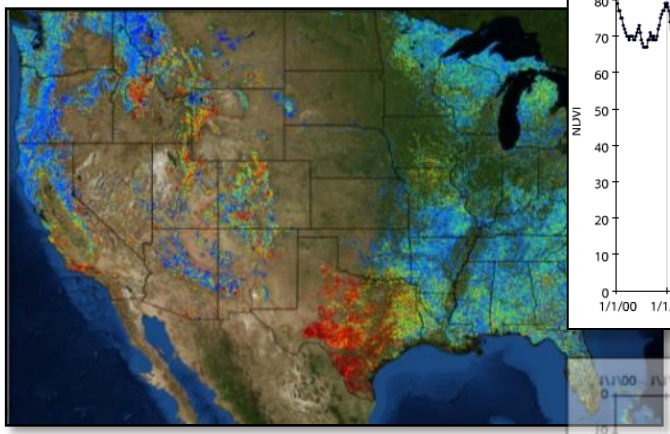
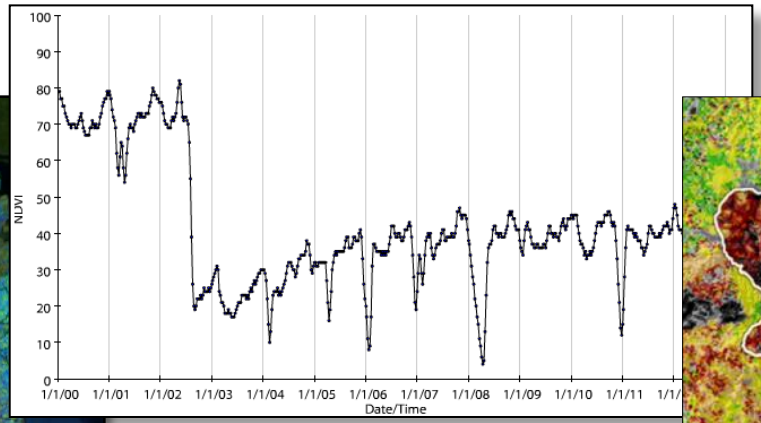
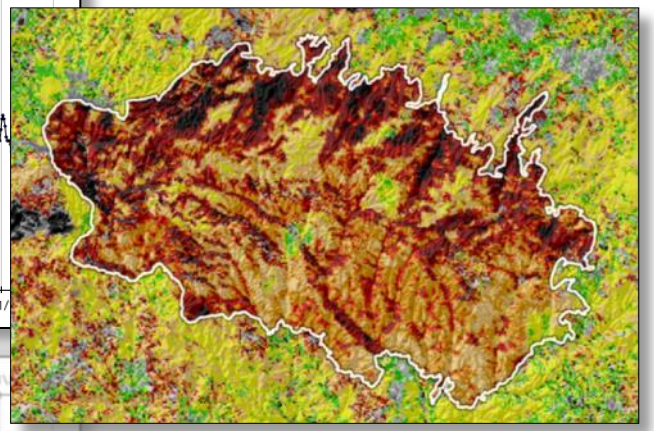






Five Applications of the *ForWarn* System for Wildland Fire Management

Wildland Fire Management Research, Development, and Application Program
USDA Forest Service Rocky Mountain Research Station
May 1, 2014

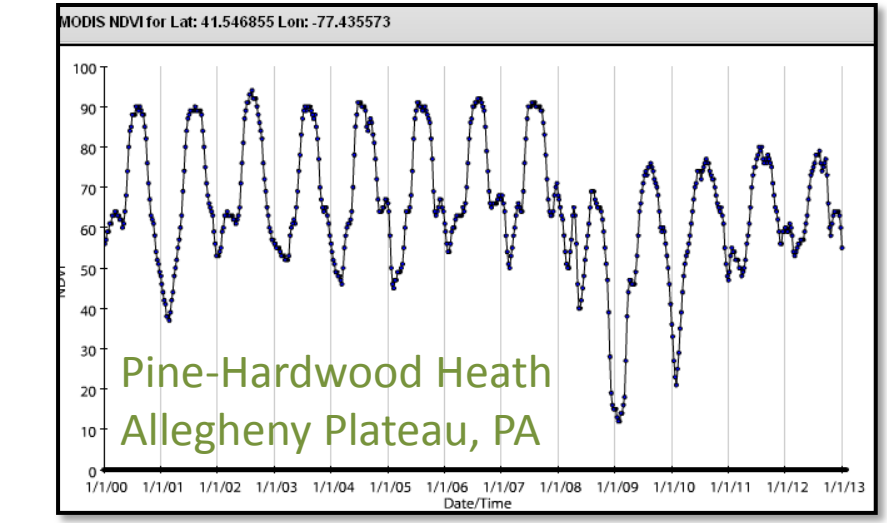
Steven P. Norman
William W. Hargrove
William M. Christie
Danny C. Lee

Eastern Threat Assessment Center

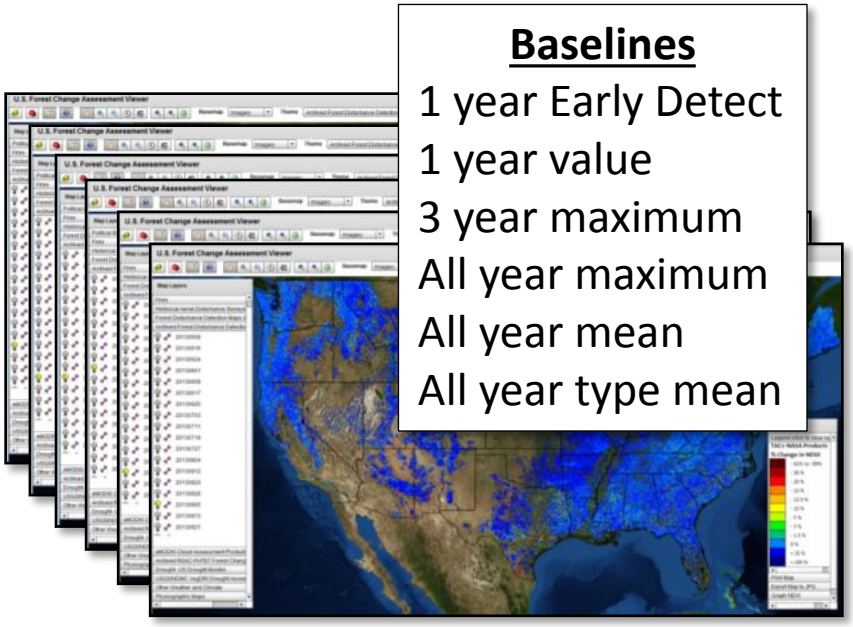
"Praemonitus Praemunitus"

ForWarn

Satellite-Based Change Recognition and Tracking

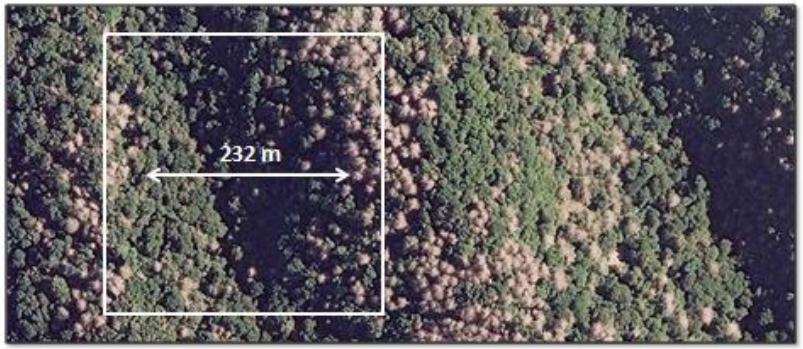


- Normalized Difference Vegetation Index (NDVI) from daily eMODIS and MODIS
- 232 meter resolution
- 46 periods per year (8-day intervals)
- Max value of 24-day moving window
- 2000 to present historical database
- Includes NDVI time series and change maps
- Online: http://forwarn.forestthreats.org

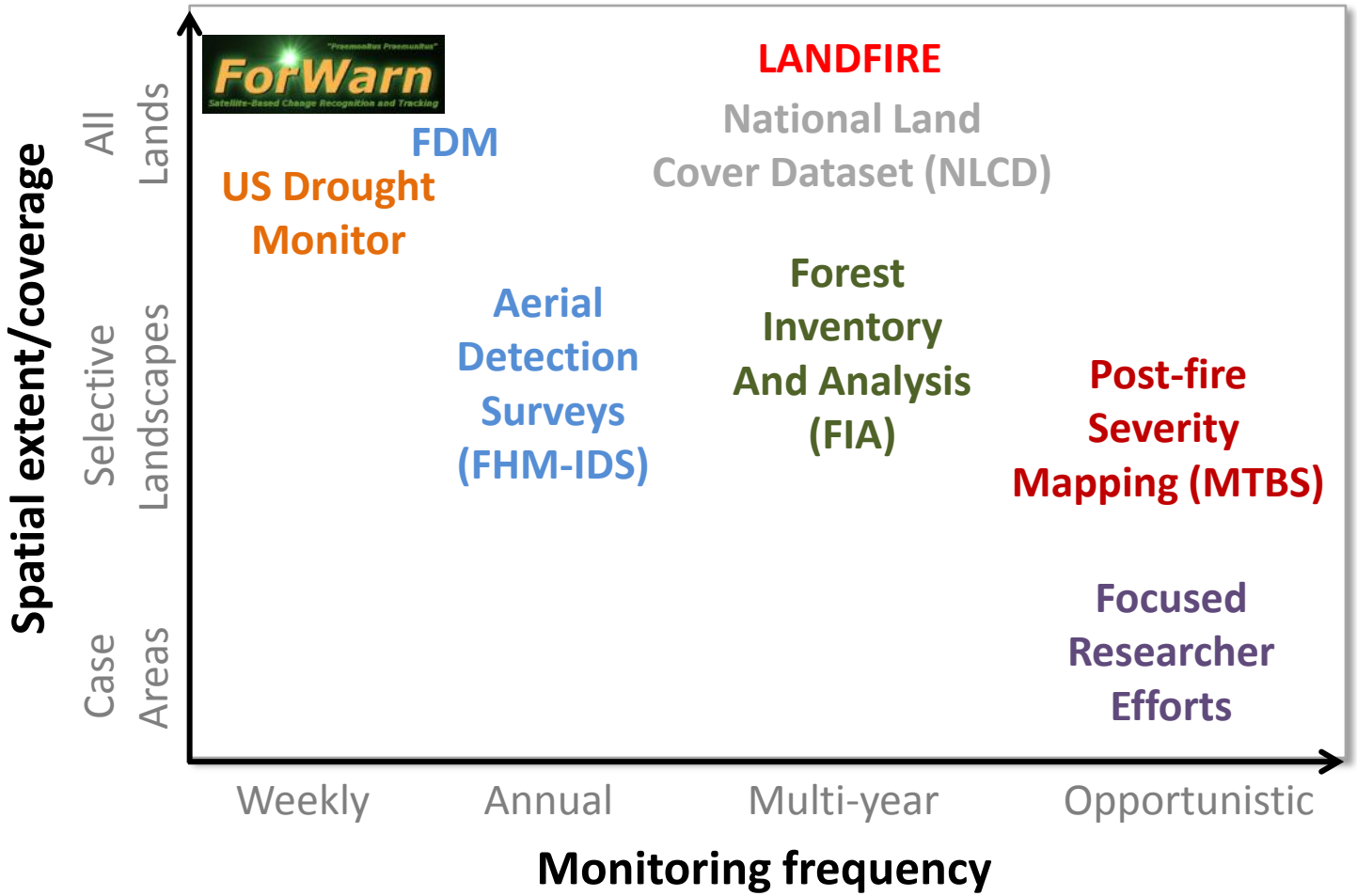


Baselines

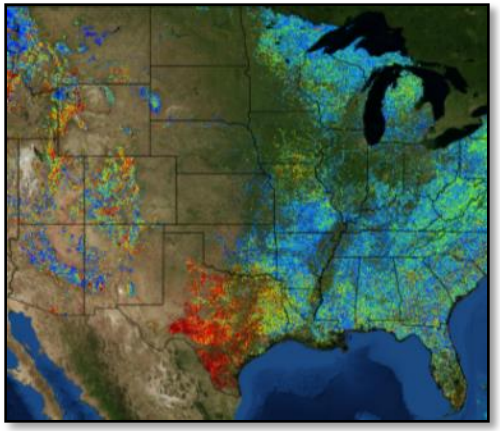
1 year Early Detect
1 year value
3 year maximum
All year maximum
All year mean
All year type mean



Existing approaches to wildland landscape and disturbance monitoring in the conterminous United States



Five Applications of the *ForWarn* System for Monitoring, Assessment and Prediction



1. Near-real-time disturbance detection
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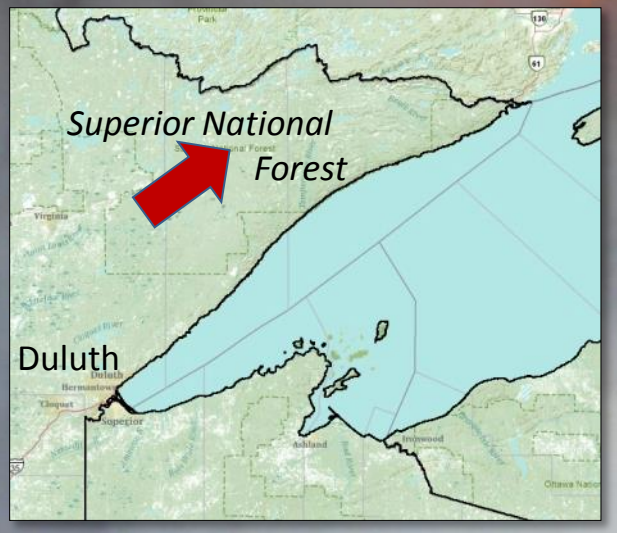
Near real time disturbance detection

Pagami Creek Fire, Superior National Forest MN

Ignition date: Aug. 18, 2011
Cause: Lightning
Primary growth: Sep. 5-16, 2011
Area burned: 92,700 acres



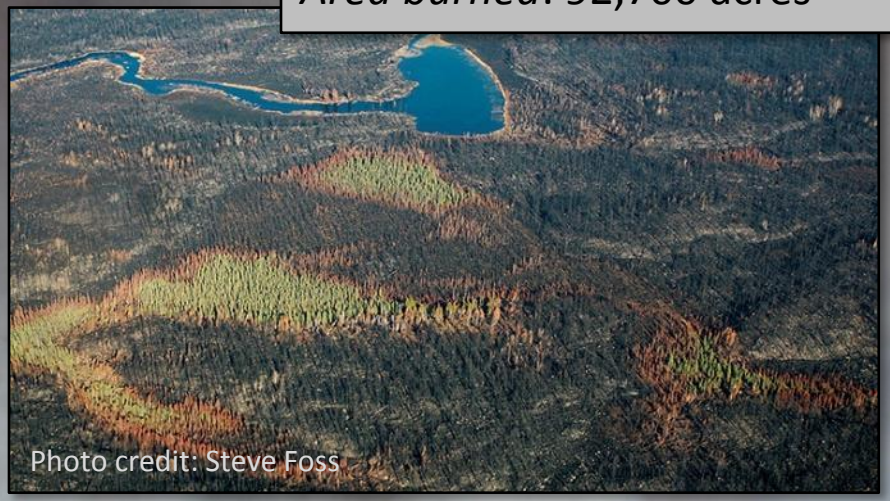
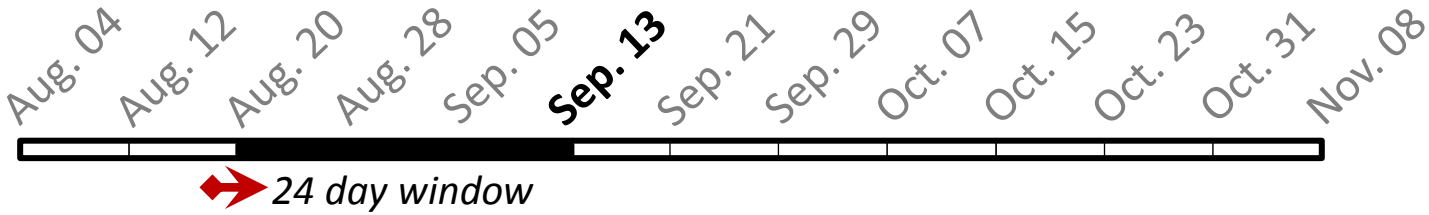


