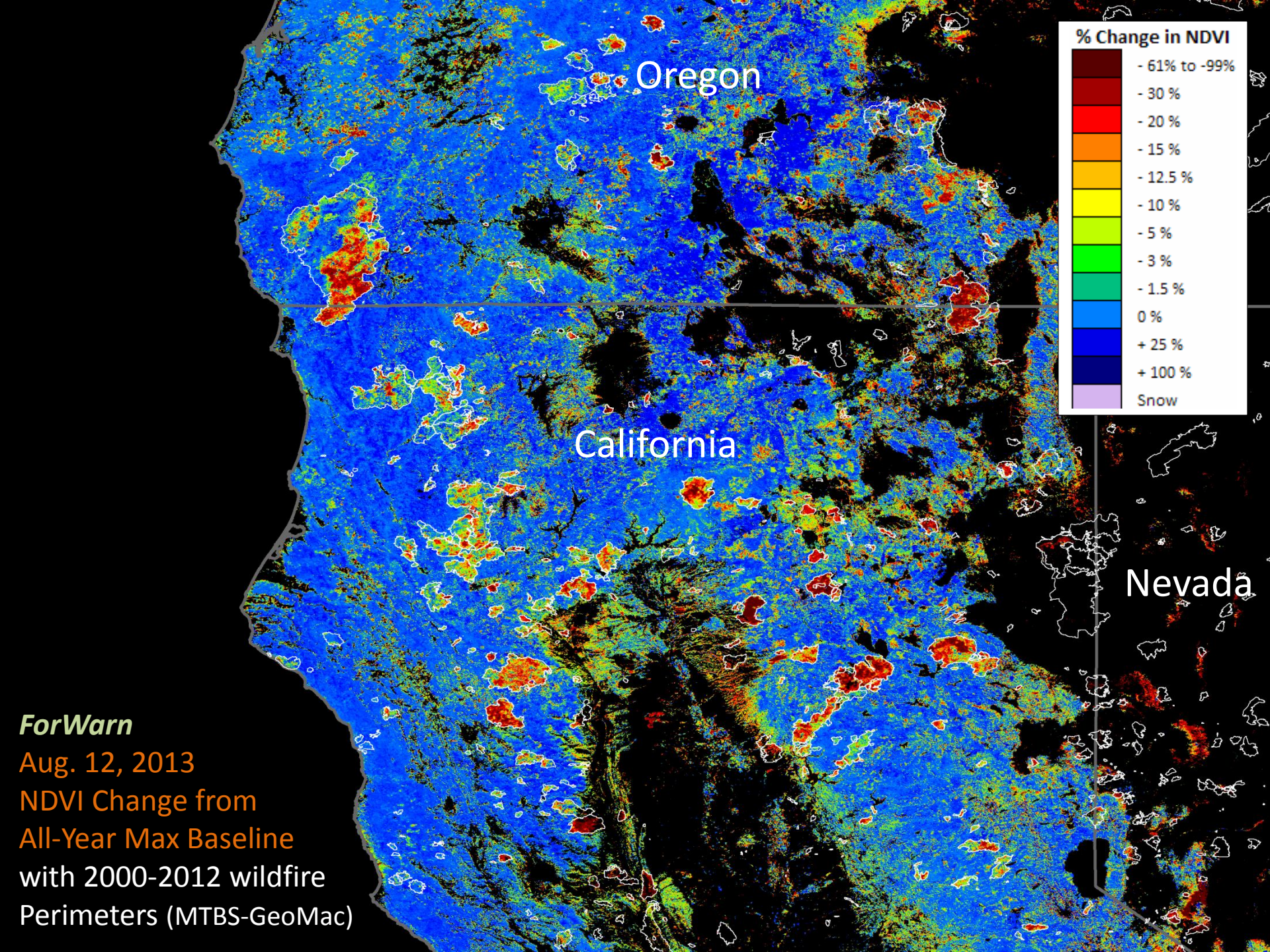
PART II—Efficient coarse-filter landscape monitoring

PART III—Predicting long-term wildfire effects

with respect to specifiable *Desired Future Conditions*.

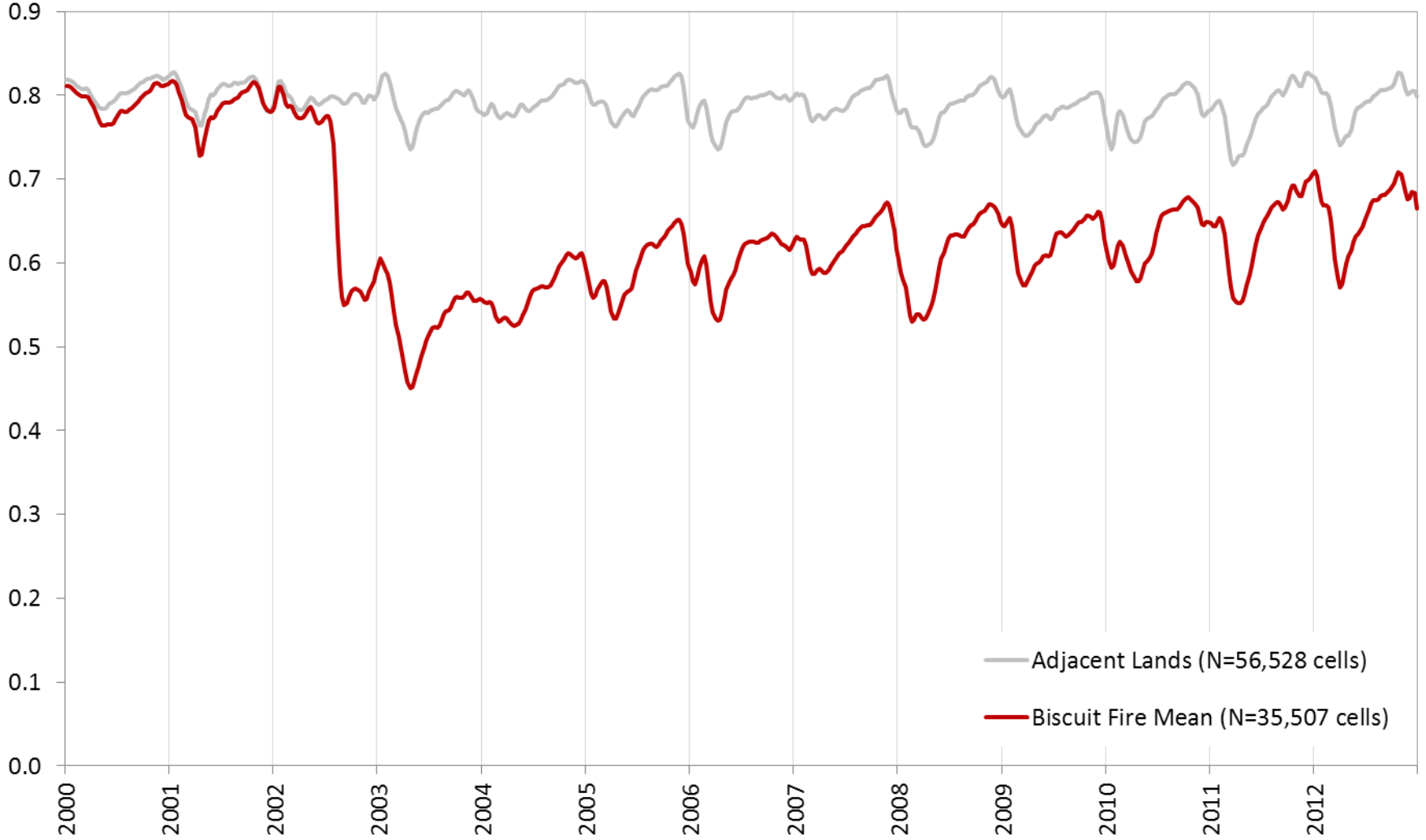
PART III—Predicting long-term fire effects




Oregon
California
Nevada
% Change in NDVI
- 61% to -99%
- 30 %
- 20 %
- 15 %
- 12.5 %
- 10 %
- 5 %
- 3 %
- 1.5 %
0 %
+ 25 %
+ 100 %
Snow
ForWarn
Aug. 12, 2013
NDVI Change from
All-Year Max Baseline
with 2000-2012 wildfire
Perimeters (MTBS-GeoMac)

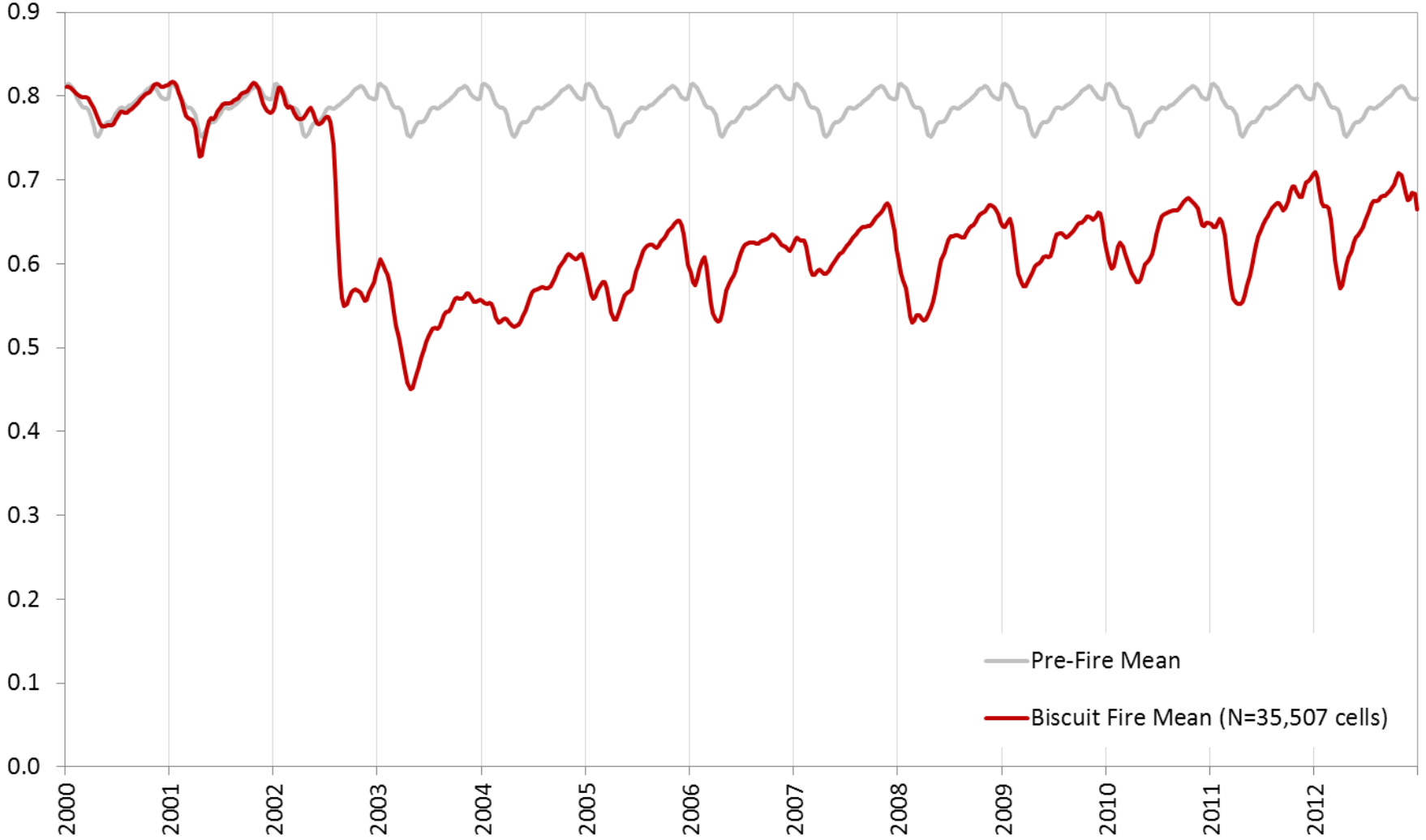
PART III—Biscuit Fire

Reference conditions as phenology of adjacent unburned area



PART III—Biscuit Fire

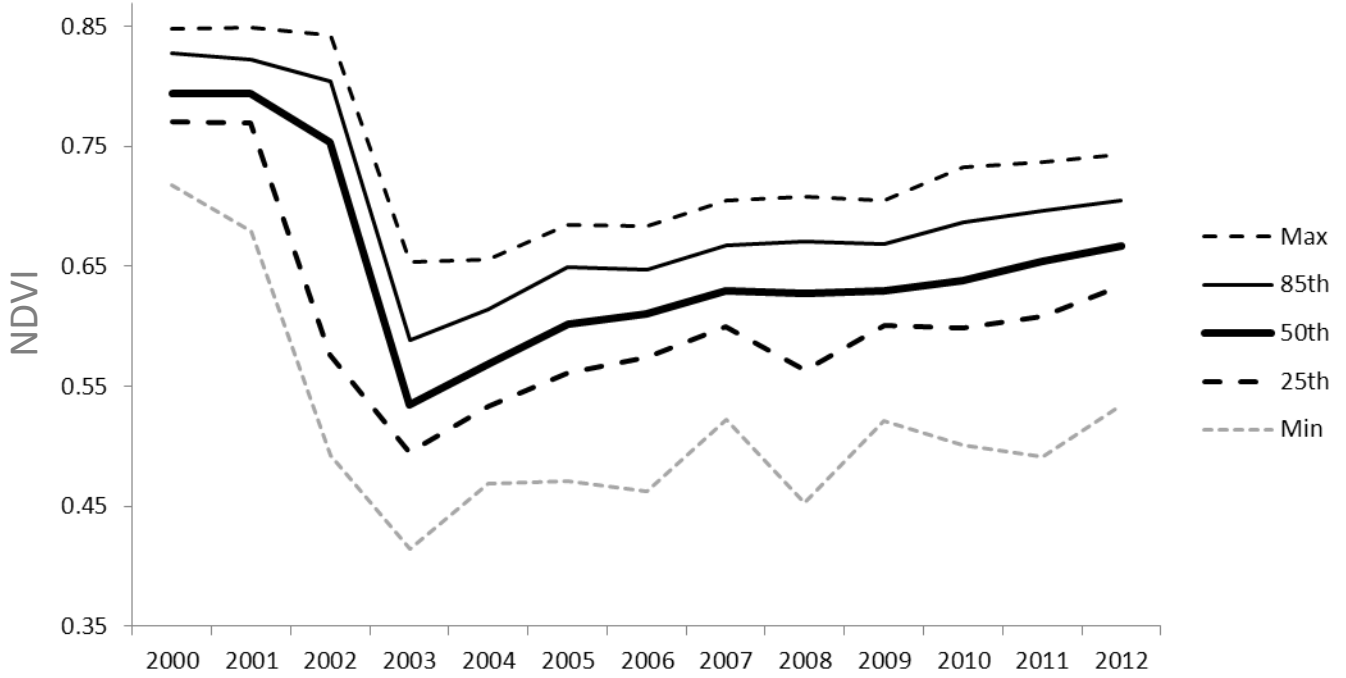
Reference conditions as phenology of pre-fire mean



