When monitoring is not enough:

Predicting post-wildfire trajectories from MODIS time series

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Aug. 22, 2013
ORNL, Oak Ridge TN

Outline

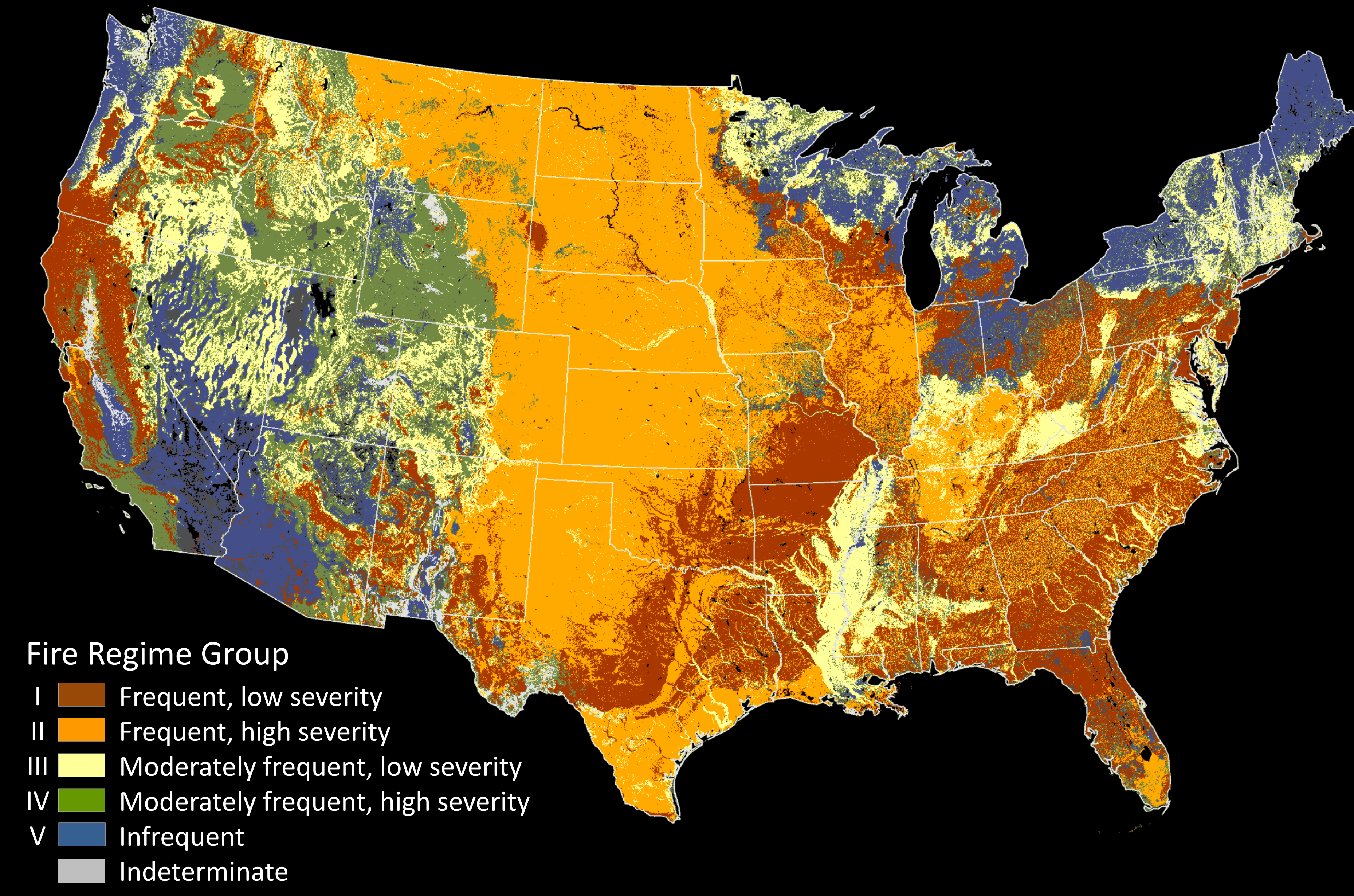
PART I—The wildland fire and management crisis of the Western US

PART II—Theoretical challenges that can impede management success

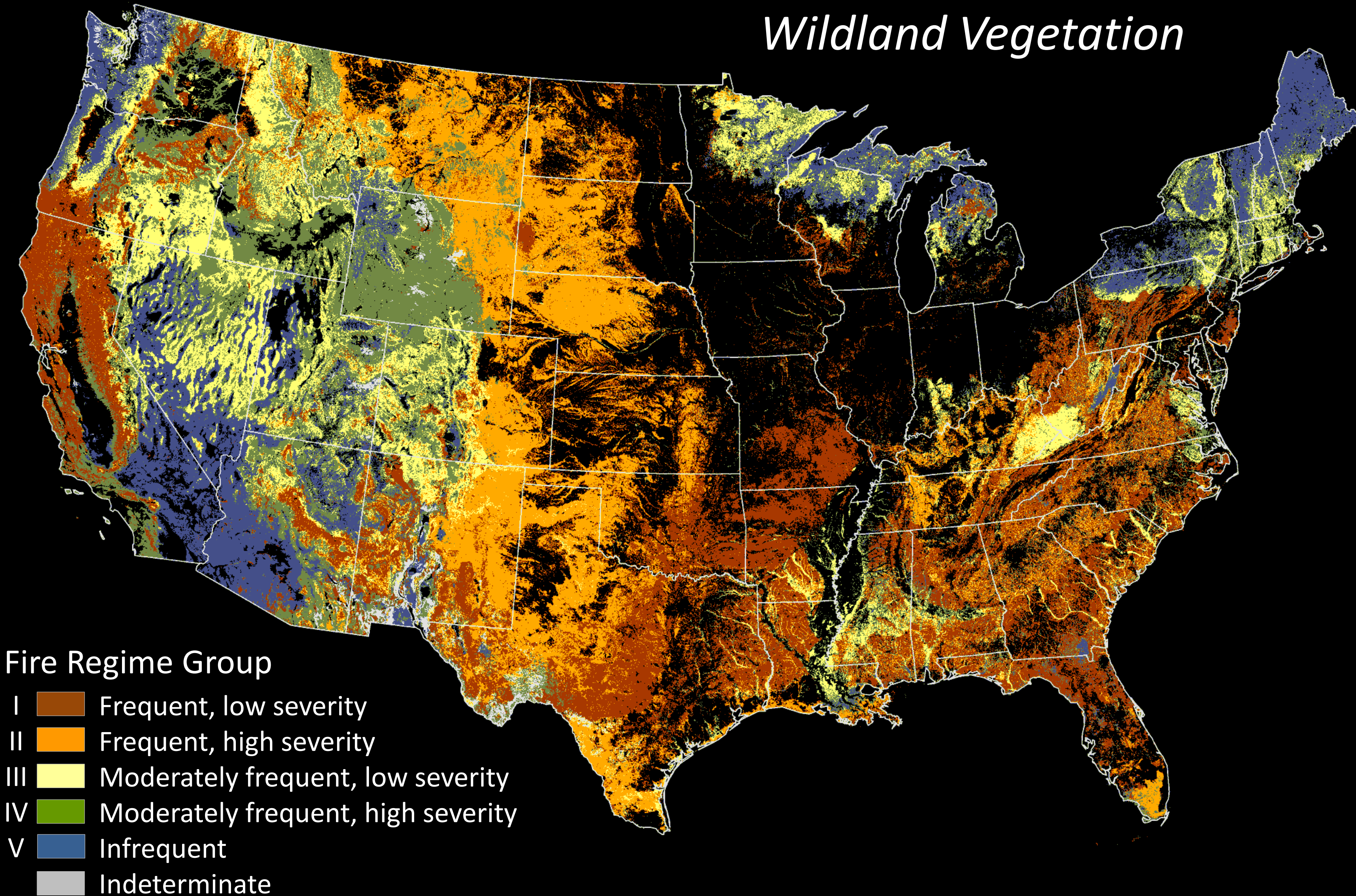
PART III—Efficient coarse-filter landscape monitoring

PART IV—Predicting long-term wildfire effects

Historical Fire Regimes



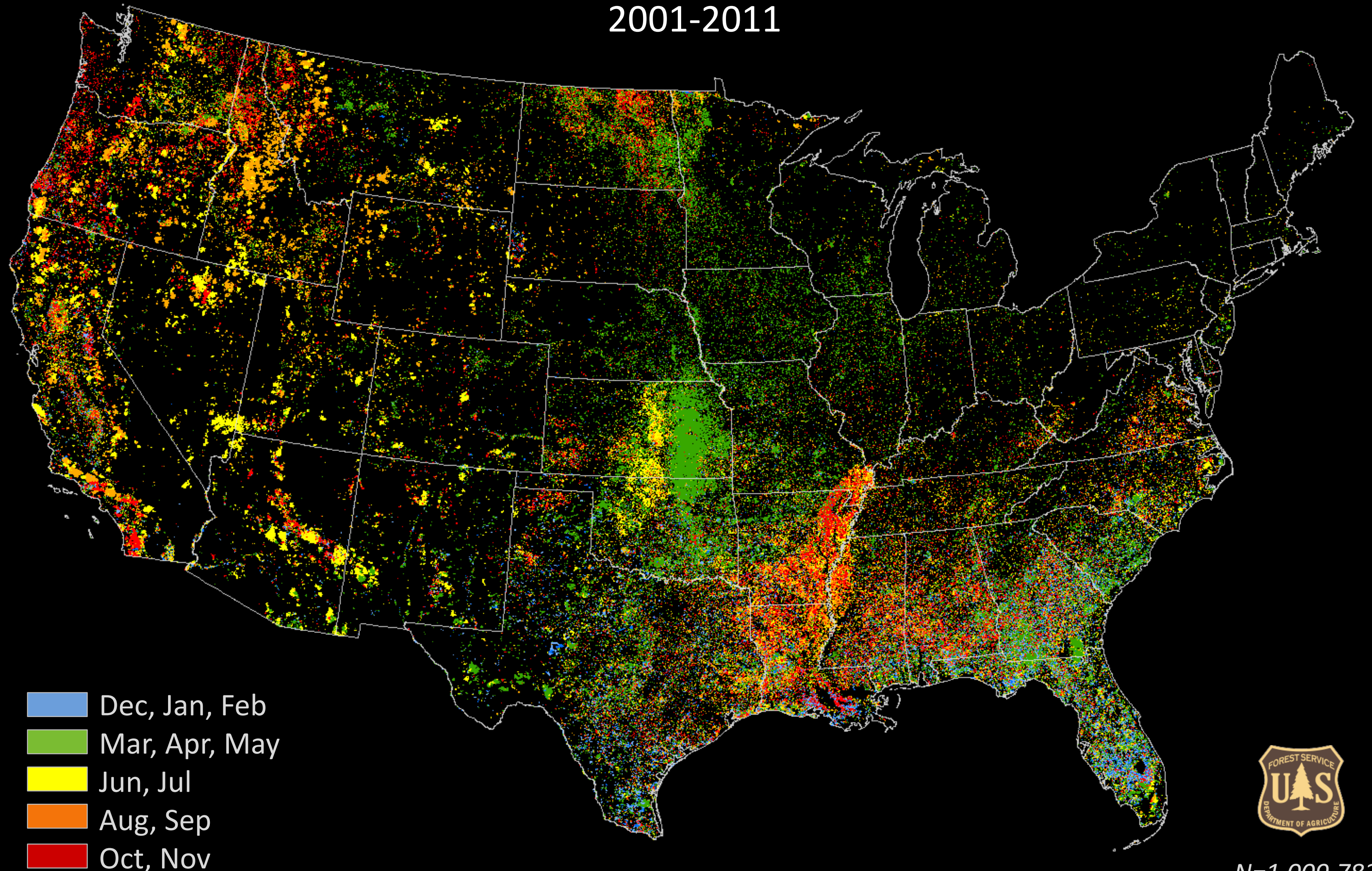
Historical Fire Regimes *of Existing Wildland Vegetation*



Seasonality of all fires

as inferred from MODIS hotspots

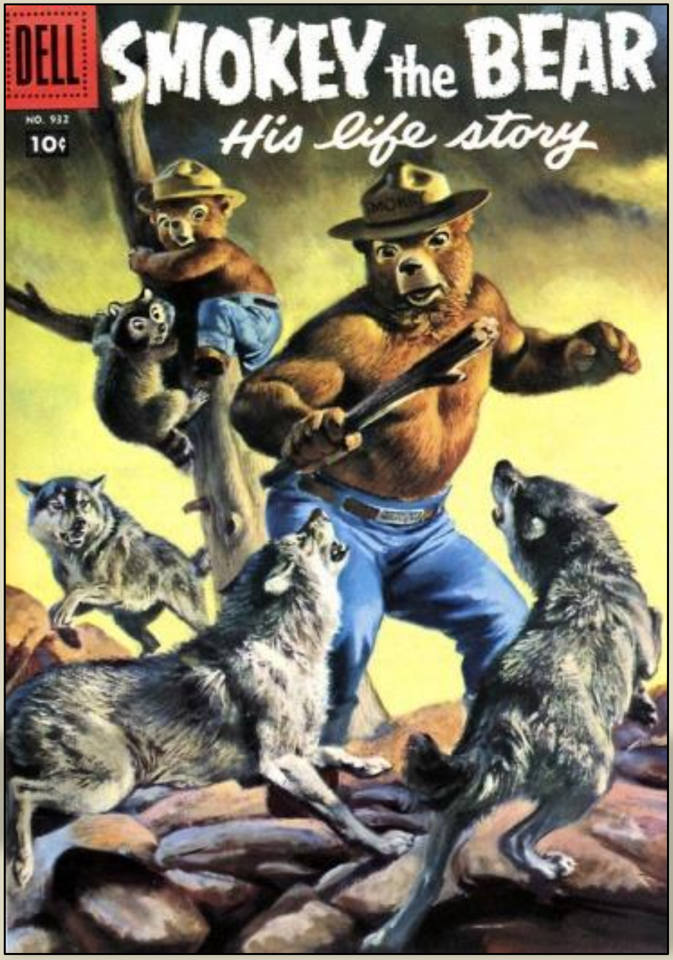
2001-2011

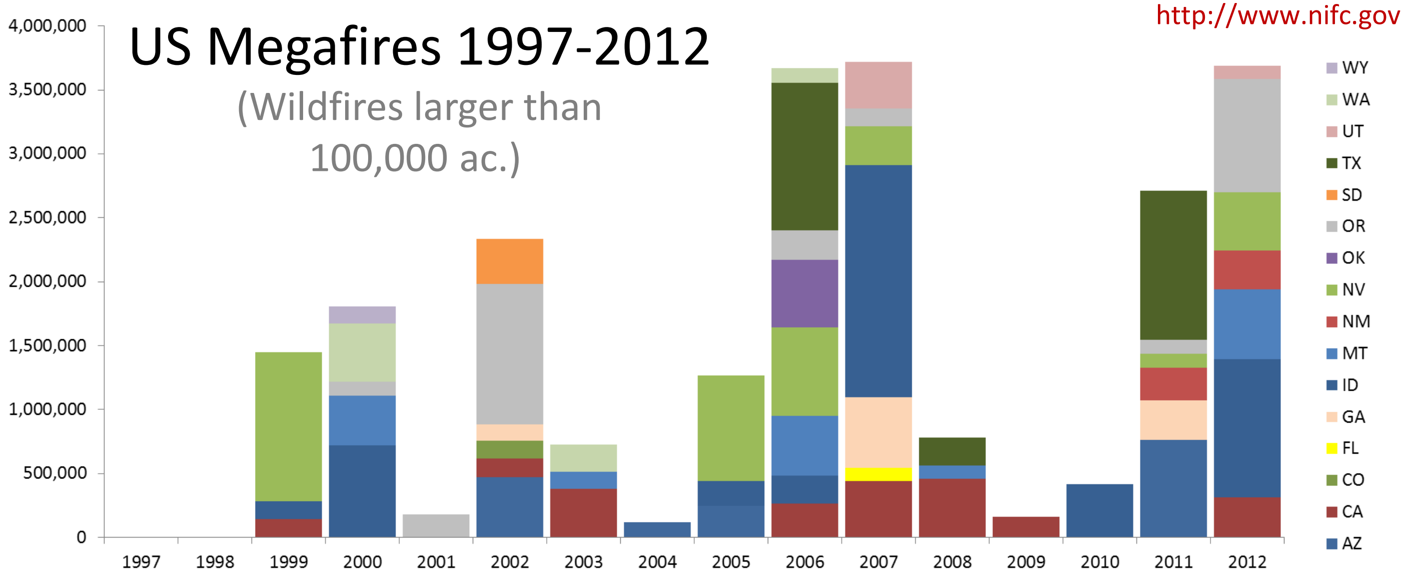


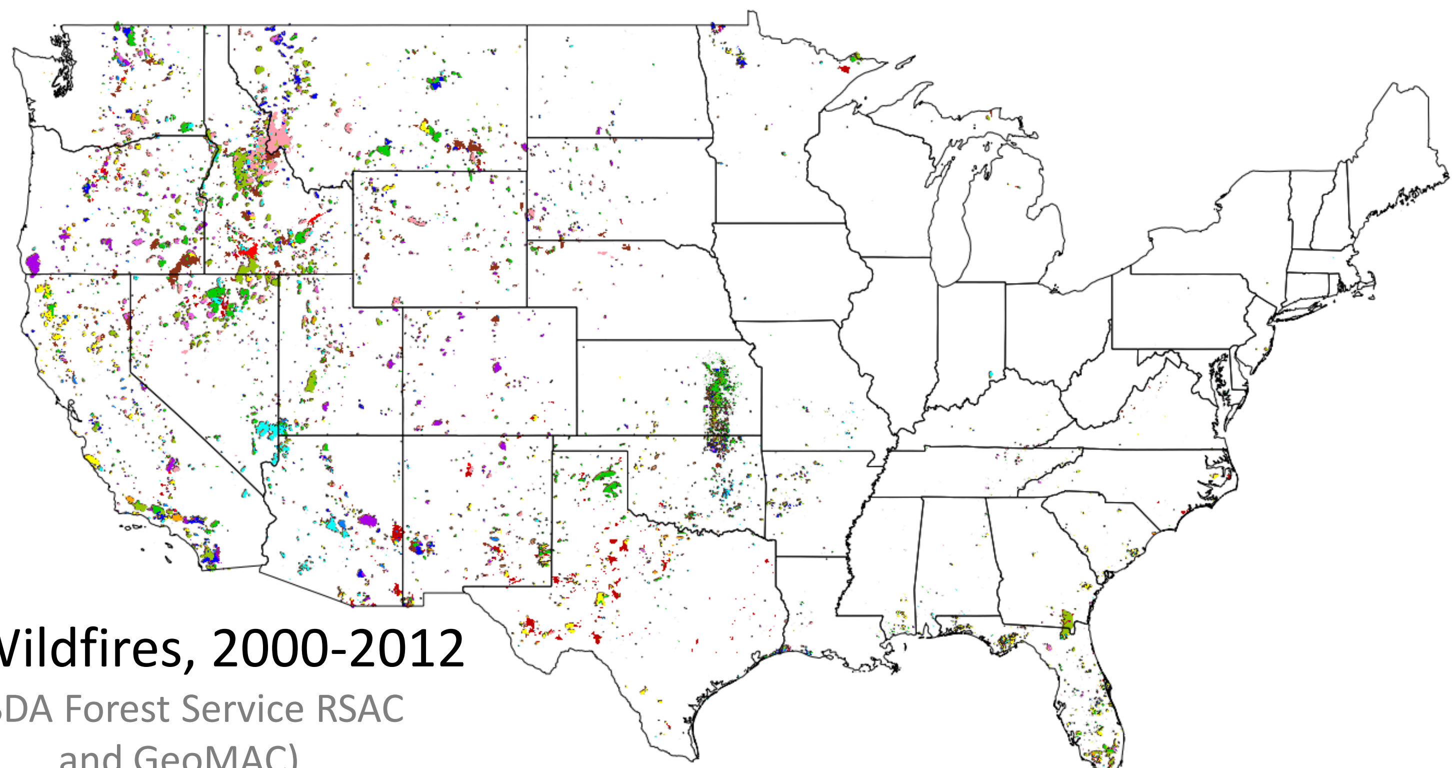
N=1,009,782

Steve Norman 5/2012

Does our wildland fire problem result from our past management decisions?