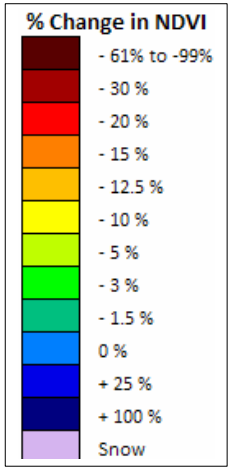
Photo credit: Steve Foss

Photo credit: USGS / Hans Martin

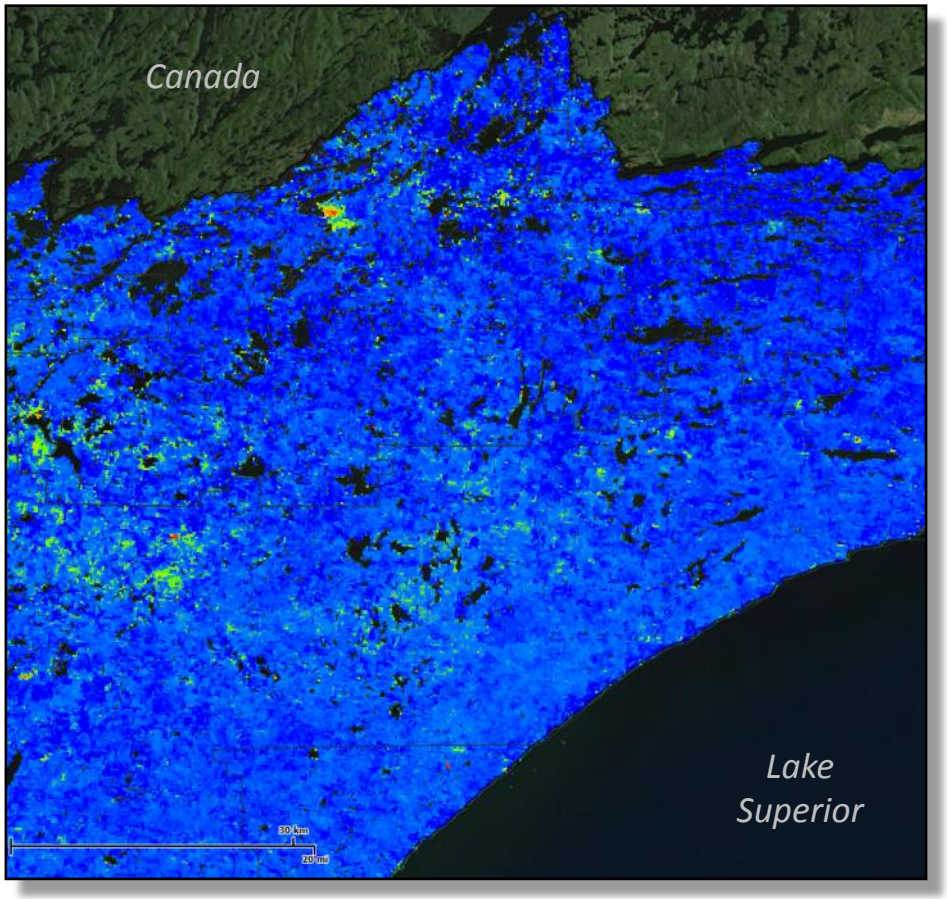
Near real time disturbance detection

Pagami Creek Fire, Superior National Forest MN

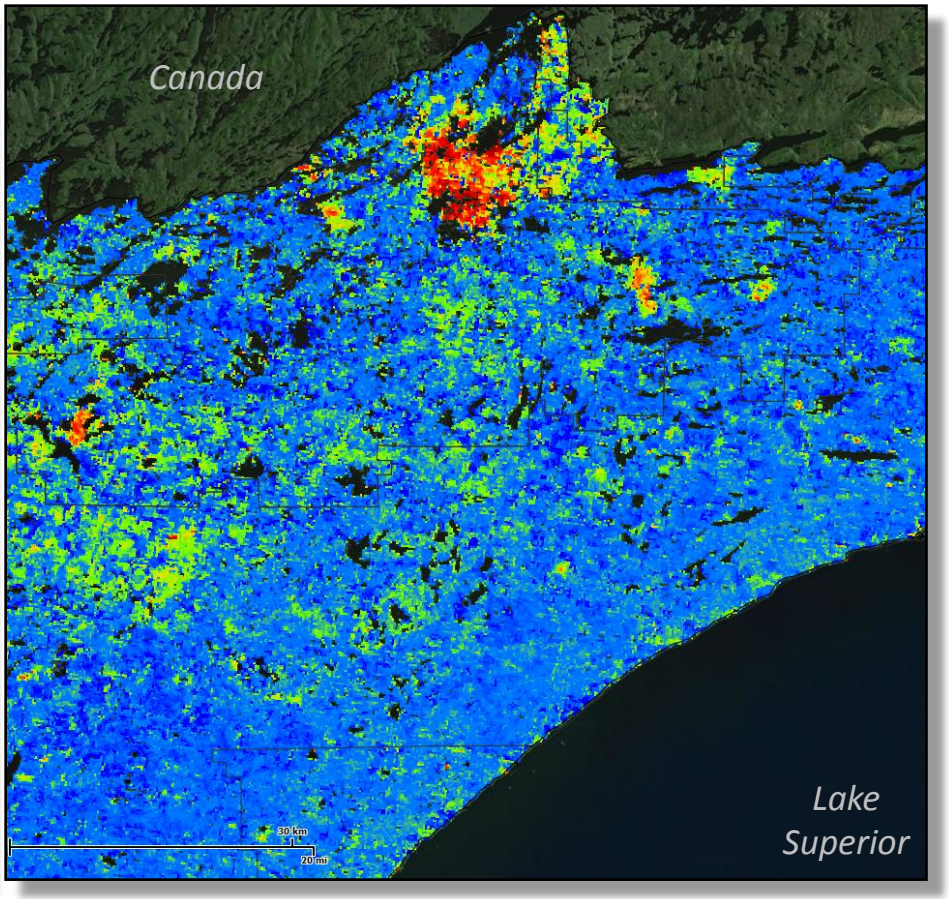




1 Year Baseline

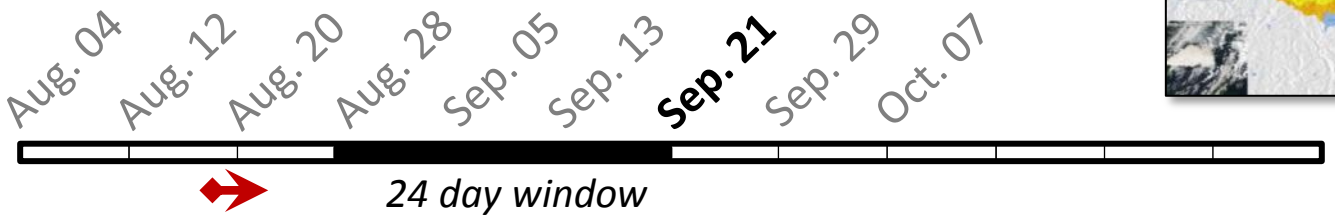


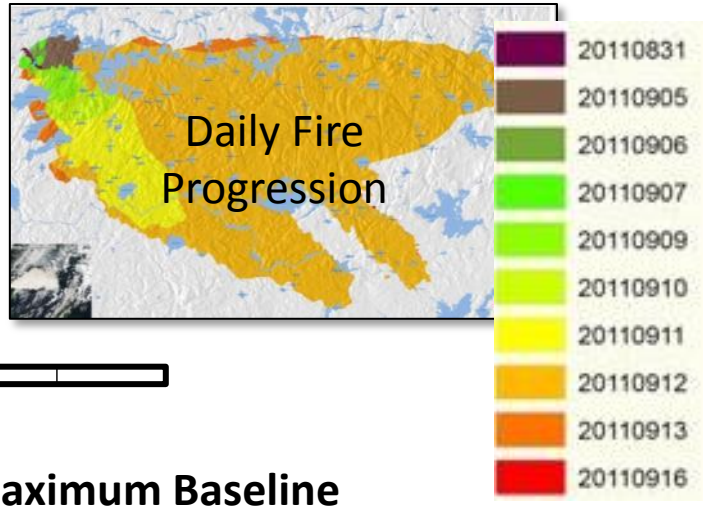
All Year Maximum Baseline



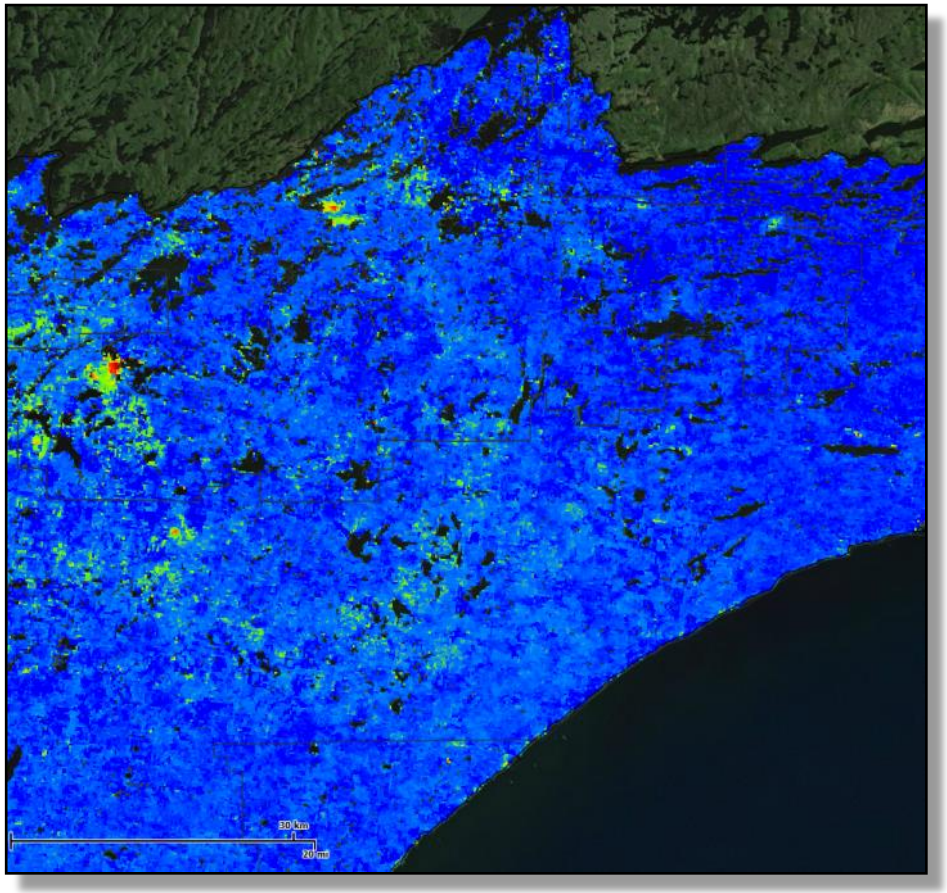
Near real time disturbance detection

Pagami Creek Fire, Superior National Forest MN

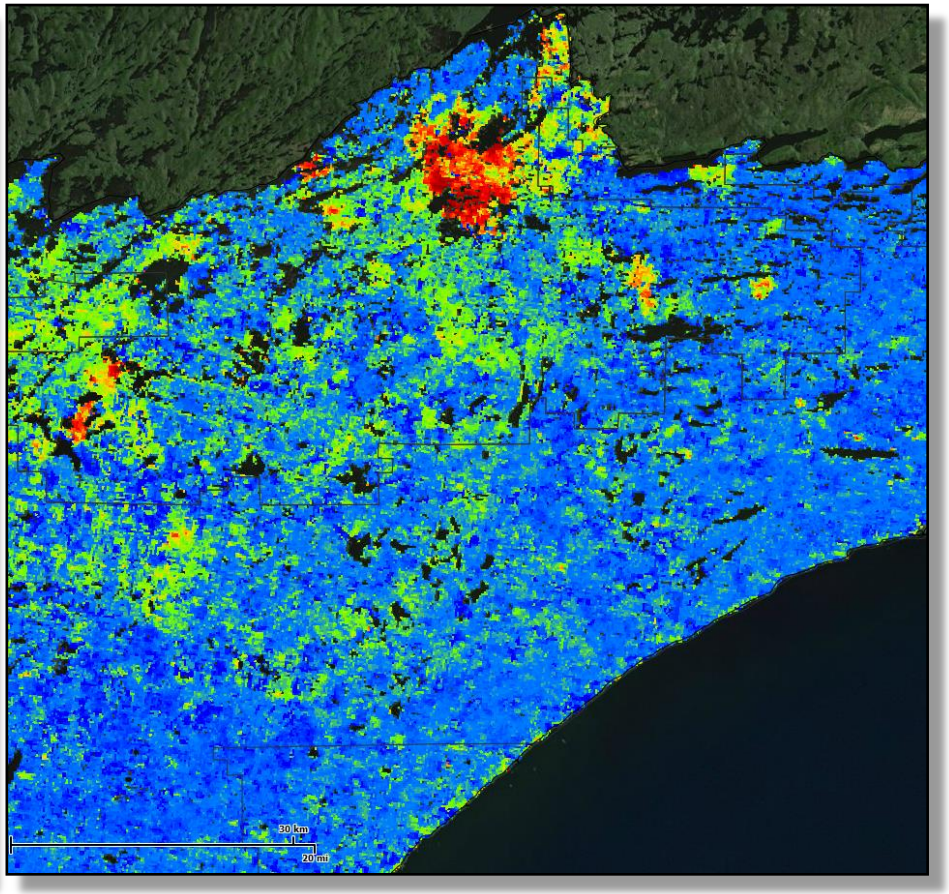




1 Year Baseline

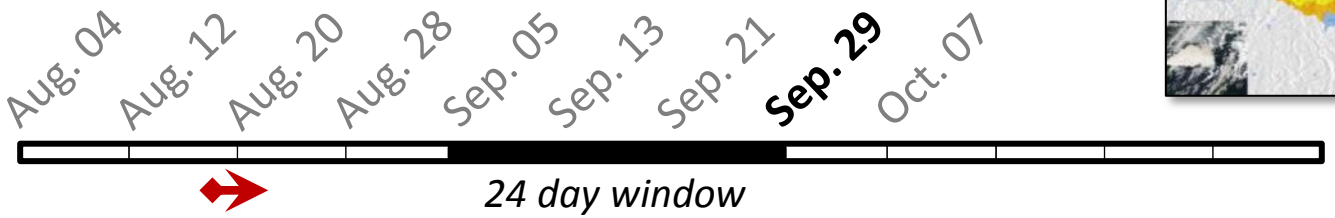


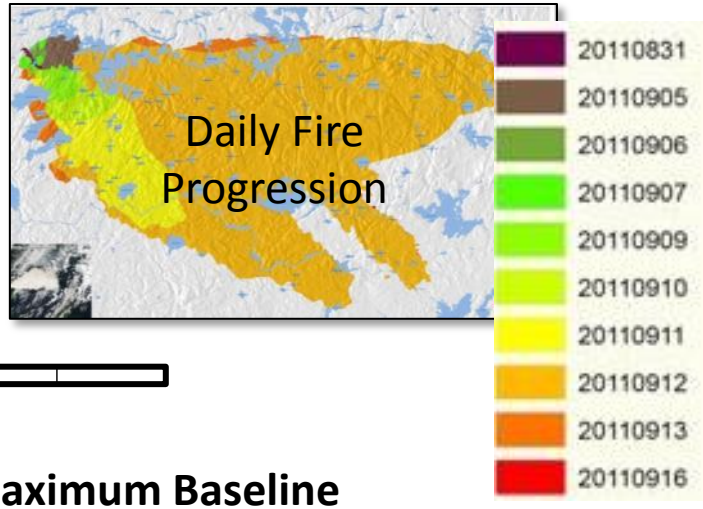
All Year Maximum Baseline



Near real time disturbance detection

Pagami Creek Fire, Superior National Forest MN





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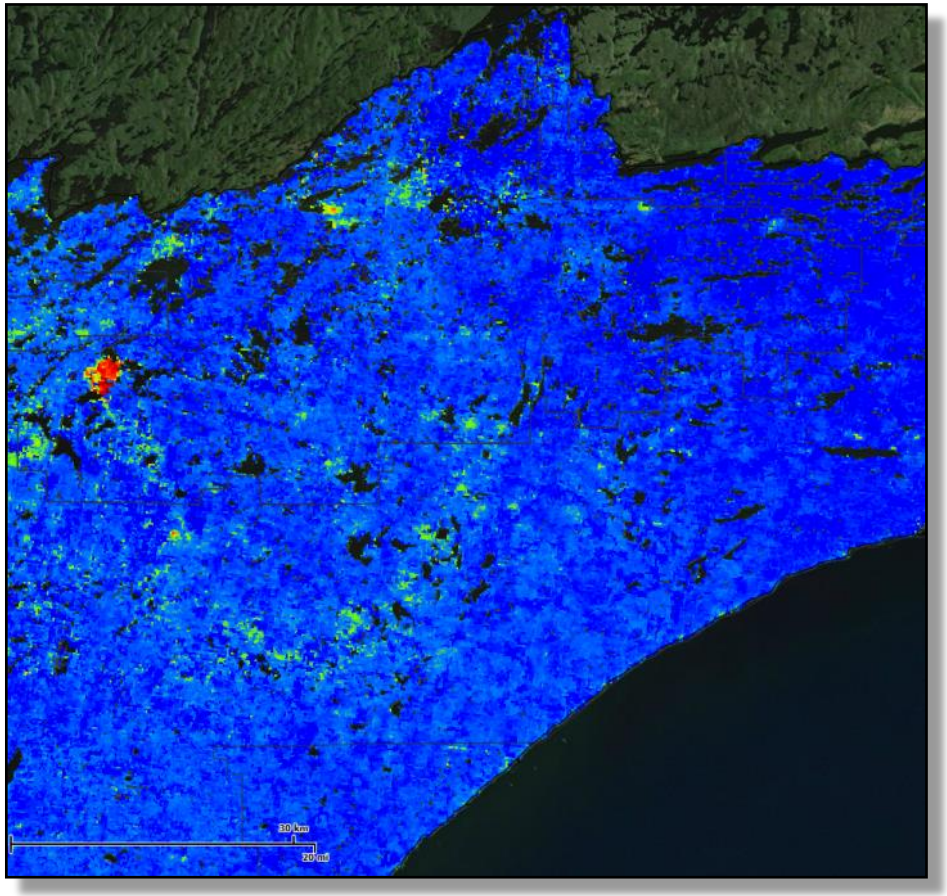

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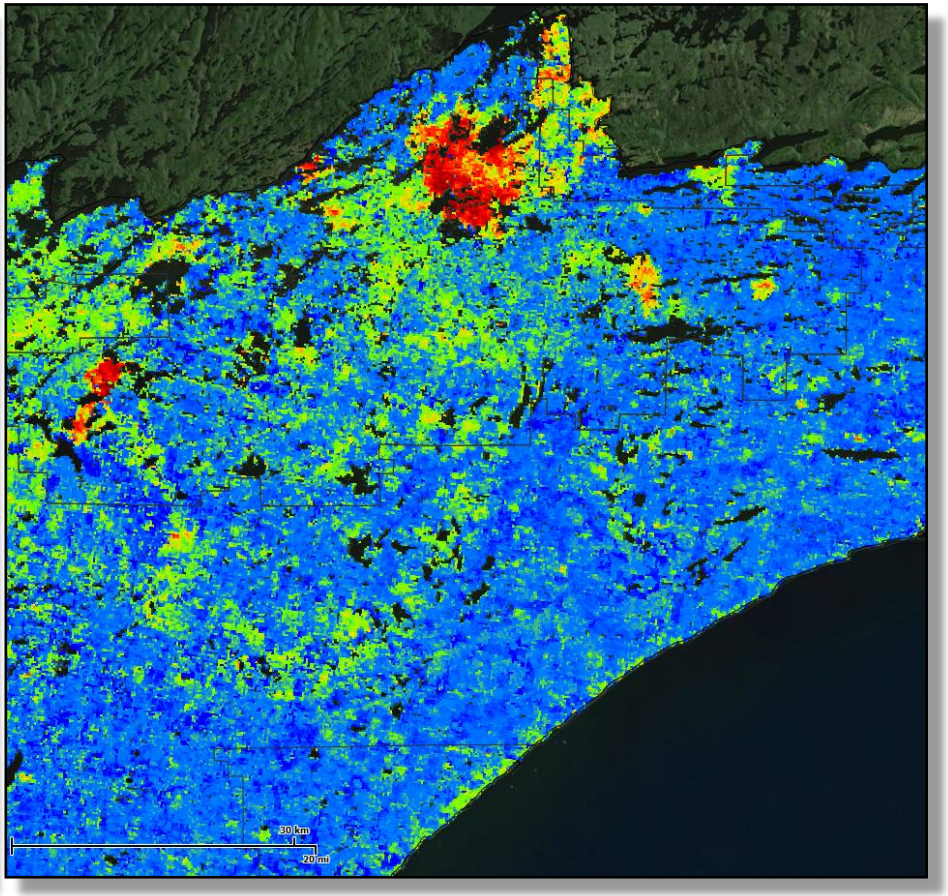
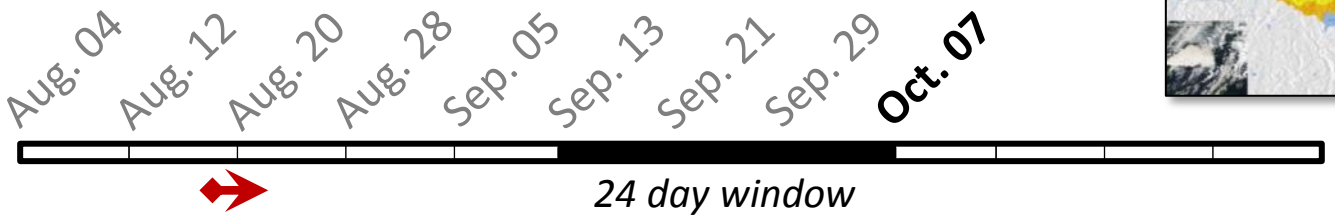
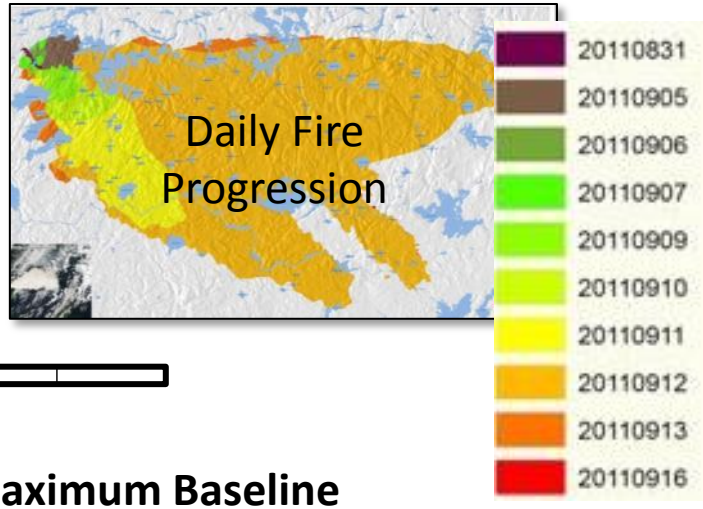


Near real time disturbance detection

Pagami Creek Fire, Superior National Forest MN





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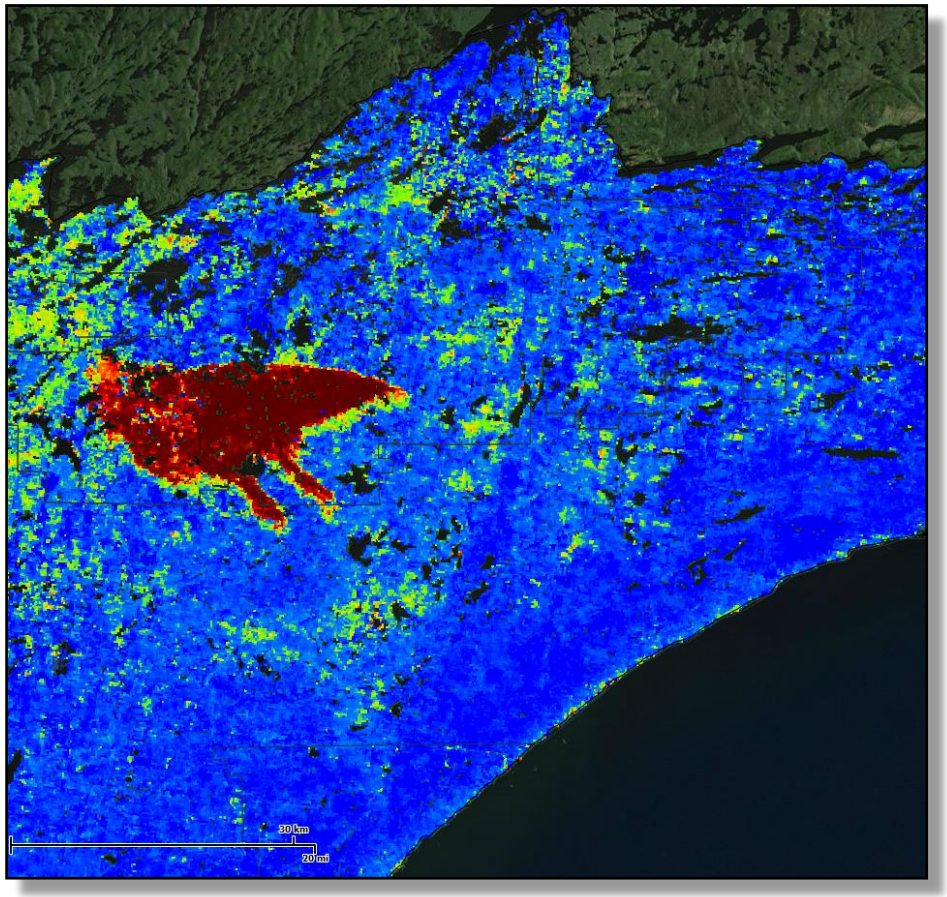

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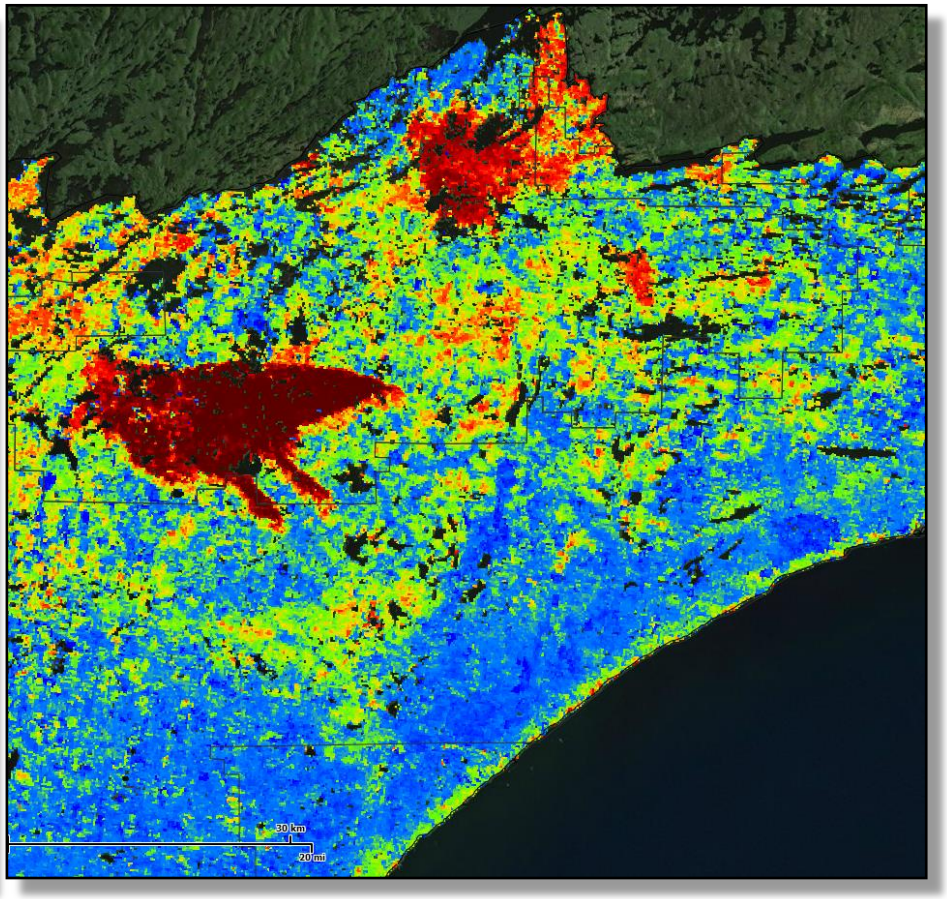
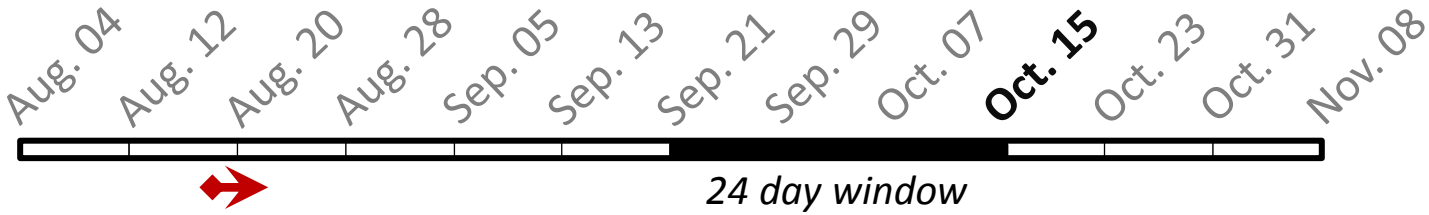
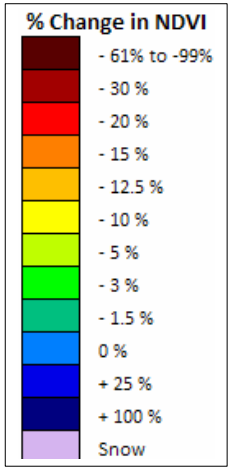


Near real time disturbance detection

Pagami Creek Fire, Superior National Forest MN





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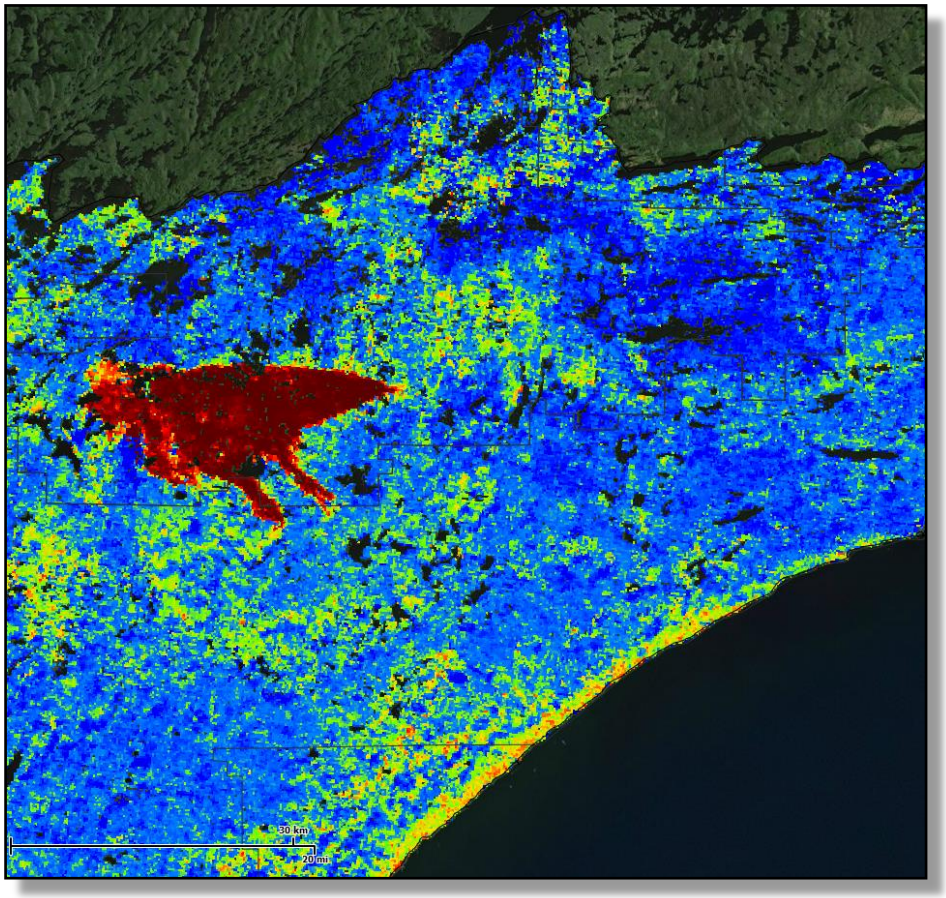