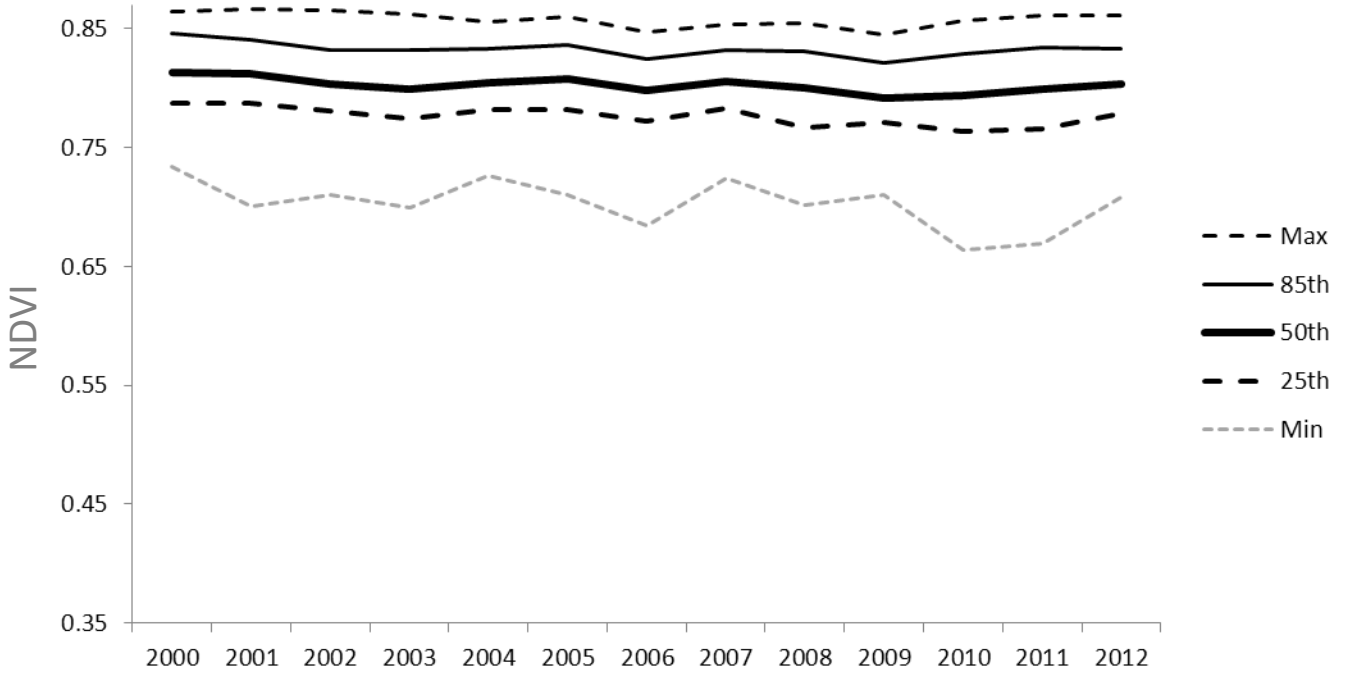
PART III—
Biscuit Fire

Change in annual percentiles over time

Burned:



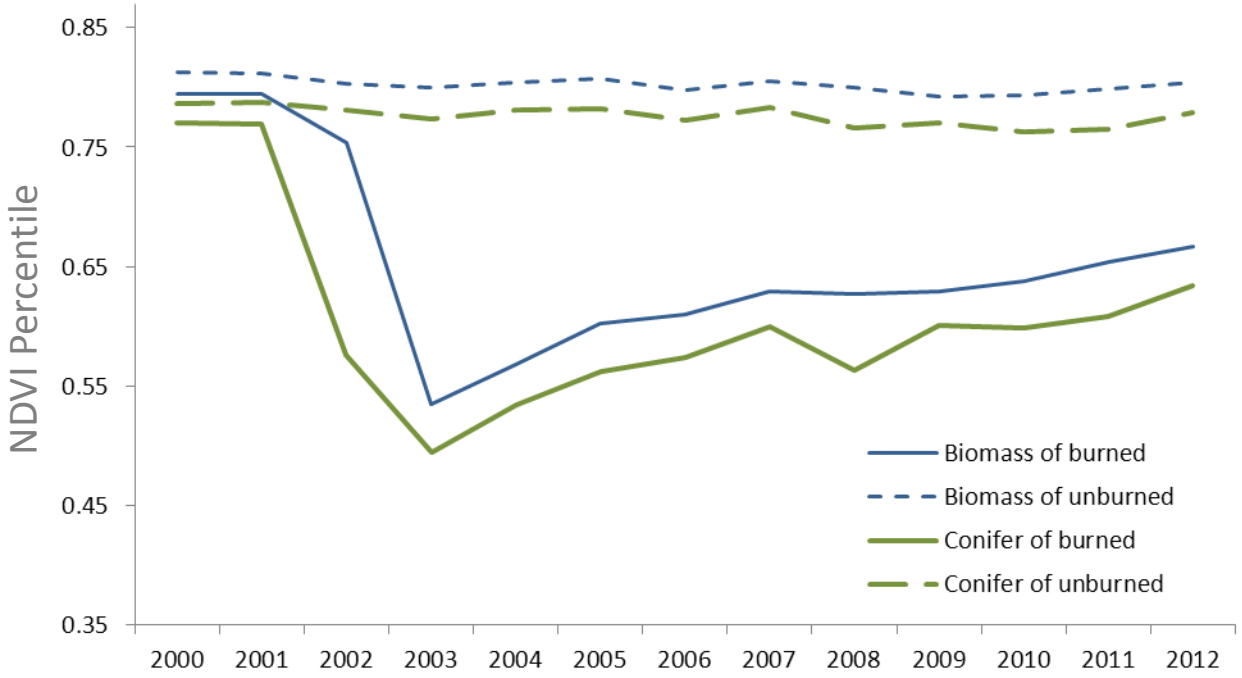
Unburned:



PART III—
Biscuit Fire

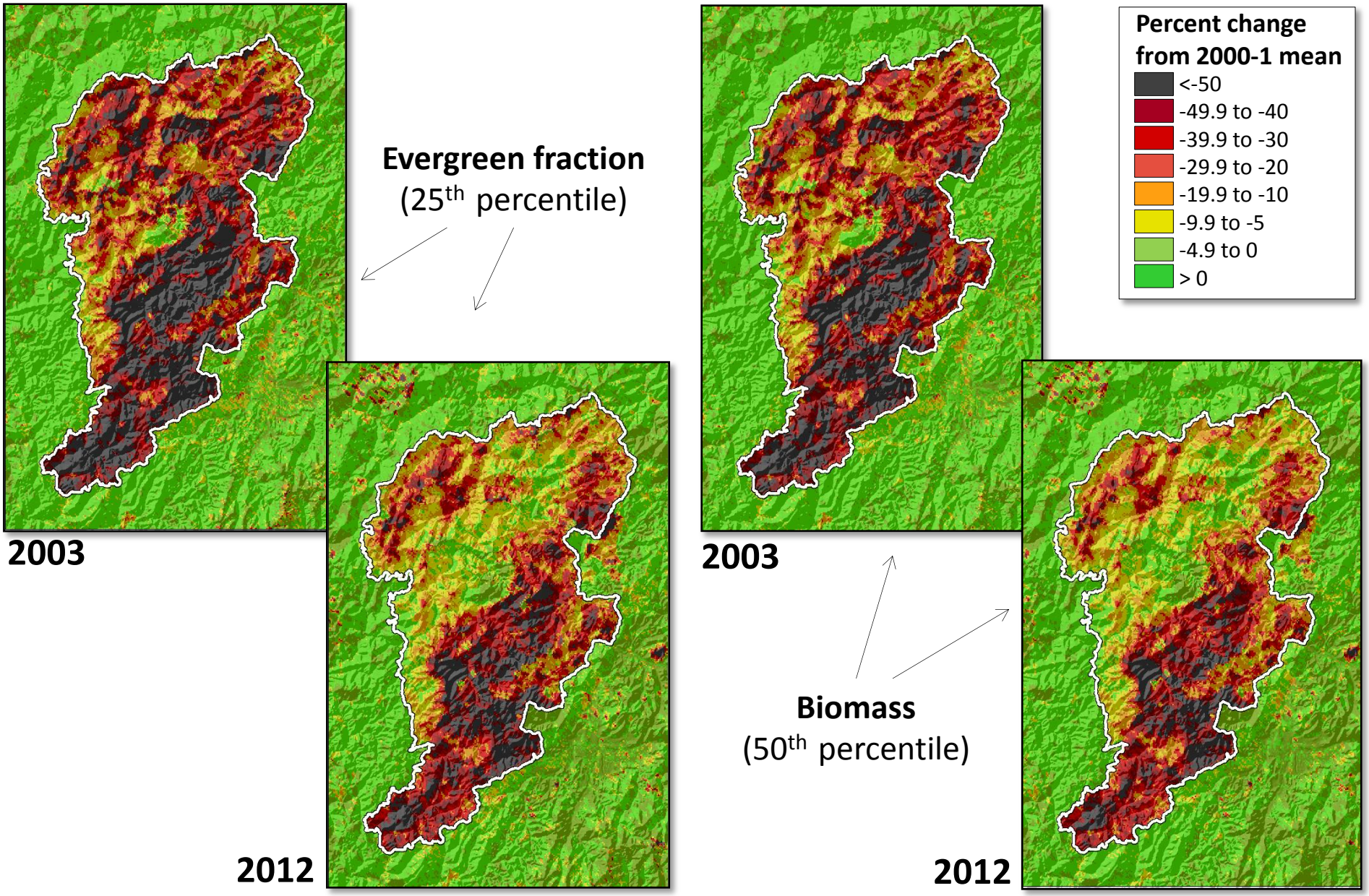
Change in fire and succession sensitive measures

Biomass and evergreen measures:



Grassiness measure:

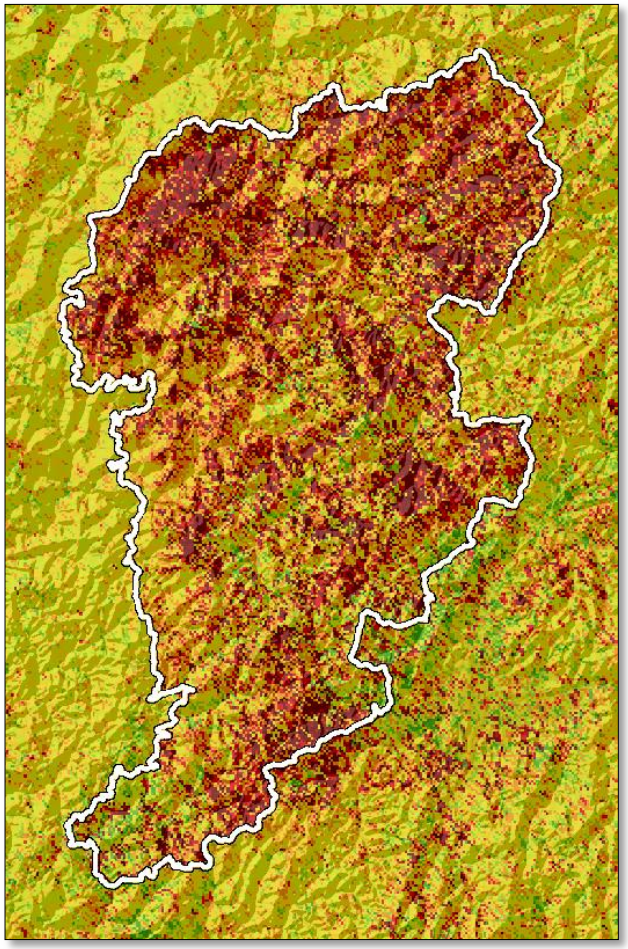
PART III—Predicting long-term effects from the **Biscuit Fire**