US Wildfires, 2000-2012

(USDA Forest Service RSAC and GeoMAC)


Little Bear Fire, Lincoln National Forest NM, 2012


Trinity Ridge Fire, Boise National Forest ID, 2012

Waldo Canyon Fire and Colorado Springs CO, 2012

Wallow Fire AZ, 2011

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PART II—Theoretical challenges that can impede forest management success

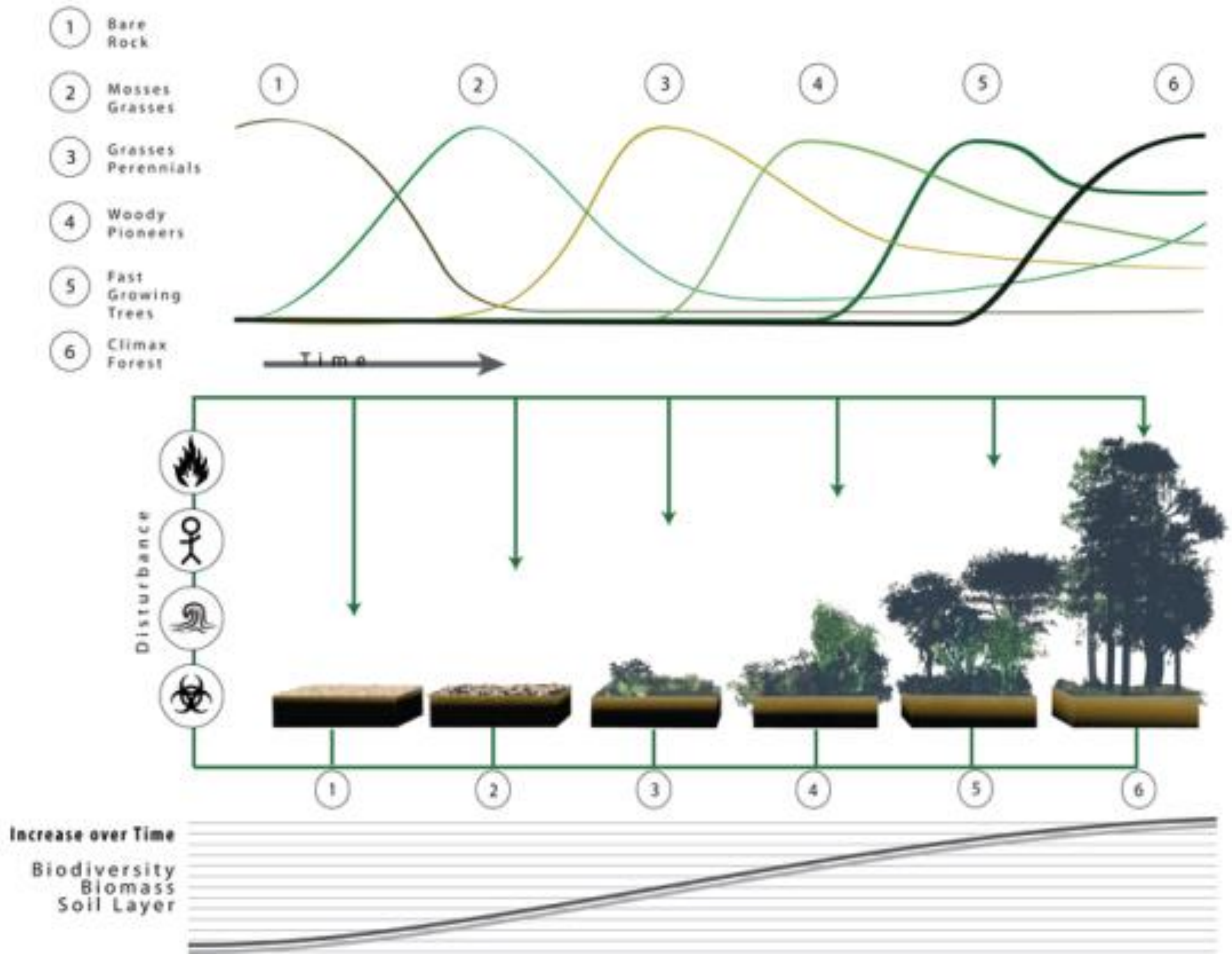
Cyclicity

STABILITY

Flux

PART II—Theoretical challenges that can impede forest management success

A typical cyclical disturbance-succession model (at the stand-scale)



CYCLICITY
at the stand scale could translate to
STABILITY
at the landscape scale

ποταμῶι γαρ ουτ έστιν εμβῆναι δις τῶι αυτῶι.
σκίδνησι και πάλιν συνάγει.....και πρόσεισι και άπεισι

“after all, one does not step into the same river twice. waters disperse and come together again ... they keep flowing on and flowing away”

Heraclitus

c. 535 – c. 475 BCE

PART II—Theoretical challenges that can impede forest management success

DRIVERS of STABILITY in the fire environment

- Evolutionary-scale species responses to fire
- Evolutionary-scale competitive relationships among species
- Fuel accumulation and succession
- Consistency of climate (fire seasonality, microclimate)
- Topography
- Consistent management regimes

PART II—Theoretical challenges that can impede forest management success

DRIVERS of STABILITY in the fire environment

- Evolutionary-scale species responses to fire
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- Fuel accumulation and succession
- Consistency of climate (fire seasonality, microclimate)
- Topography
- Consistent management regimes

DRIVERS of FLUX in the fire environment

- Inconstant human influence:
    - changing ignition rates or patterns
    - fire management (e.g., fire suppression)
    - land management (e.g., grazing, logging)
- Introductions of non-native species
- Climate change
- Complex disturbance interactions

"Only I can prevent forest fires? What's fire?"


Buffelgrass


Cheatgrass


Cogongrass


Tamarix spp.

Complex disturbance interactions (drainage, logging, hurricanes, repeated fires) in the Okefenokee NWR, Georgia

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

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

Complex disturbance interactions (blowdown, wildfires) in the 2012 Wenatchee Fire, Washington

PART II—Theoretical challenges that can impede forest management success

Cyclicity

STABILITY

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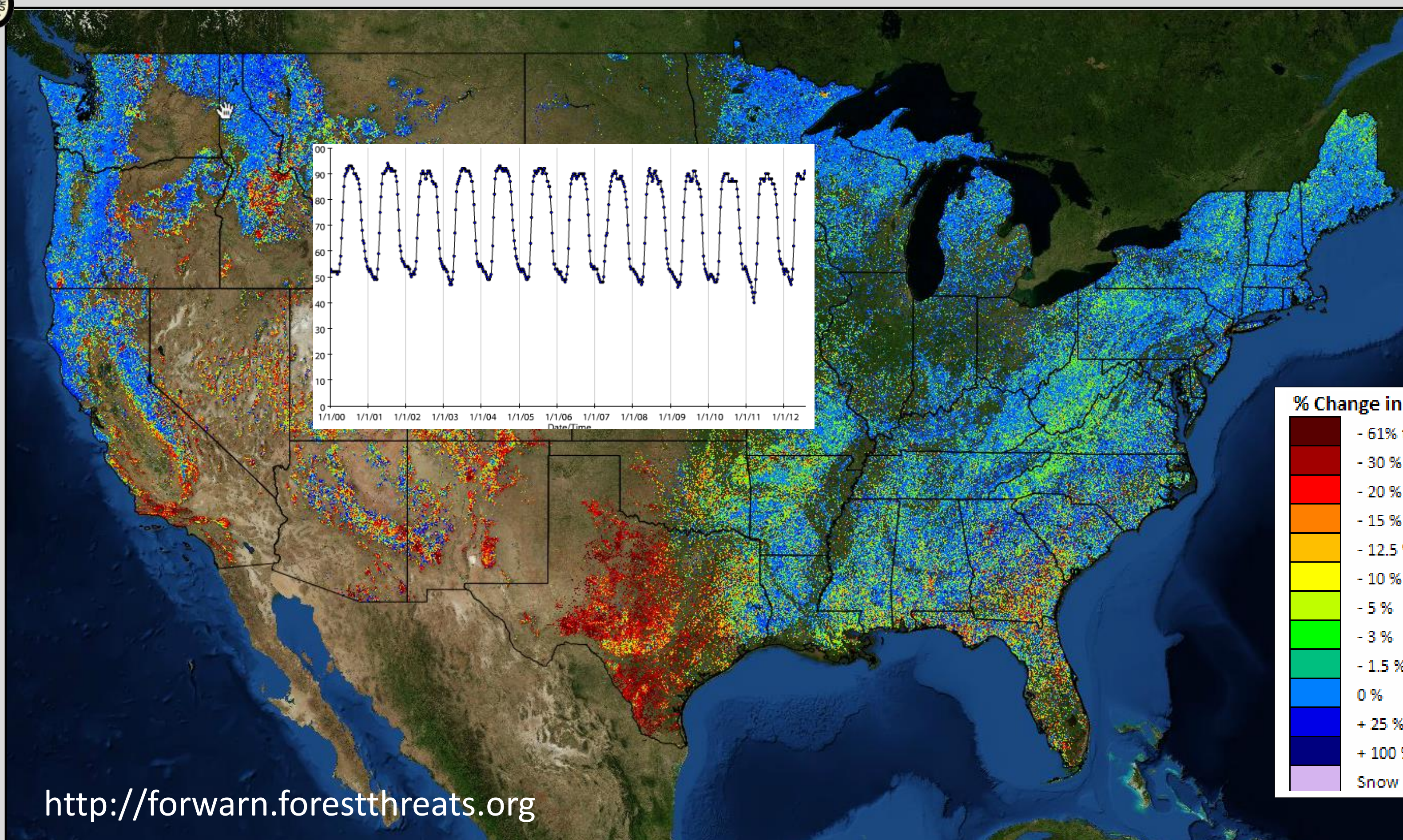
"Praemonitus Praemunitus"

ForWarn

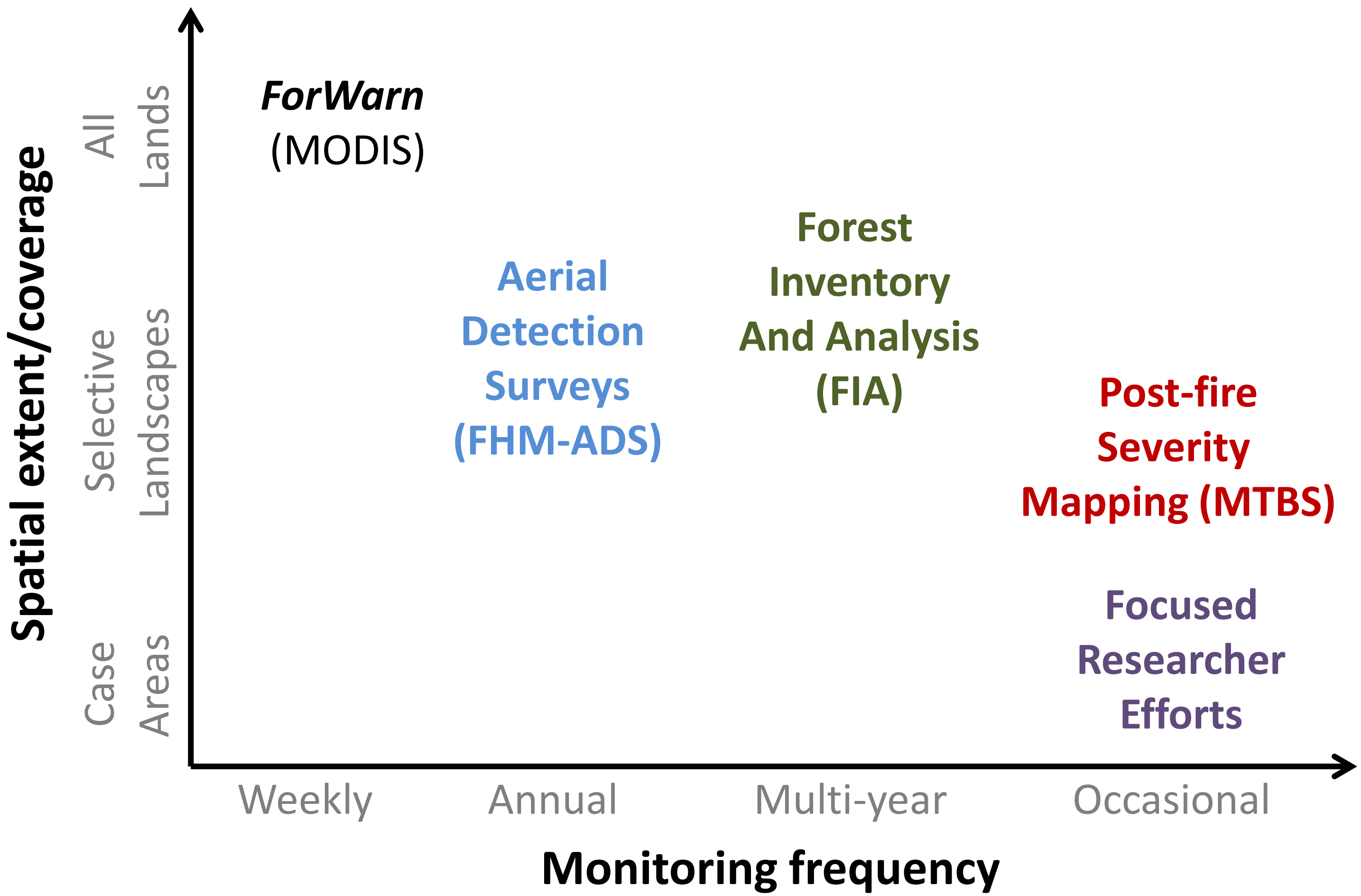
Satellite-Based Change Recognition and Tracking

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



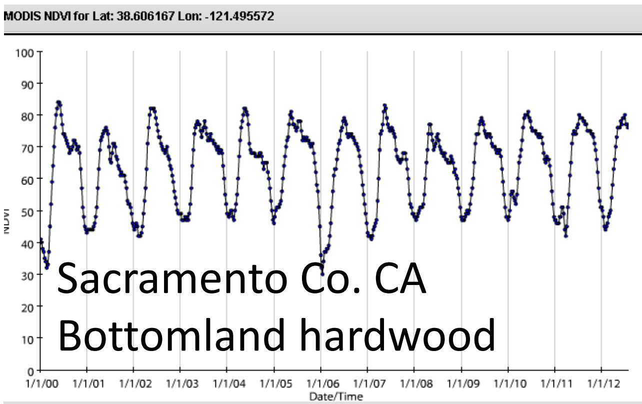
PART III—Efficient coarse-filter landscape monitoring

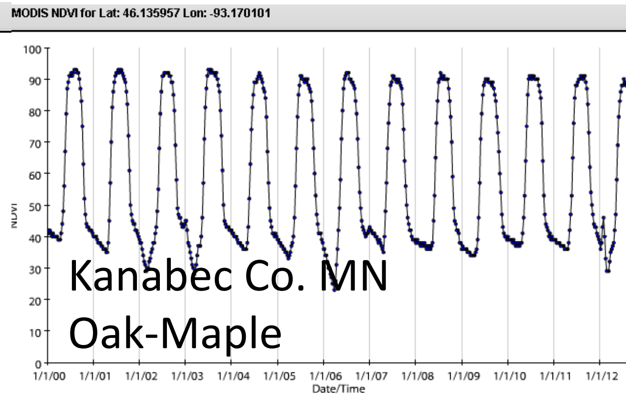
Available approaches and datasets

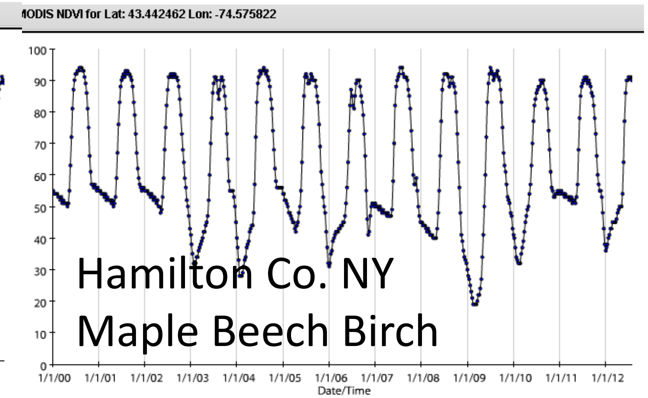


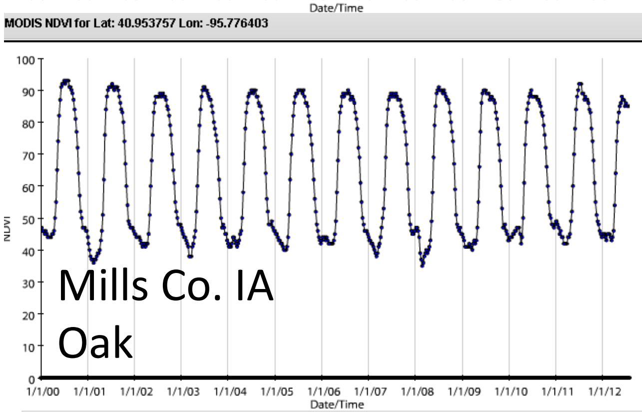
PART III—Efficient coarse-filter landscape monitoring