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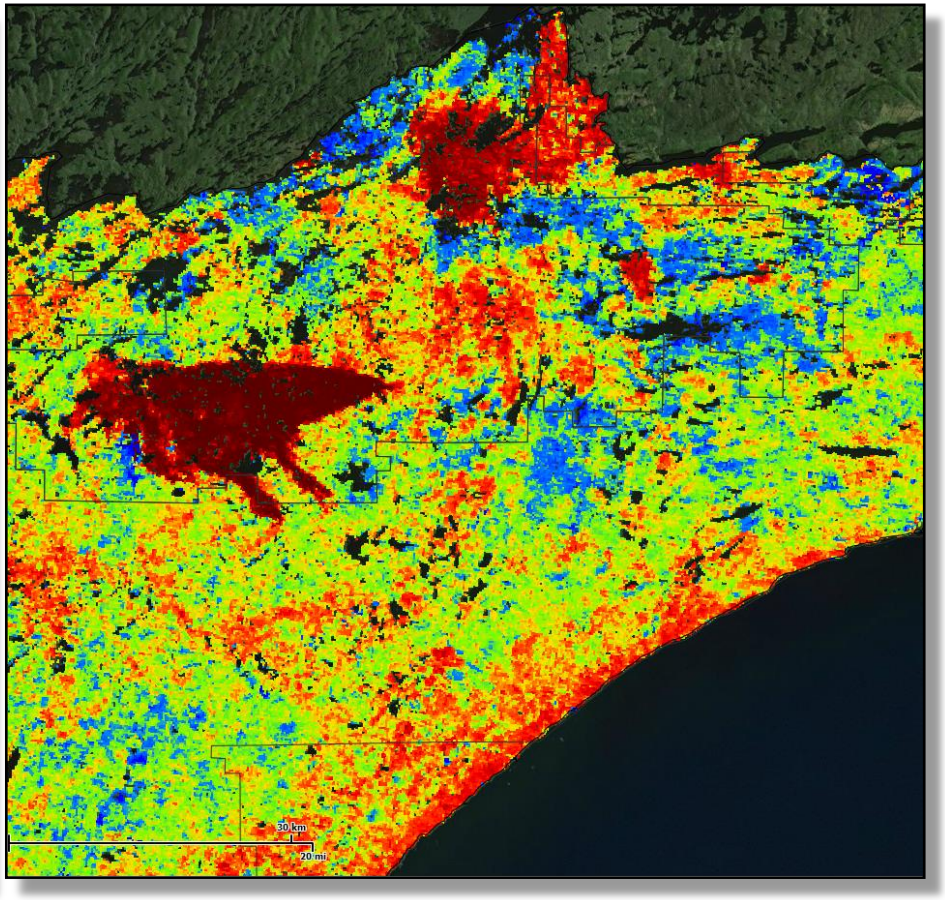

Near real time disturbance detection

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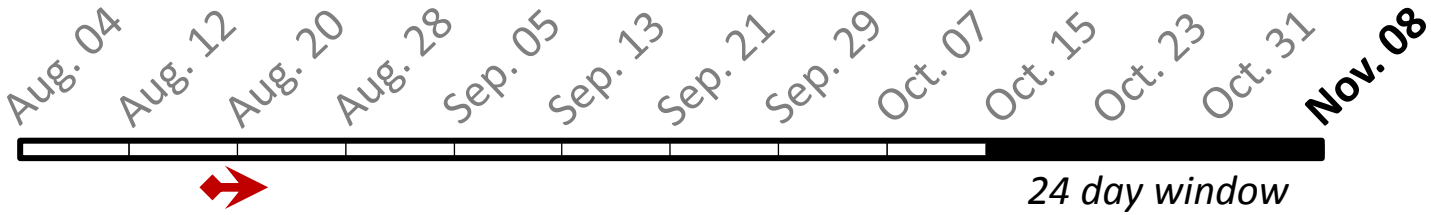

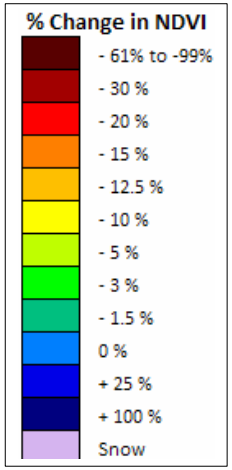

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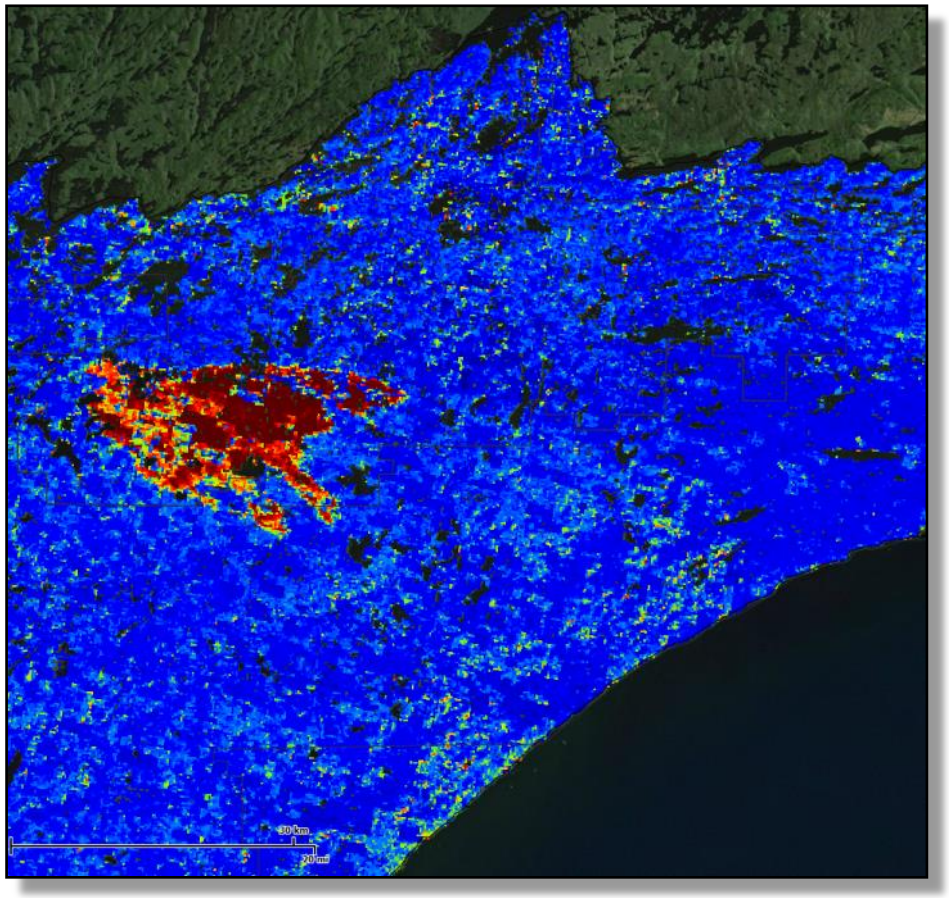
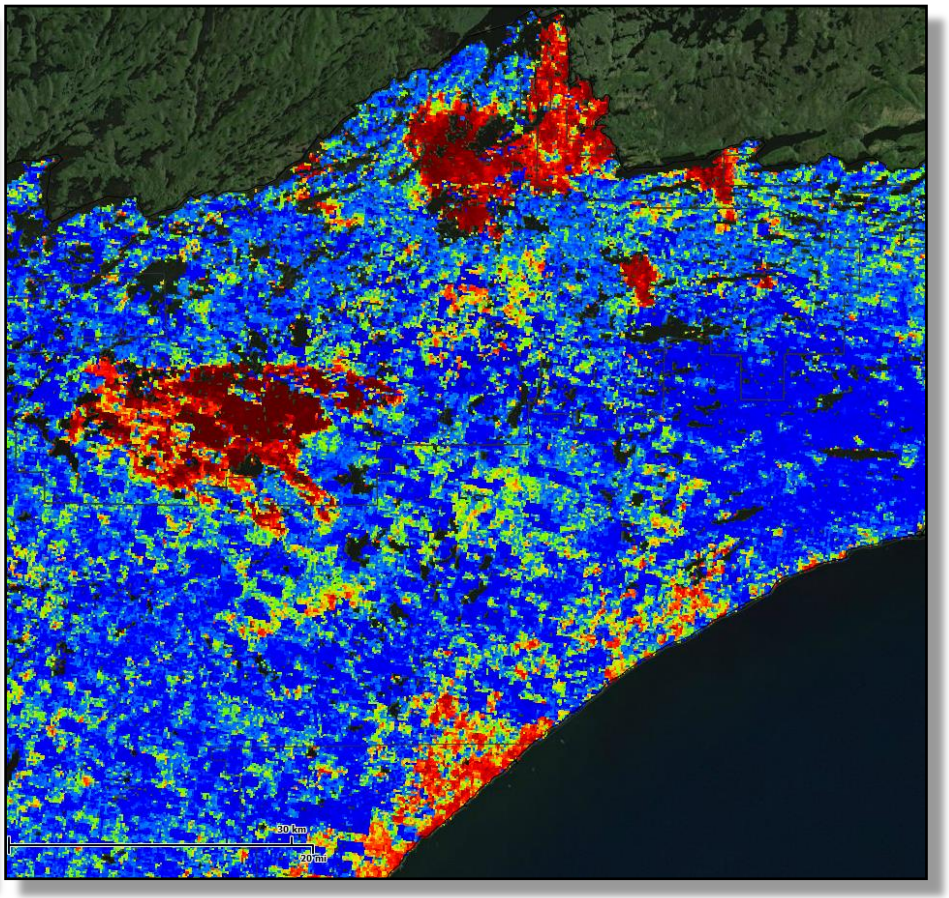


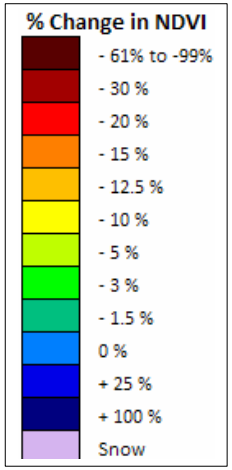
All Year Maximum Baseline



Near real time disturbance detection

Pagami Creek Fire, Superior National Forest MN

Dec 18, 2011 showing canopy loss effects on snow cover visibility



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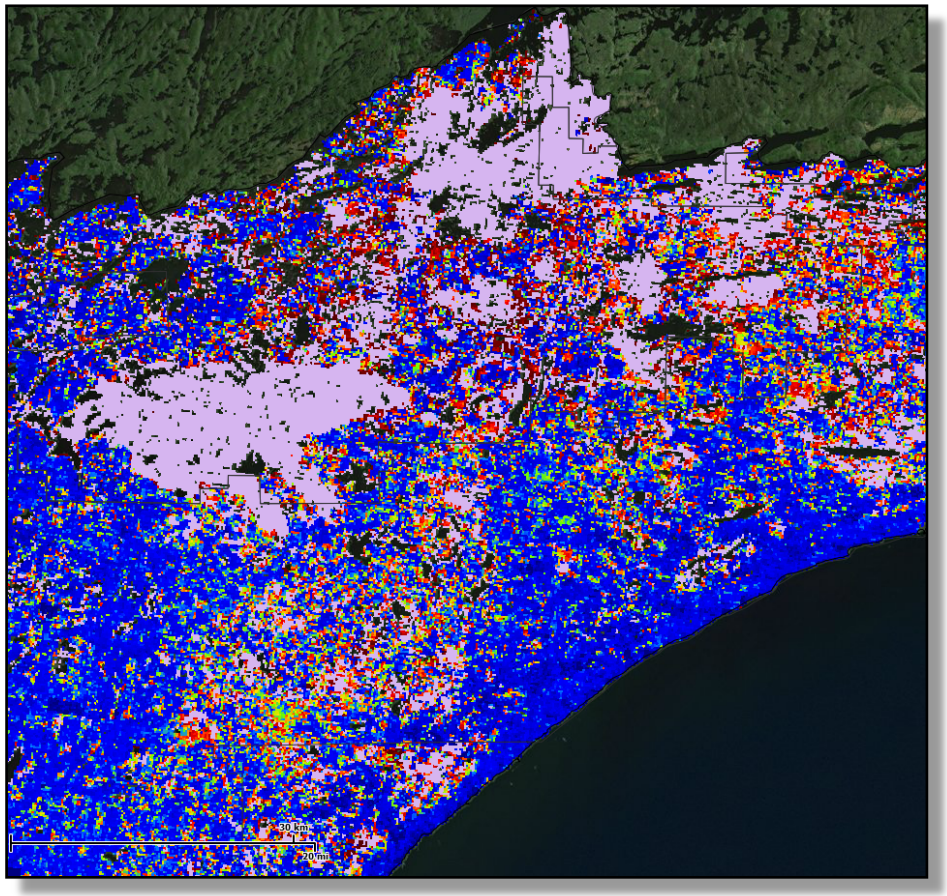

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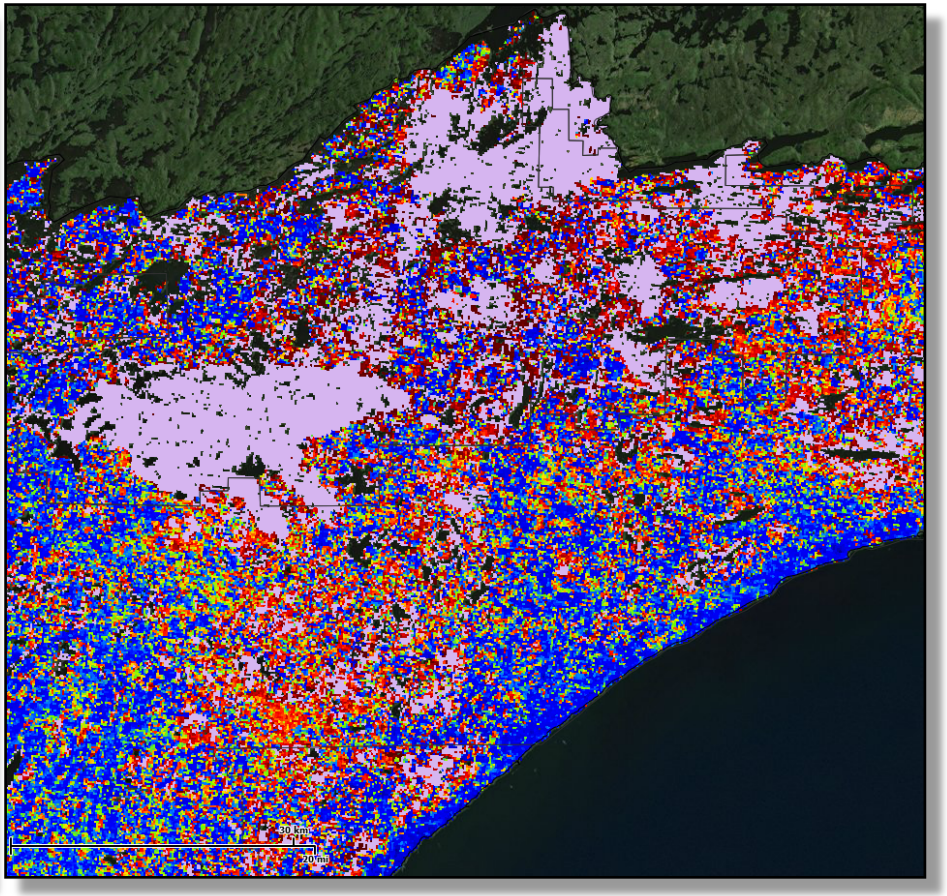
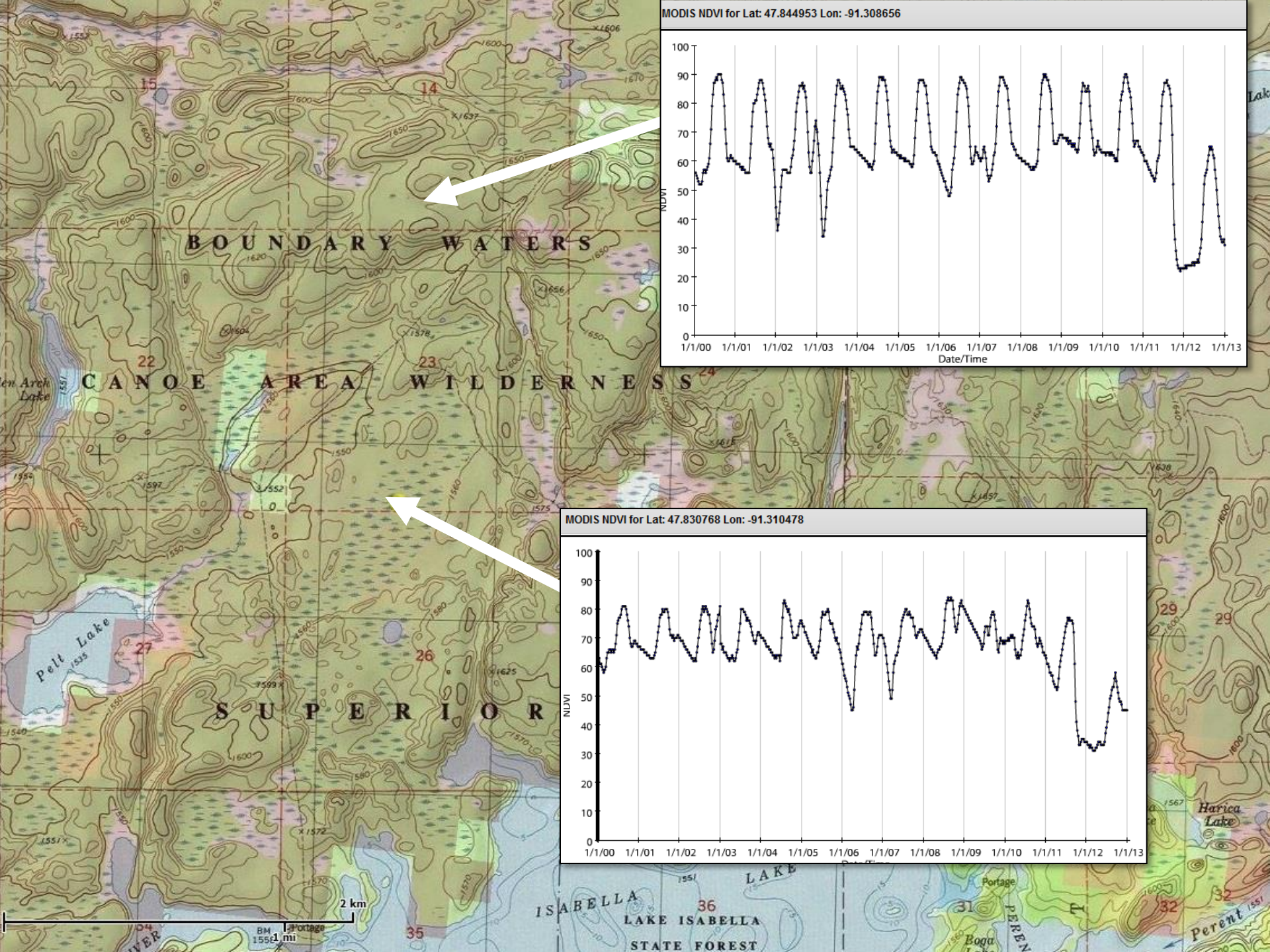
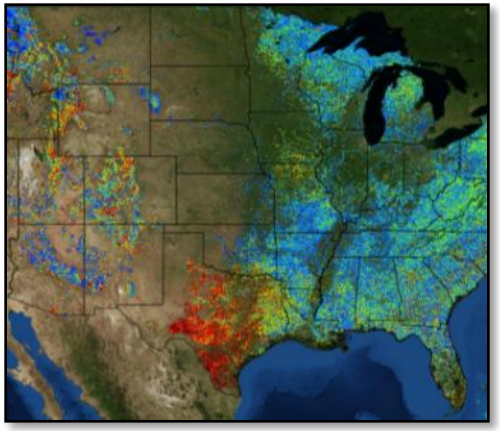



MODIS NDVI for Lat: 47.844953 Lon: -91.308656
NDVI
Date/Time
1/1/00 1/1/01 1/1/02 1/1/03 1/1/04 1/1/05 1/1/06 1/1/07 1/1/08 1/1/09 1/1/10 1/1/11 1/1/12 1/1/13
MODIS NDVI for Lat: 47.830768 Lon: -91.310478
NDVI
BOUNDARY WATERS
CANOE AREA WILDERNESS
SUPERIOR
Pelt Lake
Harica Lake
ISABELLA LAKE
LAKE ISABELLA STATE FOREST
2 km
1 mi

Five Applications of the *ForWarn* System for Monitoring, Assessment and Prediction



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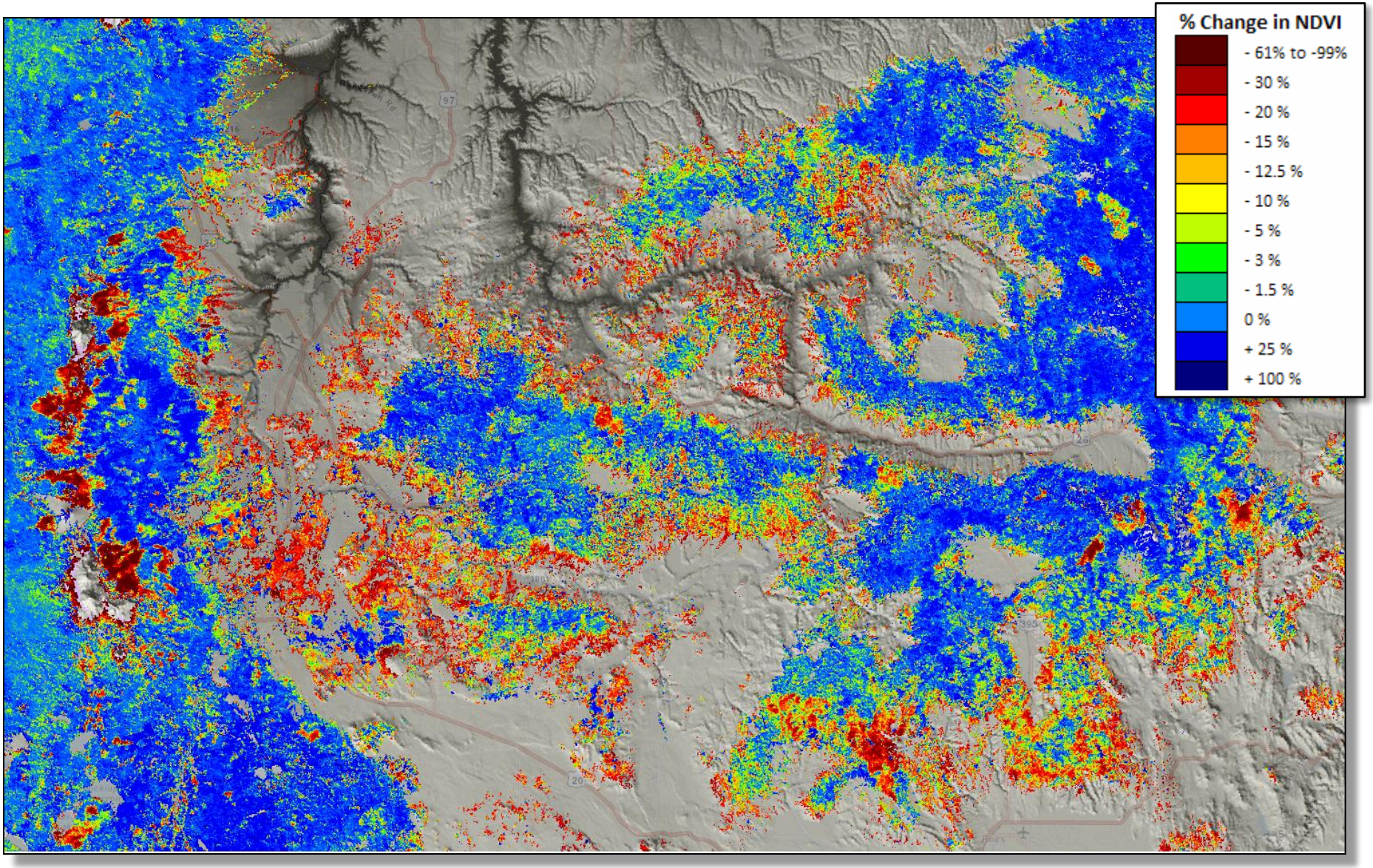
Inferring fuel dynamics