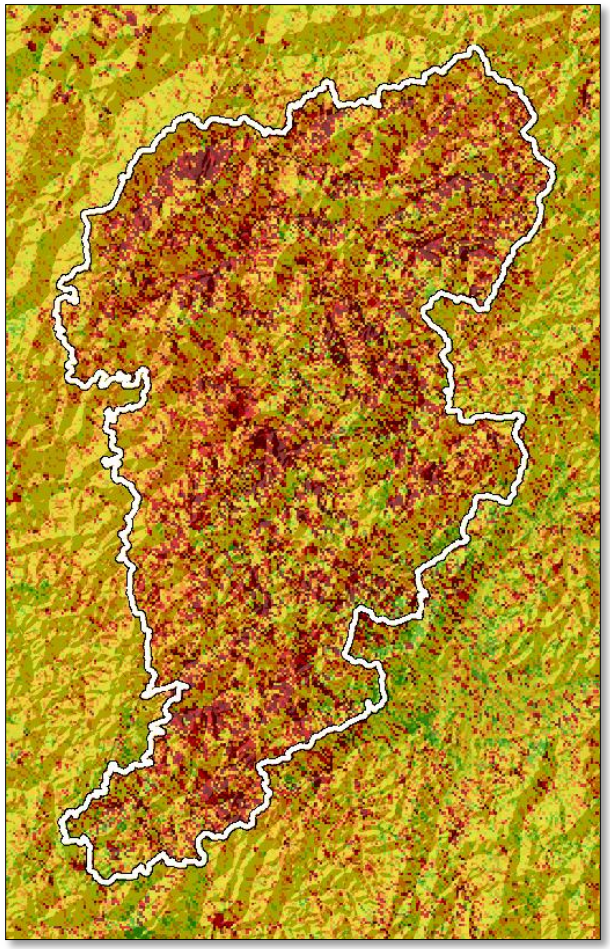
PART III—Predicting long-term effects

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

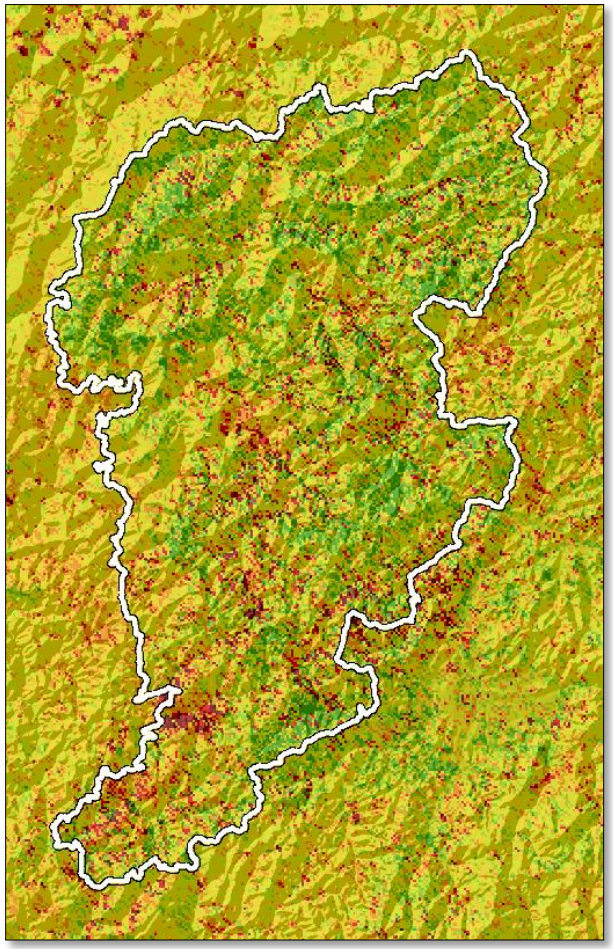
Pre-fire to 2003-7 mean



Pre-fire to 2008-12 mean



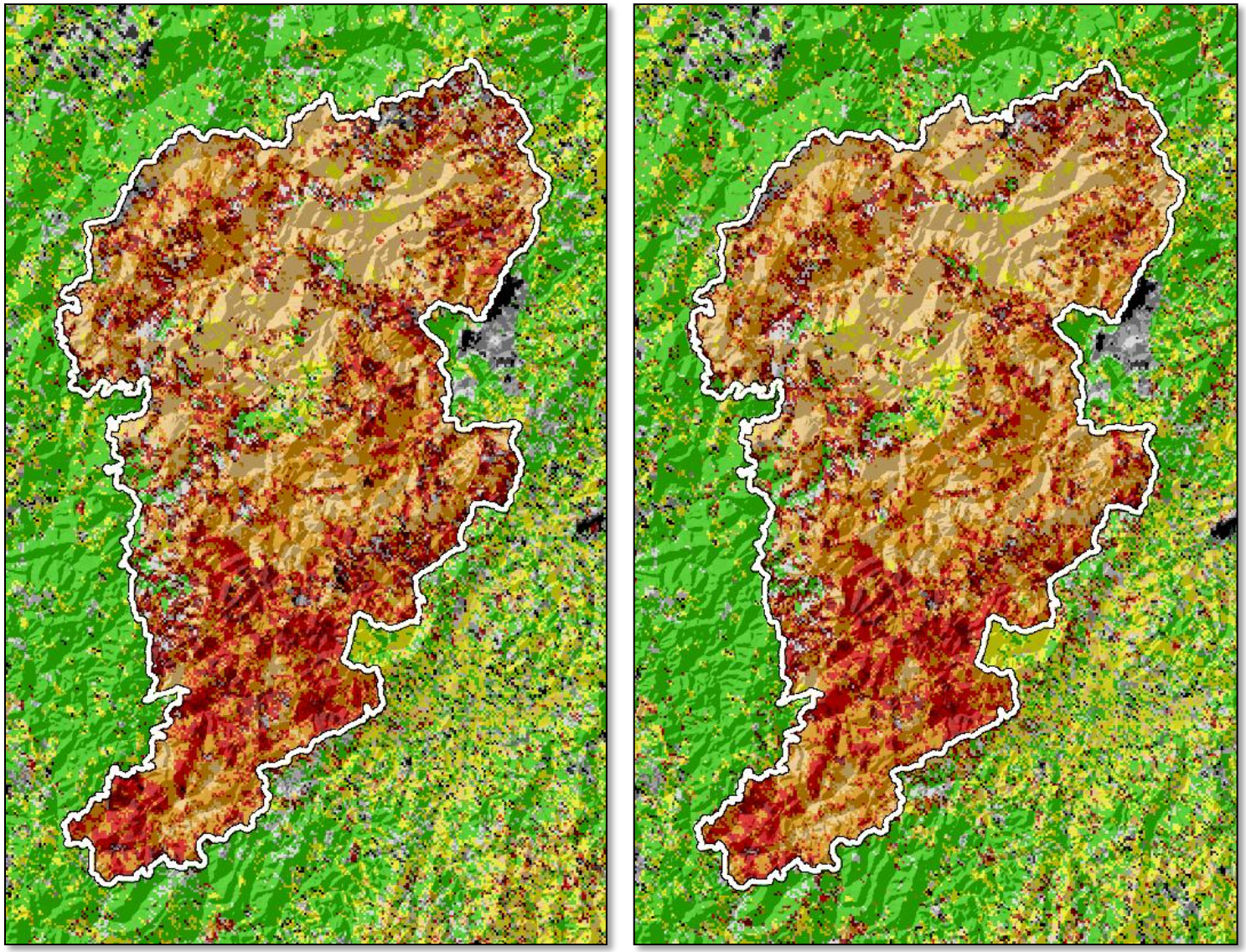
2003-7 to 2008-12 mean

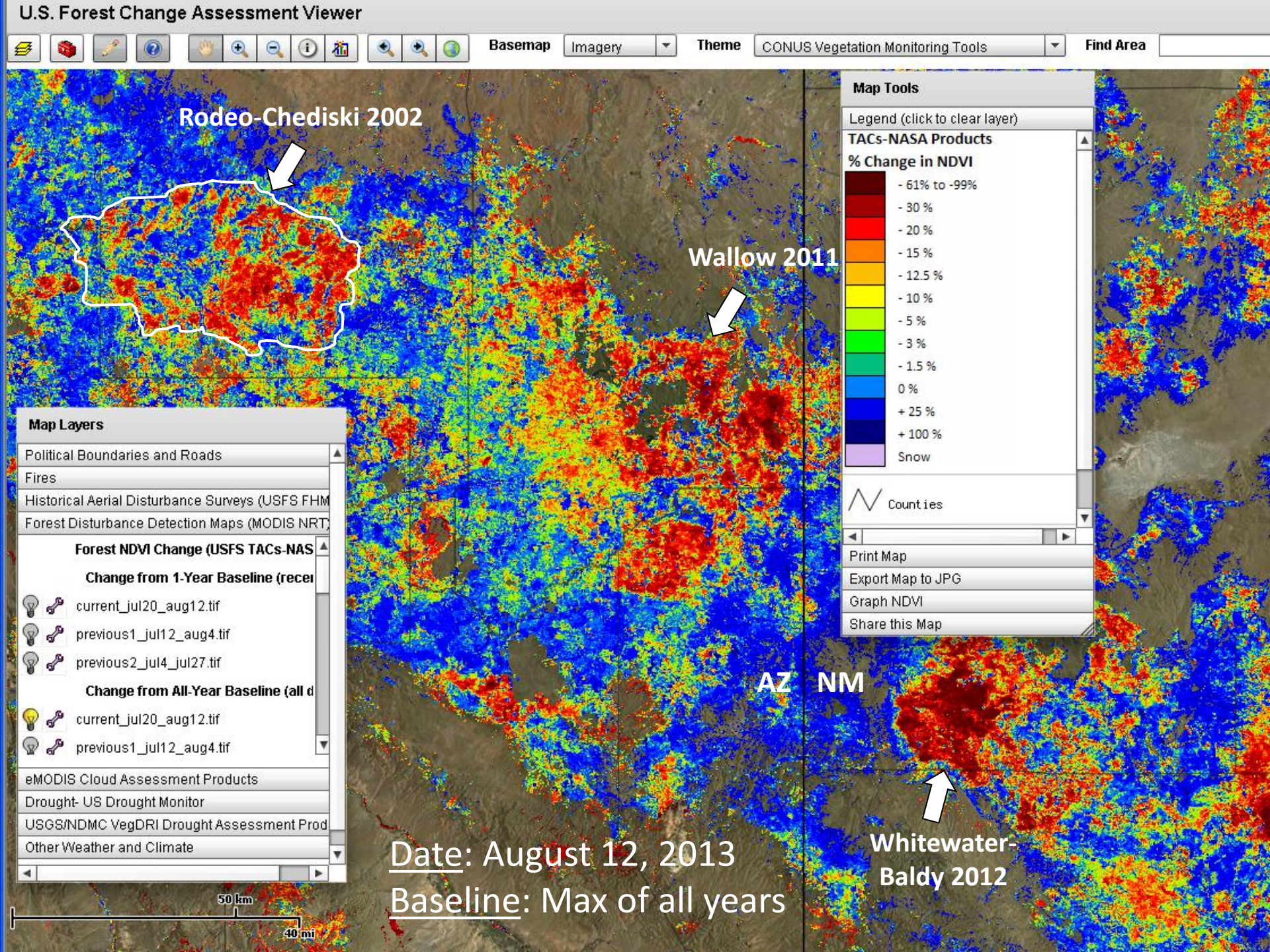


PART III—Predicting long-term effects

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

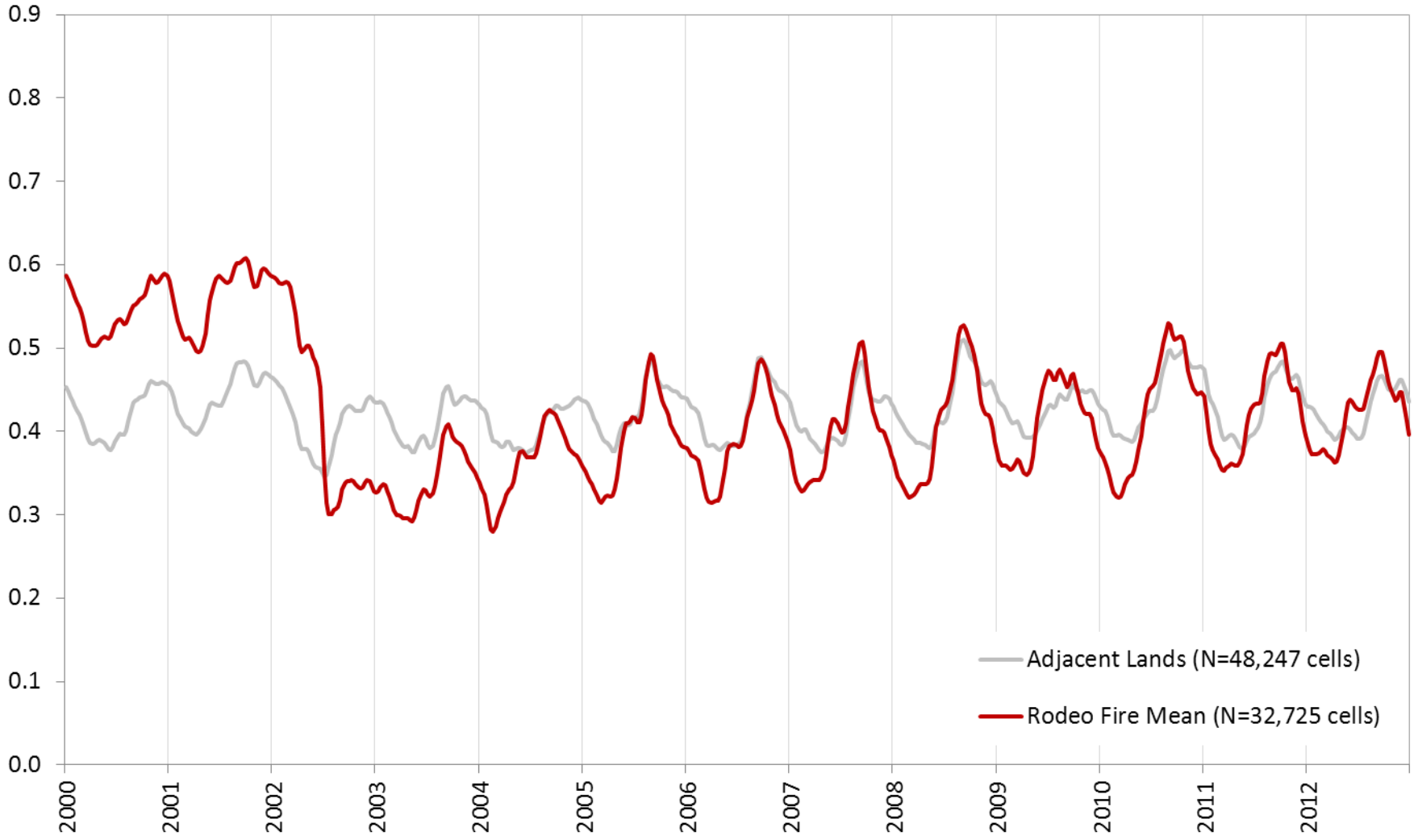
Time to recovery of biomass (50th %ile)