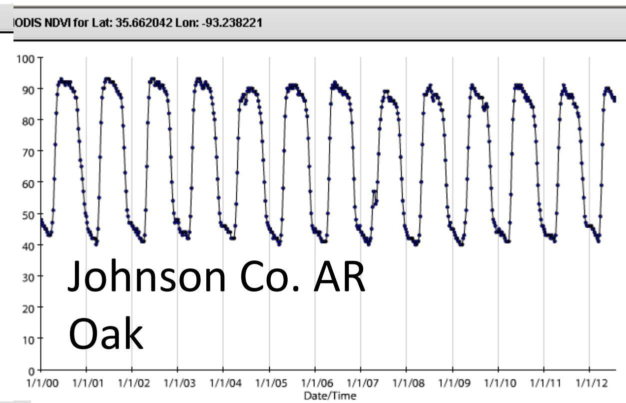
Phenological signatures of **deciduous forest** dominated pixels

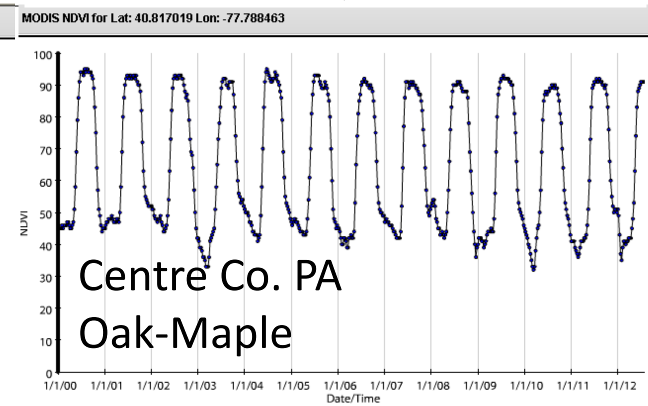


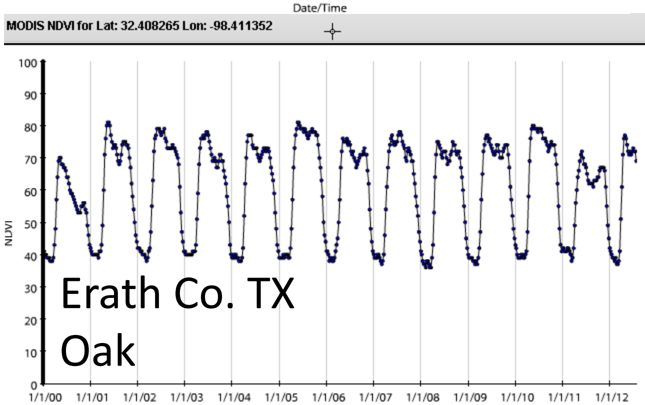


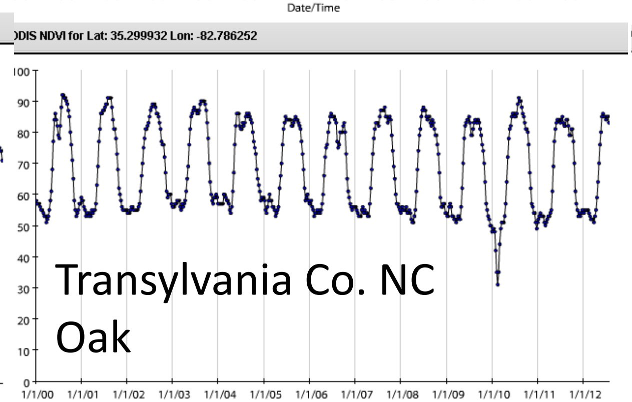


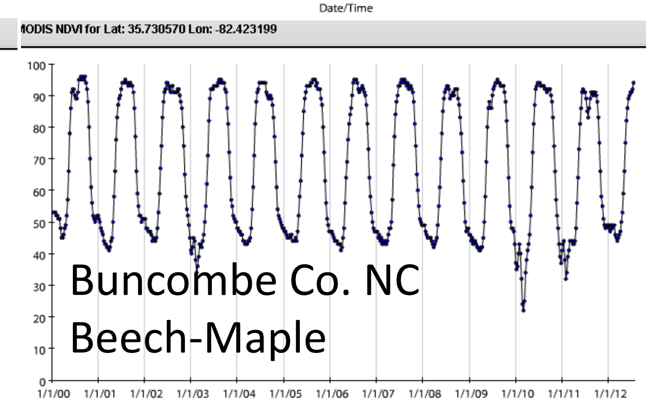






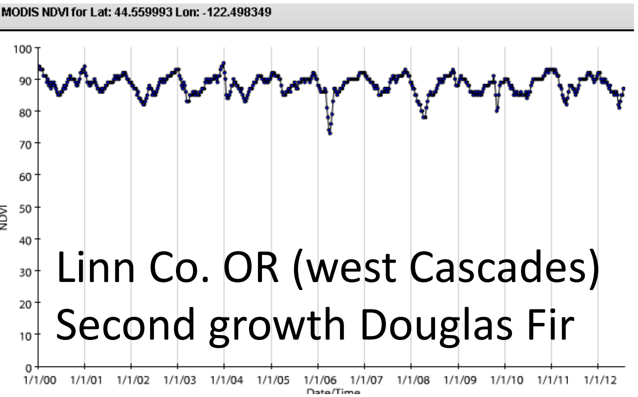


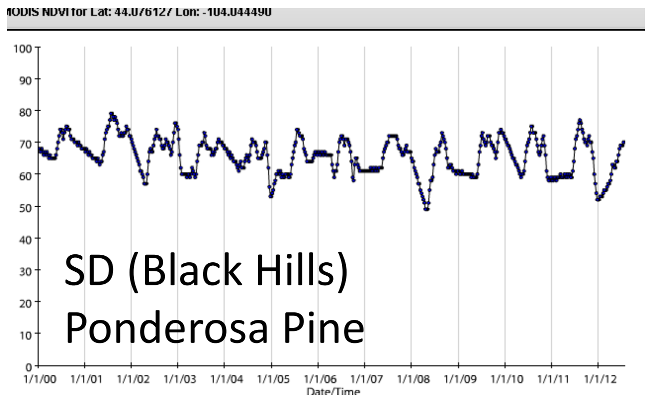


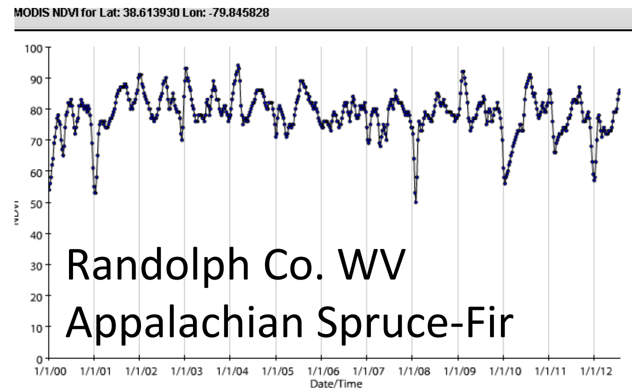


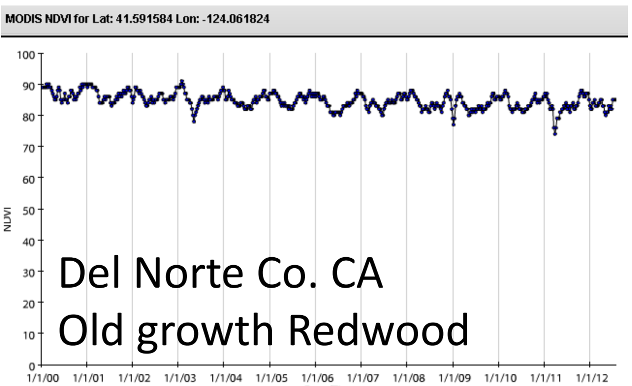
PART III—Efficient coarse-filter landscape monitoring

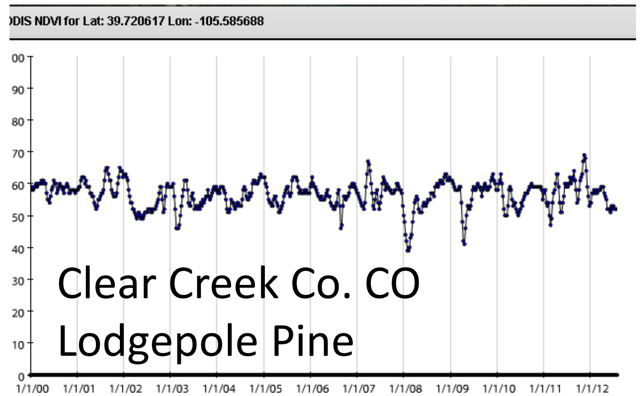
Phenological signatures of **conifer forest** dominated pixels

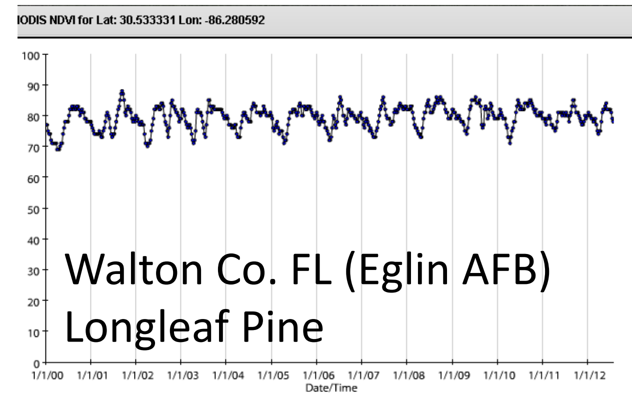


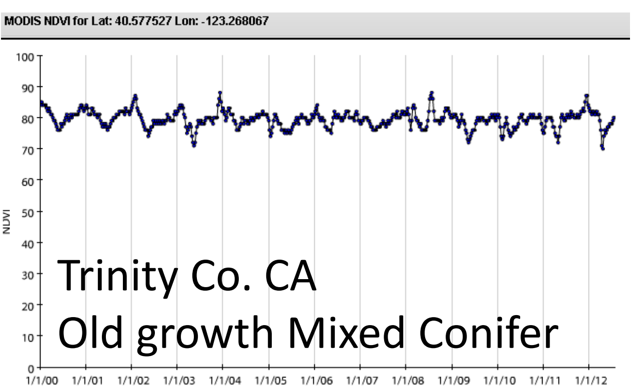


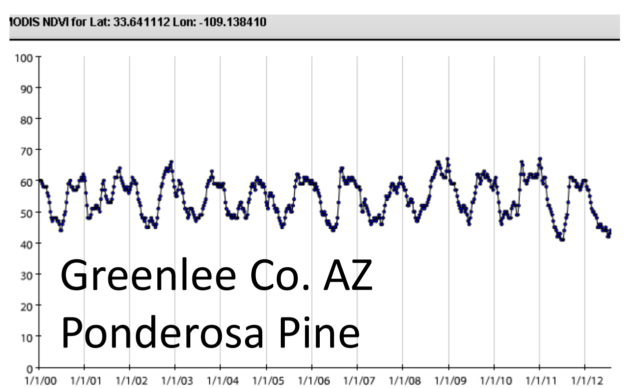


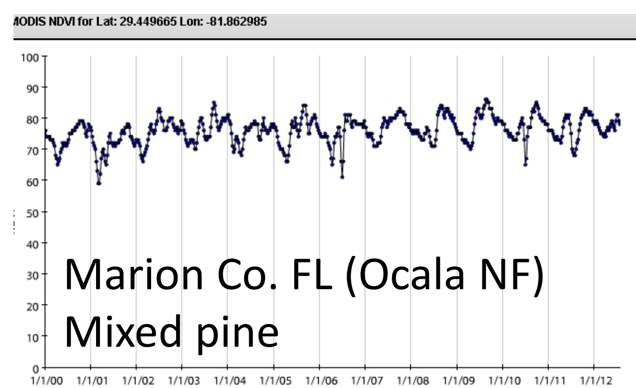






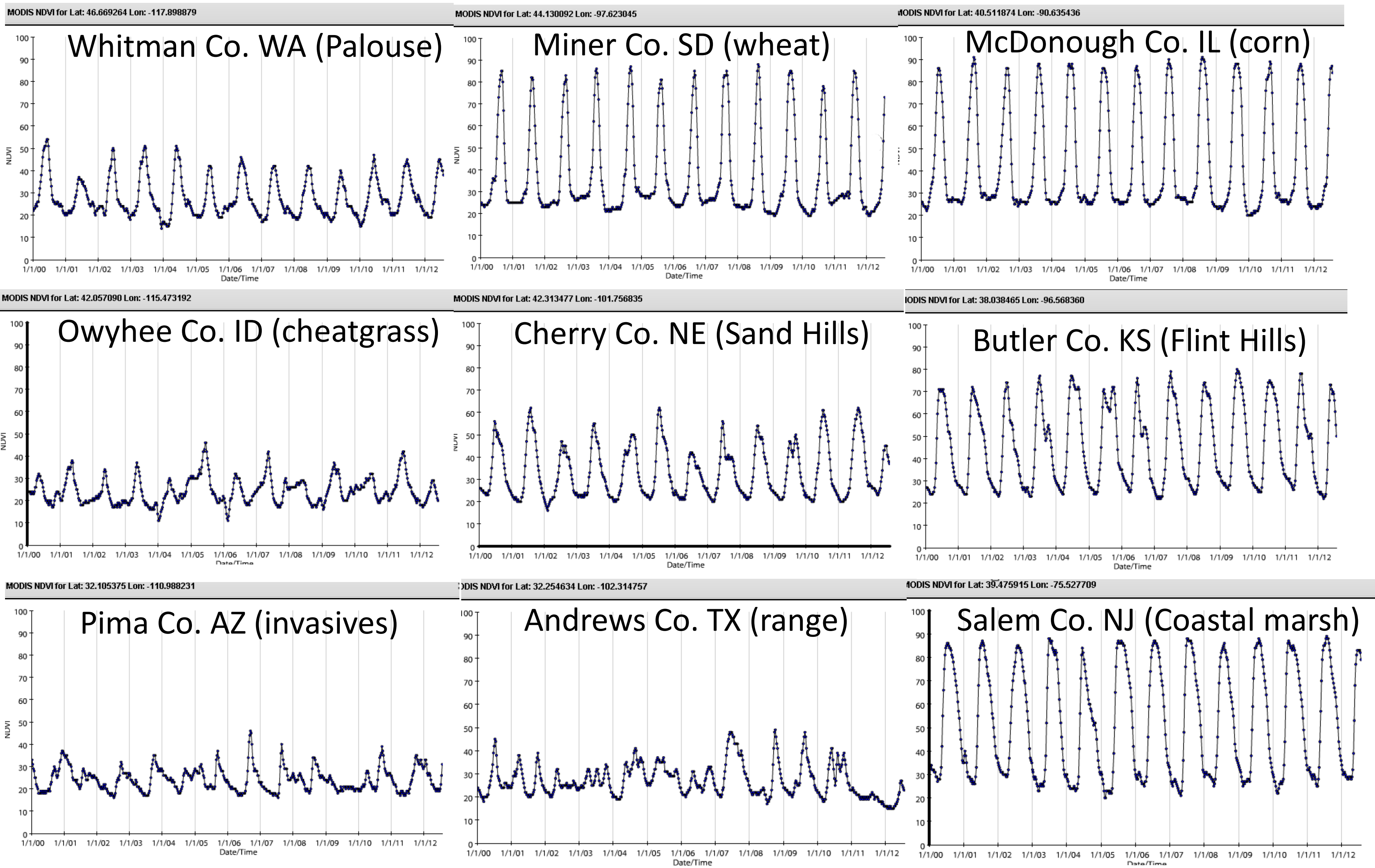






PART III—Efficient coarse-filter landscape monitoring

Phenological signatures of **grass** dominated pixels



PART III—Efficient coarse-filter landscape monitoring

Potential measures of fire effects and desired vegetation

Maximum NDVI
Minimum NDVI
Mean NDVI
Median NDVI

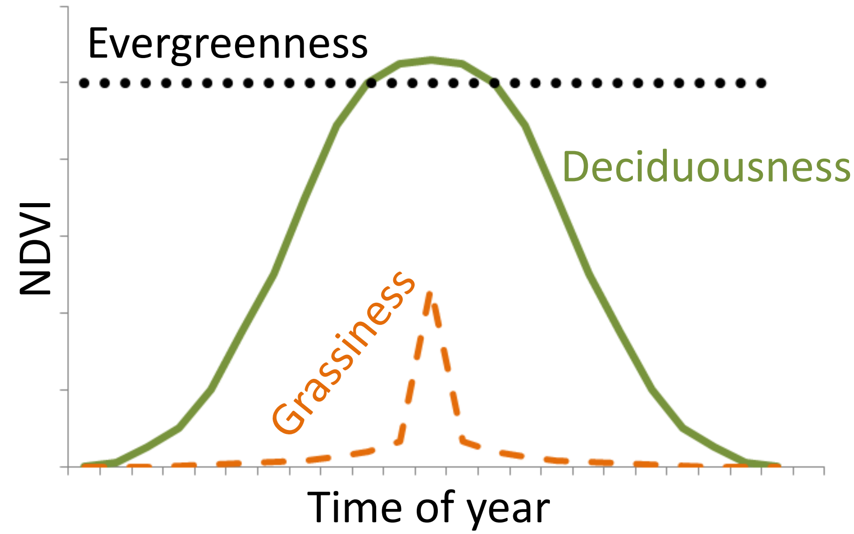
Percentiles of the annual distribution
Amplitude of NDVI (of extremes)
NDVI Difference (between thresholds)
Duration above some threshold
Area under the growing season curve

Key Measures for Vegetation Change Associated With Wildland Fire:

(1) LIVING BIOMASS
(median NDVI)