Central Oregon Drought Sensitivity

ForWarn All-year baseline Jul. 3, 2013



Inferring fuel dynamics

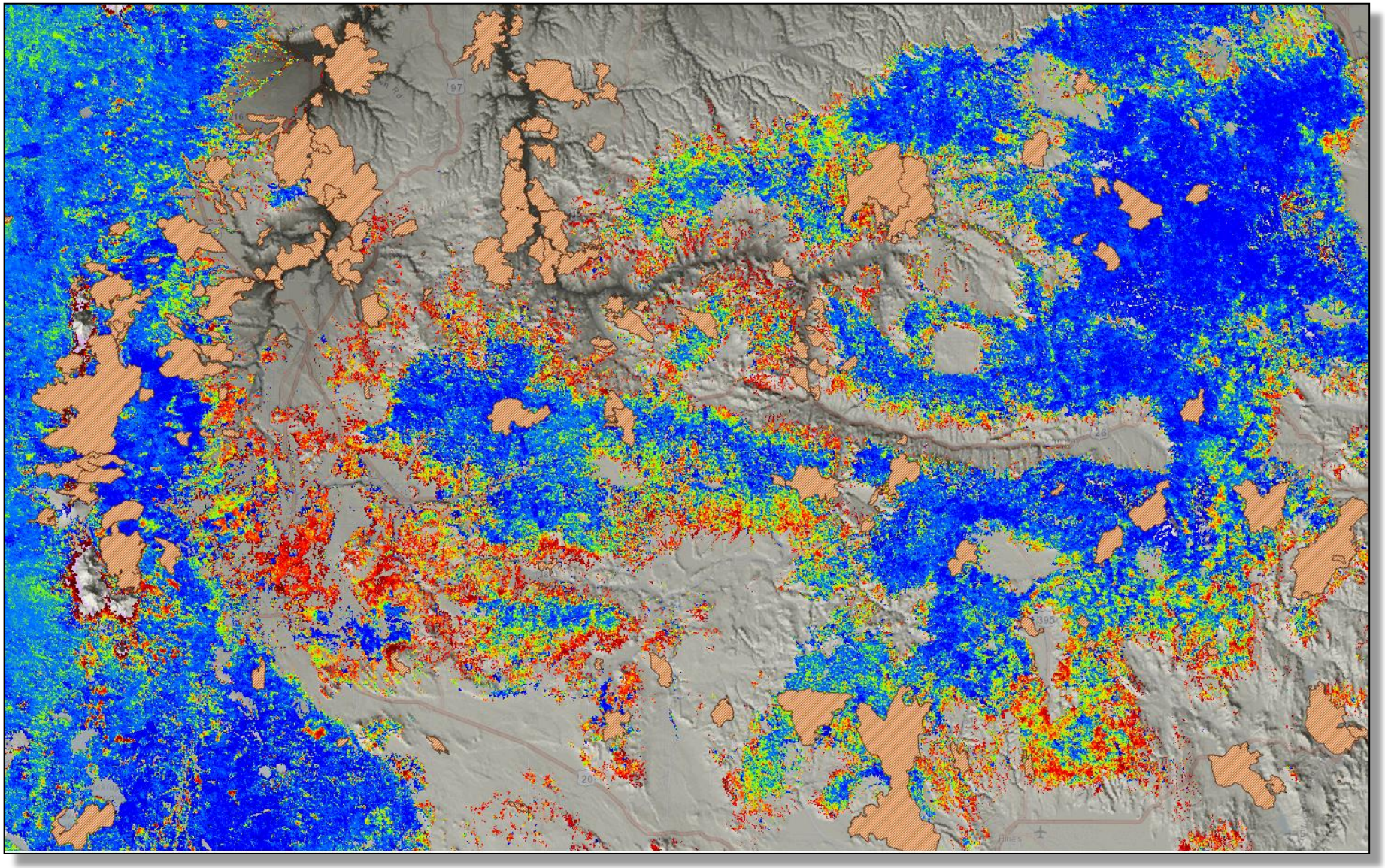
Central Oregon Drought Sensitivity

ForWarn All-year baseline

Jul. 3, 2013

Large Fires 2000-2013

Wildland fires



Inferring fuel dynamics

Central Oregon Drought Sensitivity

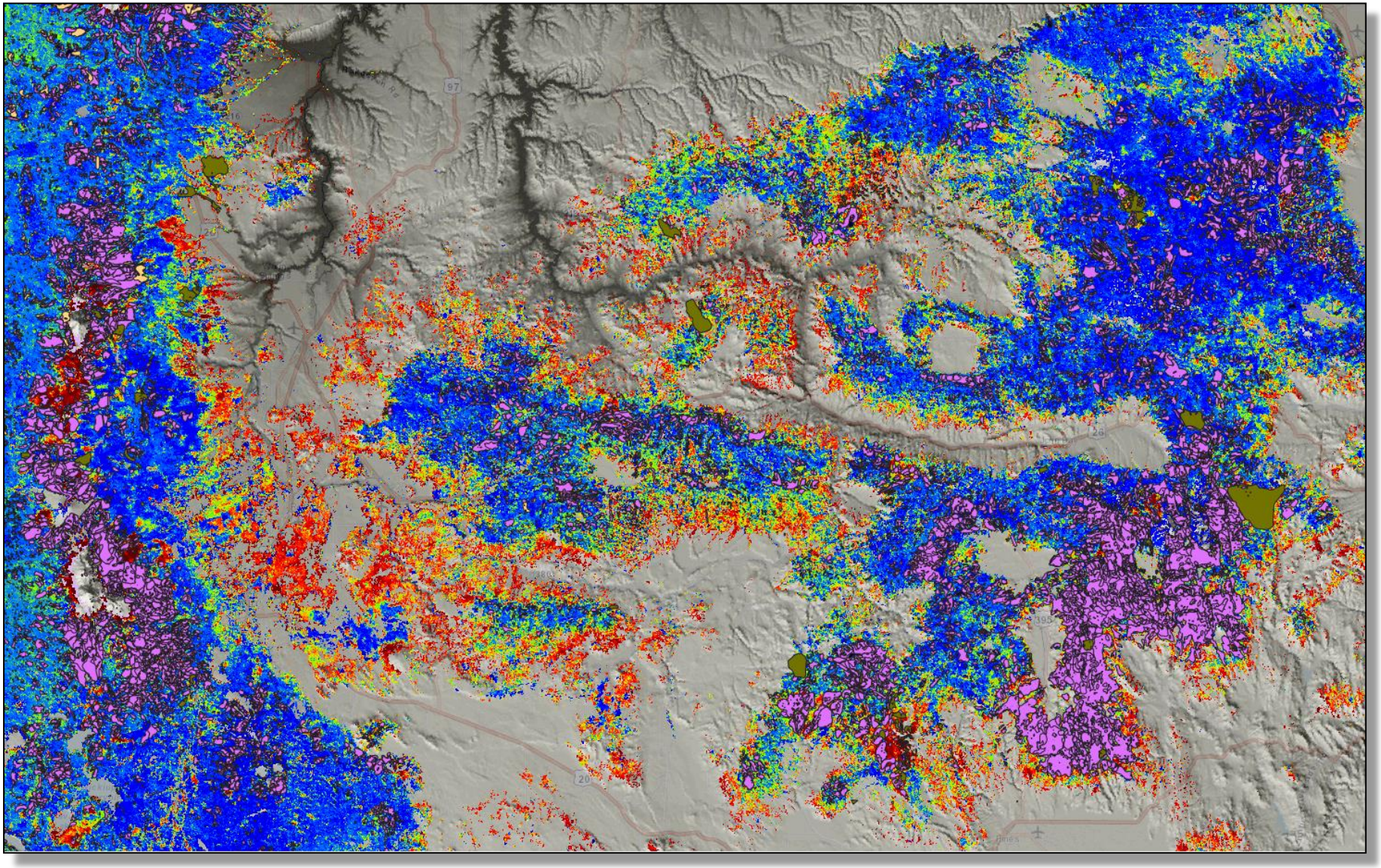
ForWarn All-year baseline

Jul. 3, 2013

Aerial surveys 2000-12

Biotic

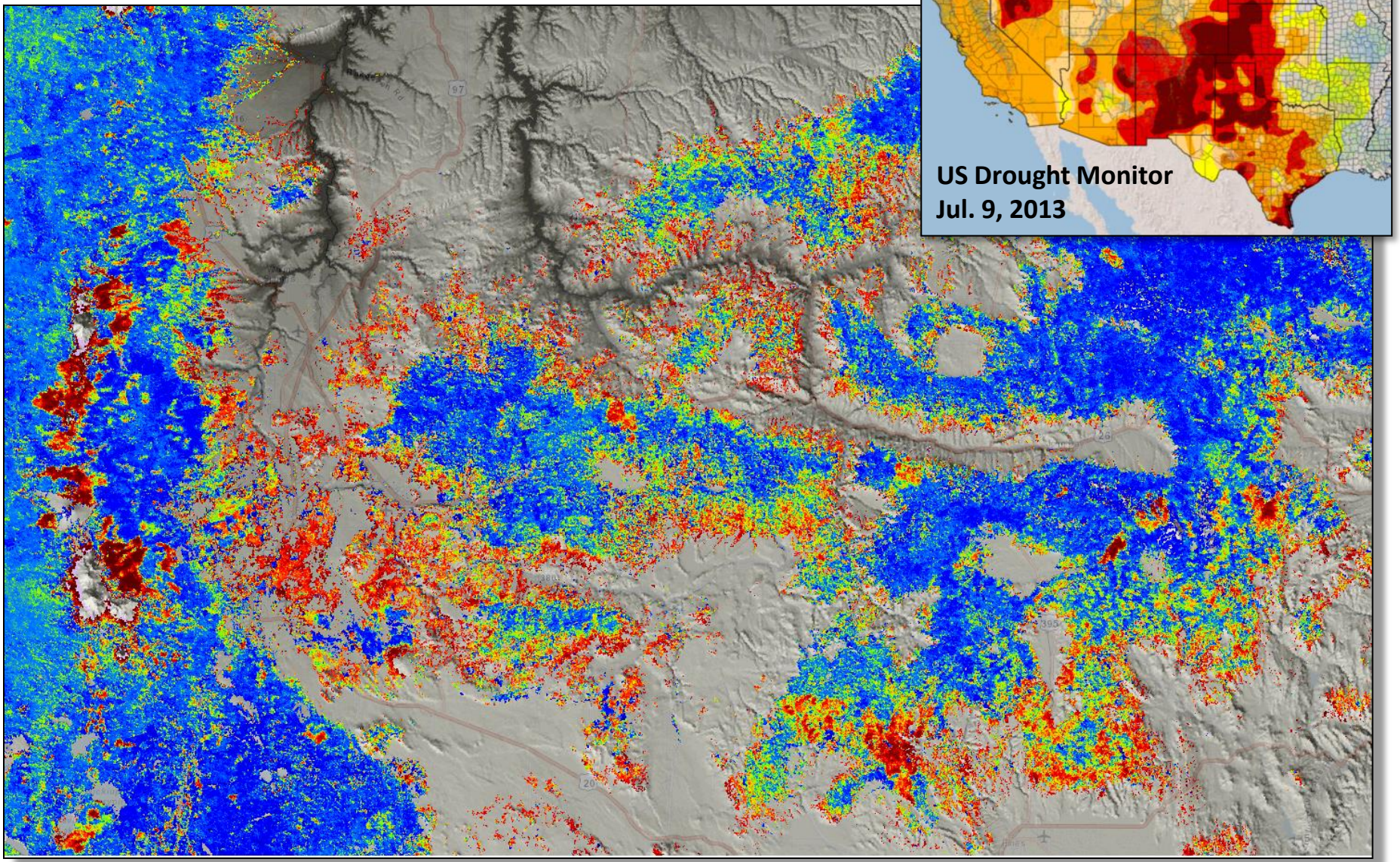
Abiotic

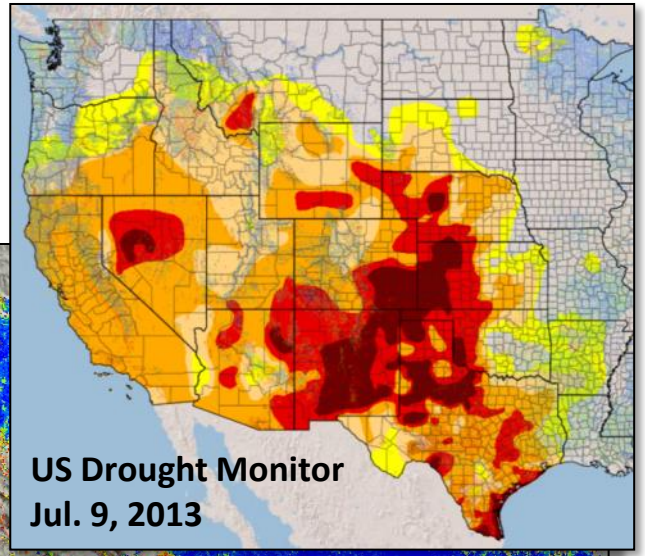


Inferring fuel dynamics

Central Oregon Drought Sensitivity

ForWarn All-year baseline Jul. 3, 2013

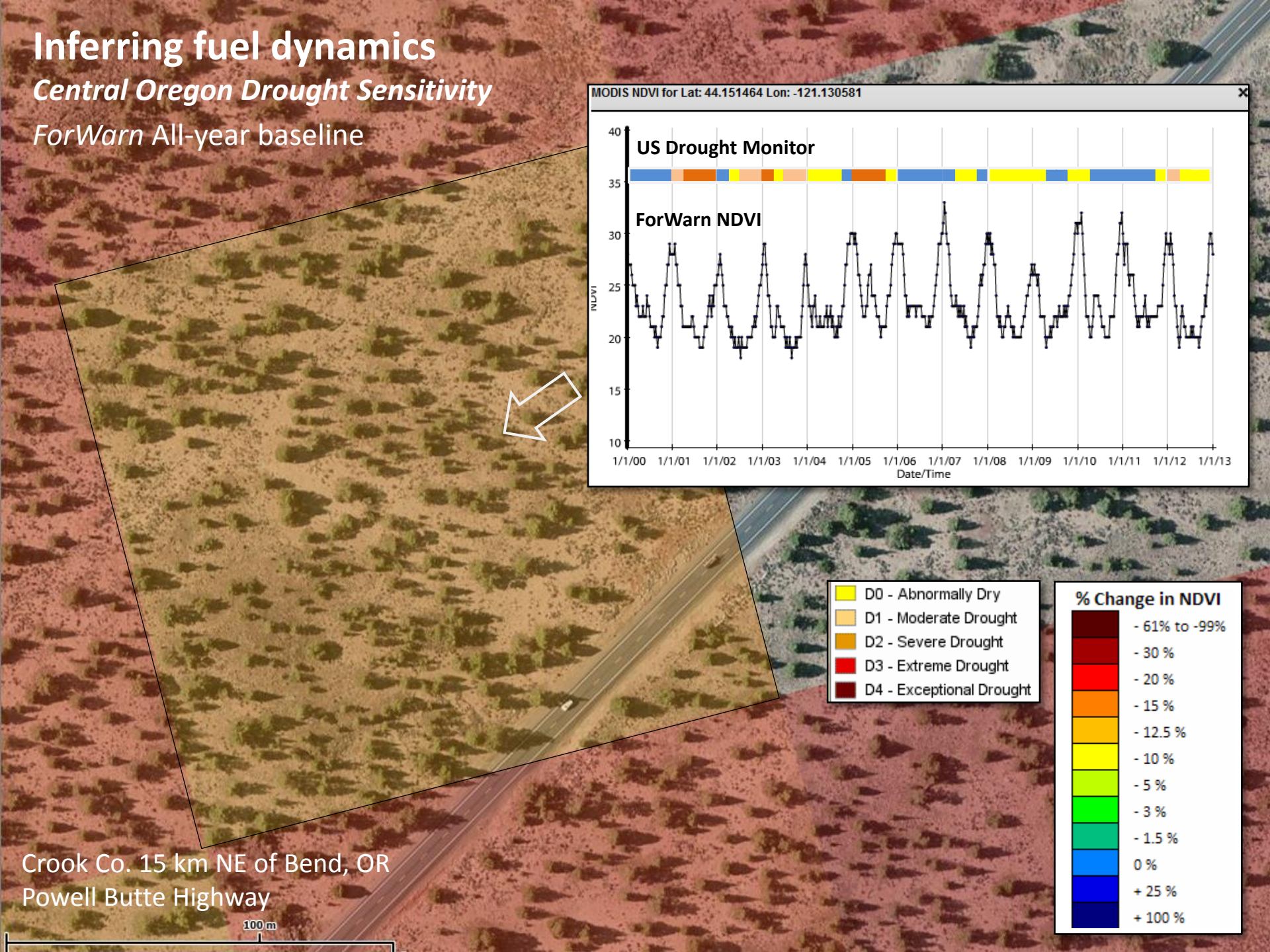




Inferring fuel dynamics

Central Oregon Drought Sensitivity

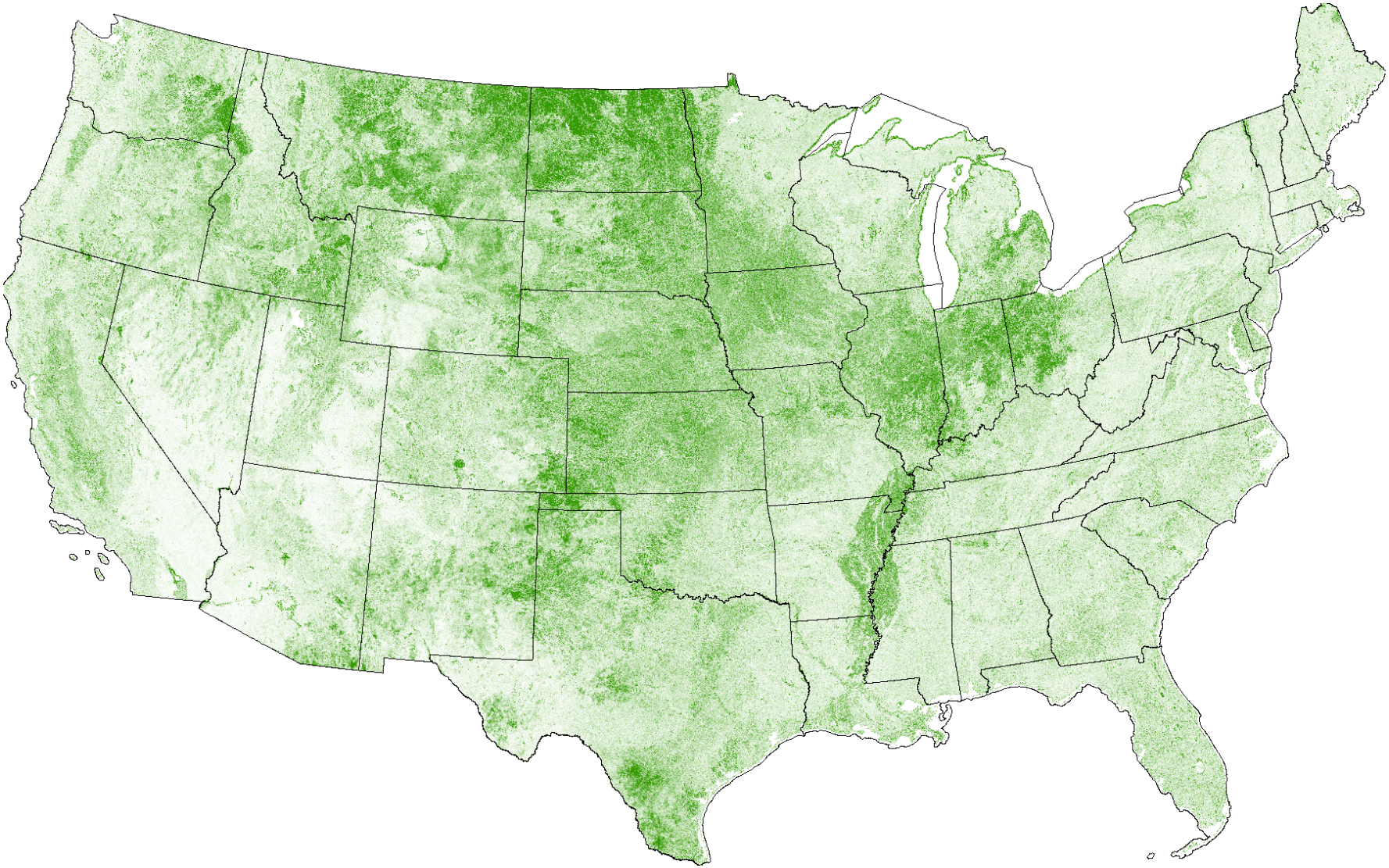
ForWarn All-year baseline



Crook Co. 15 km NE of Bend, OR
Powell Butte Highway

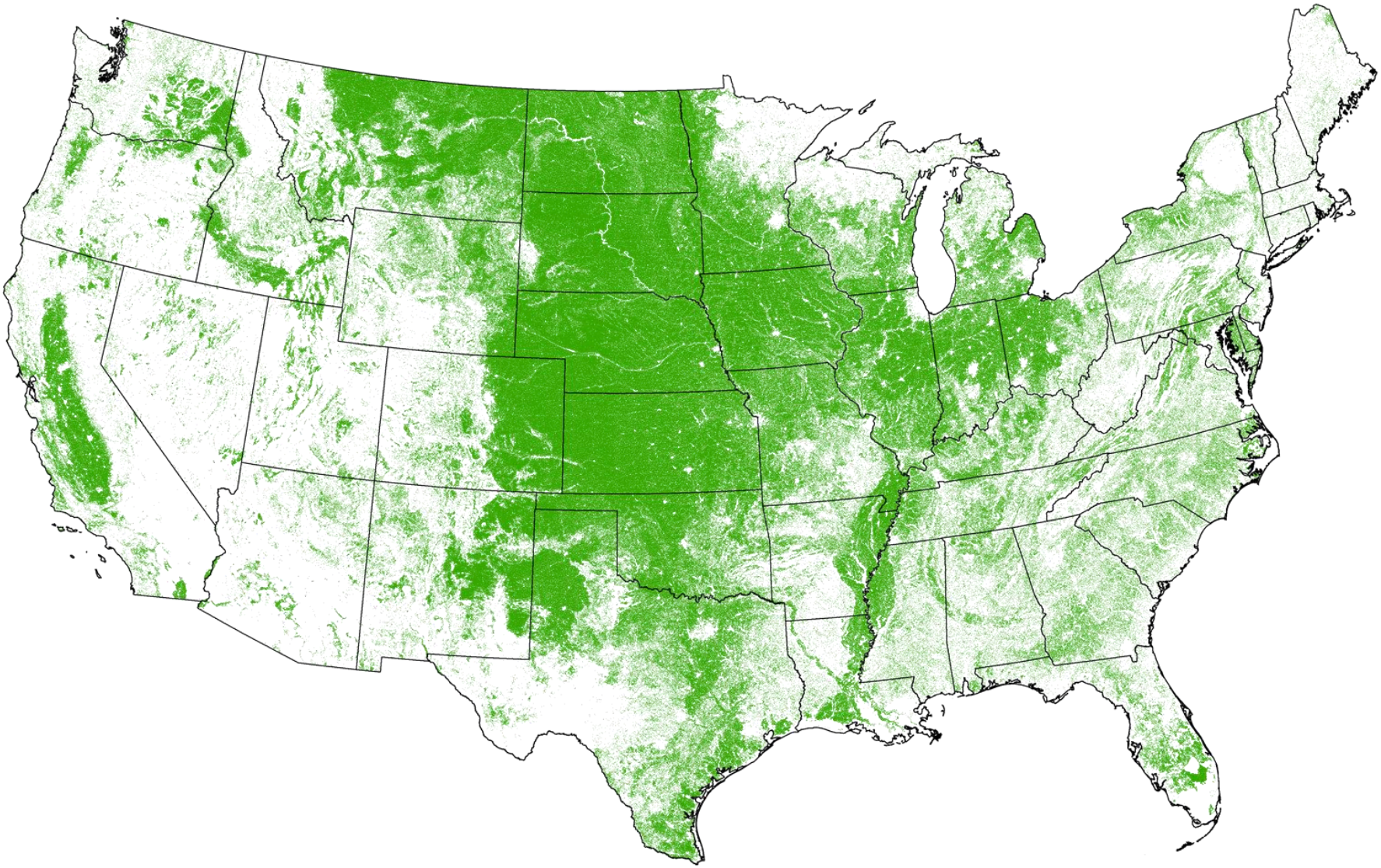
Inferring fuel dynamics

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

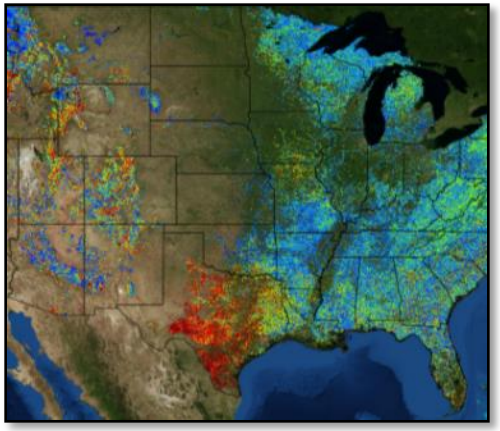


Inferring fuel dynamics

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



Five Applications of the *ForWarn* System for Monitoring, Assessment and Prediction