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

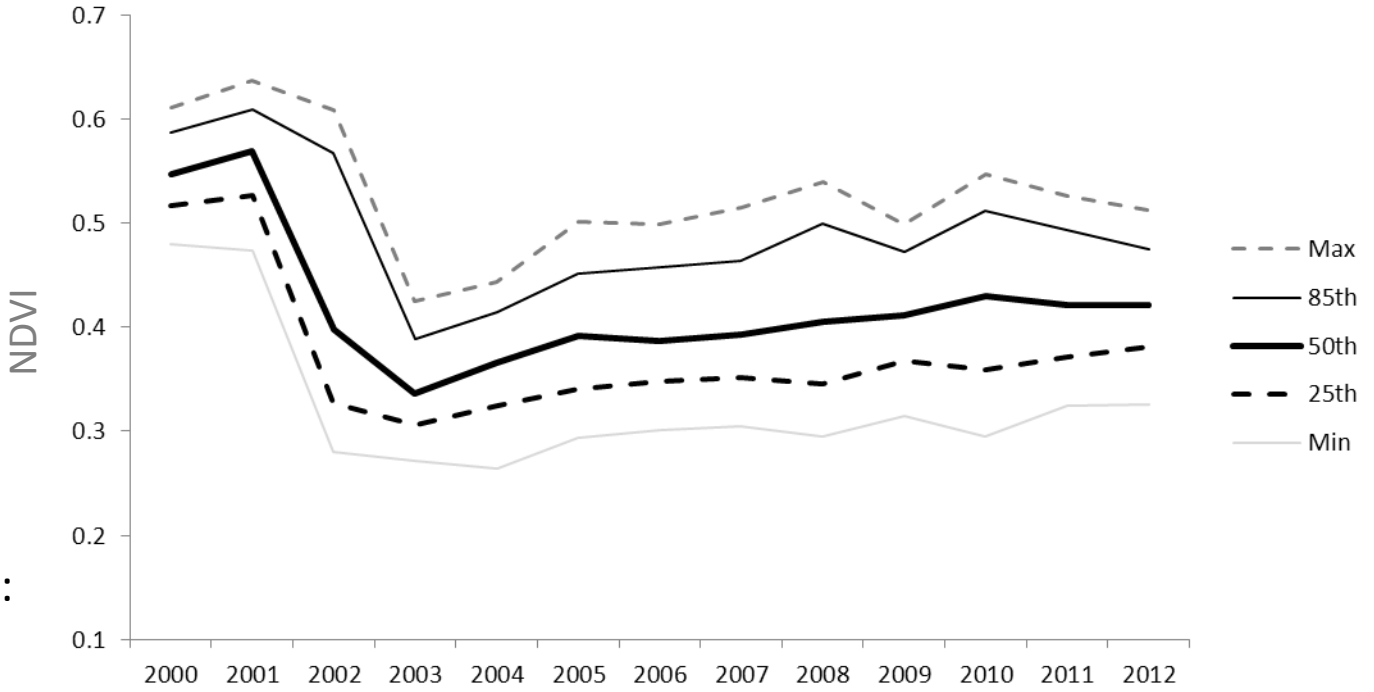
Reference conditions as phenology of adjacent unburned area



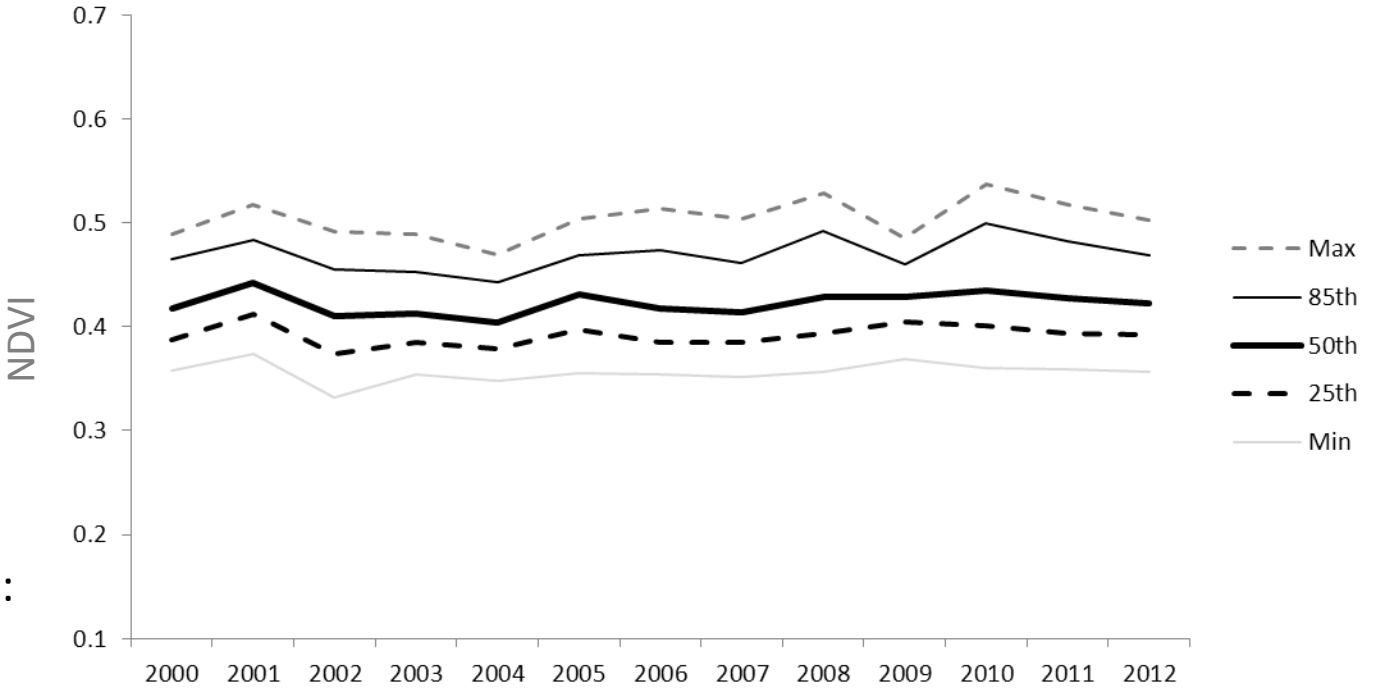
PART III—
Rodeo Fire

Change in annual percentiles over time

Burned:



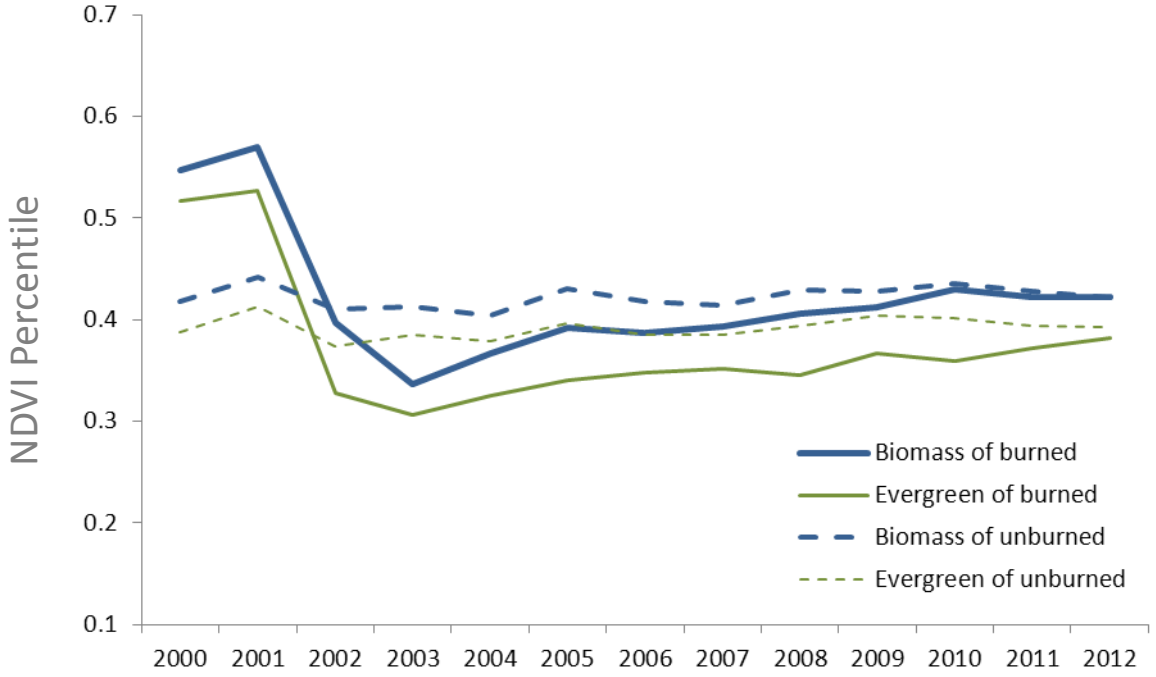
Unburned:



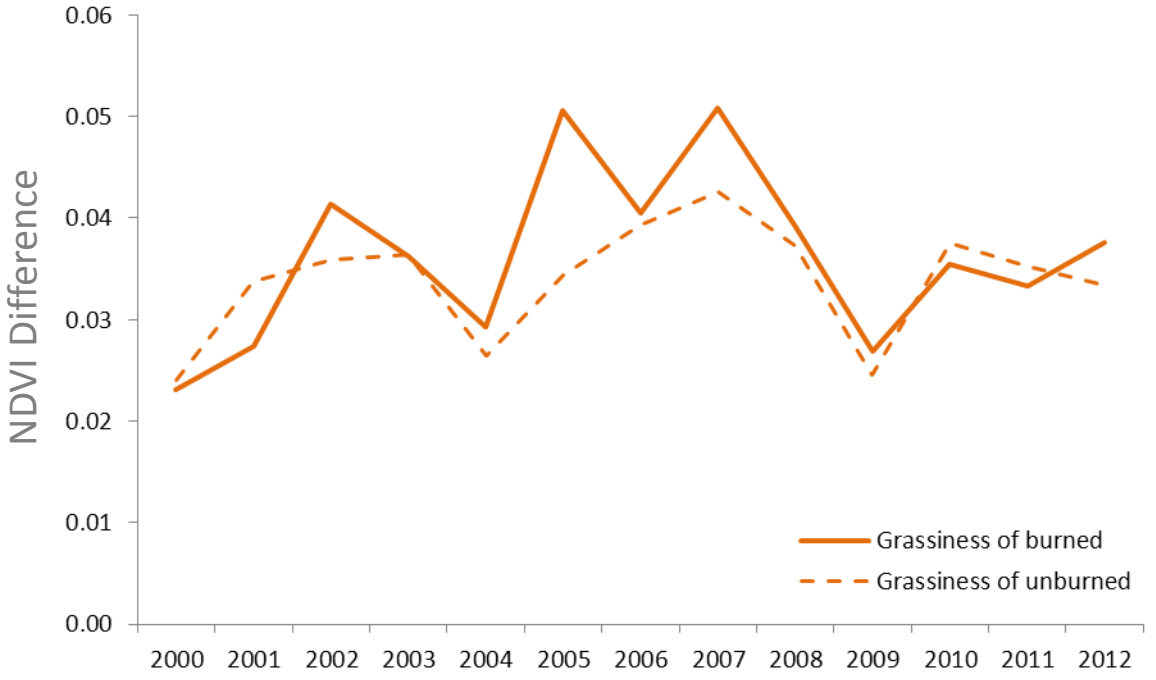
PART III—
Rodeo Fire

Change in fire and succession sensitive measures

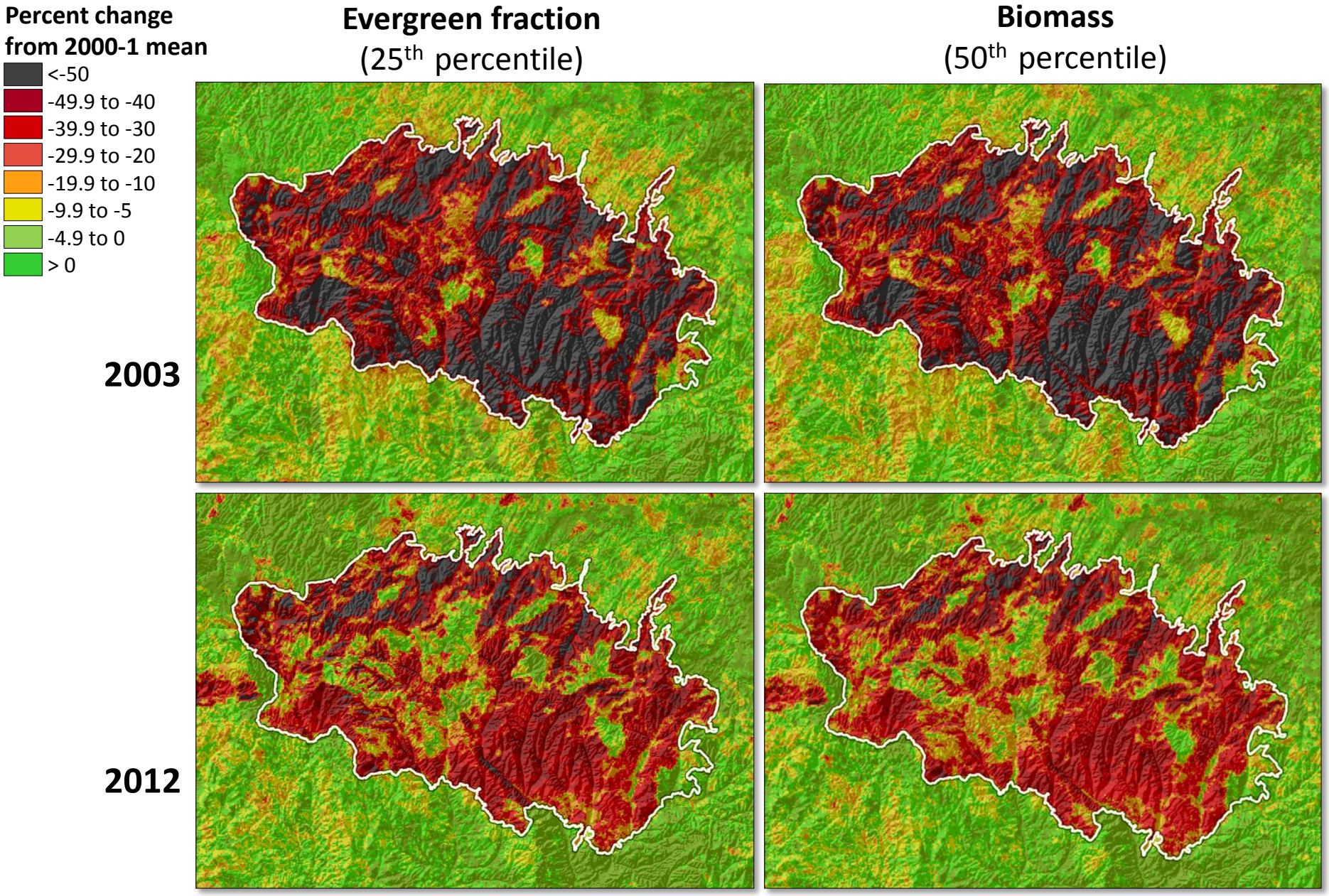
Biomass and evergreen measures:



Grassiness measure:



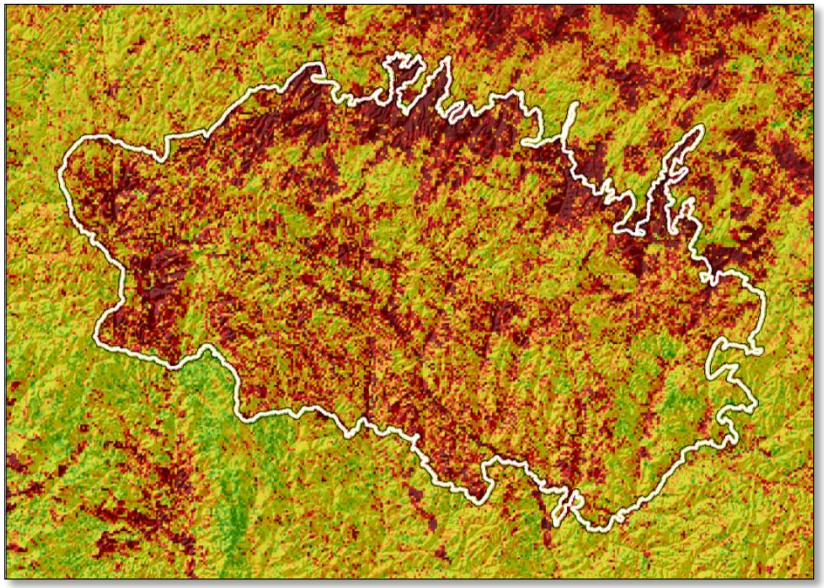
PART III—Predicting long-term effects from the **Rodeo Fire**



PART III—Predicting long-term fire effects

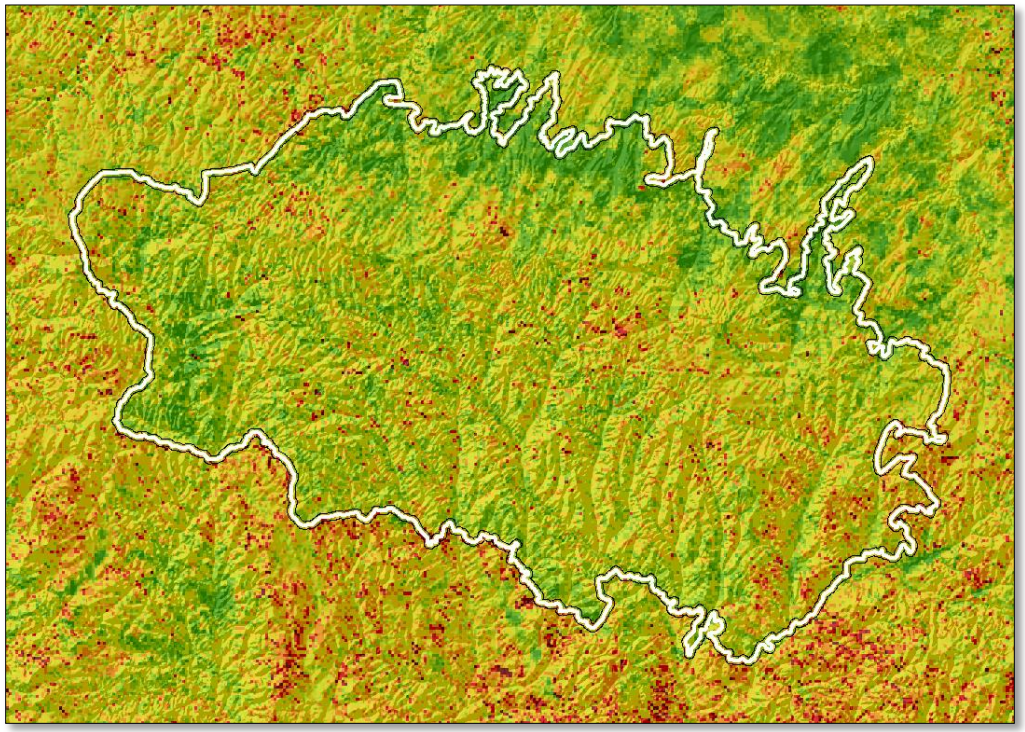
Change in peakedness/grassiness (difference between 100th and 85th %iles)

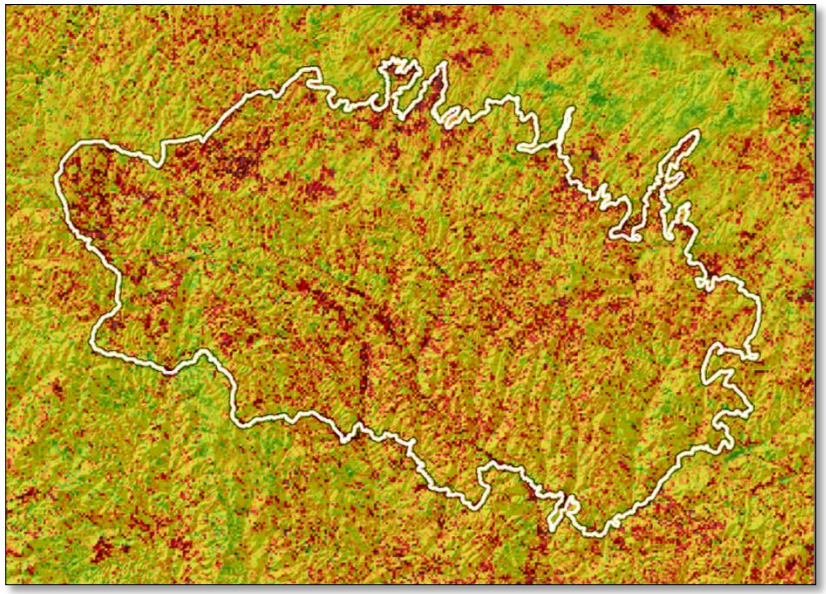
More peaked
> 3
2.1 to 3
1.1 to 2
0.1 to 1
-0.9 to 0
-1.9 to -1
-2.9 to -2
Less peaked
< -3