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

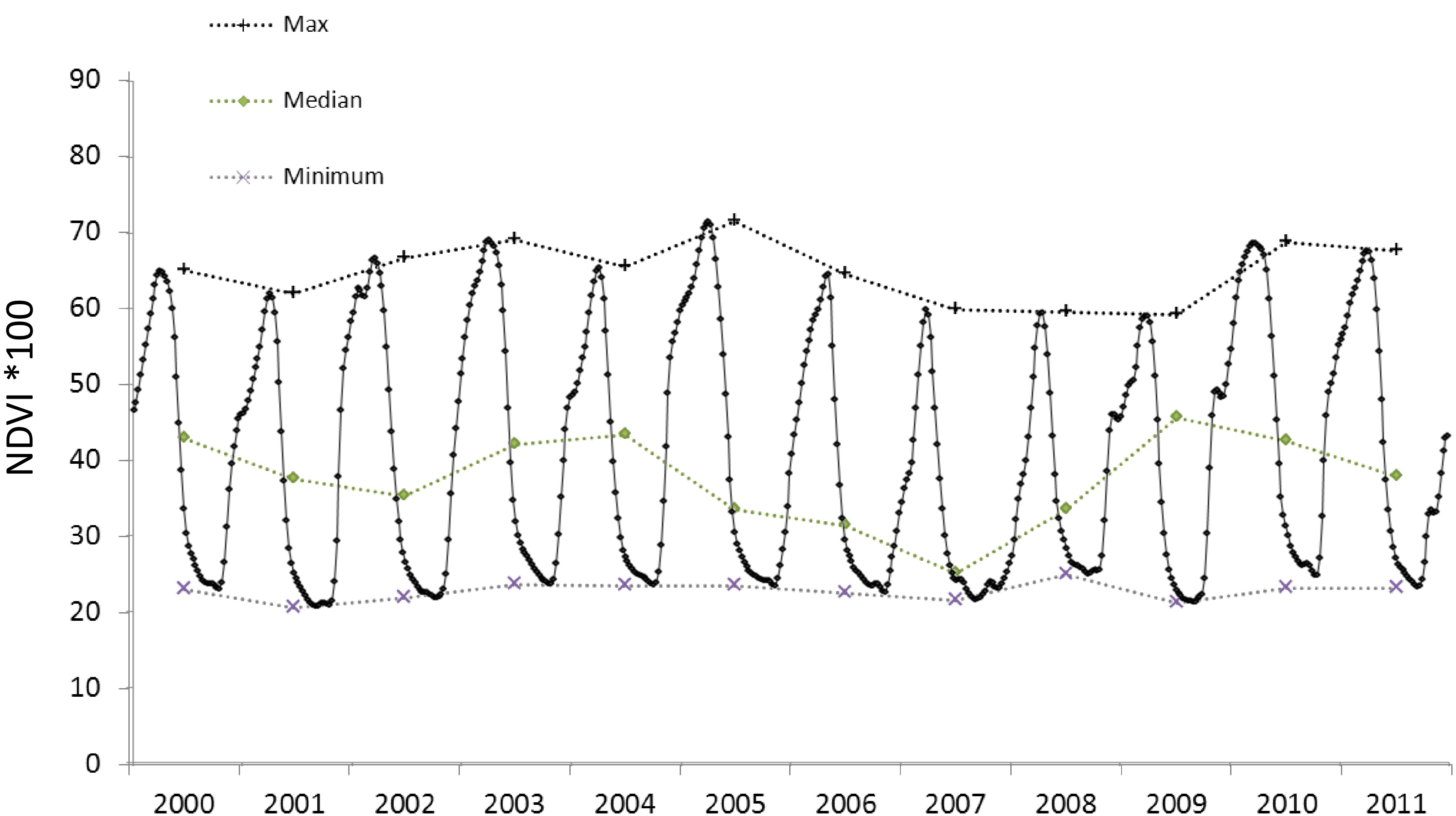
(3) GRASS FRACTION
(peakedness of upper distribution)



PART III—Efficient coarse-filter landscape monitoring

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

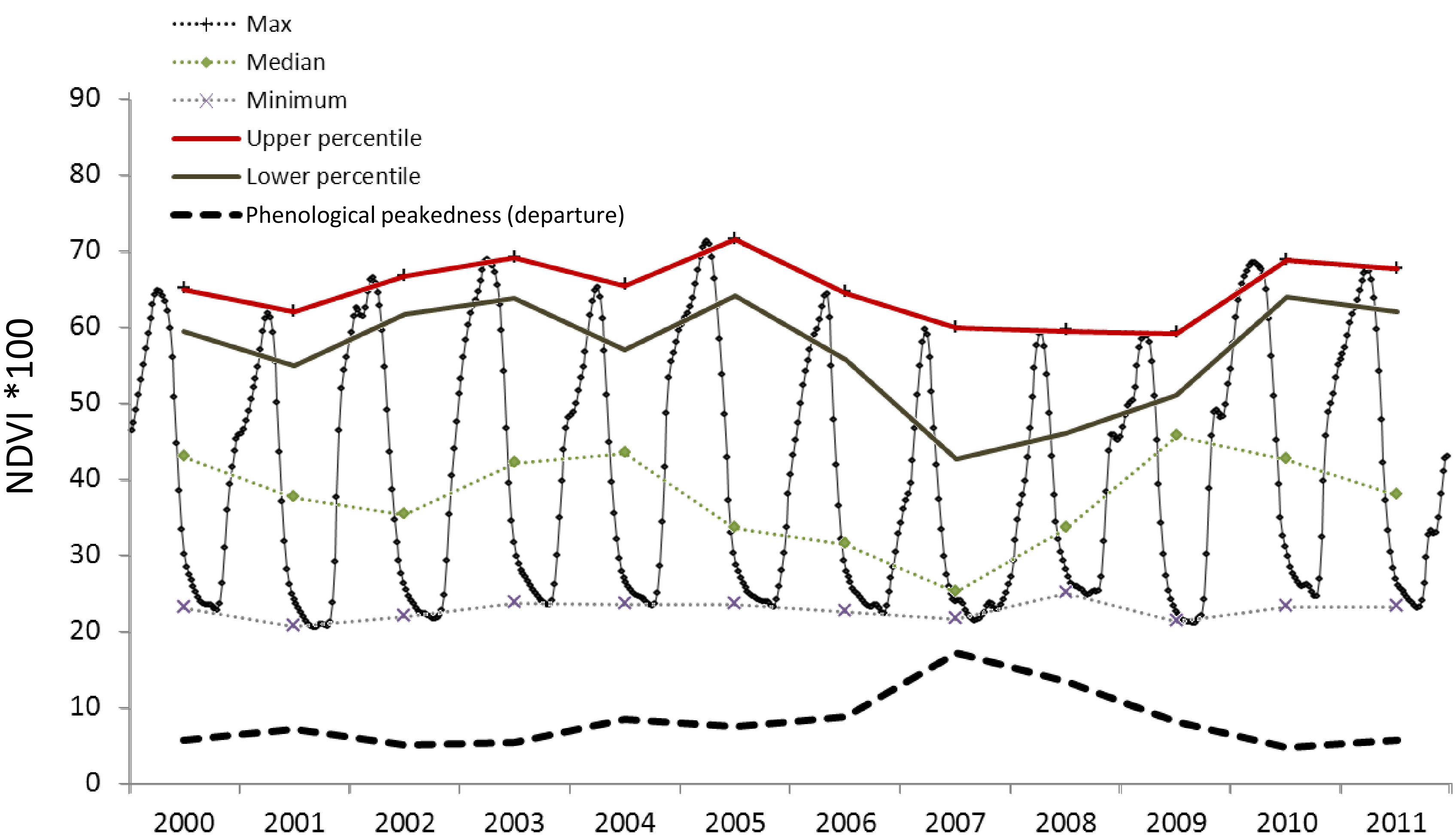
(The landscape mean of 9,345 MODIS pixels)



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

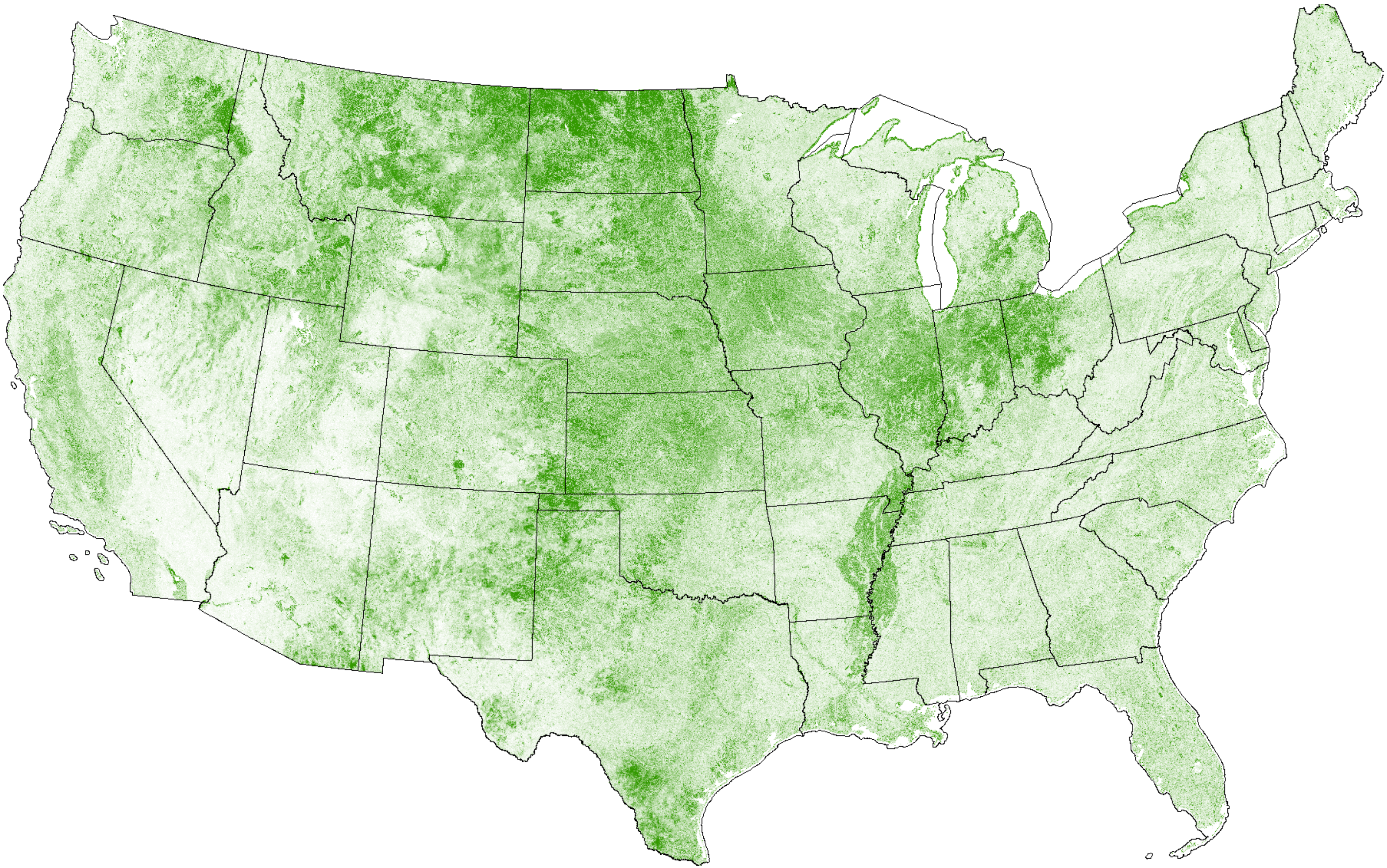
PART III—Efficient coarse-filter landscape monitoring

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



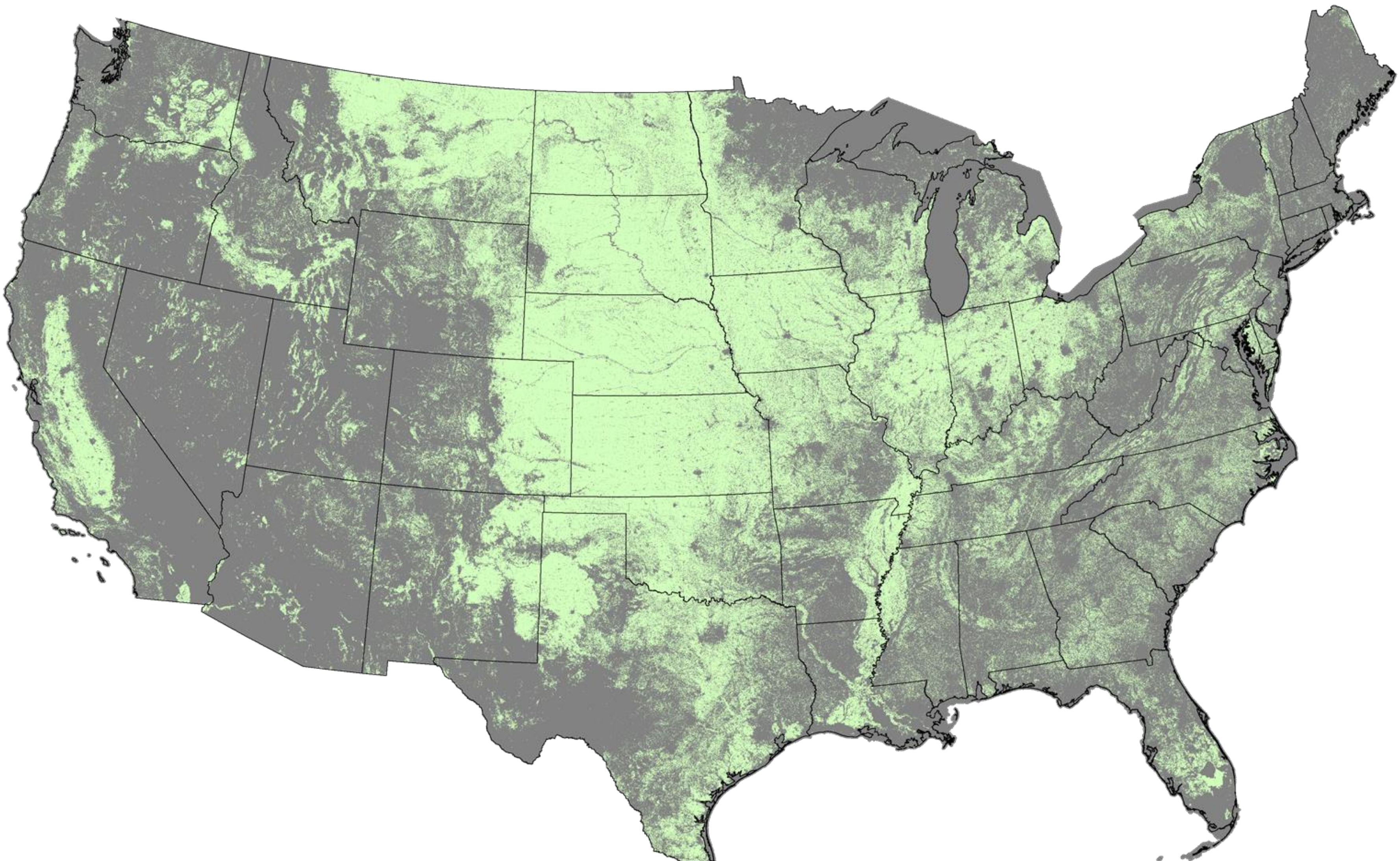
PART III—Efficient coarse-filter landscape monitoring

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



PART III—Efficient coarse-filter landscape monitoring

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



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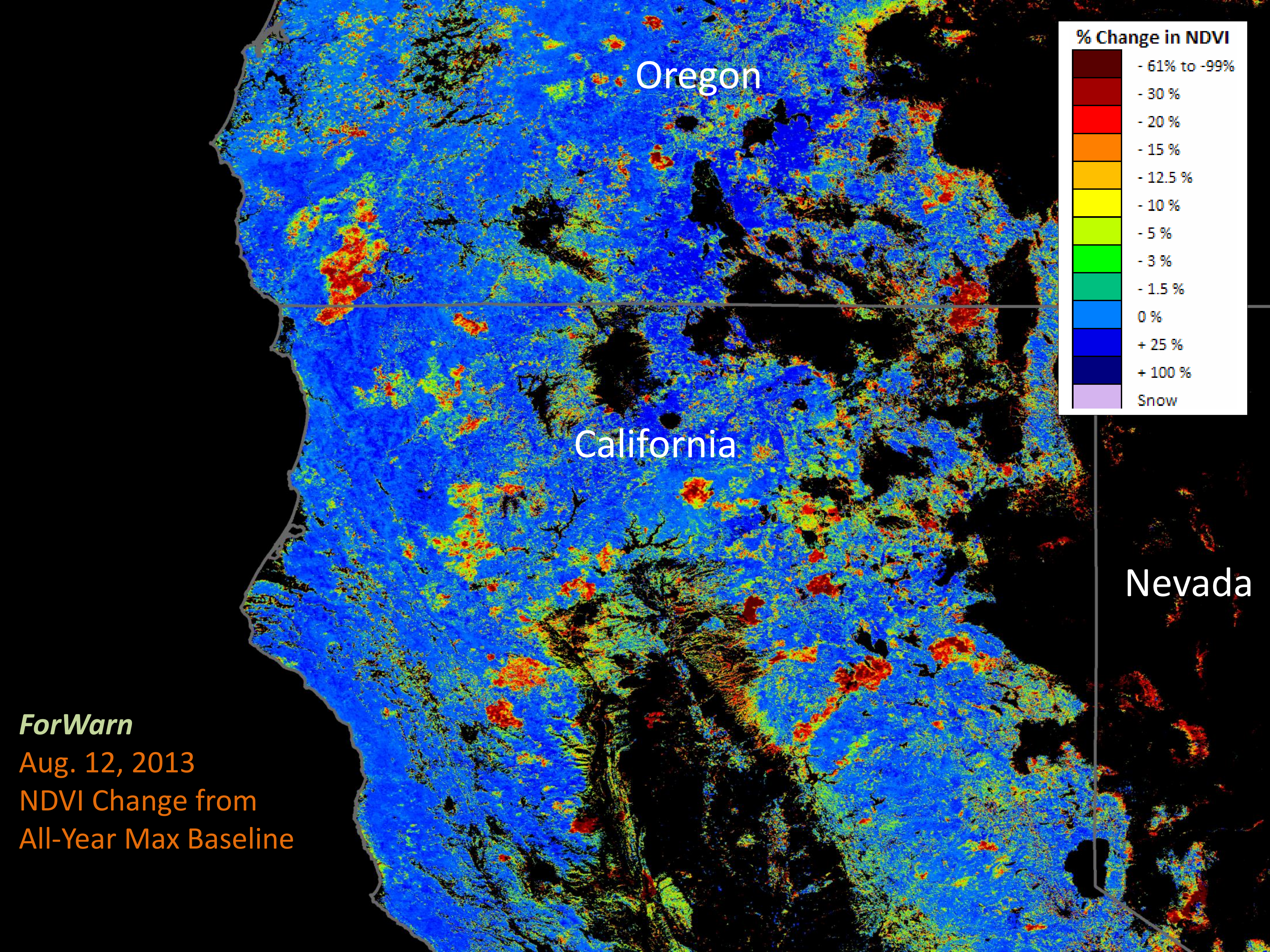
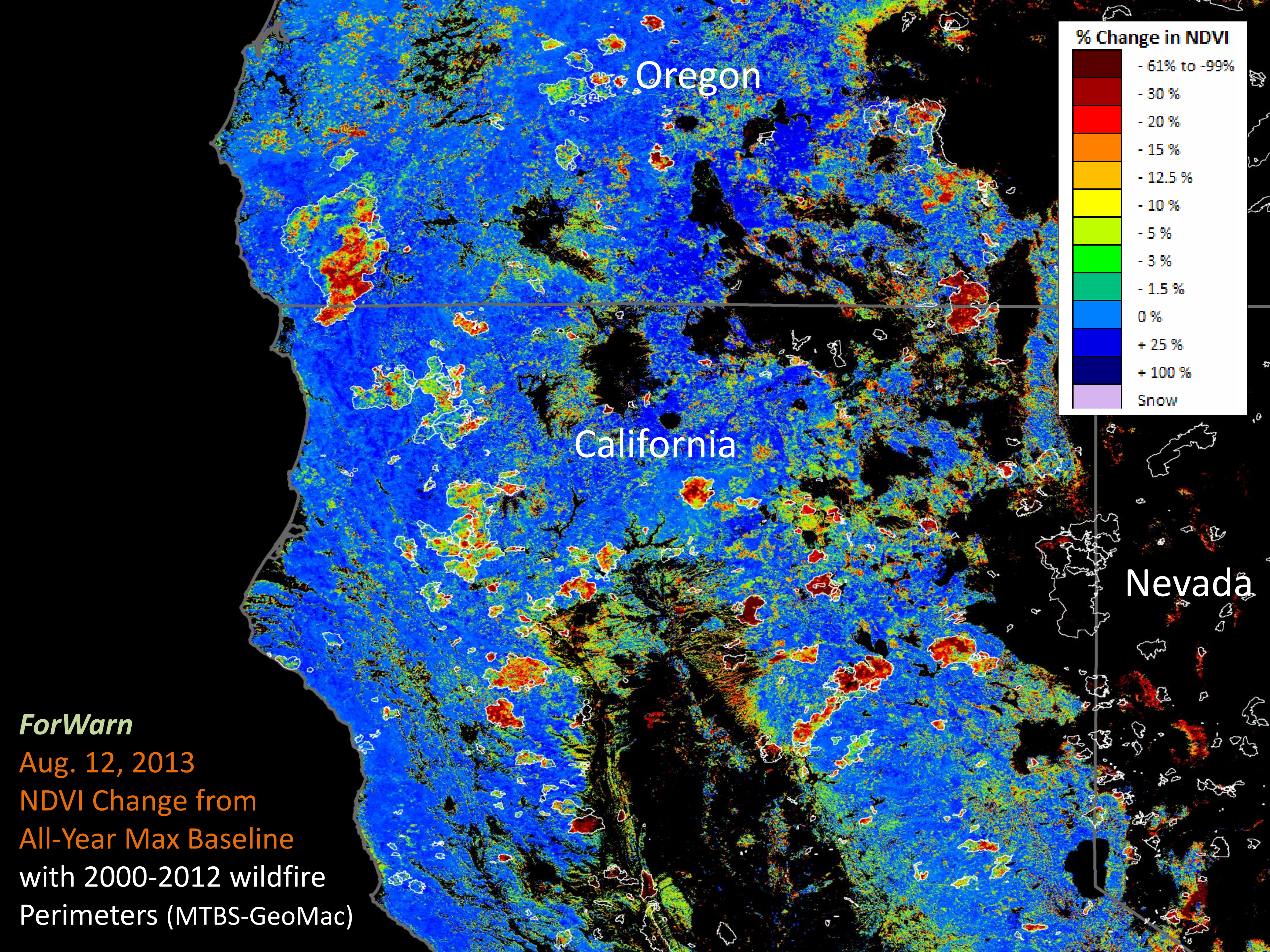