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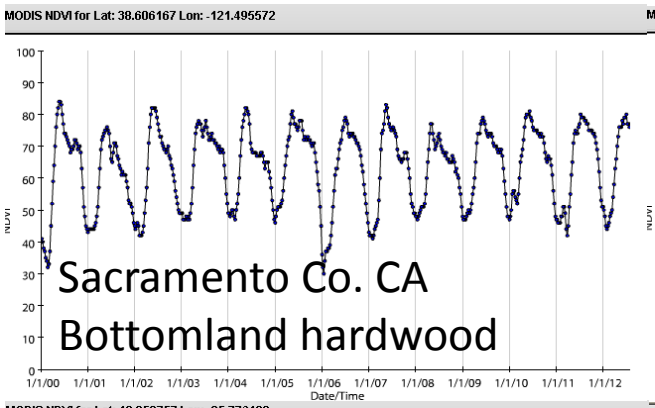
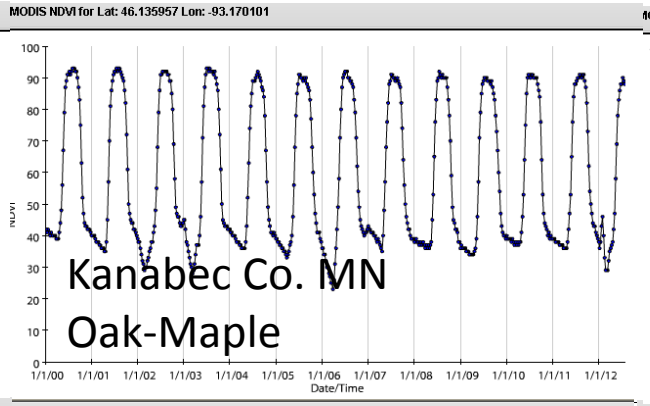
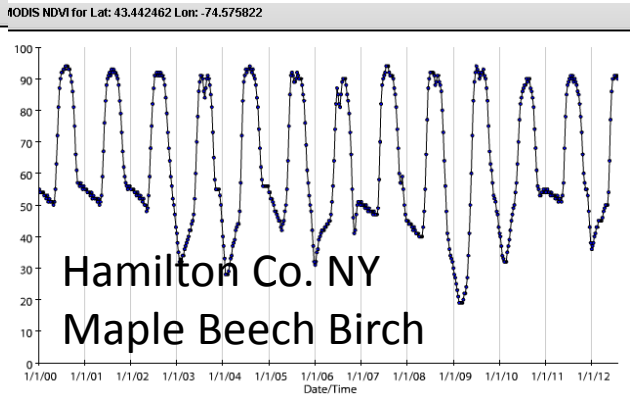
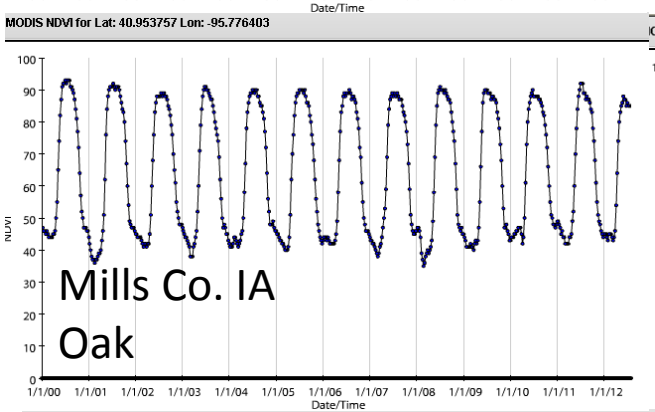
Tracking and predicting post-disturbance response

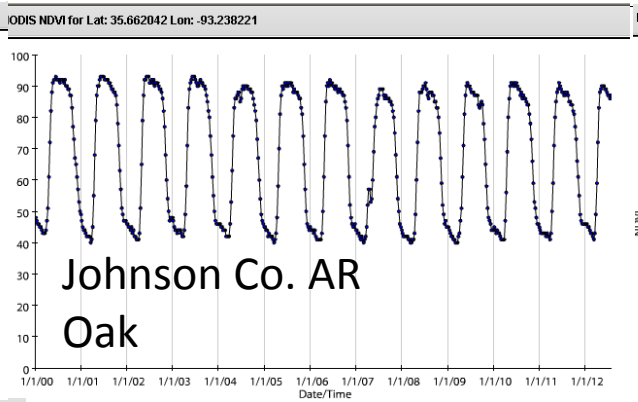
Phenological signatures of **deciduous forest-**dominated pixels

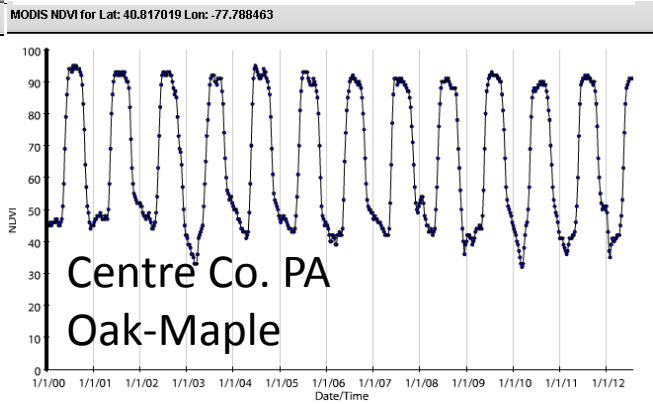


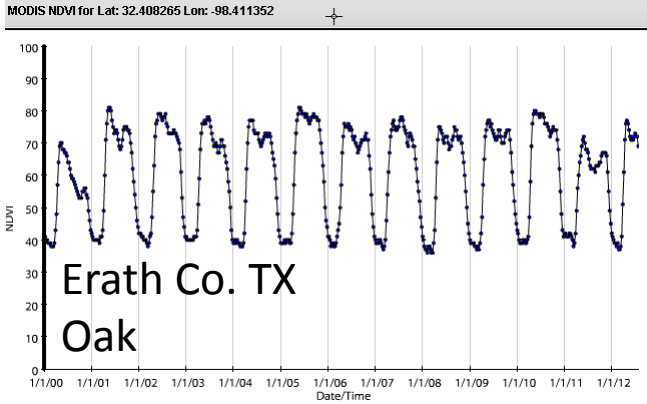


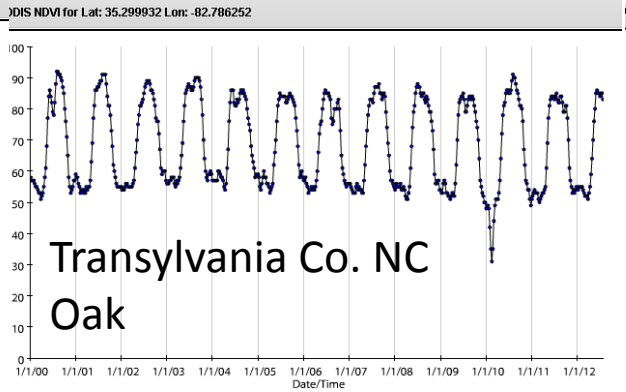


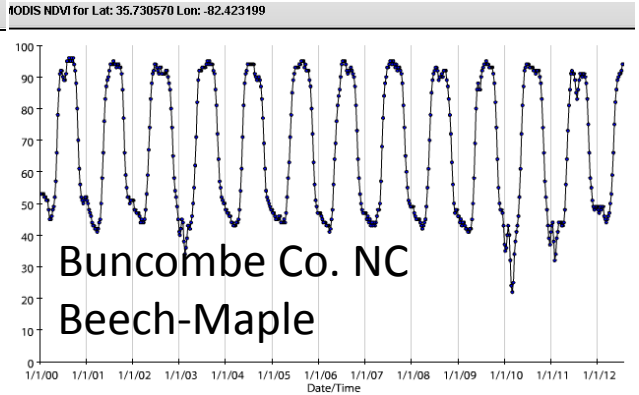






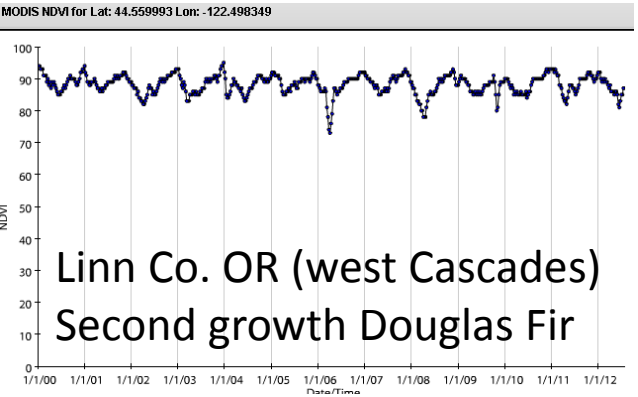


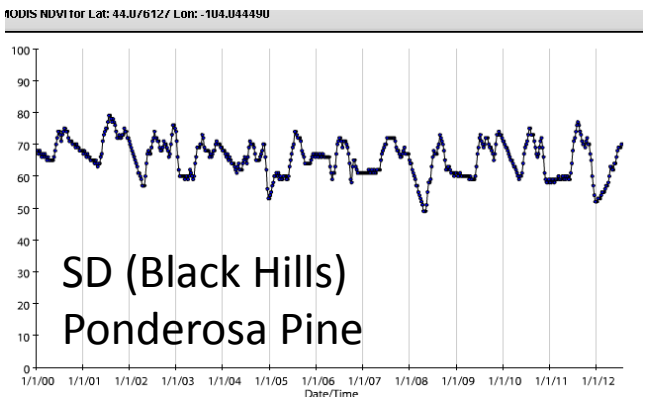


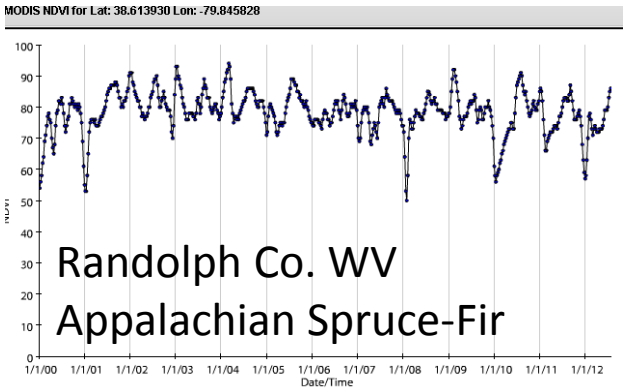


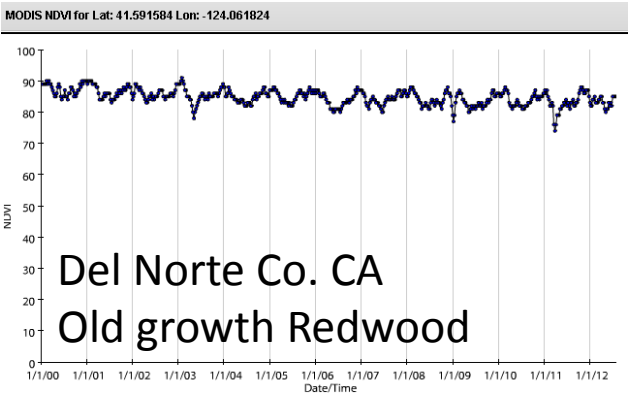
Tracking and predicting post-disturbance response

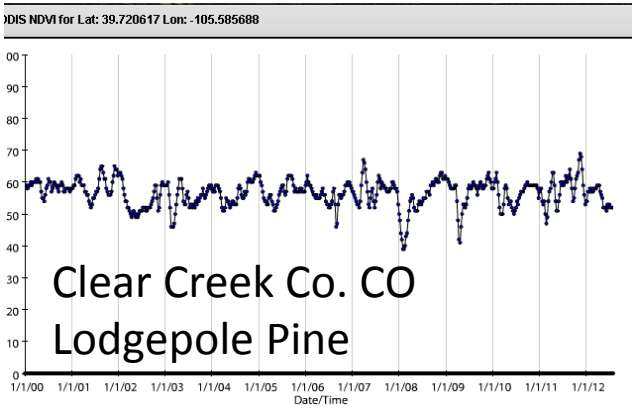
Phenological signatures of **conifer forest-**dominated pixels

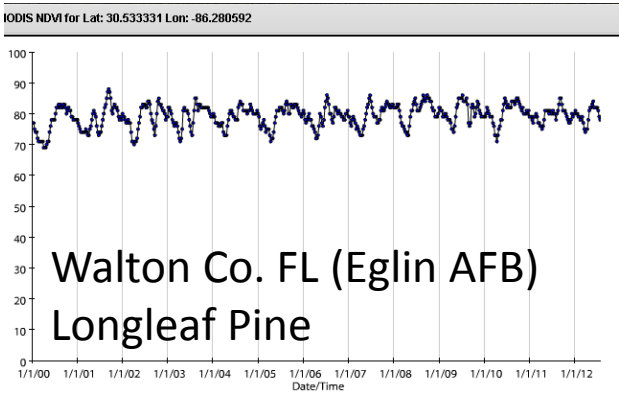


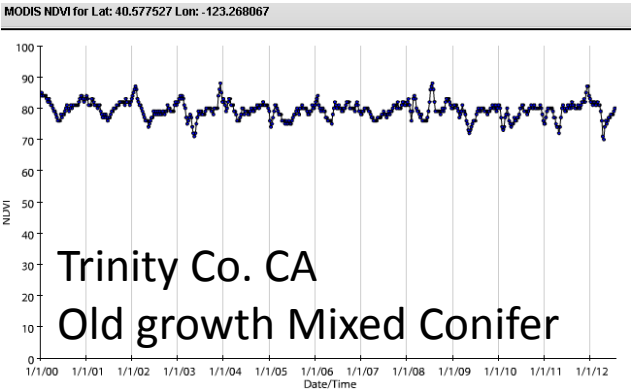


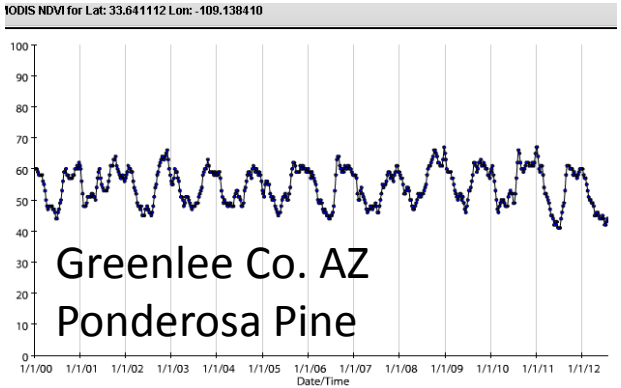


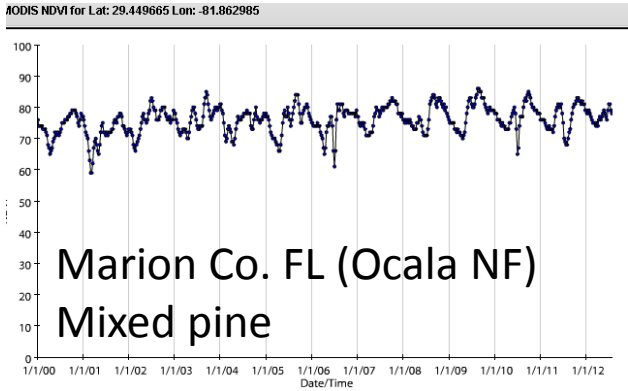






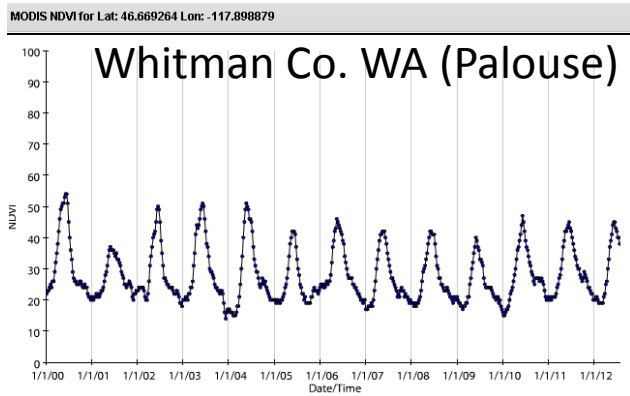


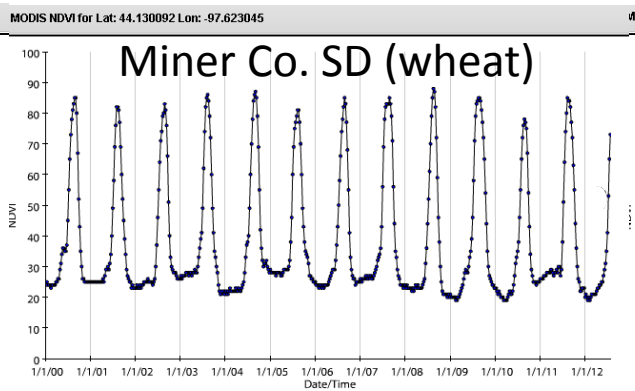


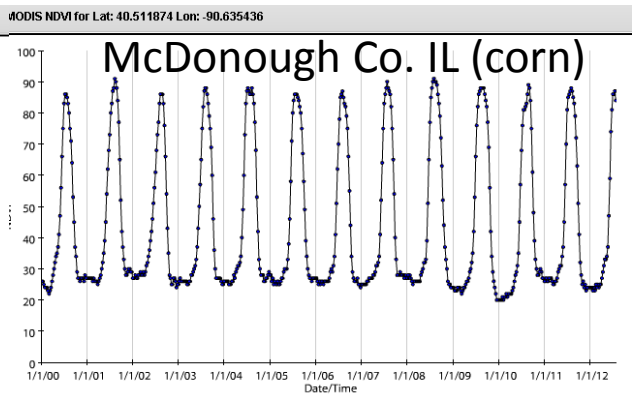


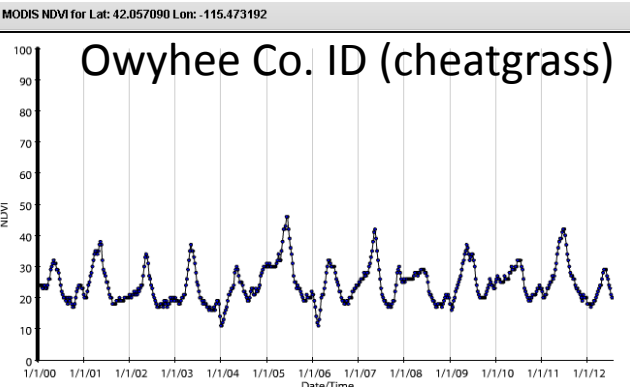
Tracking and predicting post-disturbance response

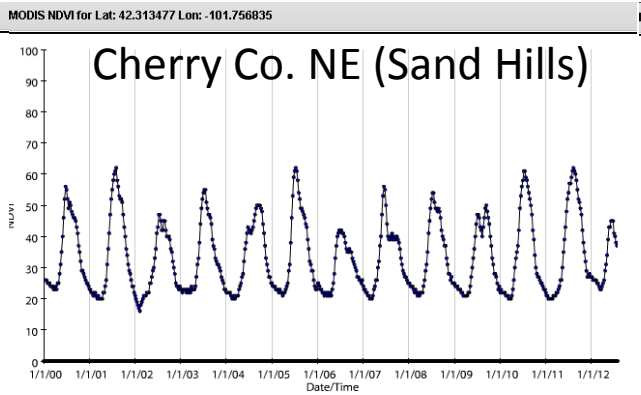
Phenological signatures of **grass**-dominated pixels

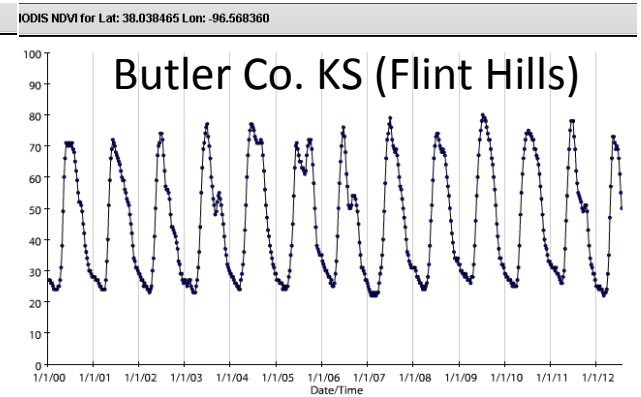


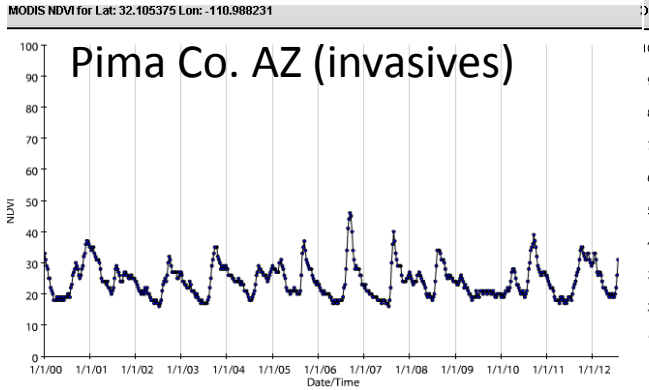


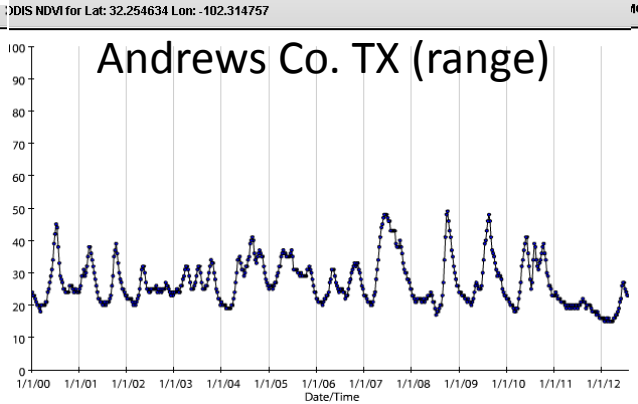


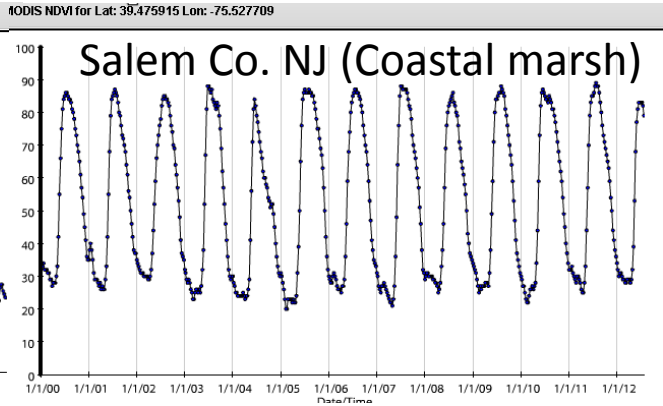












Tracking and predicting post-disturbance response

Potential measures of fire effects and desired vegetation

Maximum NDVI
Minimum NDVI
Mean NDVI
Median NDVI

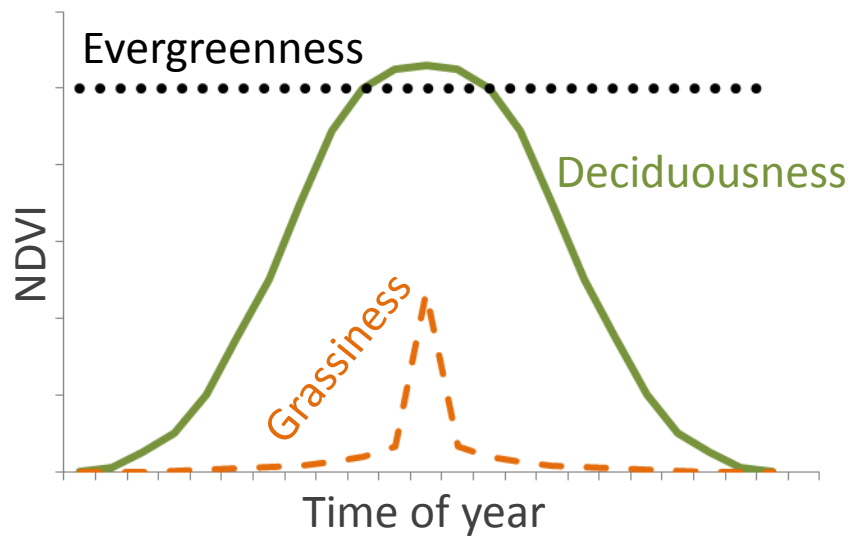
Percentiles of the annual distribution
Amplitude of NDVI (of extremes)
NDVI difference (between thresholds)
Duration above some threshold
Area under the growing season curve