Pre-fire to 2003-7 mean

2003-7 to 2008-12 mean

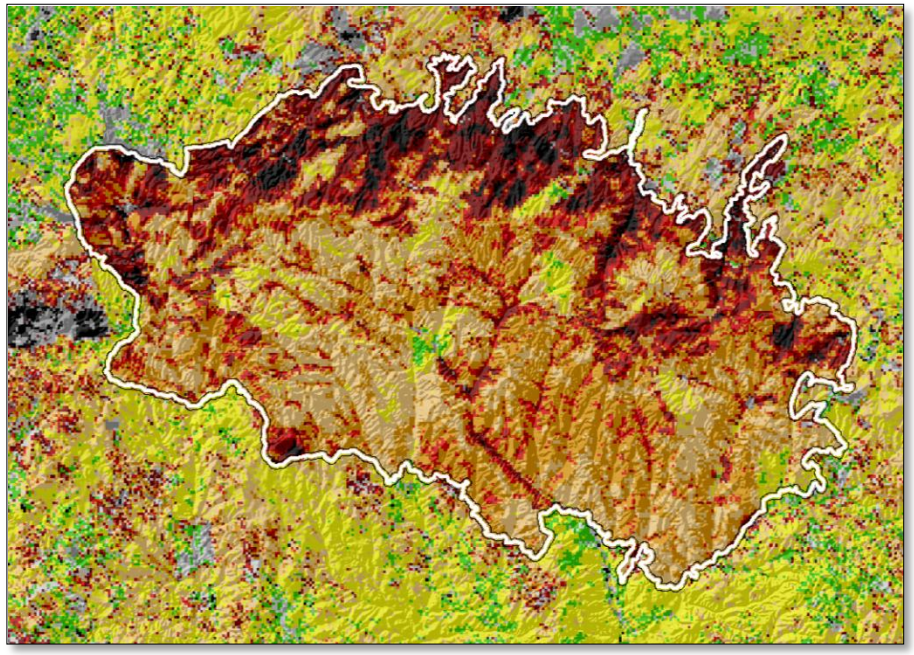




Pre-fire to 2008-12 mean

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

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



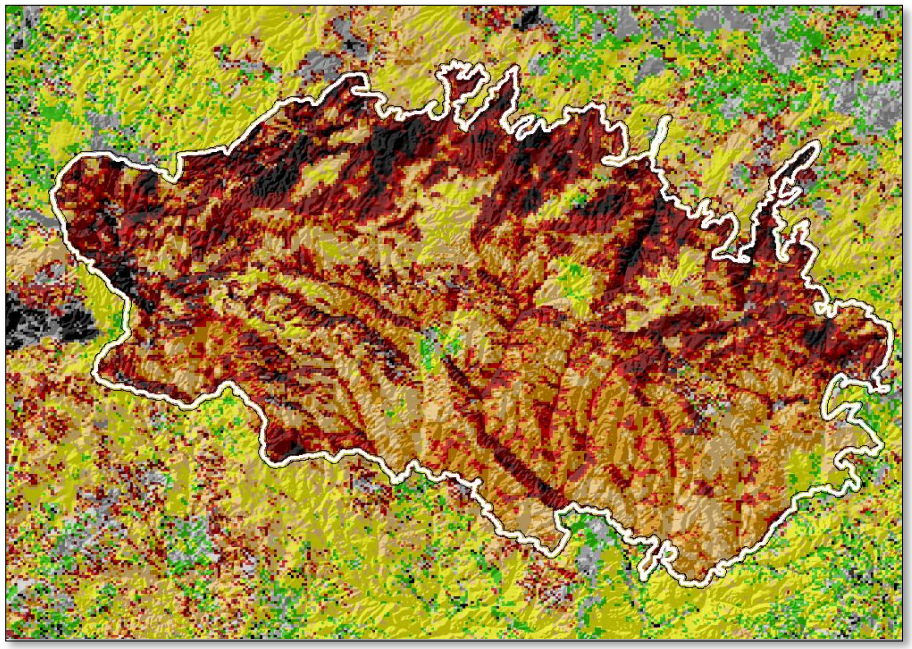
Years to recovery

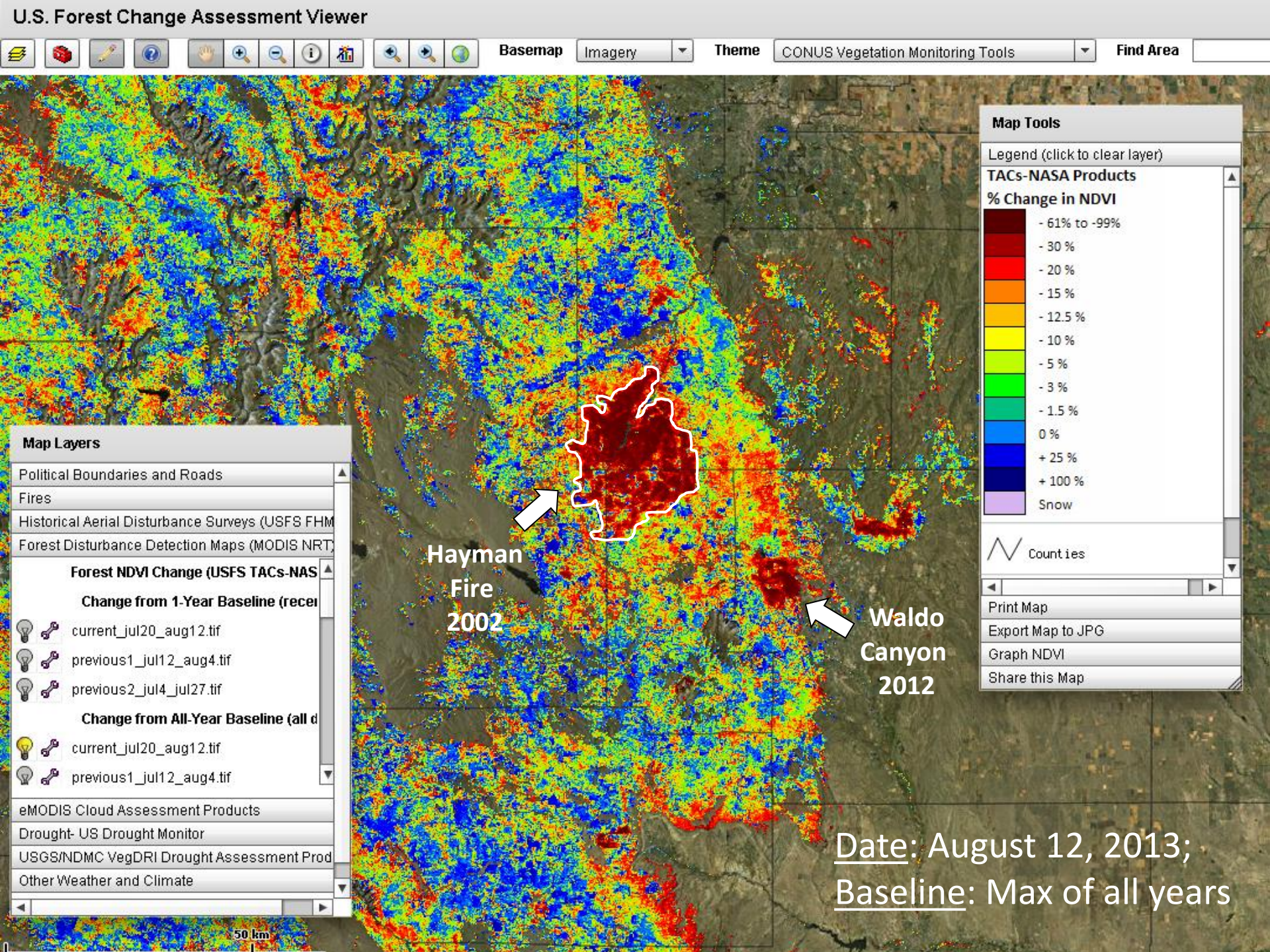
- > 50
- 40.1 to 50
- 30.1 to 40
- 20.1 to 30
- 10.1 to 20
- 0 to 10

No observed recovery (% decline in 2012)

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

Time to recovery of biomass (50th %ile)




U.S. Forest Change Assessment Viewer
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% Change in NDVI
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Snow
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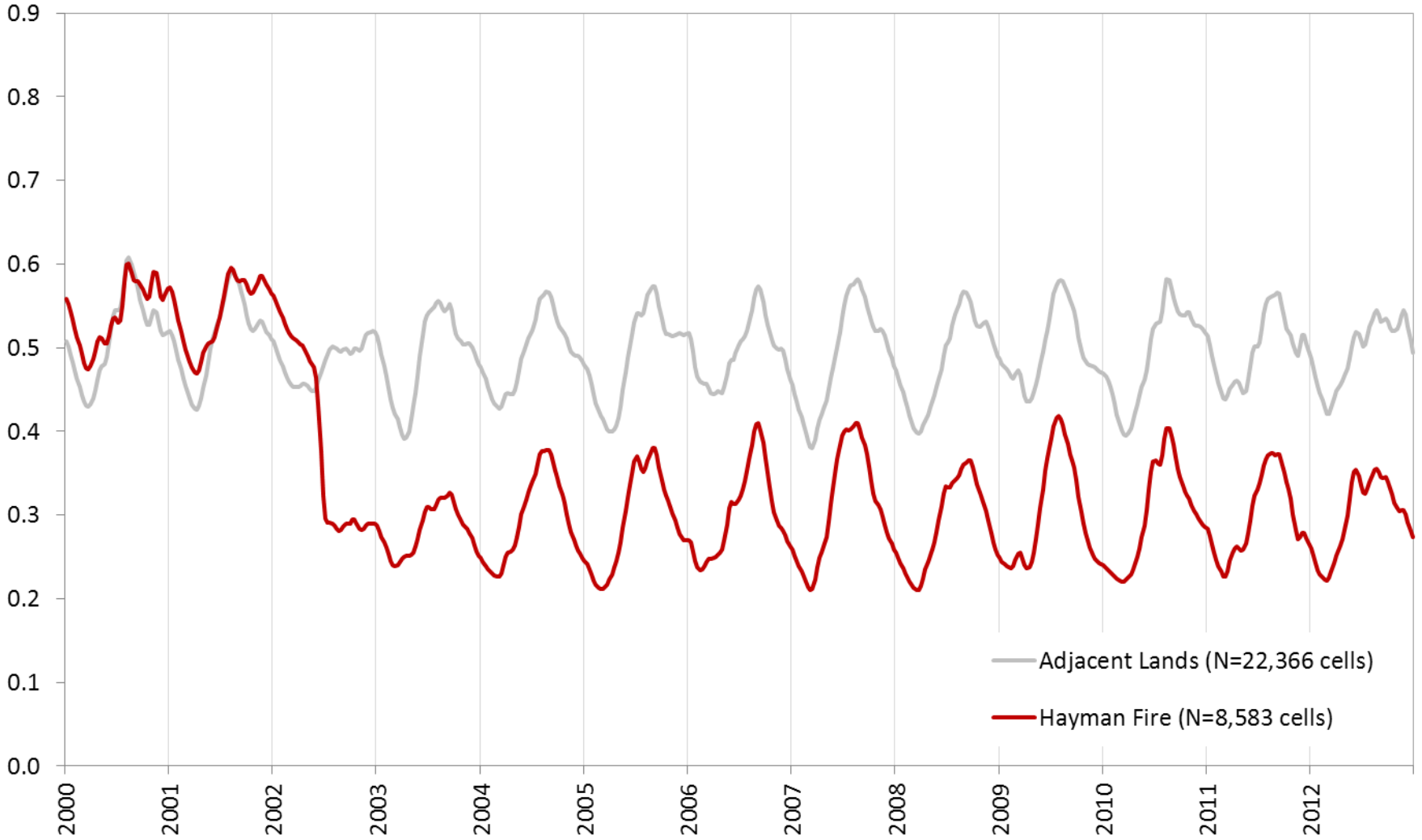
Forest NDVI Change (USFS TACs-NAS
Change from 1-Year Baseline (recei
current_jul20_aug12.tif
previous1_jul12_aug4.tif
previous2_jul4_jul27.tif
Change from All-Year Baseline (all d
current_jul20_aug12.tif
previous1_jul12_aug4.tif
eMODIS Cloud Assessment Products
Drought- US Drought Monitor
USGS/NDMC VegDRI 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

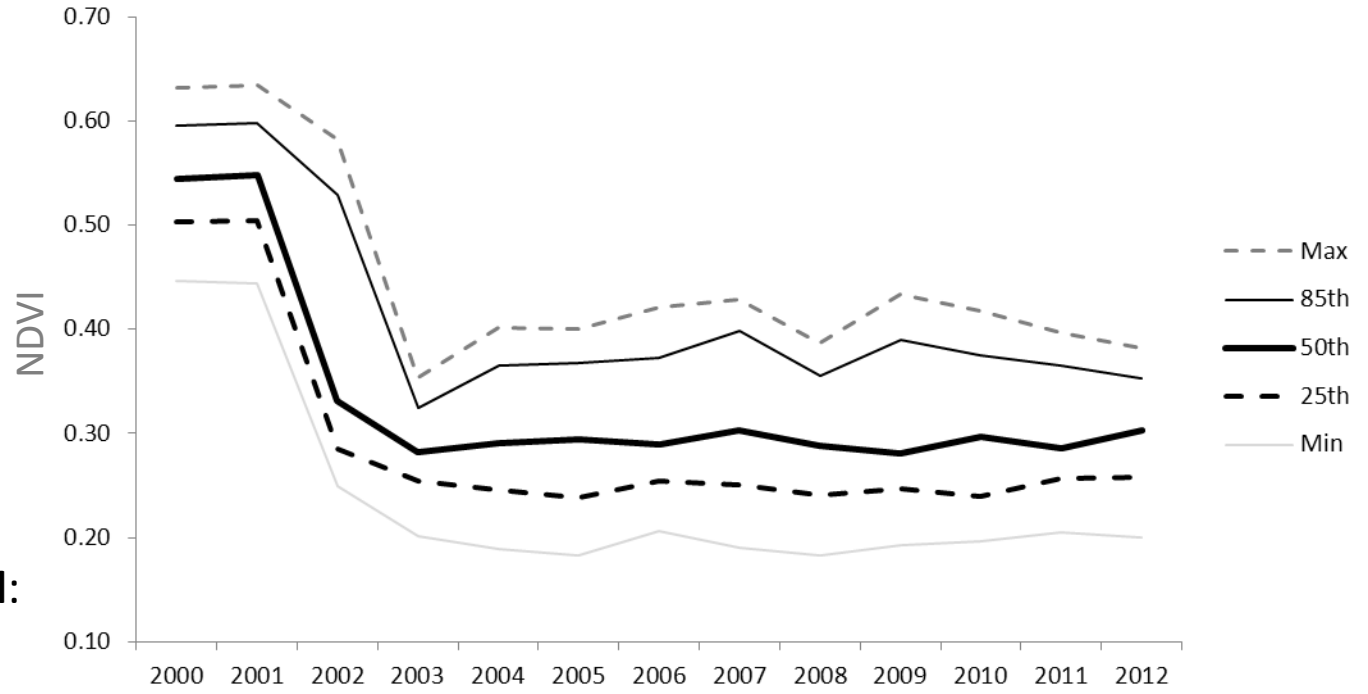
Reference conditions as phenology of adjacent unburned area



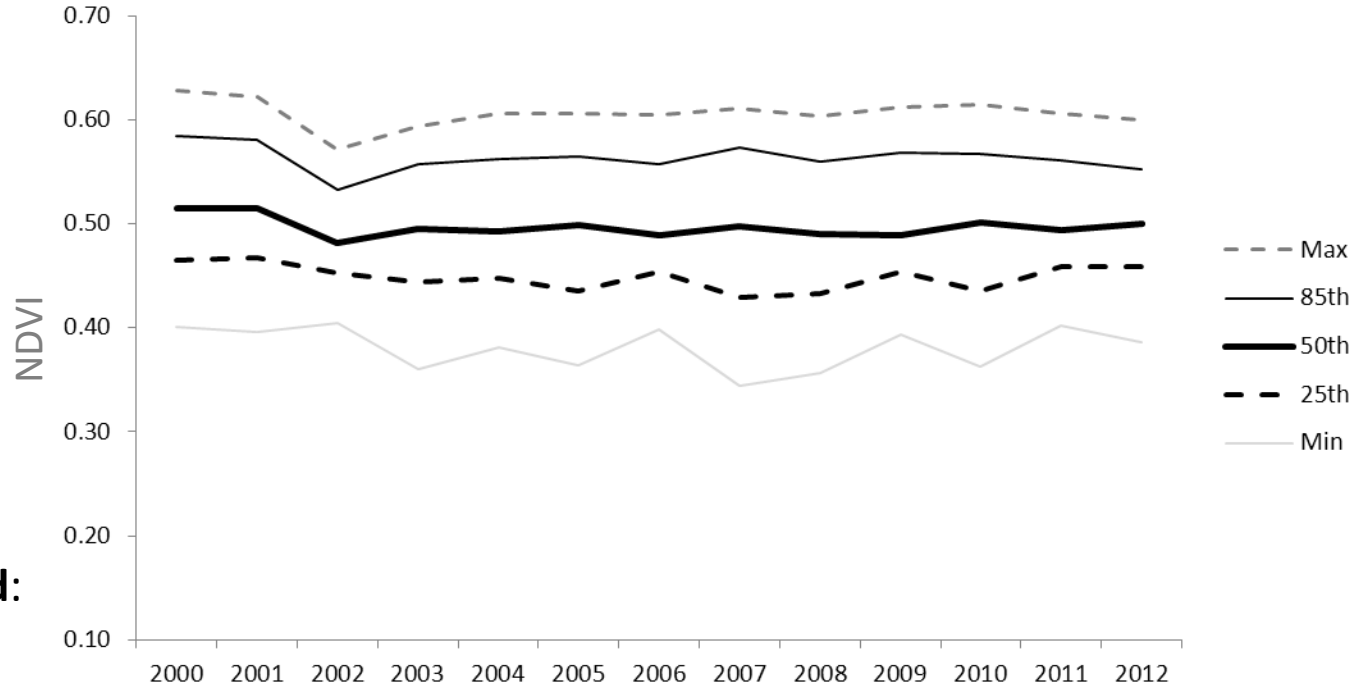
PART III—Hayman Fire

Change in annual percentiles over time

Burned:



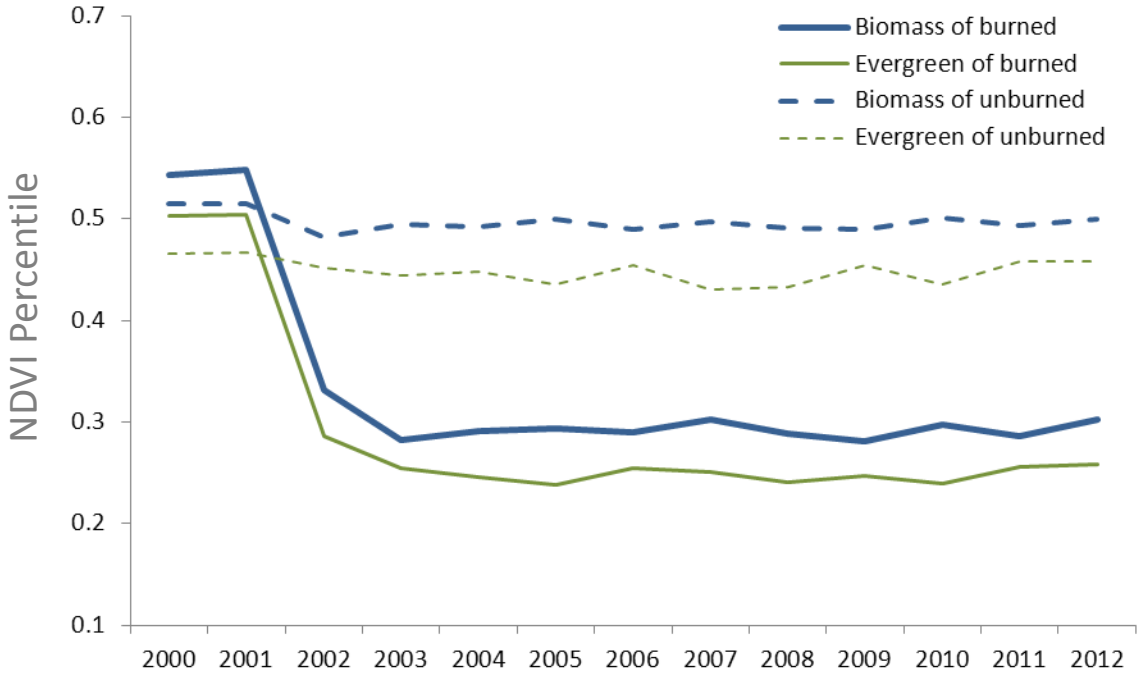
Unburned:



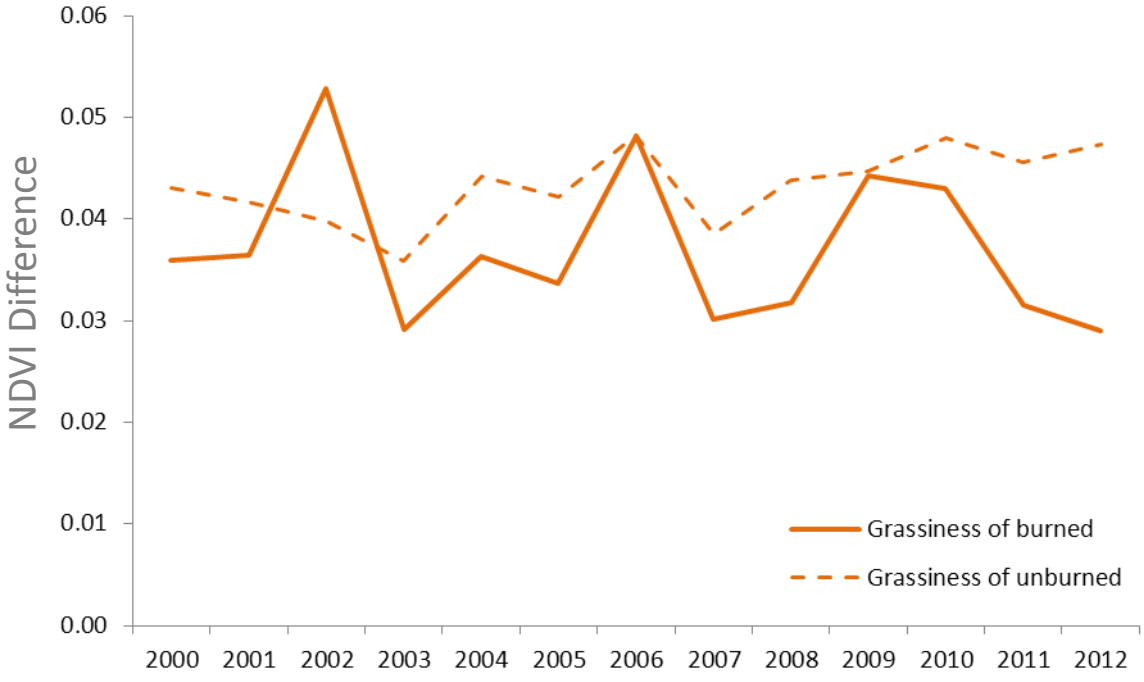
PART III—
Hayman Fire

Change in fire and succession sensitive measures

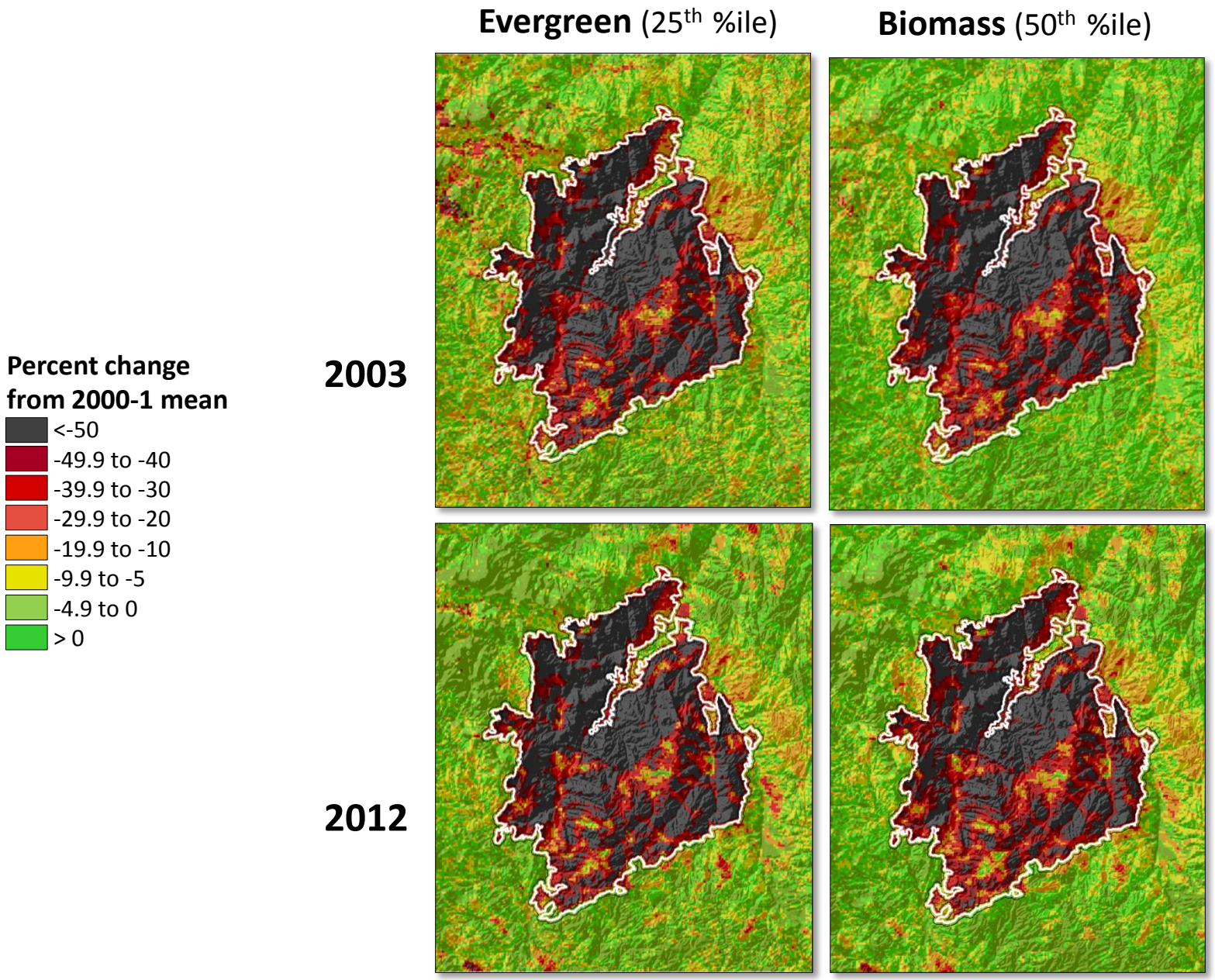
Biomass and evergreen measures:



Grassiness measure:



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

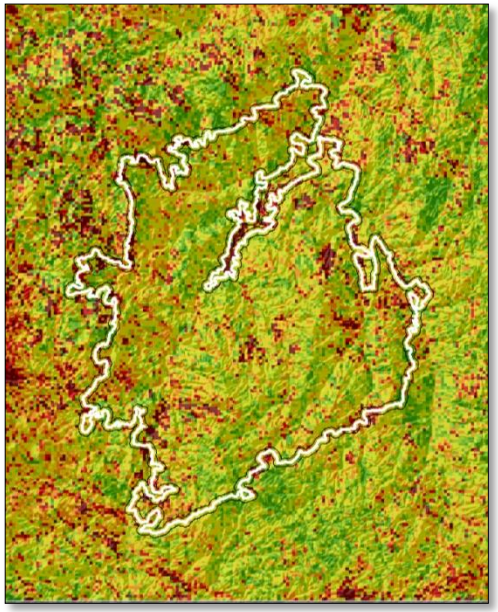


PART III—Predicting long-term fire effects

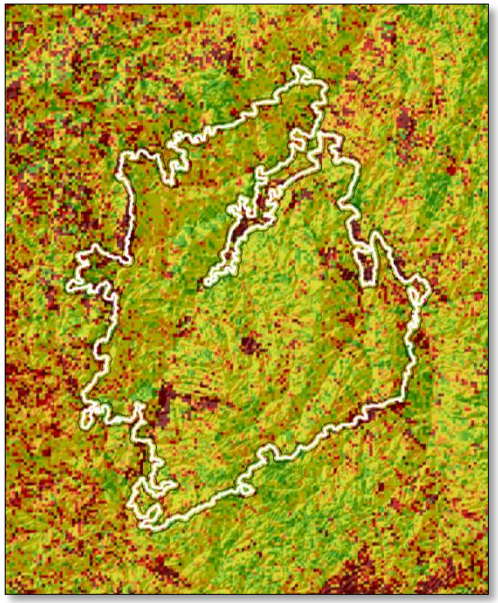
Change in peakedness/grassiness (Difference between 100th and 85th %iles)