% Change in NDVI
- 61% to -99%
- 30 %
- 20 %
- 15 %
- 12.5 %
- 10 %
- 5 %
- 3 %
- 1.5 %
0 %
+ 25 %
+ 100 %
Snow
Oregon
California
Nevada
ForWarn
Aug. 12, 2013
NDVI Change from
All-Year Max Baseline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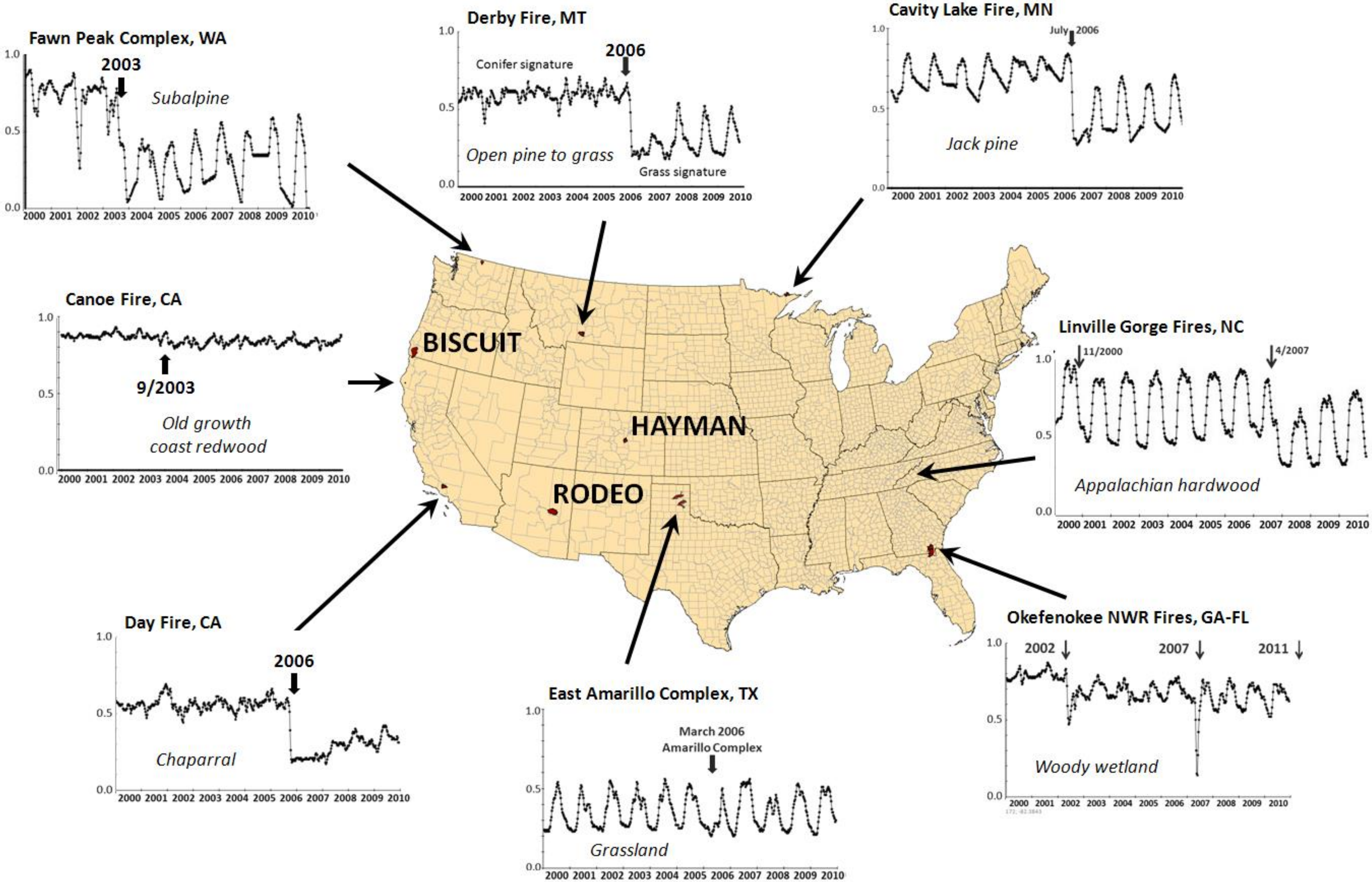
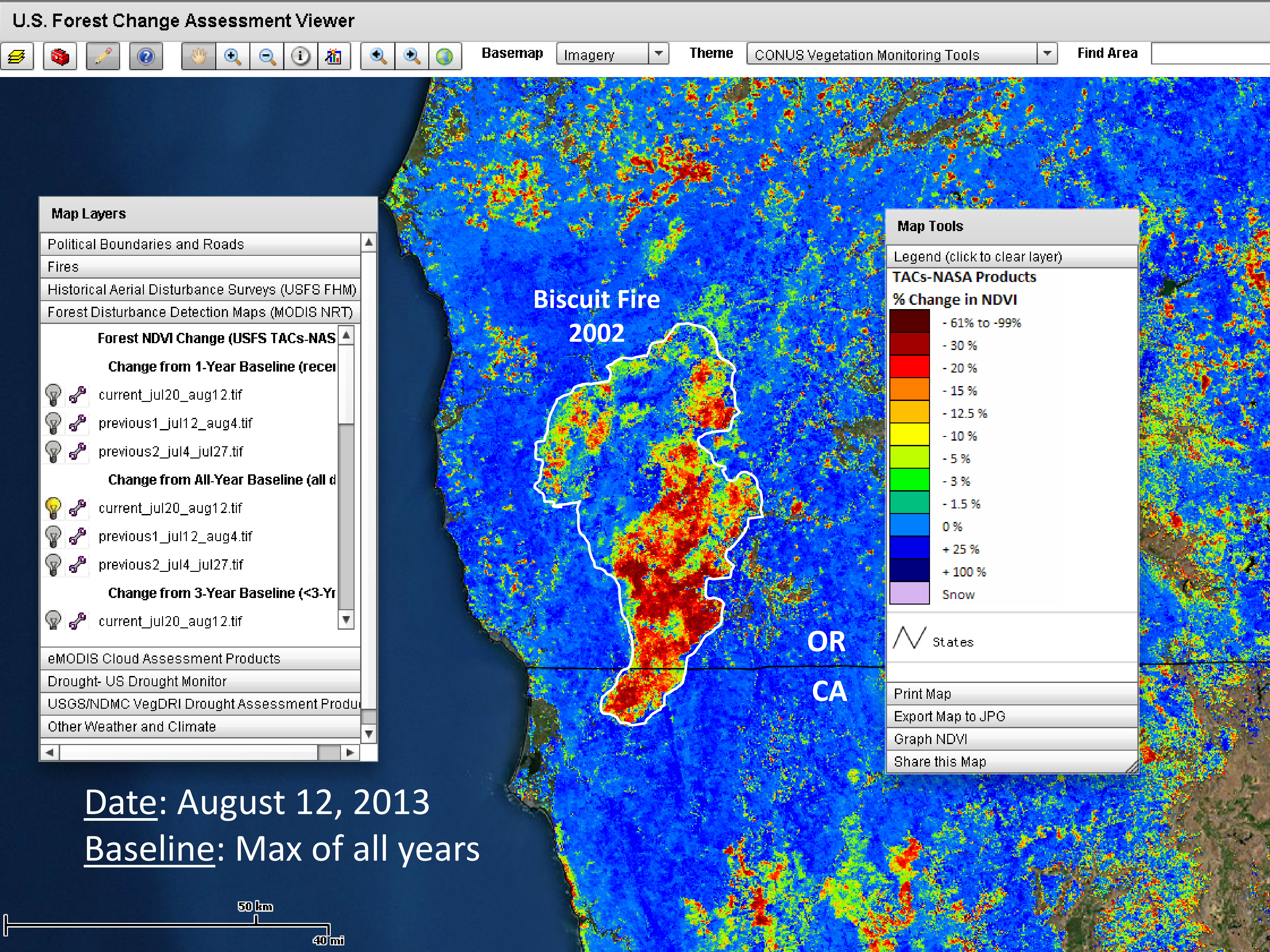
+ 25 %
+ 100 %
Snow
ForWarn
Aug. 12, 2013
NDVI Change from
All-Year Max Baseline
with 2000-2012 wildfire
Perimeters (MTBS-GeoMac)

PART IV—Predicting long-term fire effects




U.S. Forest Change Assessment Viewer
Basemap
Imagery
Theme
CONUS Vegetation Monitoring Tools
Find Area
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 (recer
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
previous2_jul4_jul27.tif
Change from 3-Year Baseline (<3-Yr
current_jul20_aug12.tif
eMODIS Cloud Assessment Products
Drought- US Drought Monitor
USGS/NDMC VegDRI Drought Assessment Produ
Other Weather and Climate
Biscuit Fire
2002
OR
CA
Map Tools
Legend (click to clear layer)
TACs-NASA Products
% Change in NDVI
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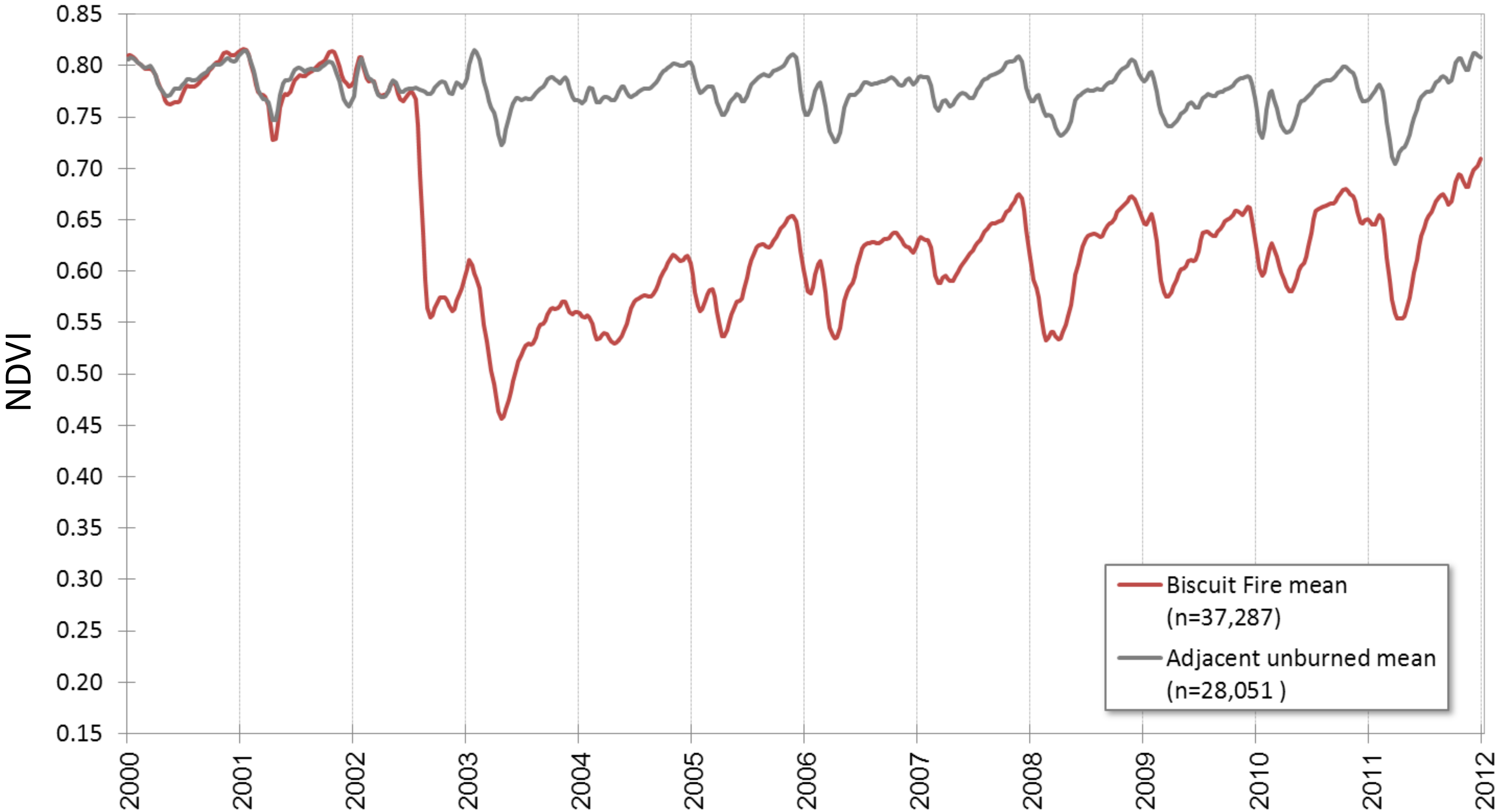
- 12.5 %
- 10 %
- 5 %
- 3 %
- 1.5 %
0 %
+ 25 %
+ 100 %
Snow
States
Print Map
Export Map to JPG
Graph NDVI
Share this Map
Date: August 12, 2013
Baseline: Max of all years
50 km
40 mi

PART IV—Predicting long-term fire effects

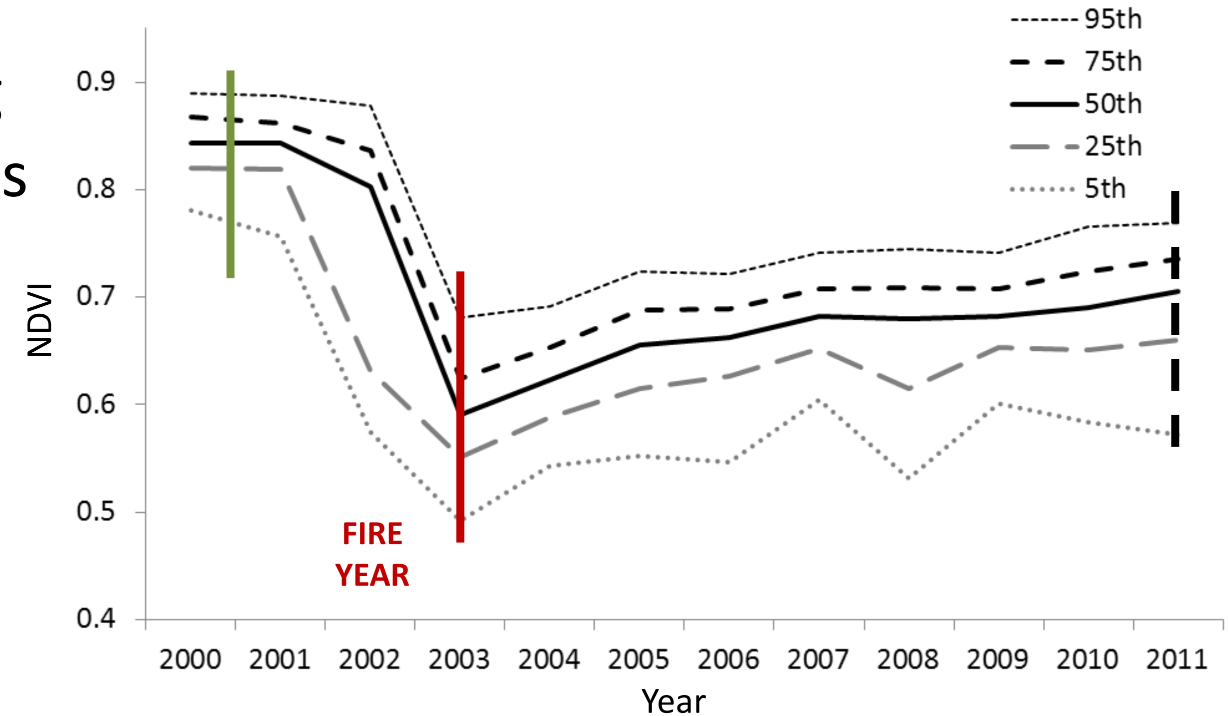
Mean observed MODIS NDVI for the 2002 BISCUIT FIRE and adjacent lands