Key measures for vegetation change associated with wildland fire:

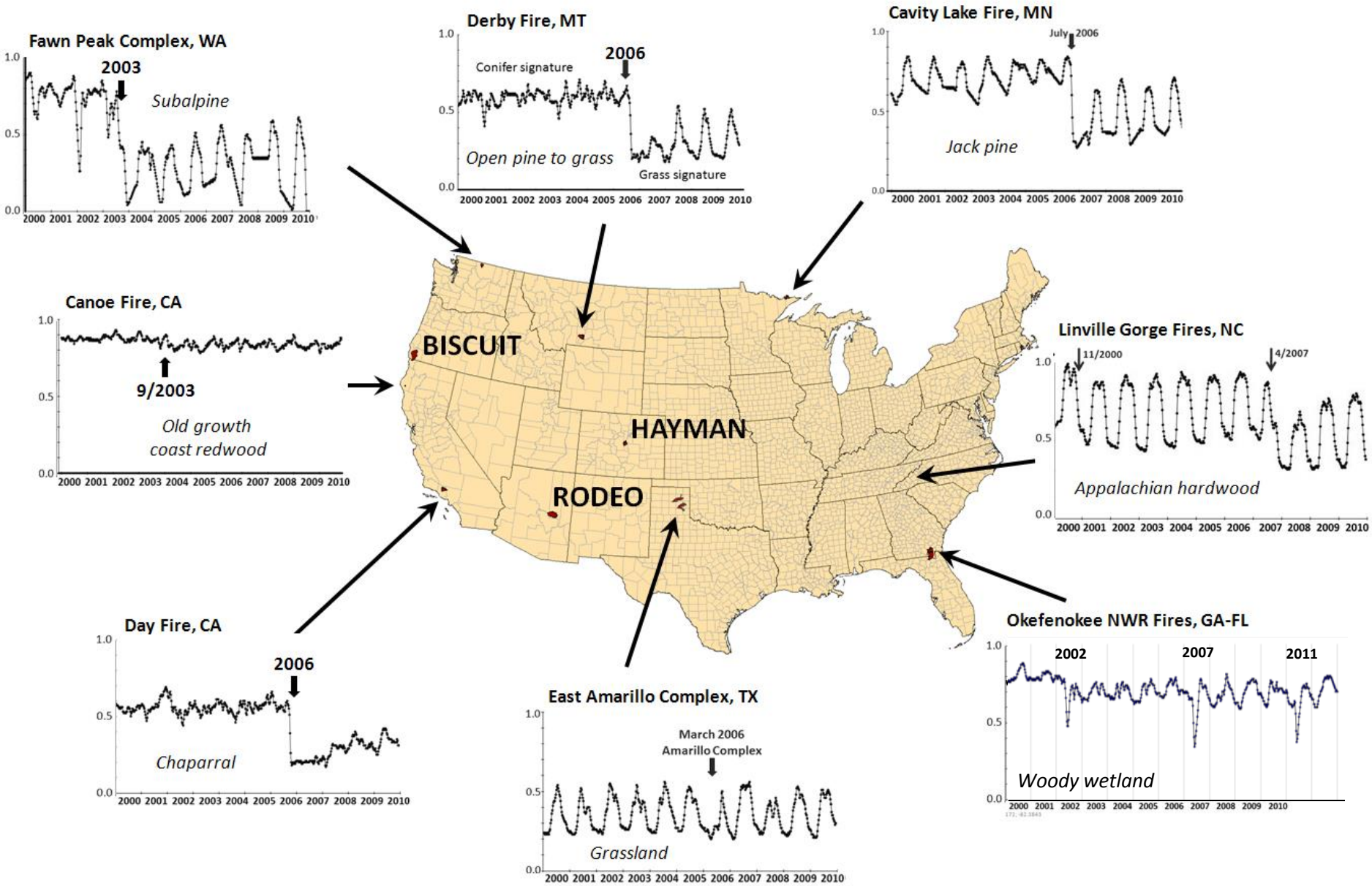
(1) MEDIAN NDVI
(50th %ile)

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

(3) GRASS FRACTION
(peakedness of uppermost distribution)

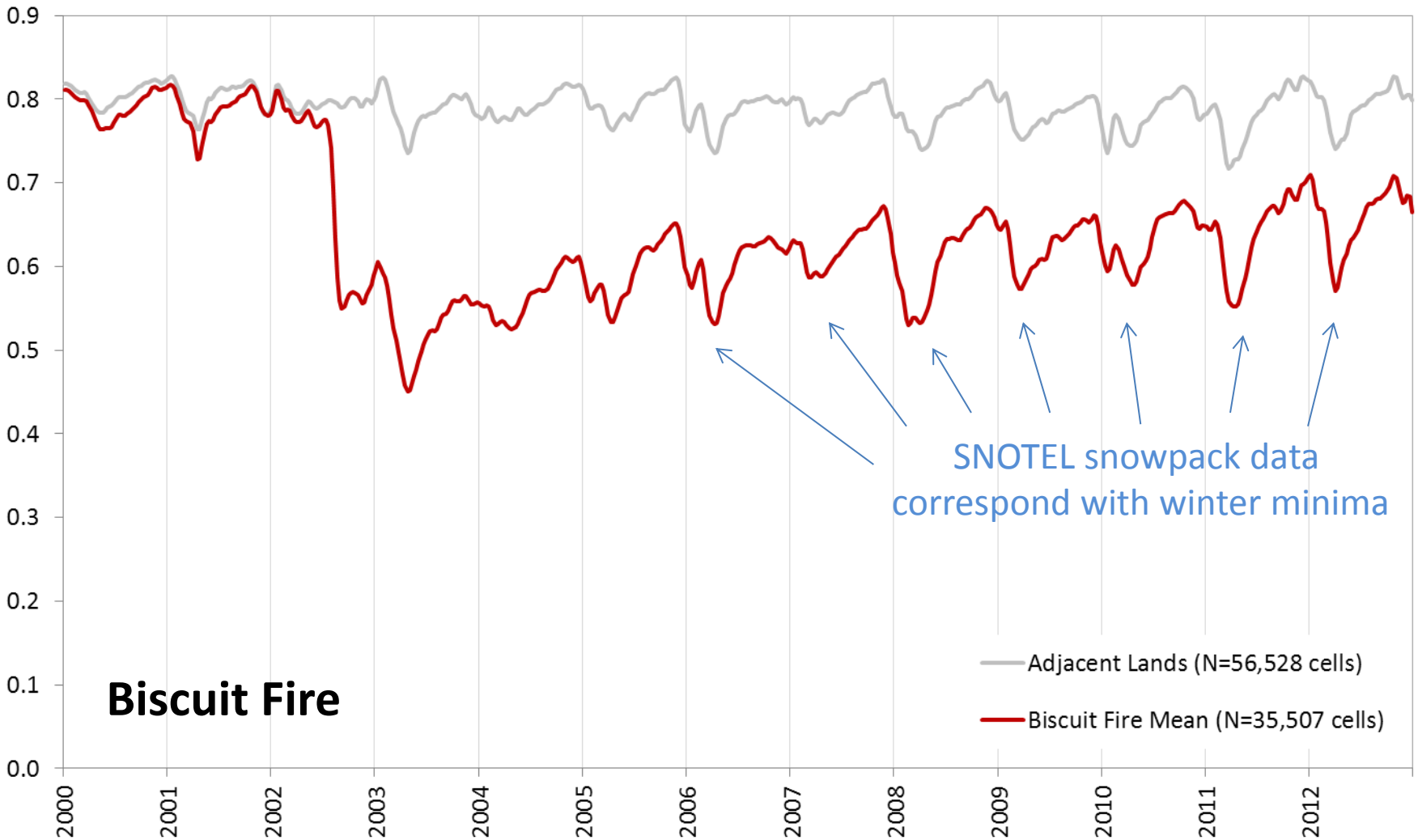


Tracking and predicting post disturbance response



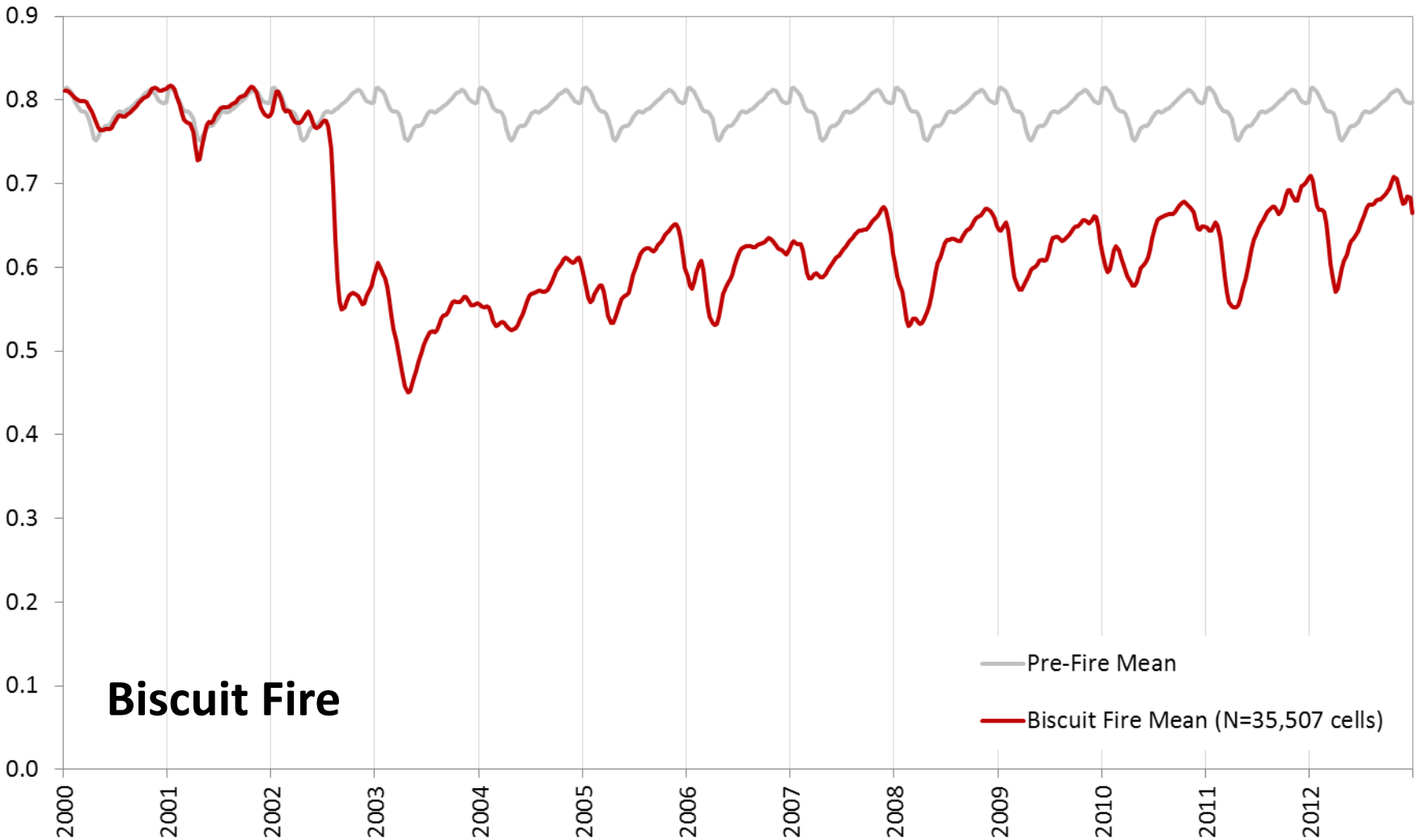
Tracking and predicting post disturbance response

Reference conditions as the phenology of adjacent unburned areas

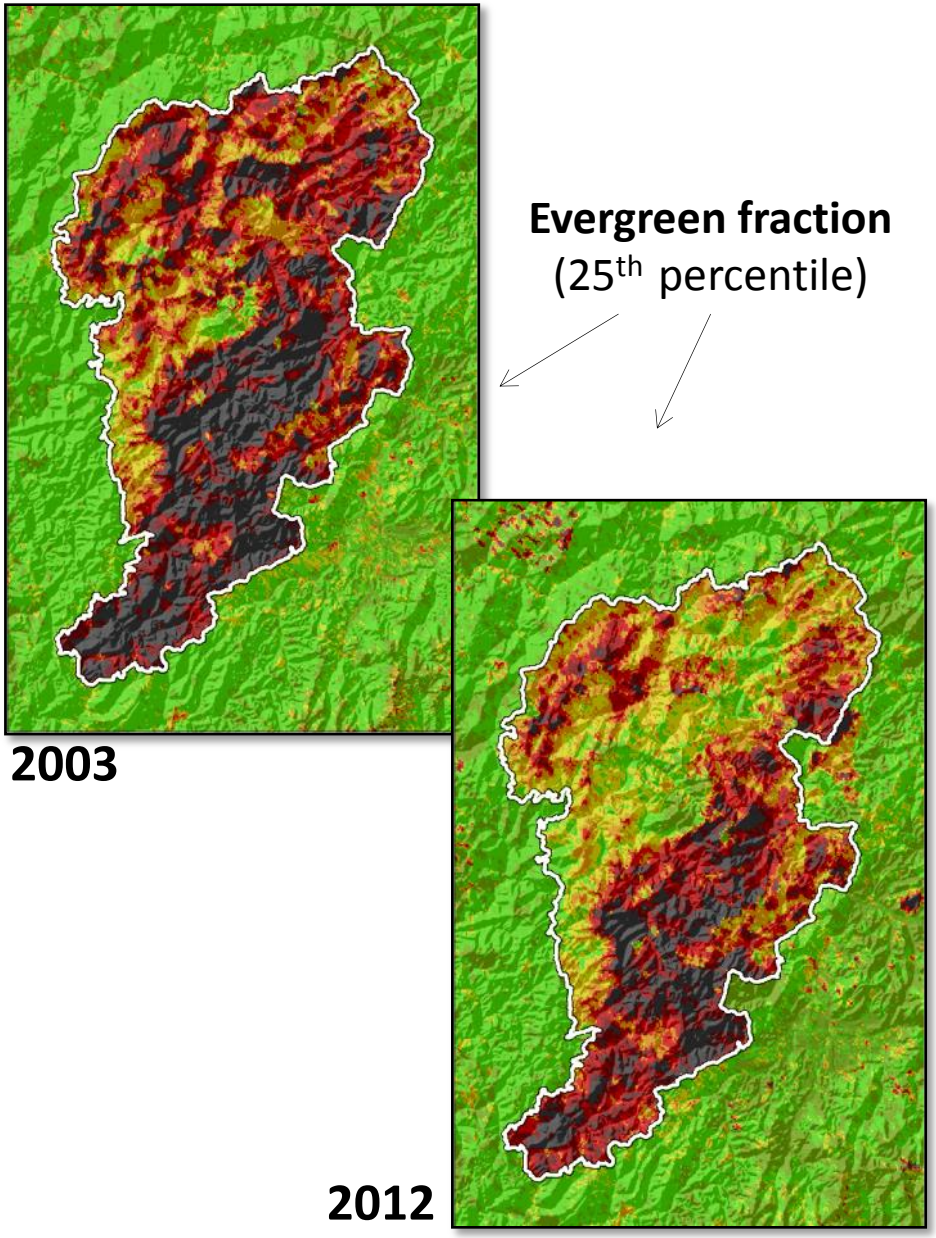


Tracking and predicting post disturbance response

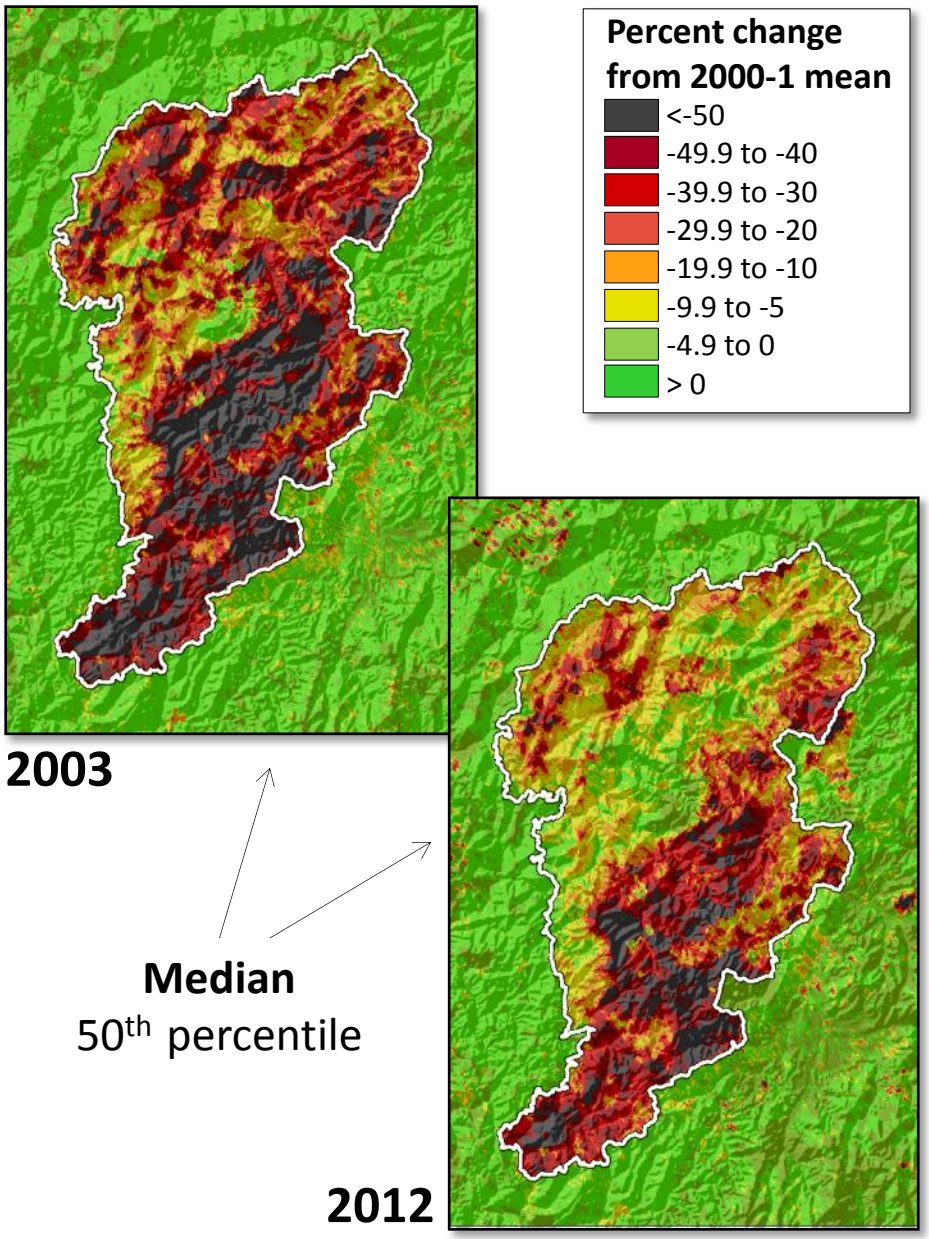
Reference conditions as the phenology of the pre-fire mean



Tracking and predicting post disturbance response



Evergreen fraction
(25th percentile)

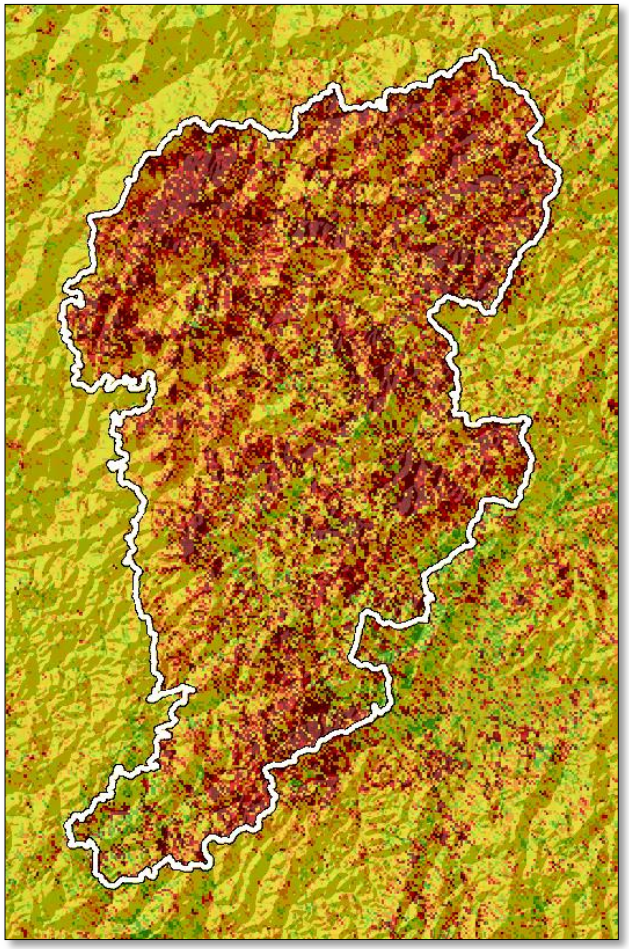


Median
50th percentile

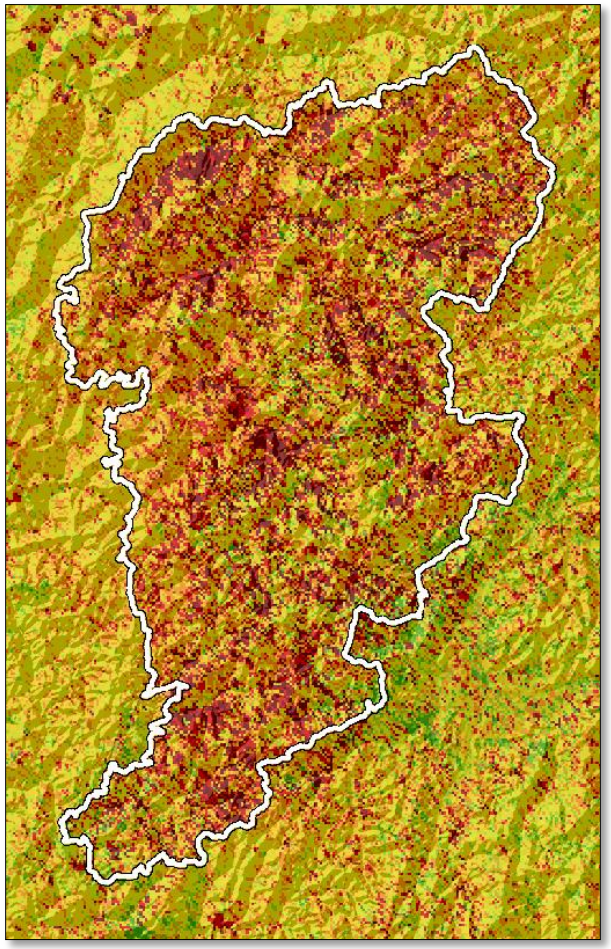
Tracking and predicting post disturbance response