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

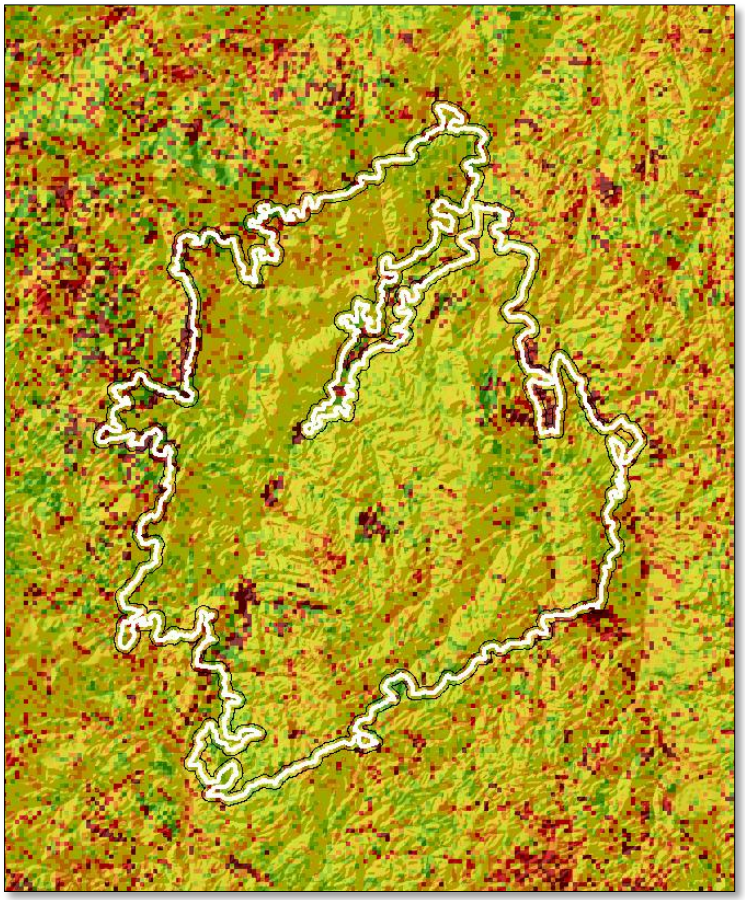
Pre-fire to 2003-7 mean



Pre-fire to 2008-12 mean



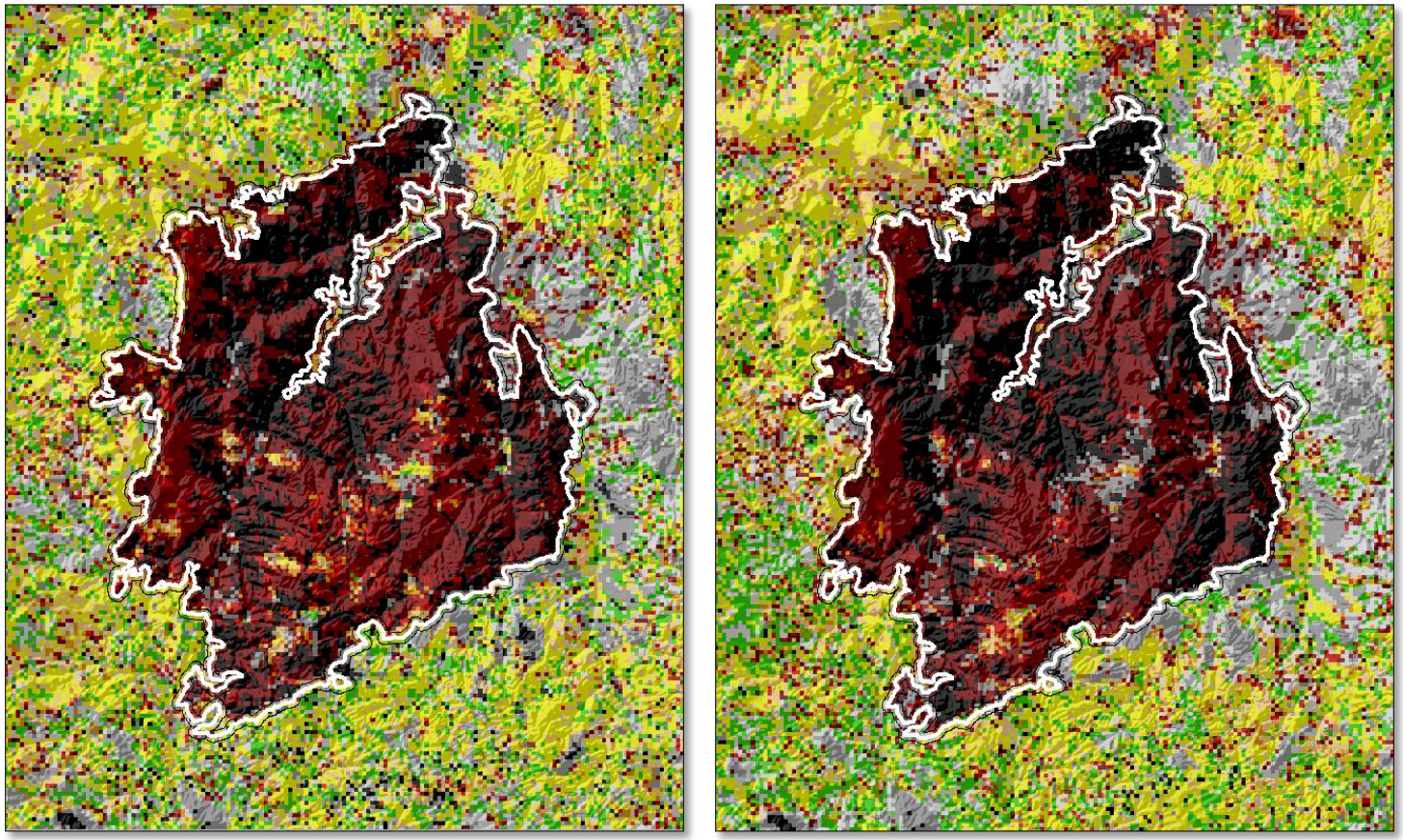
2003-7 to 2008-12 mean



PART III—Predicting long-term effects

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

Time to recovery of biomass (50th %ile)



Years to recovery

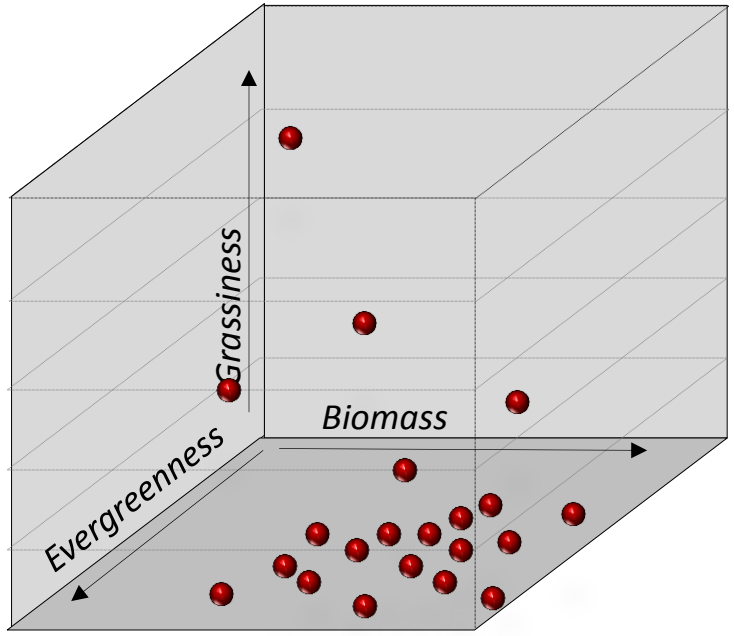
- > 50
- 40.1 to 50
- 30.1 to 40
- 20.1 to 30
- 10.1 to 20
- 0 to 10

No observed recovery (% decline in 2012)

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

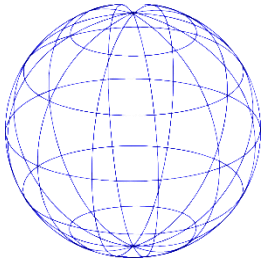
PART III—Predicting long-term fire effects

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

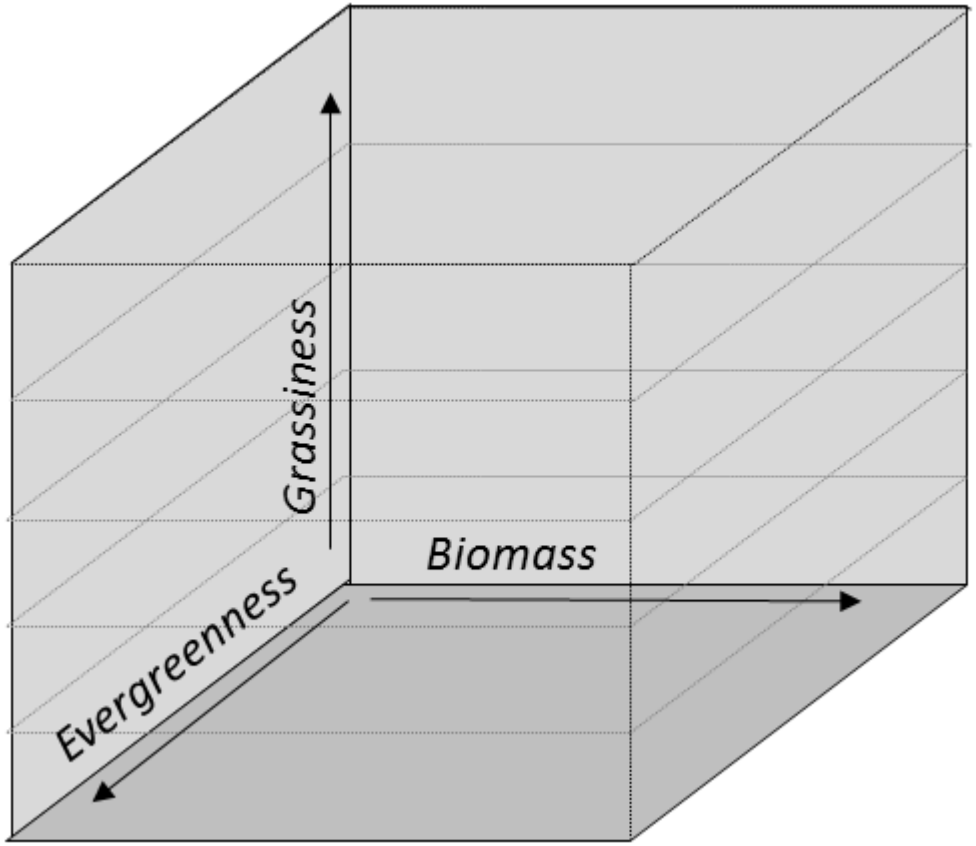
(1) High frequency, moderate resolution MODIS NDVI provides insights into *short* and *long-term* fire effects.

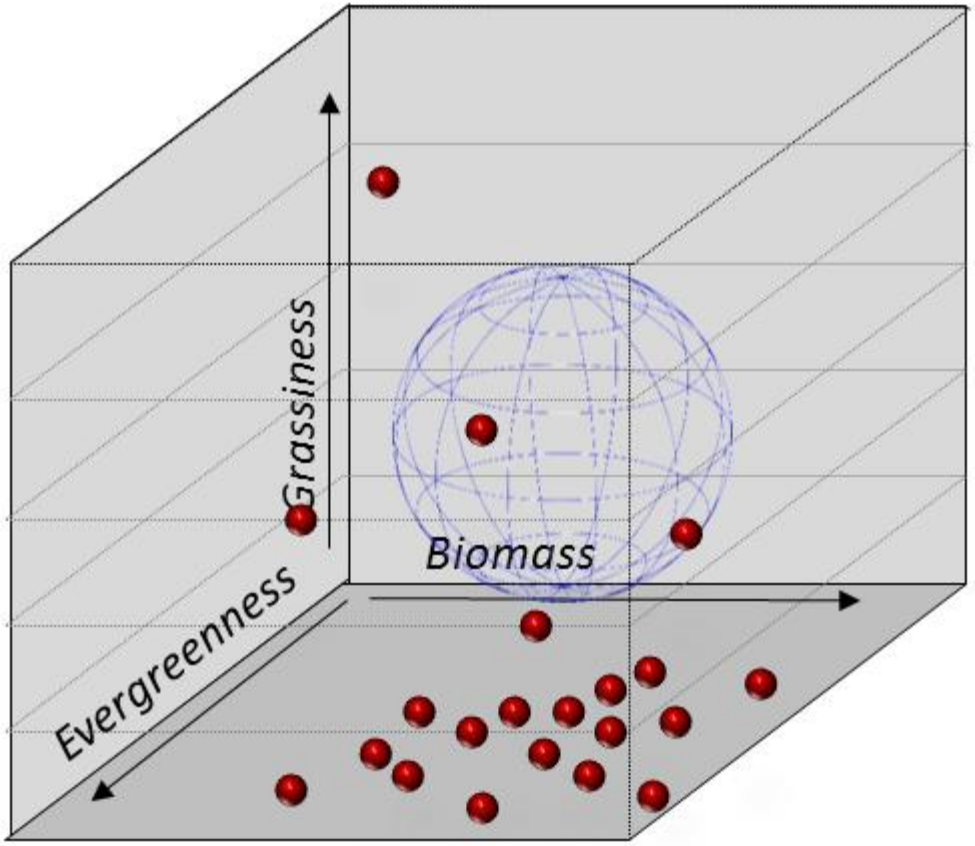
(2) Recovery to pre-fire or progress toward *desired conditions* can be *predicted*.

(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.

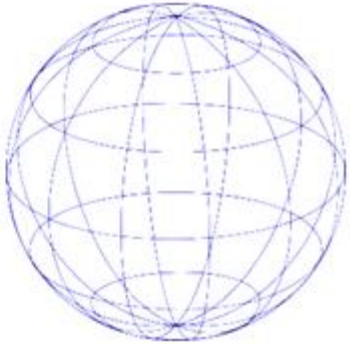
http://forwarn.forestthreats.org

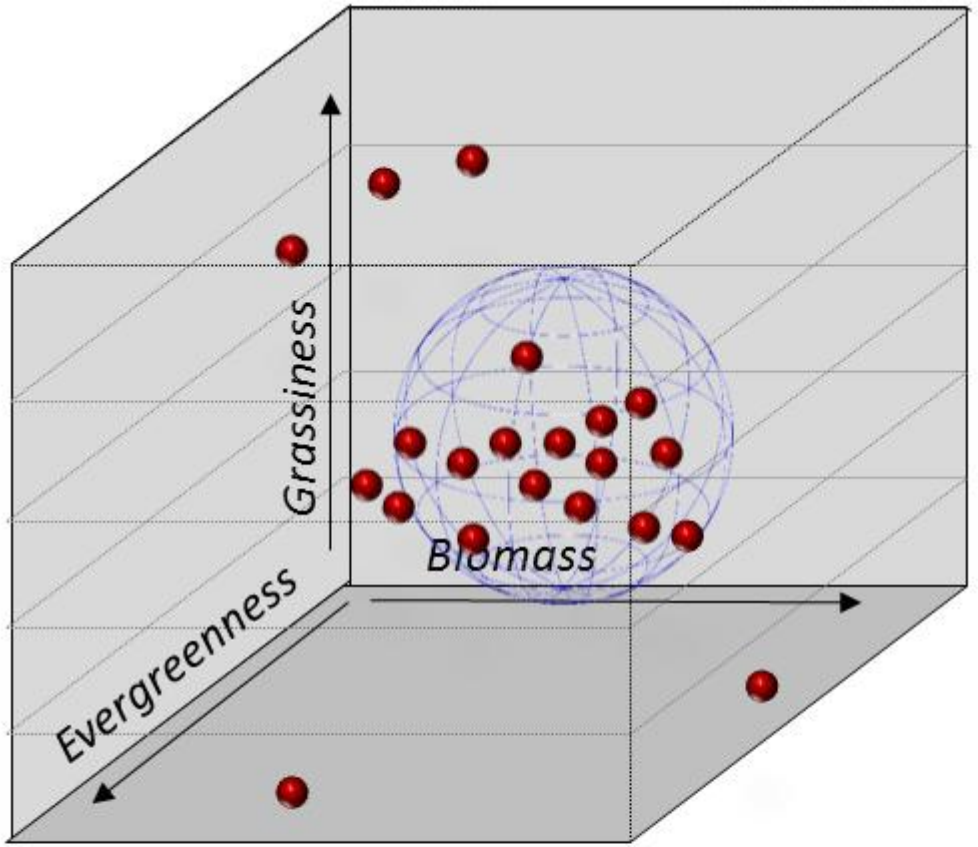

Grassiness
Biomass
Evergreenness



A location's attributes

Desired conditions





A location's attributes

Desired conditions