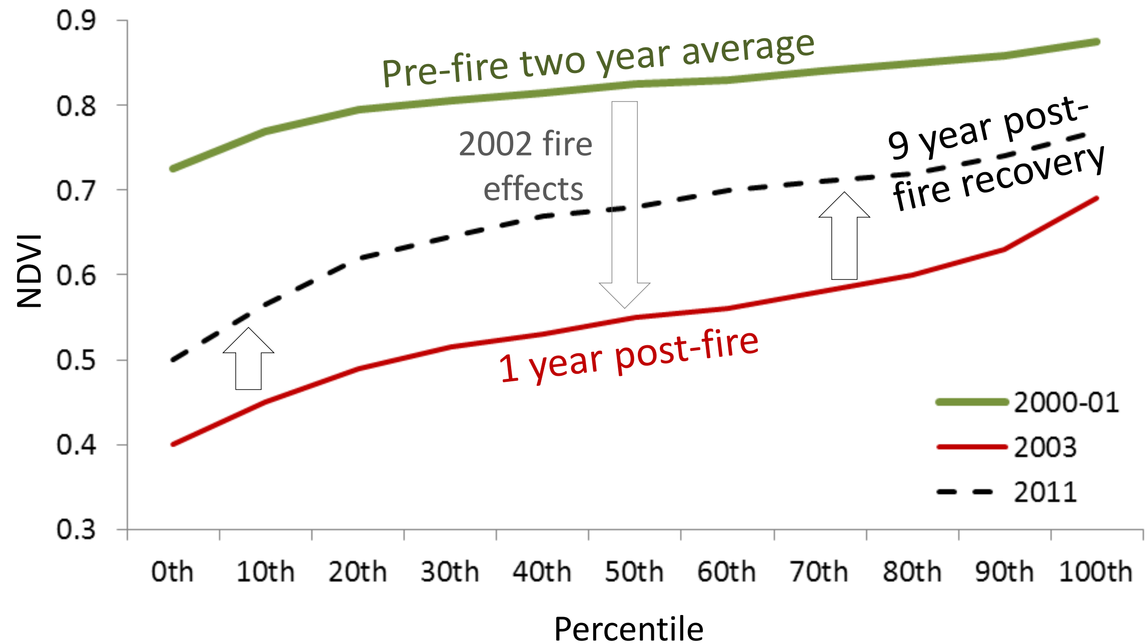


In the red, 37,288 pixels are averaged (y) for each of 552 periods (x). This is 20,582,976 values.

PART IV—Predicting long-term fire effects

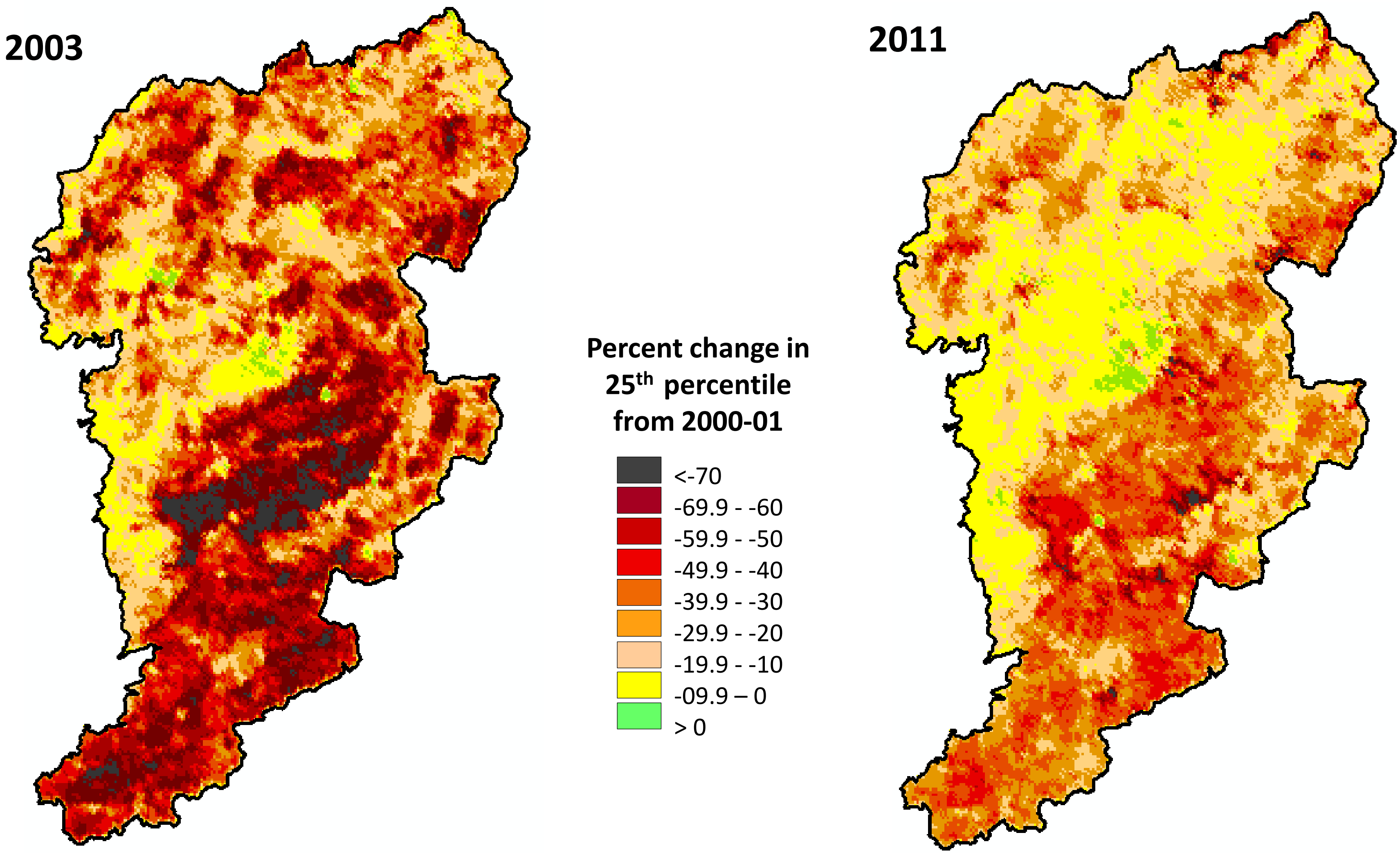
Change over time across percentiles of the annual NDVI distribution for the **BISCUIT FIRE**





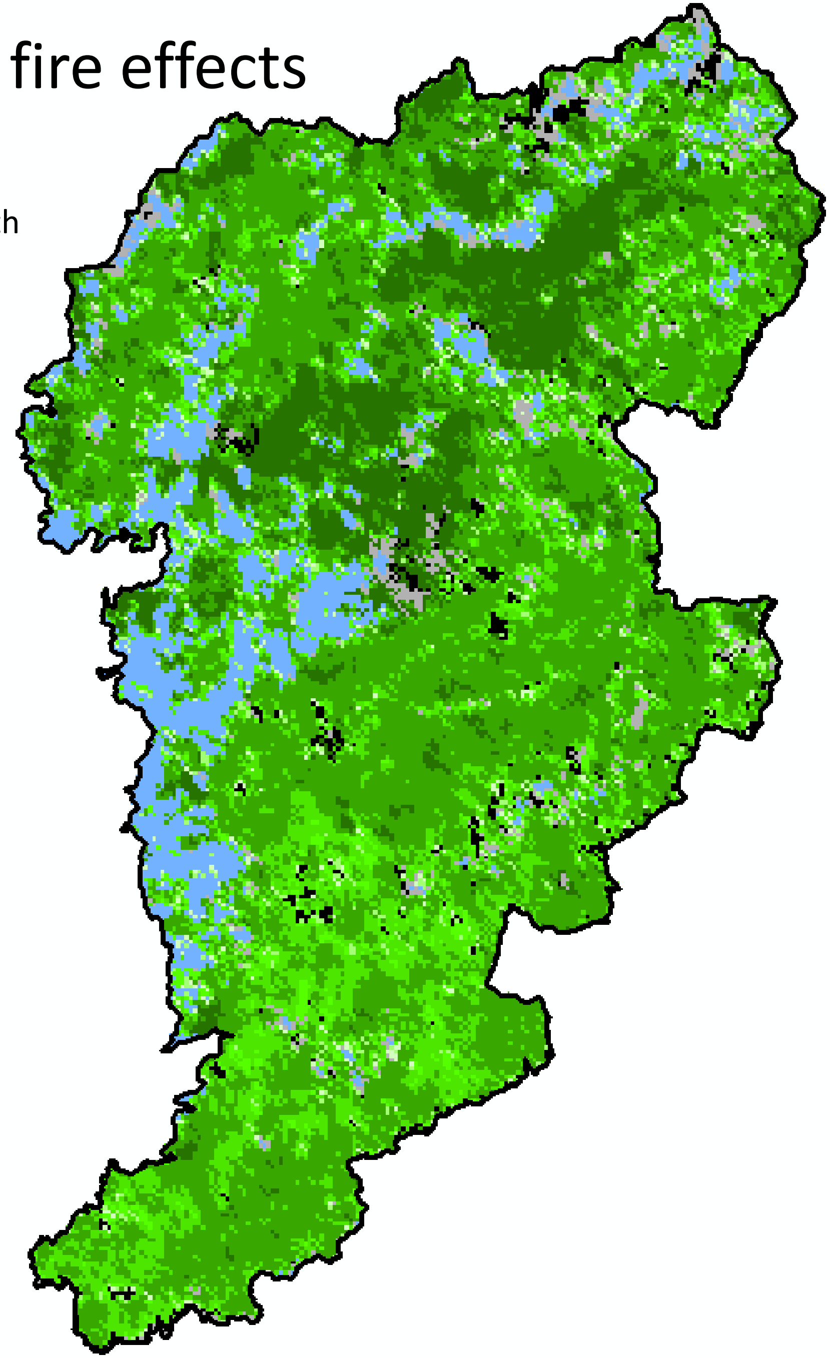
PART IV—Predicting long-term fire effects

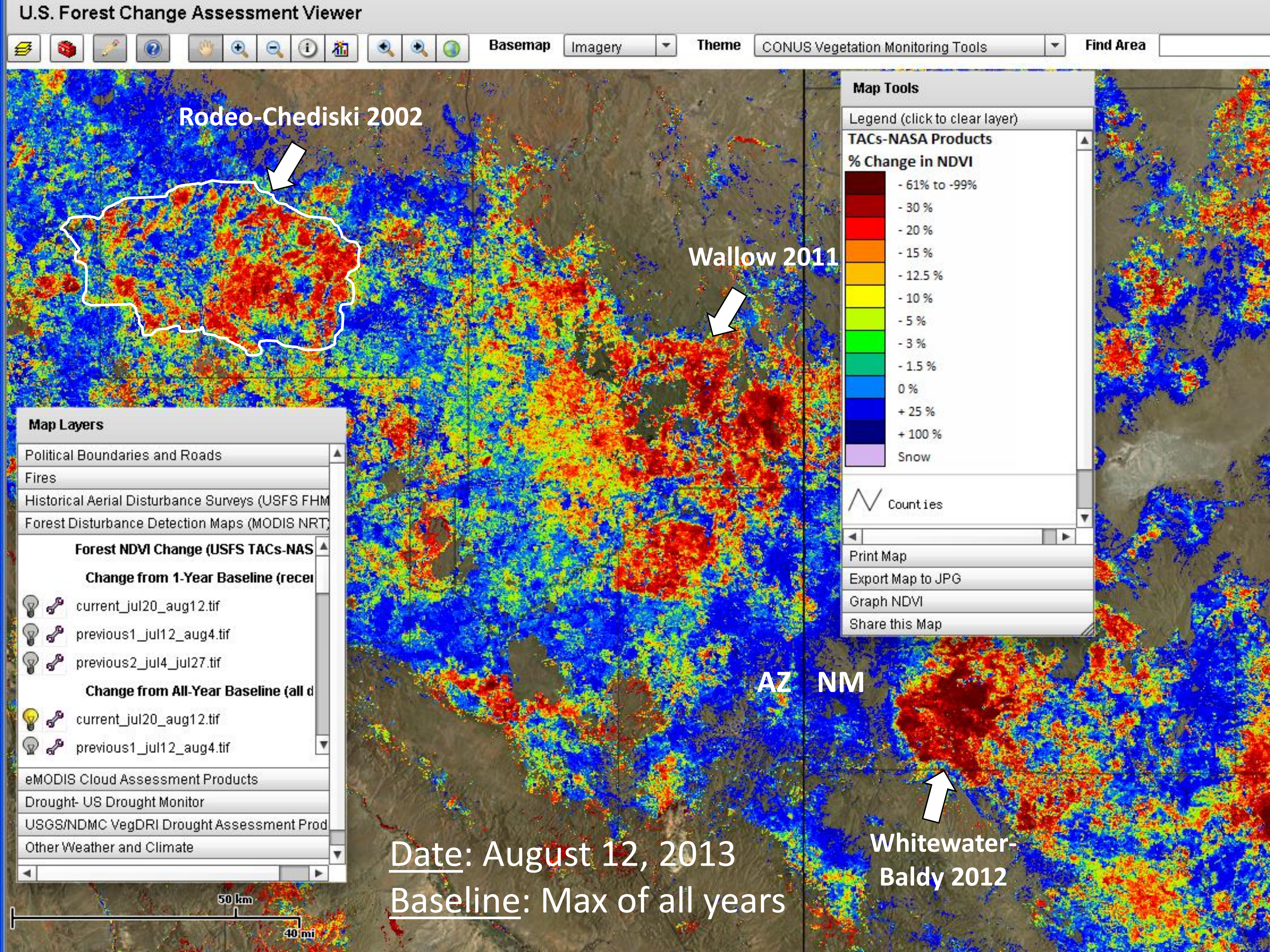
Percent change in the Evergreen Fraction for the 2002 **BISCUIT FIRE**



PART IV—Predicting long-term fire effects

Predicted years to NDVI recovery for the **BISCUIT FIRE** based on change in the 50th percentile of calendar year distributions (annual medians), 2004-2011




U.S. Forest Change Assessment Viewer
Basemap
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Find Area
Rodeo-Chediski 2002
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0 %
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+ 100 %
Snow
Counties
Print Map
Export Map to JPG
Graph NDVI
Share this Map
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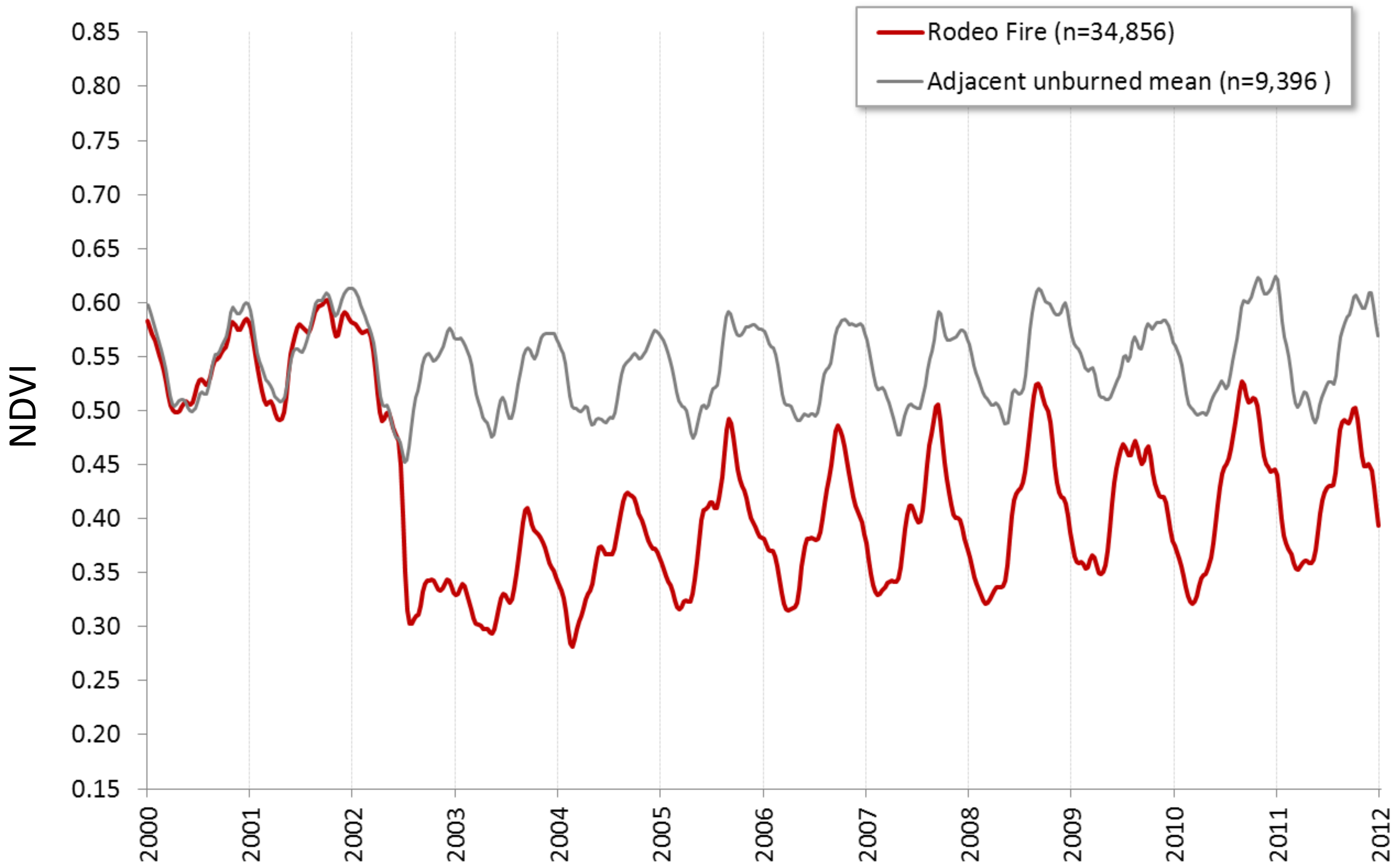
Forest NDVI Change (USFS TACs-NAS
Change from 1-Year Baseline (recei
current_jul20_aug12.tif
previous1_jul12_aug4.tif
previous2_jul4_jul27.tif
Change from All-Year Baseline (all d
current_jul20_aug12.tif
previous1_jul12_aug4.tif
eMODIS Cloud Assessment Products
Drought- US Drought Monitor
USGS/NDMC VegDRI Drought Assessment Prod
Other Weather and Climate
AZ
NM
50 km
40 mi
Whitewater-Baldy 2012
Date: August 12, 2013
Baseline: Max of all years