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

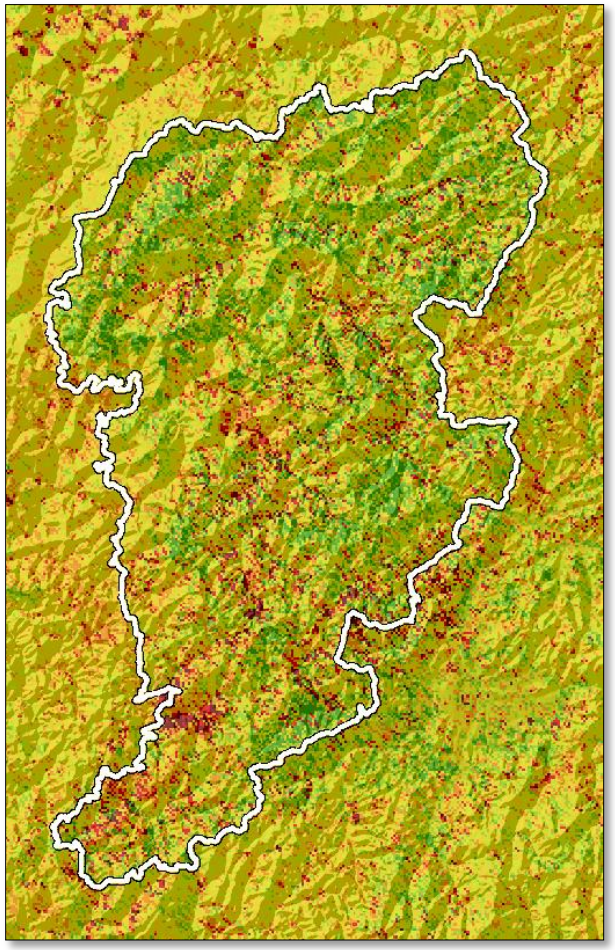
Pre-fire to 2003-7 mean



Pre-fire to 2008-12 mean



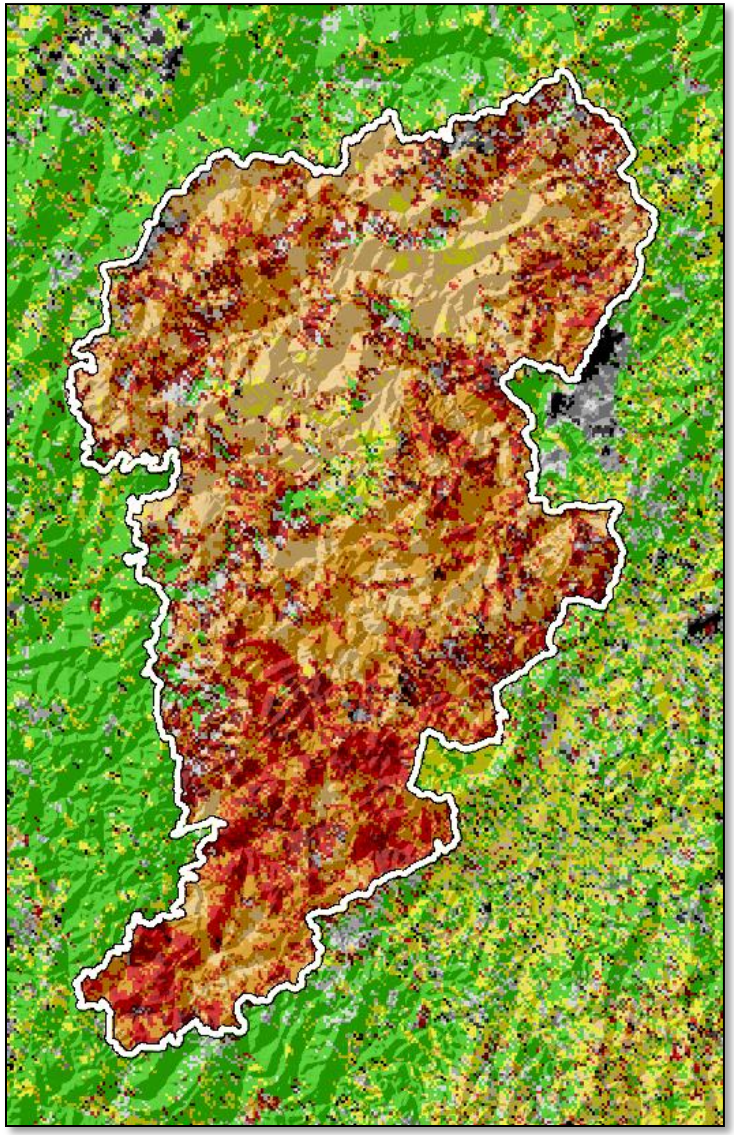
2003-7 to 2008-12 mean



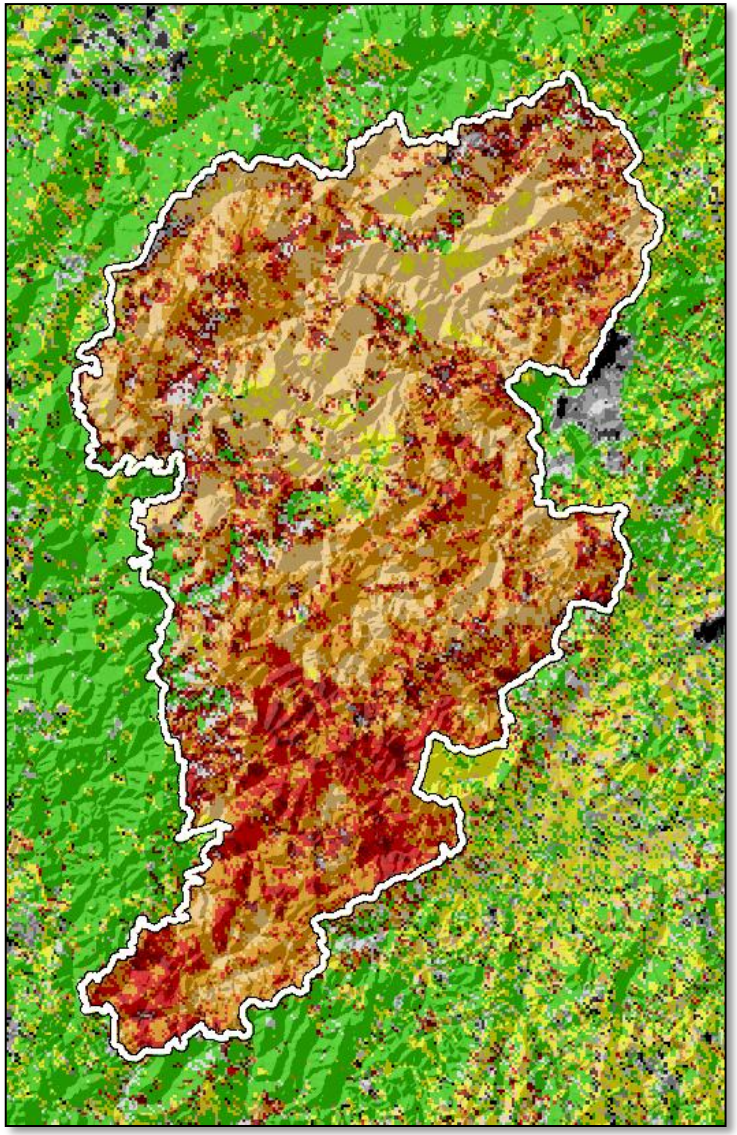
Tracking and predicting post disturbance response

Biscuit Fire

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



Time to recovery of median (50th %ile)

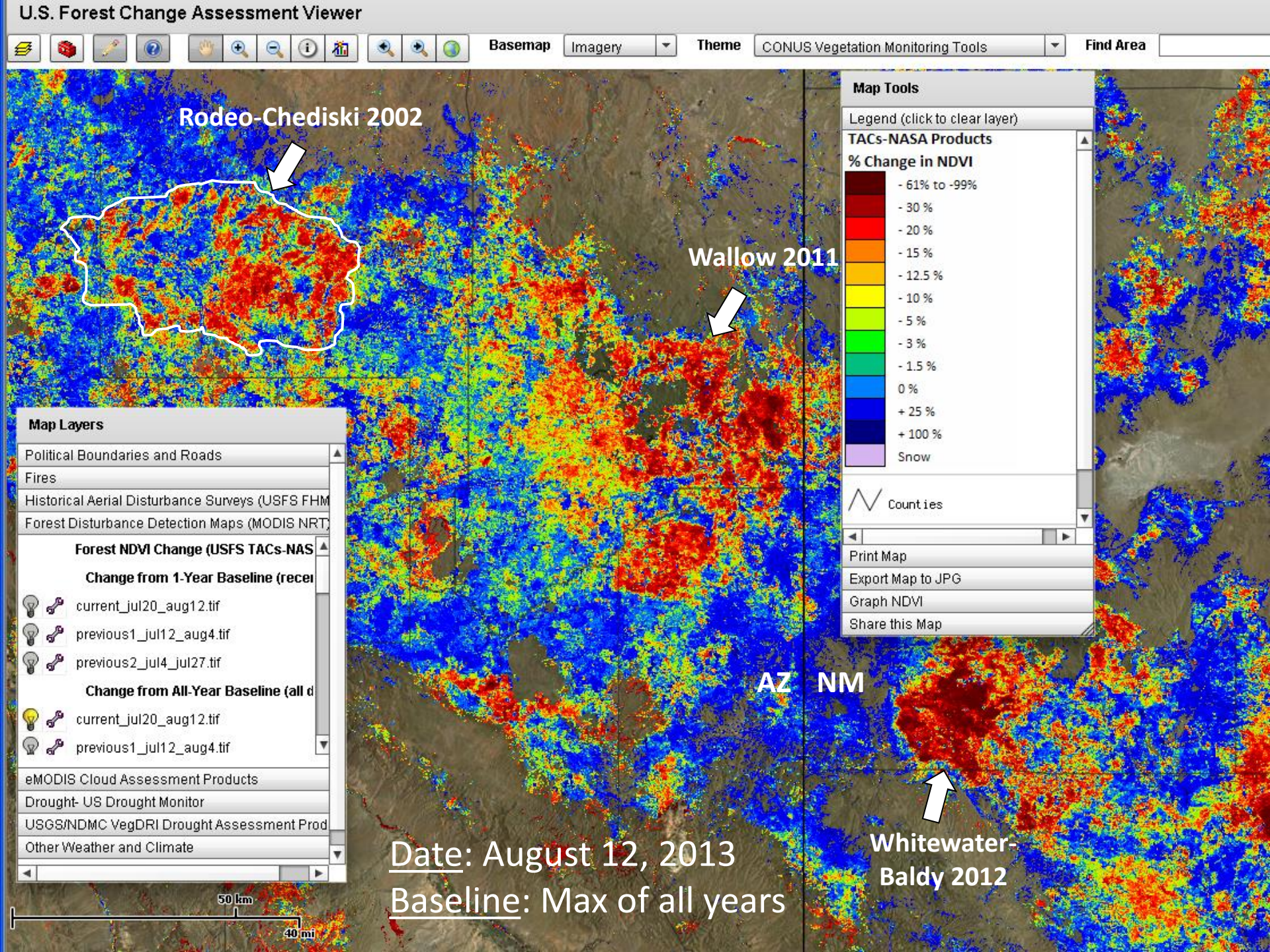


Years to recovery

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

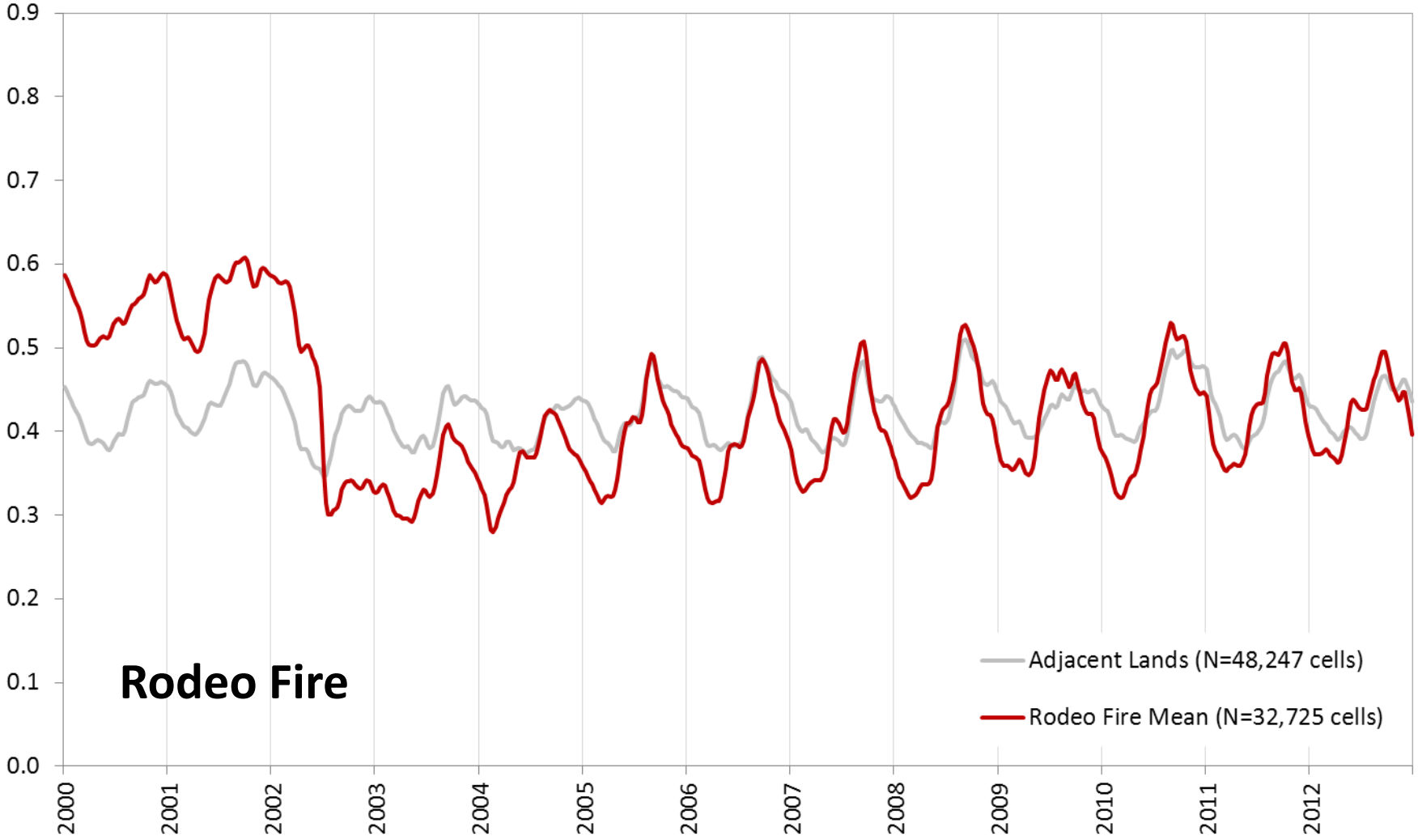
No observed recovery (% decline in 2012)

- -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

Tracking and predicting post disturbance response

Reference conditions as phenology of adjacent unburned area



Tracking and predicting post disturbance response

Percent change from 2000-1 mean

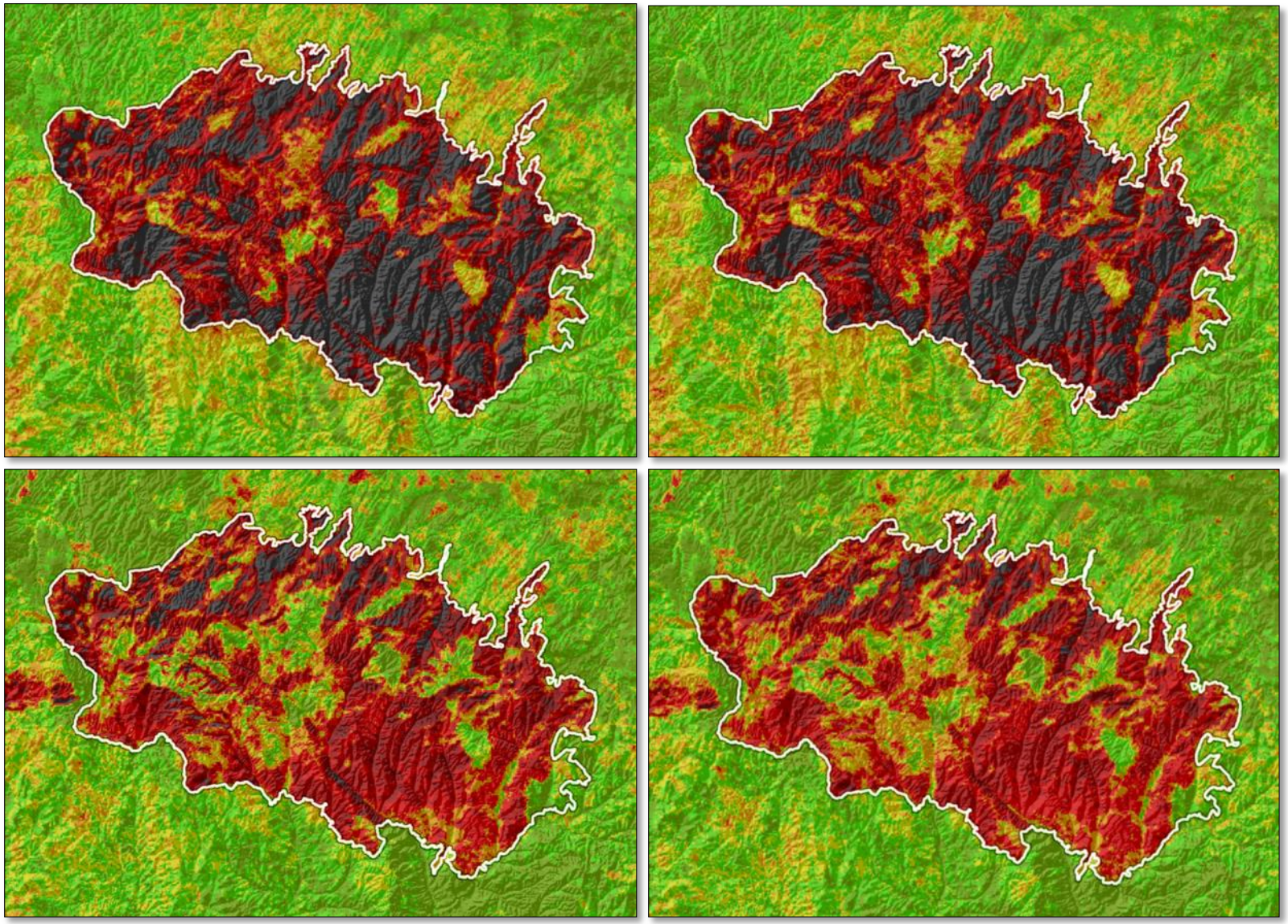
- <-50
- -49.9 to -40
- -39.9 to -30
- -29.9 to -20
- -19.9 to -10
- -9.9 to -5
- -4.9 to 0
- > 0

Evergreen fraction
(25th percentile)

Median
(50th percentile)

2003

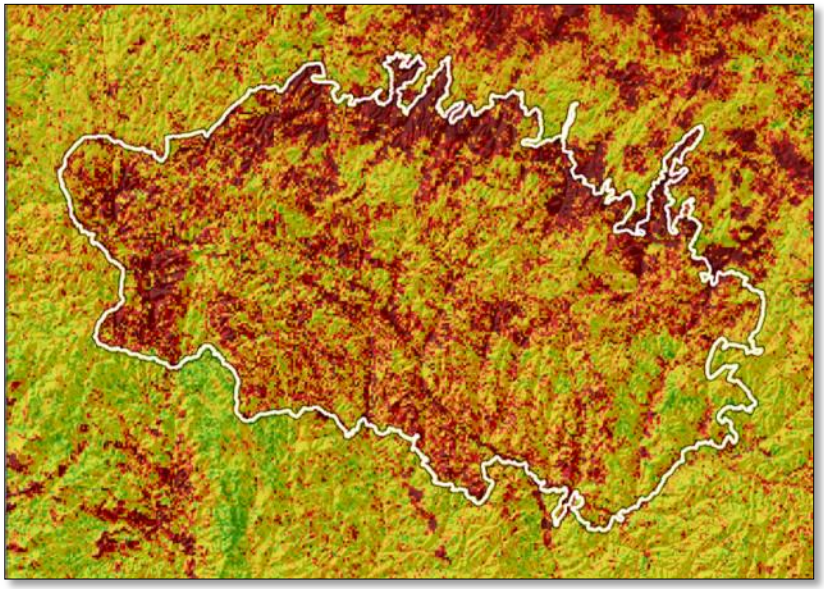
2012



Tracking and predicting post disturbance response

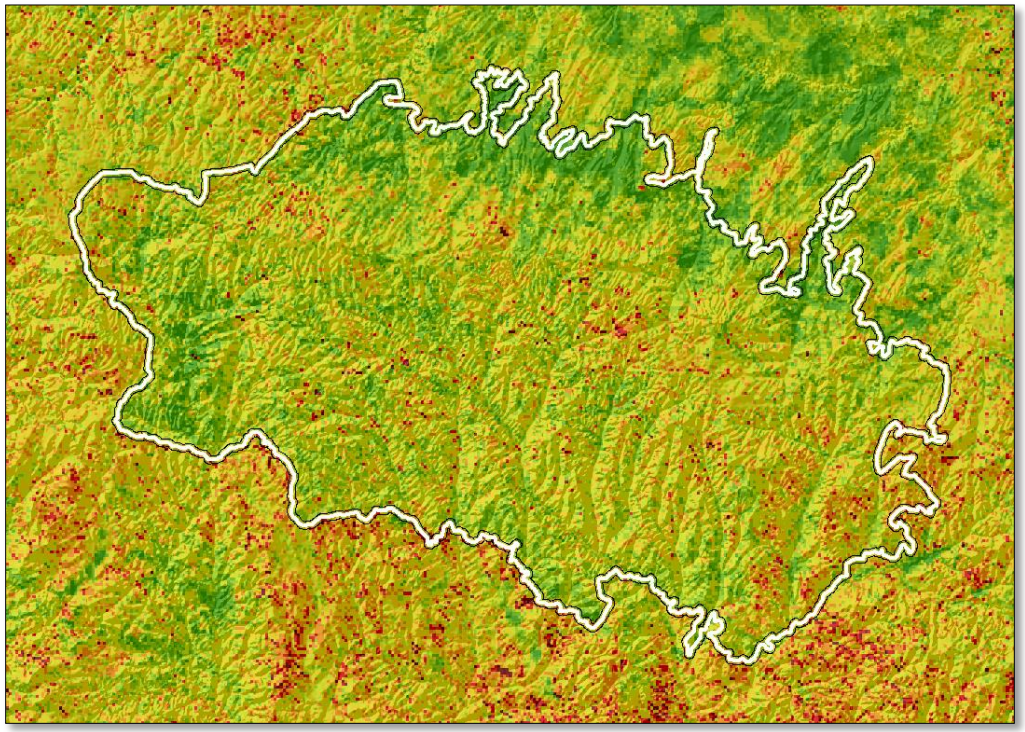
Change in peakedness/grassiness (difference between 100th and 85th %iles)

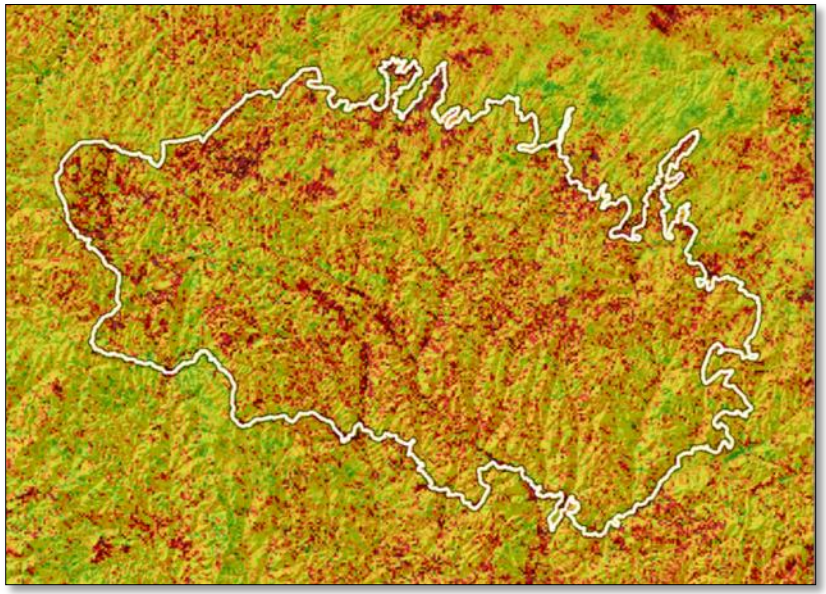
More peaked
> 3
2.1 to 3
1.1 to 2
0.1 to 1
-0.9 to 0
-1.9 to -1
-2.9 to -2
< -3
Less peaked