PART IV—Predicting long-term fire effects

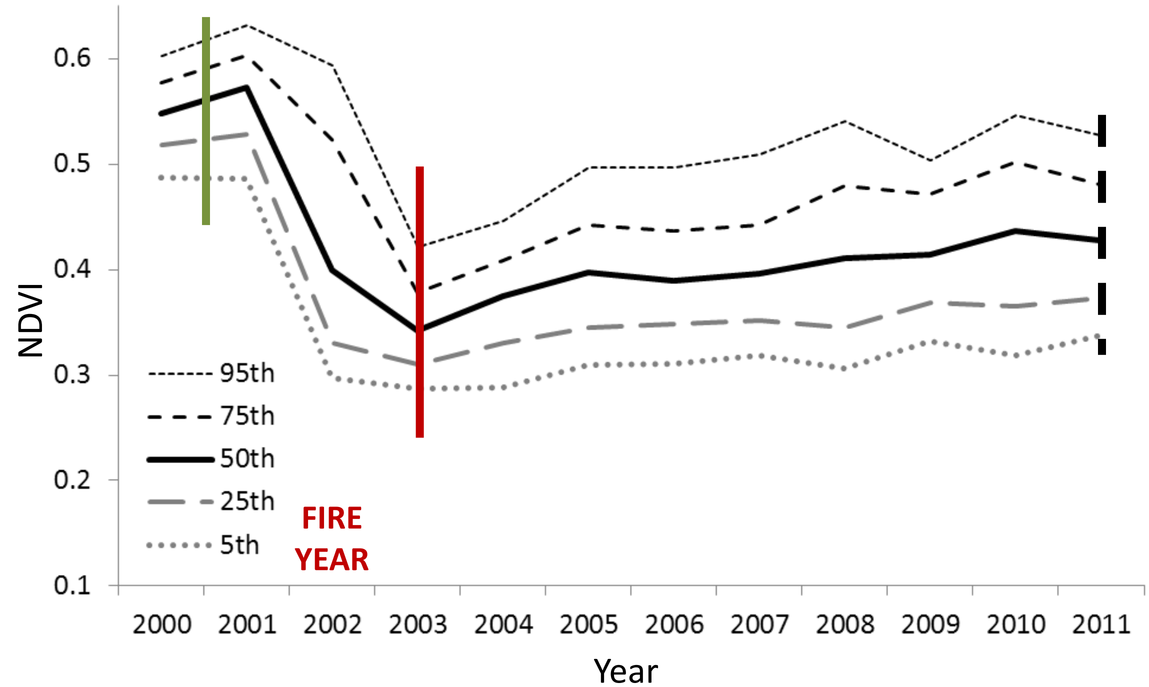
Mean observed MODIS NDVI for the **RODEO-CHEDISKI FIRE** and adjacent lands

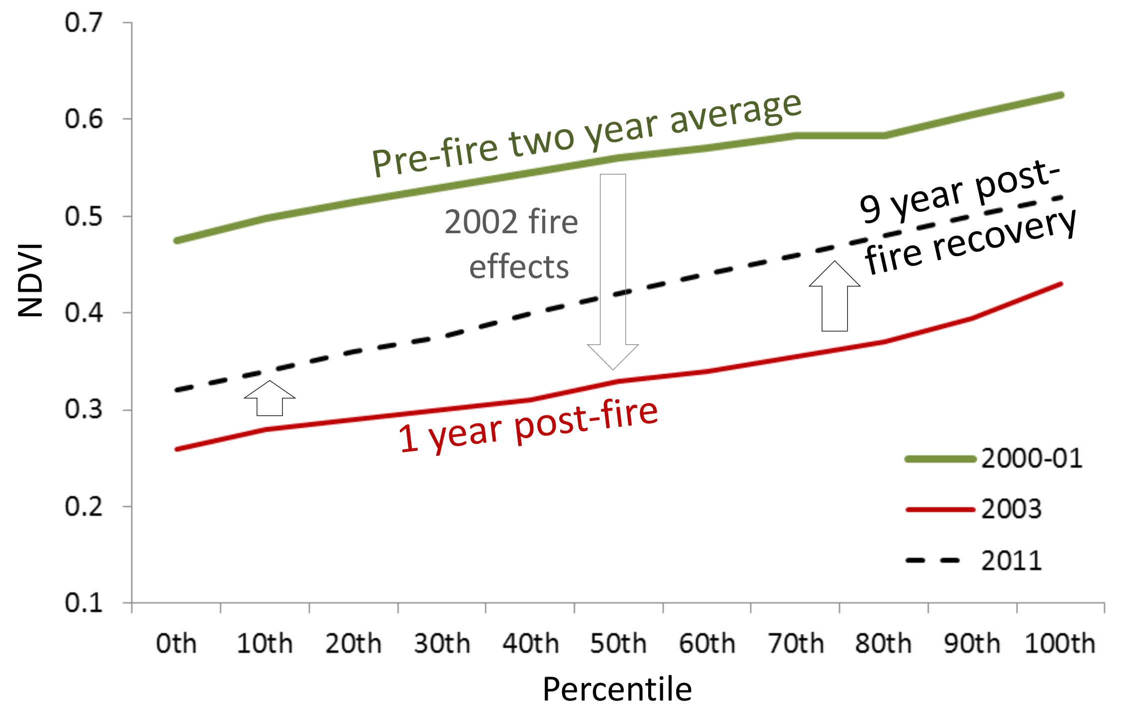


Note: For only this one of the three fires, adjacent unburned values were not simply from the grid box surrounding the fire, but only those cells with mean 2000-01 values GTE 0.50 because areas within the box of this fire include low elevation grasslands, not mountain forests. Without this, the mean of the adjacent is close to 0.45 not 0.55 as it is with this selective adjustment.

PART IV—Predicting long-term fire effects

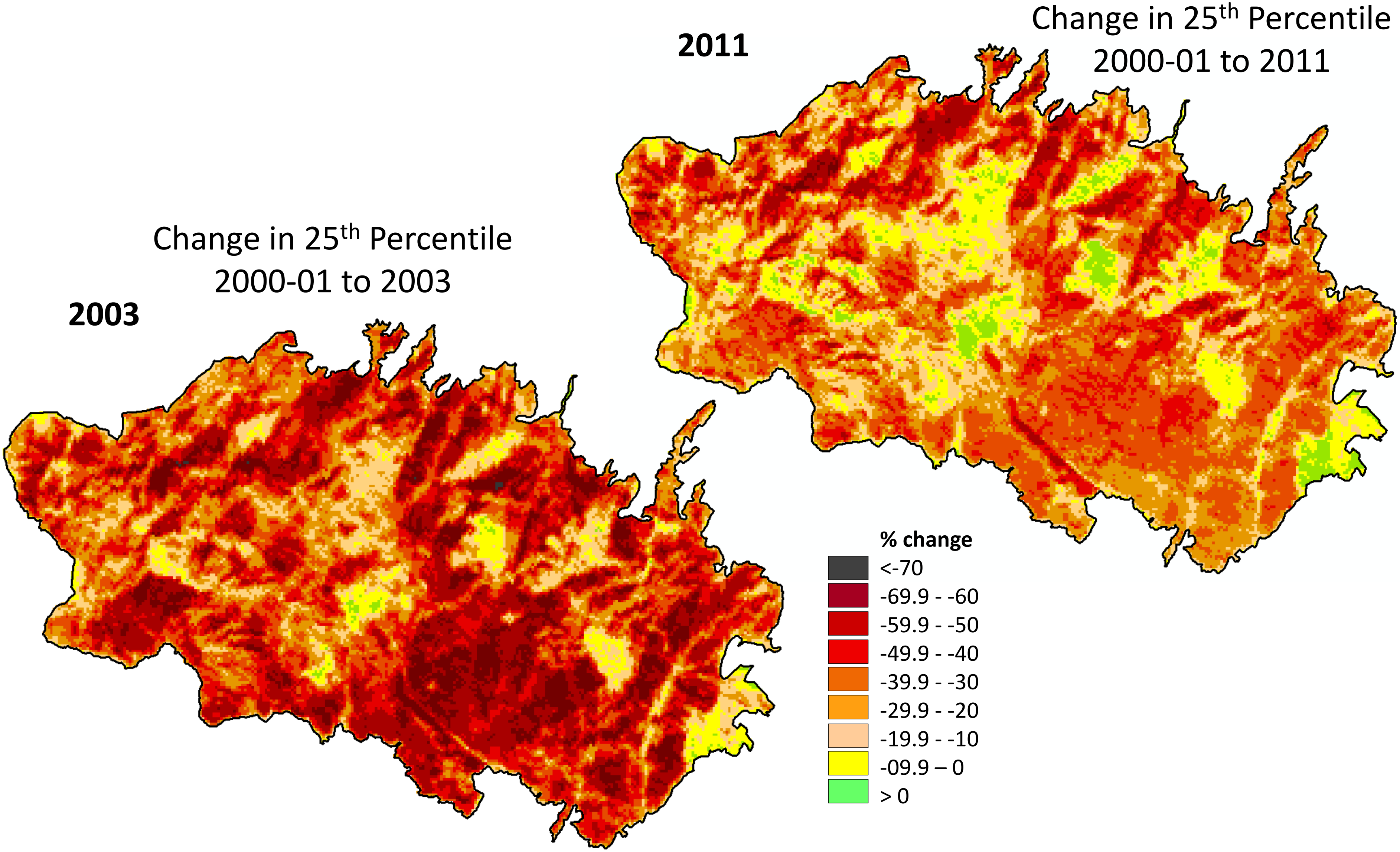
Change over time across percentiles of the annual NDVI distribution for the **RODEO-CHEDISKI FIRE**





PART IV—Predicting long-term fire effects

Percent change in the Evergreen Fraction for the 2002 RODEO-CHEDISKI FIRE



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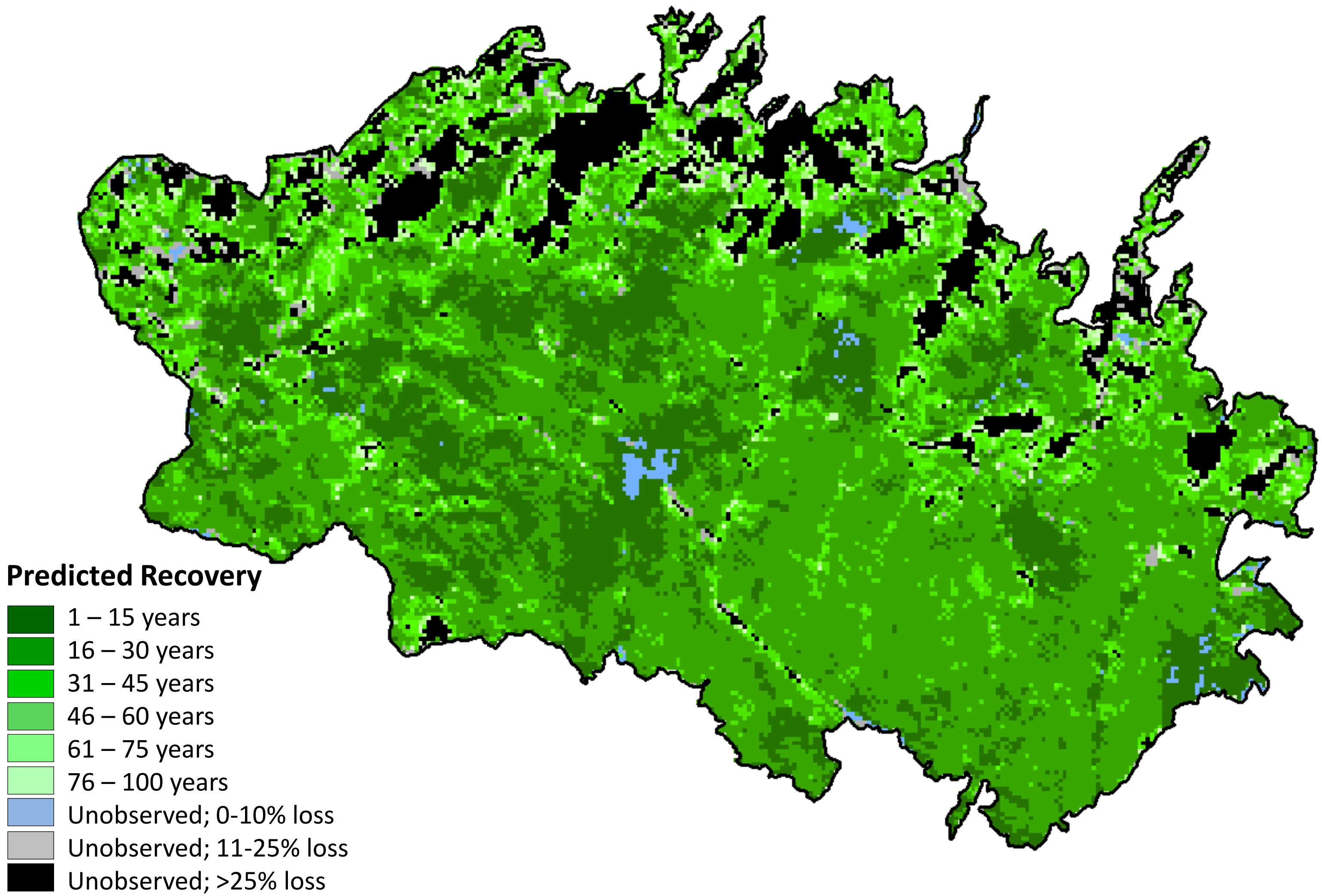
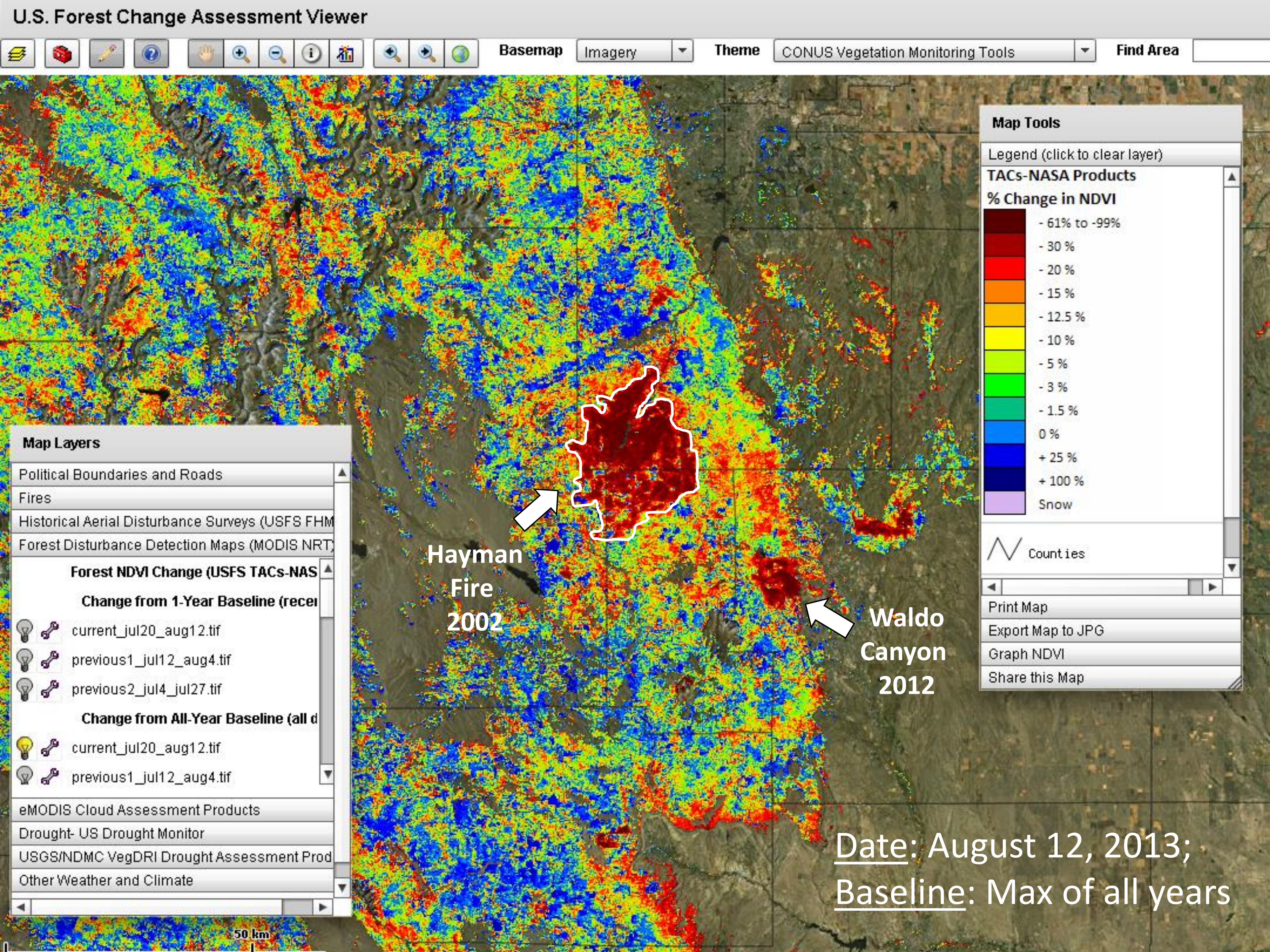
Predicted years to NDVI recovery for the **RODEO-CHEDISKI FIRE** based on change in the 50th percentile of calendar year distributions (annual medians), 2004-2011





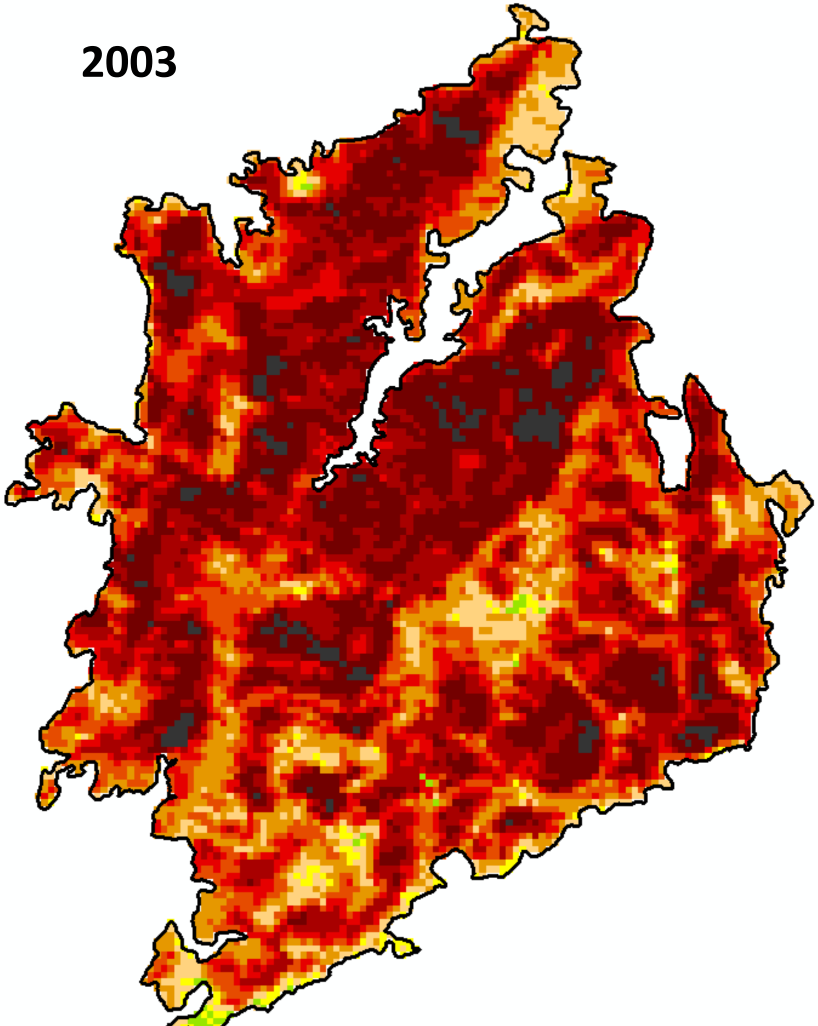
U.S. Forest Change Assessment Viewer
Basemap
Imagery
Theme
CONUS Vegetation Monitoring Tools
Find Area
Map Tools
Legend (click to clear layer)
TACs-NASA Products
% Change in NDVI
- 61% to -99%
- 30 %
- 20 %
- 15 %
- 12.5 %
- 10 %
- 5 %
- 3 %
- 1.5 %
0 %
+ 25 %
+ 100 %
Snow
Count ies
Print Map
Export 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
Hayman Fire 2002
Waldo Canyon 2012
Date: August 12, 2013;
Baseline: Max of all years

PART IV—Predicting long-term fire effects

Percent change in the Evergreen Fraction for the 2002 **HAYMAN FIRE**

Change in 25^{th} Percentile
2000-01 to 2003

2003

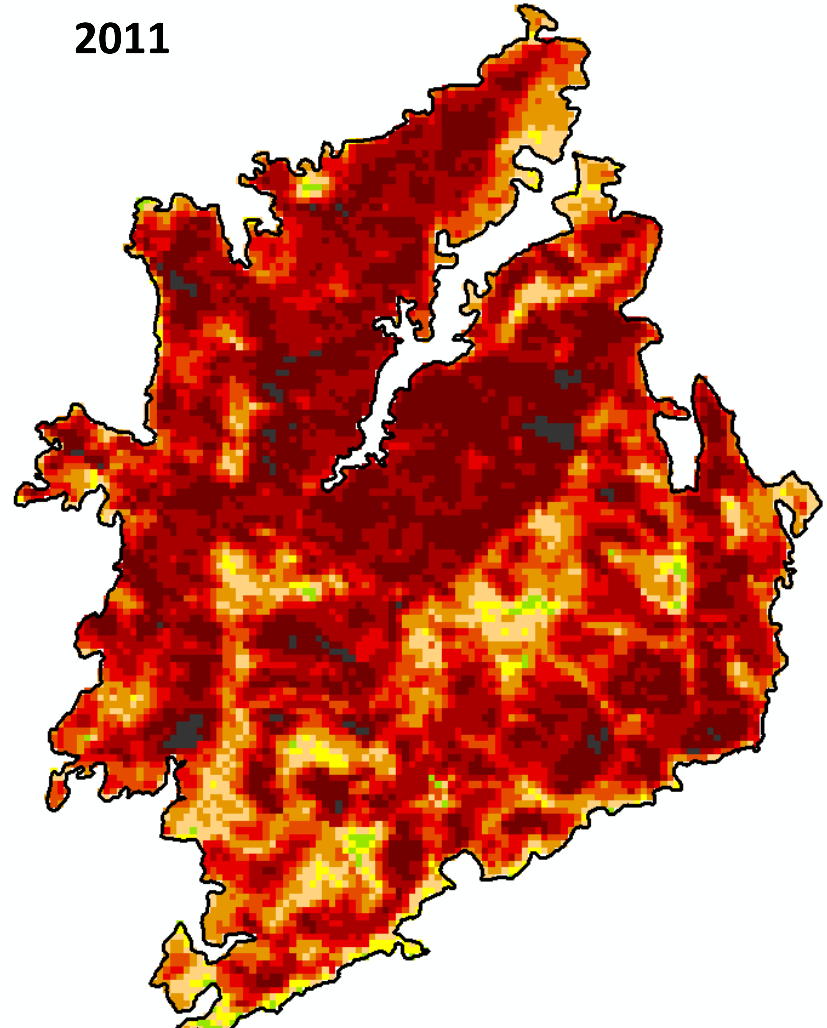


% change

- <-70
- -69.9 - -60
- -59.9 - -50
- -49.9 - -40
- -39.9 - -30
- -29.9 - -20
- -19.9 - -10
- -09.9 – 0
- > 0

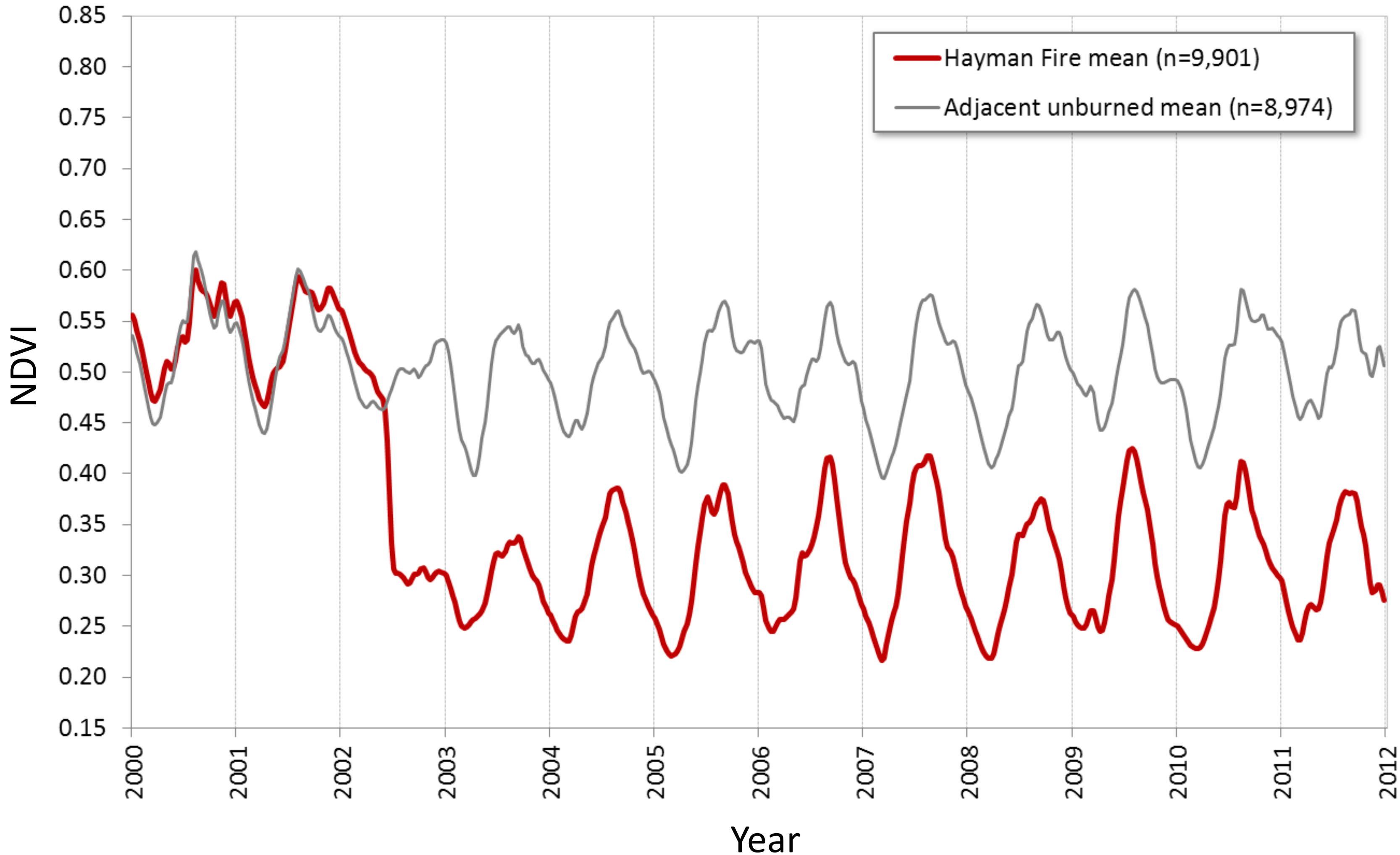
Change in 25^{th} Percentile
2000-01 to 2011

2011



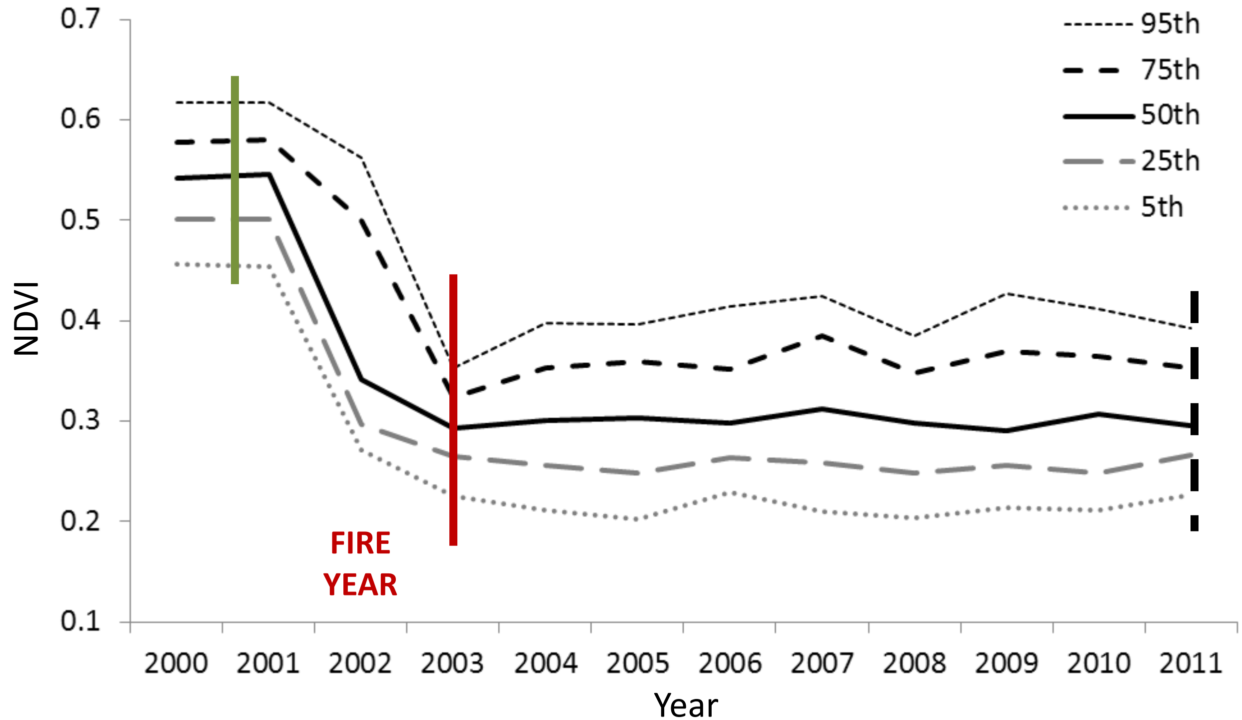
PART IV—Predicting long-term fire effects

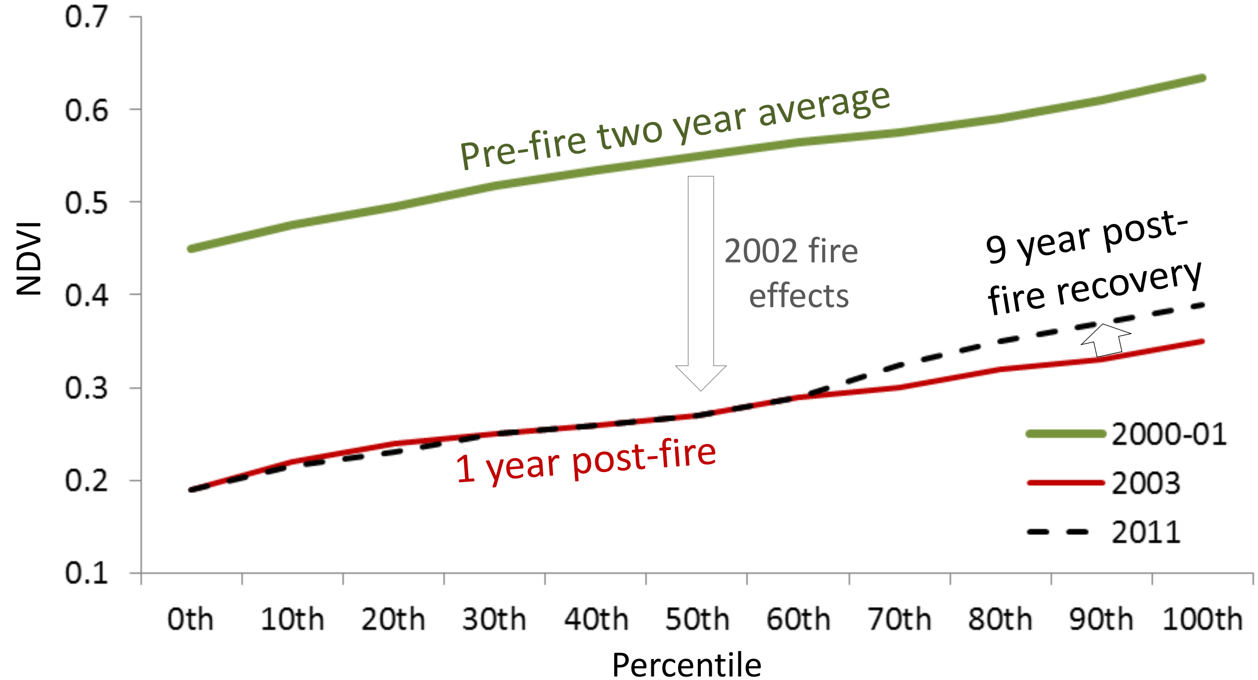
Mean MODIS NDVI for the 2002 **HAYMAN FIRE** and adjacent lands



PART IV—Predicting long-term fire effects

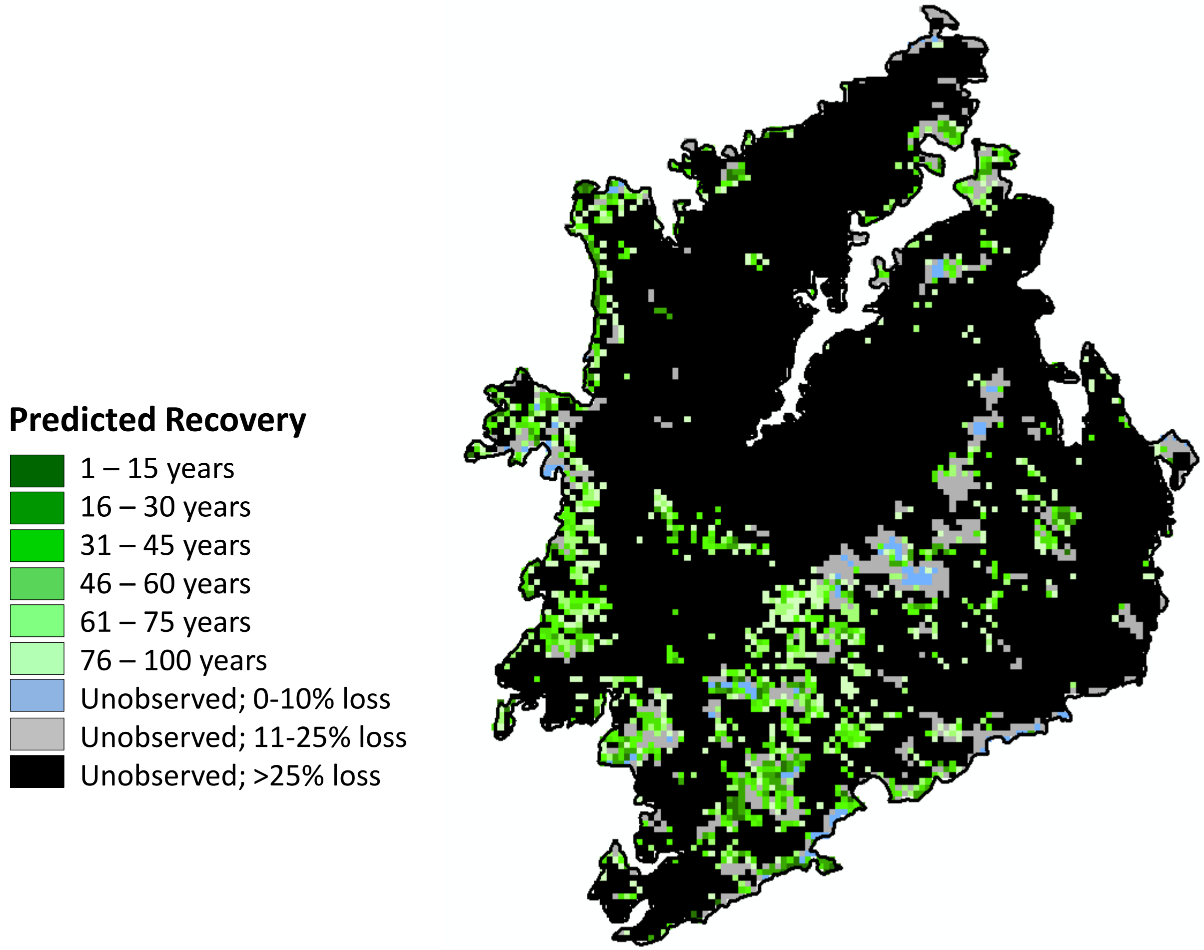
Change over time across percentiles of the annual NDVI distribution for the **HAYMAN FIRE**, Colorado.





PART IV—Predicting long-term fire effects

Predicted years to NDVI recovery for the **HAYMAN FIRE** based on change in the 50th percentile of calendar year distributions (annual medians), 2004-2011



"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