Pre-fire to 2003-7 mean

2003-7 to 2008-12 mean



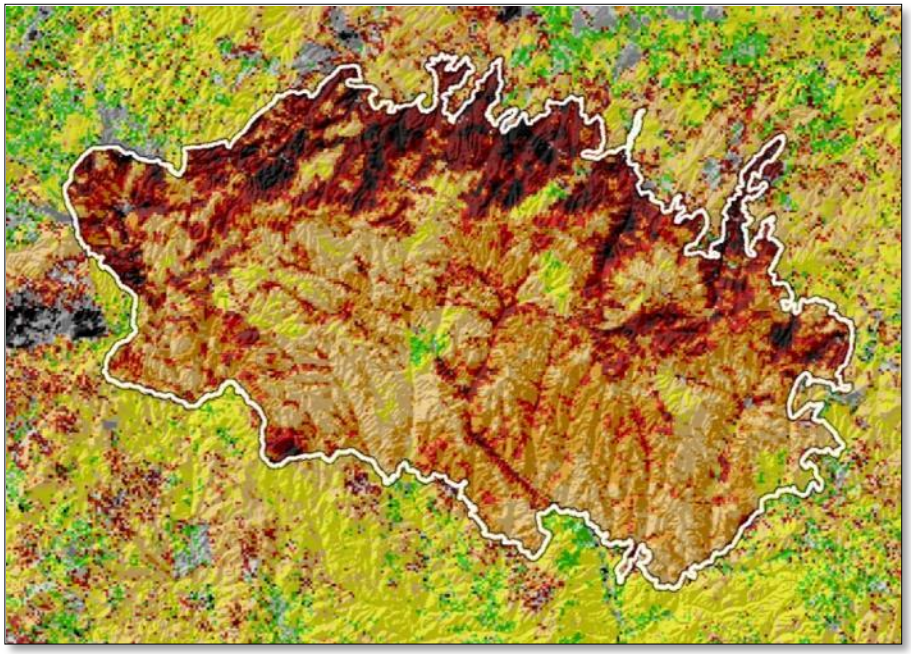


Pre-fire to 2008-12 mean

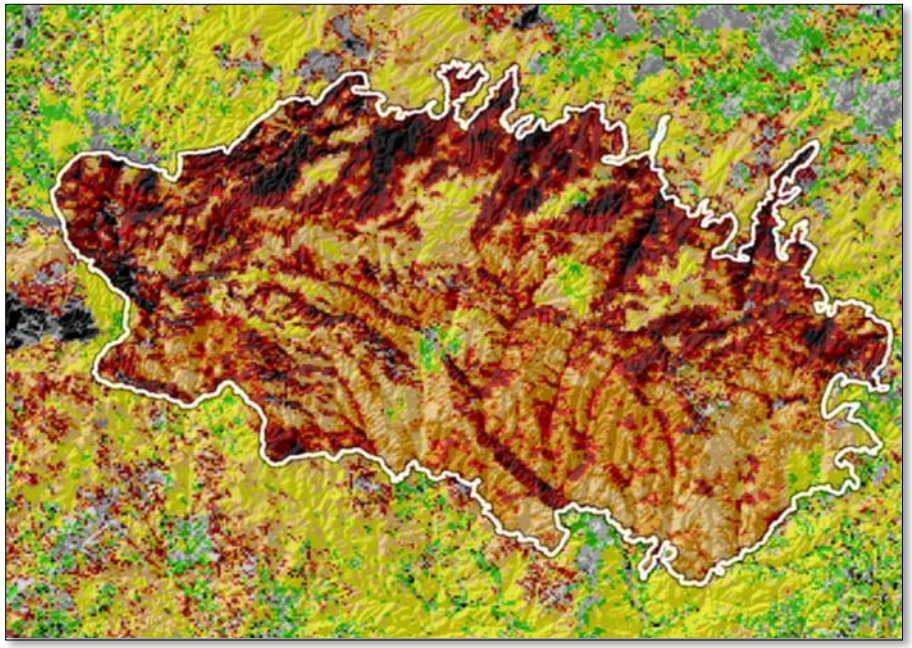
Tracking and predicting post disturbance response

Rodeo Fire

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



Time to recovery of median (50th %ile)



Years to recovery

- > 50
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- 20.1 to 30
- 10.1 to 20
- 0 to 10

No observed recovery (% decline in 2012)

- -4.9 to 0
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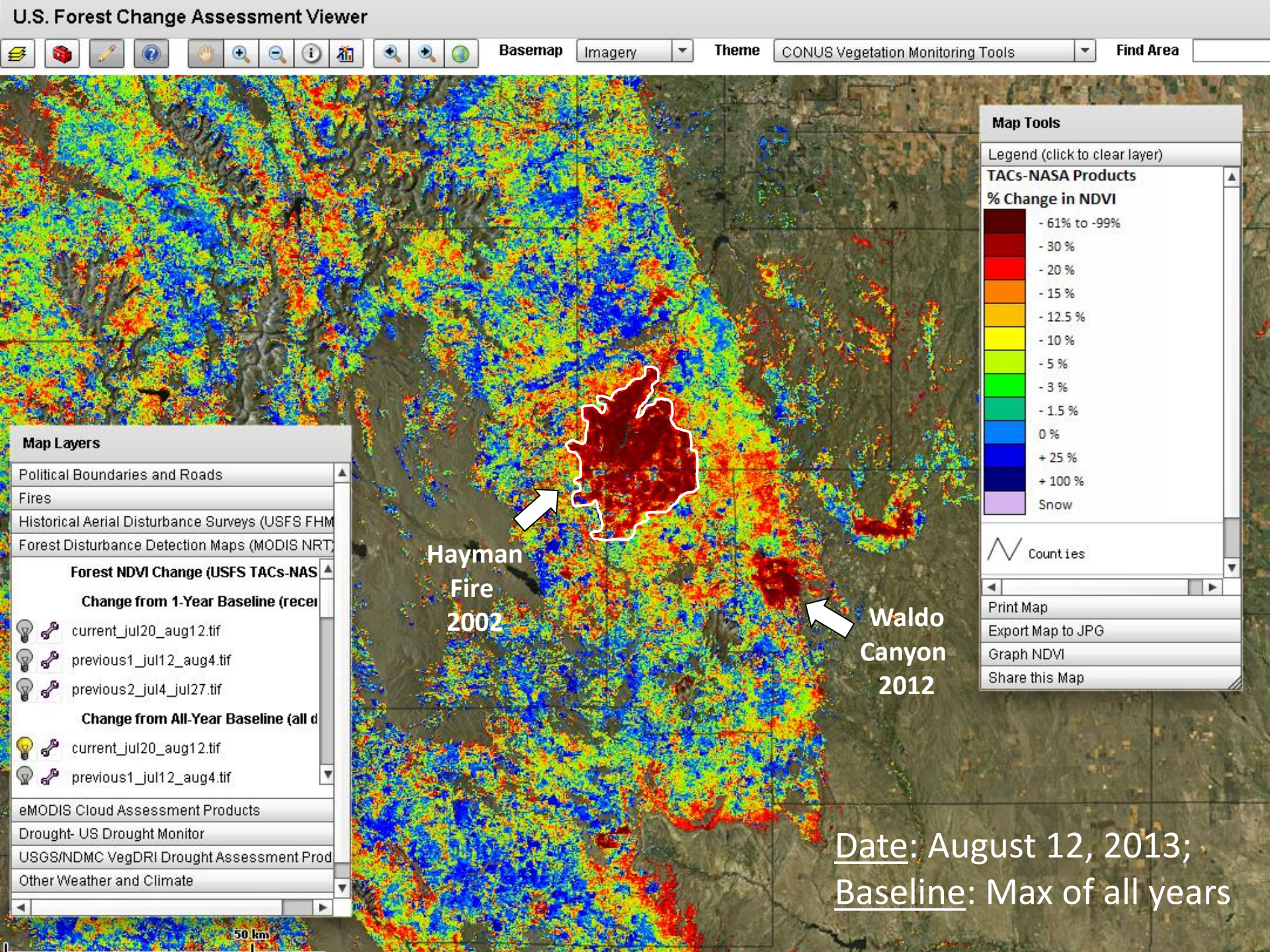
U.S. Forest Change Assessment Viewer
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TACs-NASA Products
% Change in NDVI
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- 10 %
- 5 %
- 3 %
- 1.5 %
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Snow
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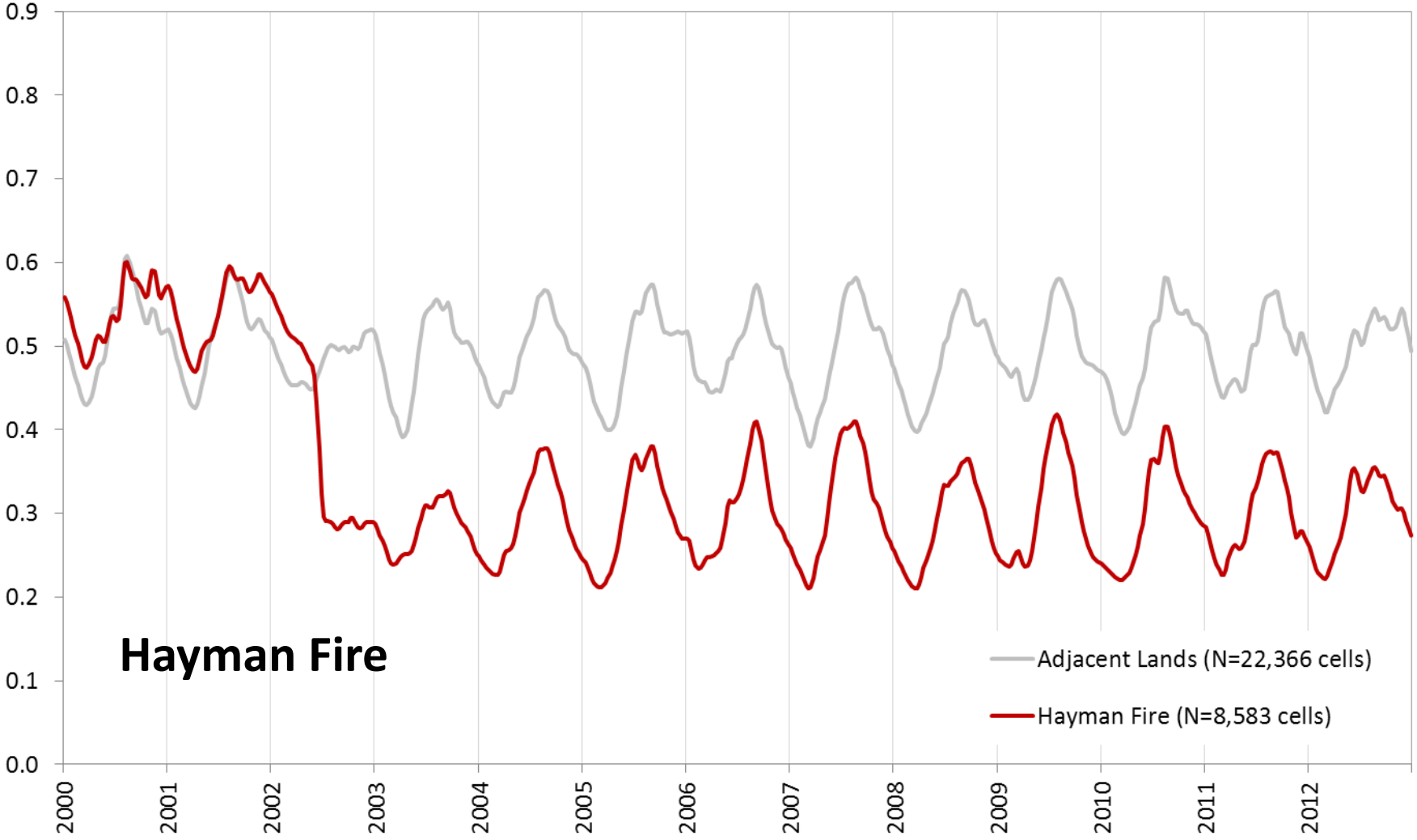
Historical Aerial Disturbance Surveys (USFS FHM
Forest Disturbance Detection Maps (MODIS NRT)
Forest NDVI Change (USFS TACs-NAS
Change from 1-Year Baseline (recei
current_jul20_aug12.tif
previous1_jul12_aug4.tif
previous2_jul4_jul27.tif
Change from All-Year Baseline (all d
current_jul20_aug12.tif
previous1_jul12_aug4.tif
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

Tracking and predicting post disturbance response

Reference conditions as phenology of adjacent unburned area



Tracking and predicting post disturbance response

Hayman Fire

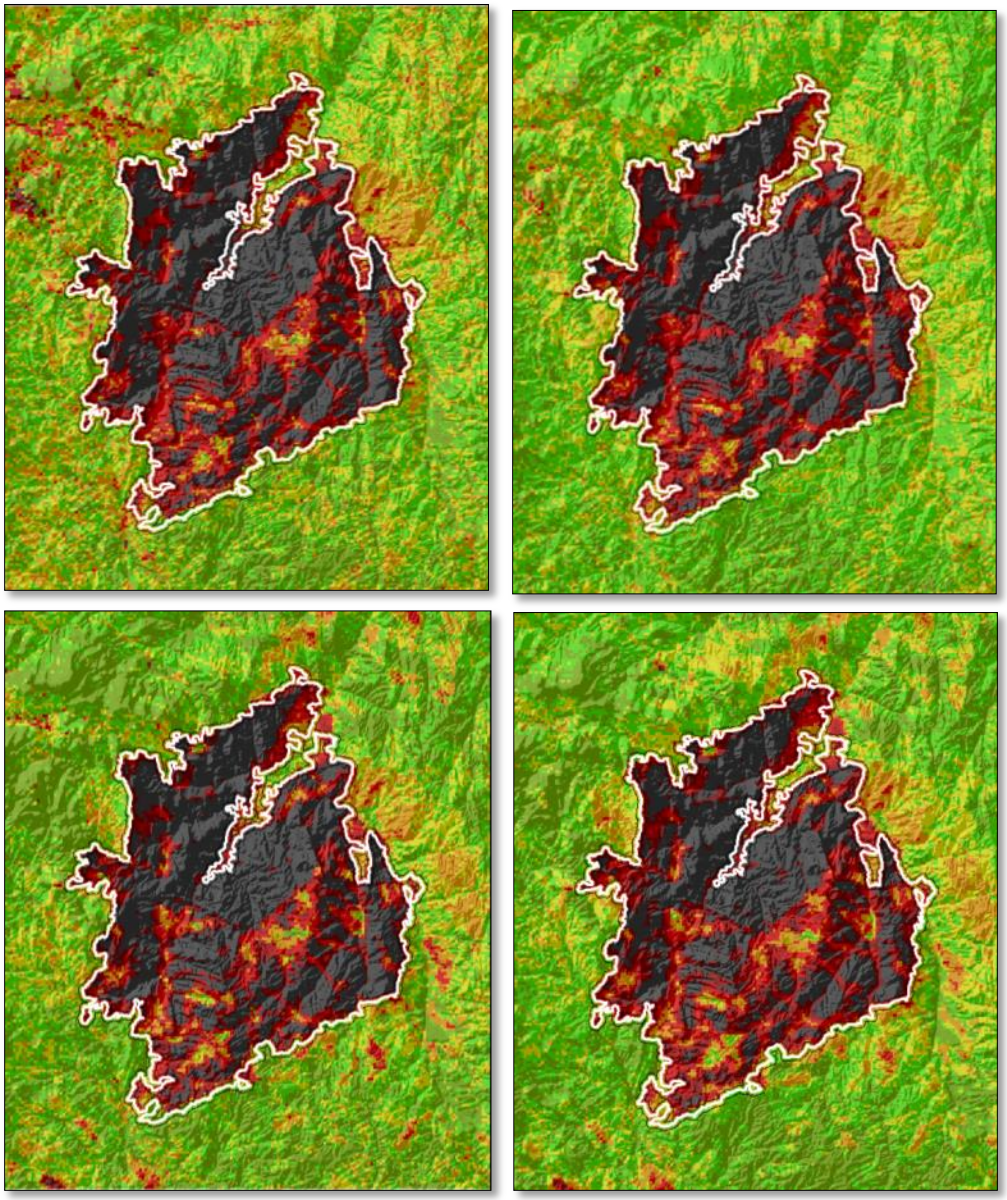
Percent change from 2000-1 mean

- <-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

Evergreen (25th %ile) **Median** (50th %ile)

2003

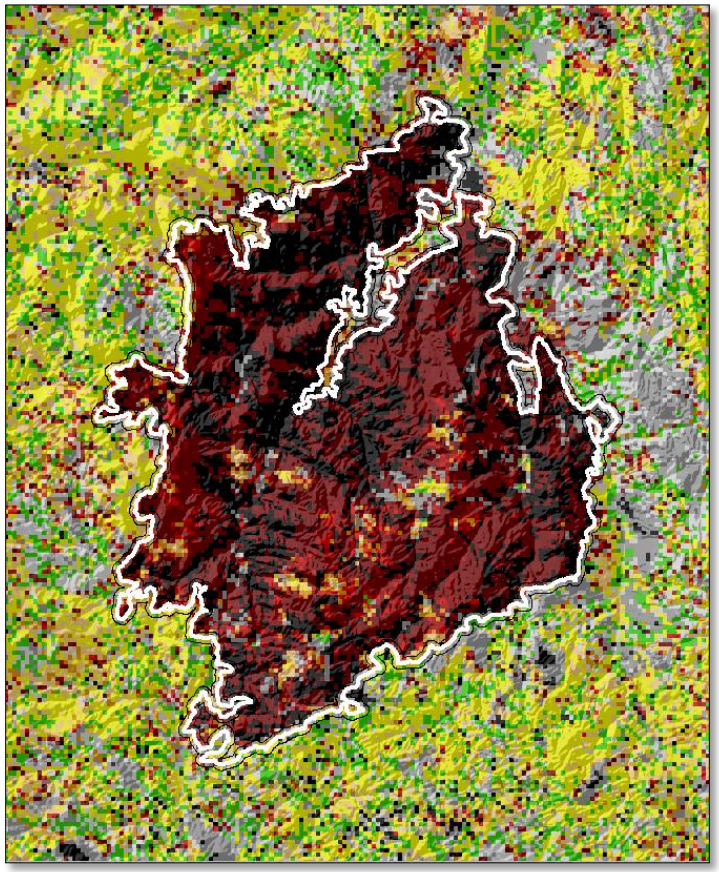
2012



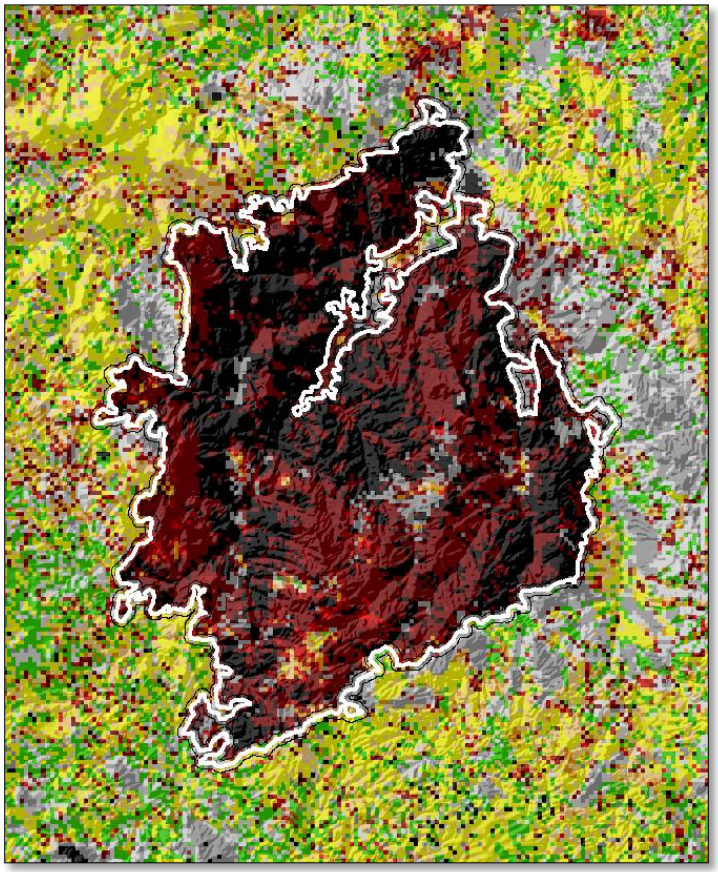
Tracking and predicting post disturbance response

Hayman Fire

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



Time to recovery of median (50th %ile)



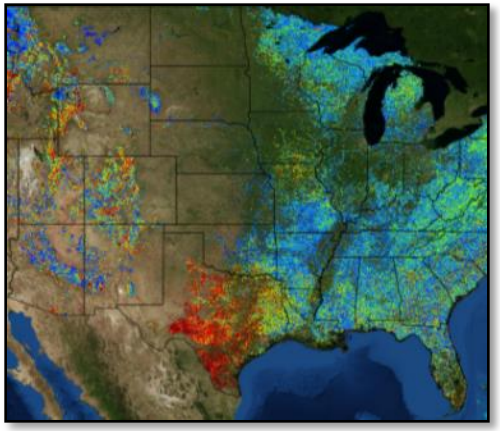
Years to recovery

- > 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

Five Applications of the *ForWarn* System for Monitoring, Assessment and Prediction



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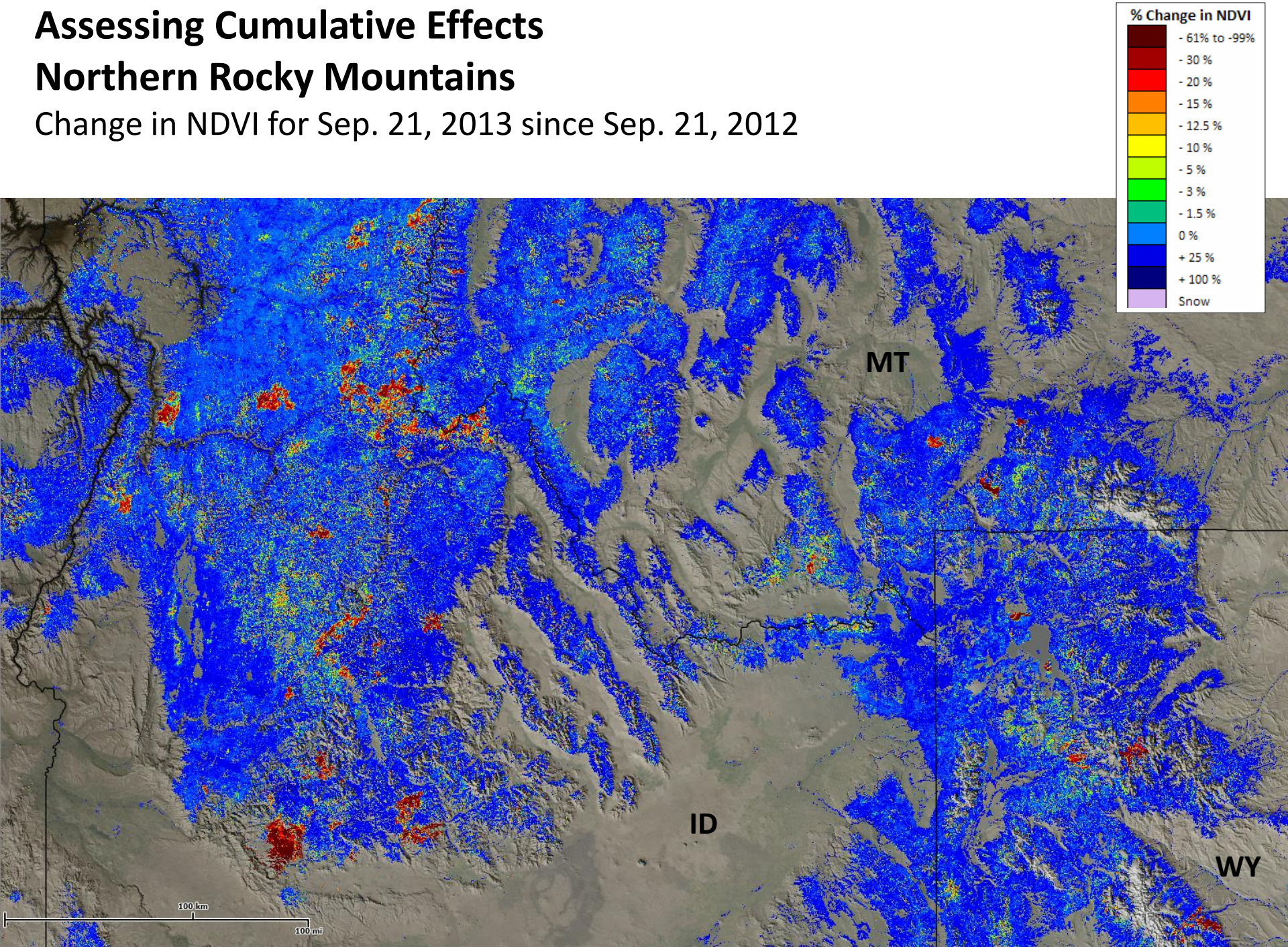
5. Providing a coarse monitoring framework for tracking landscapes with respect to desired conditions

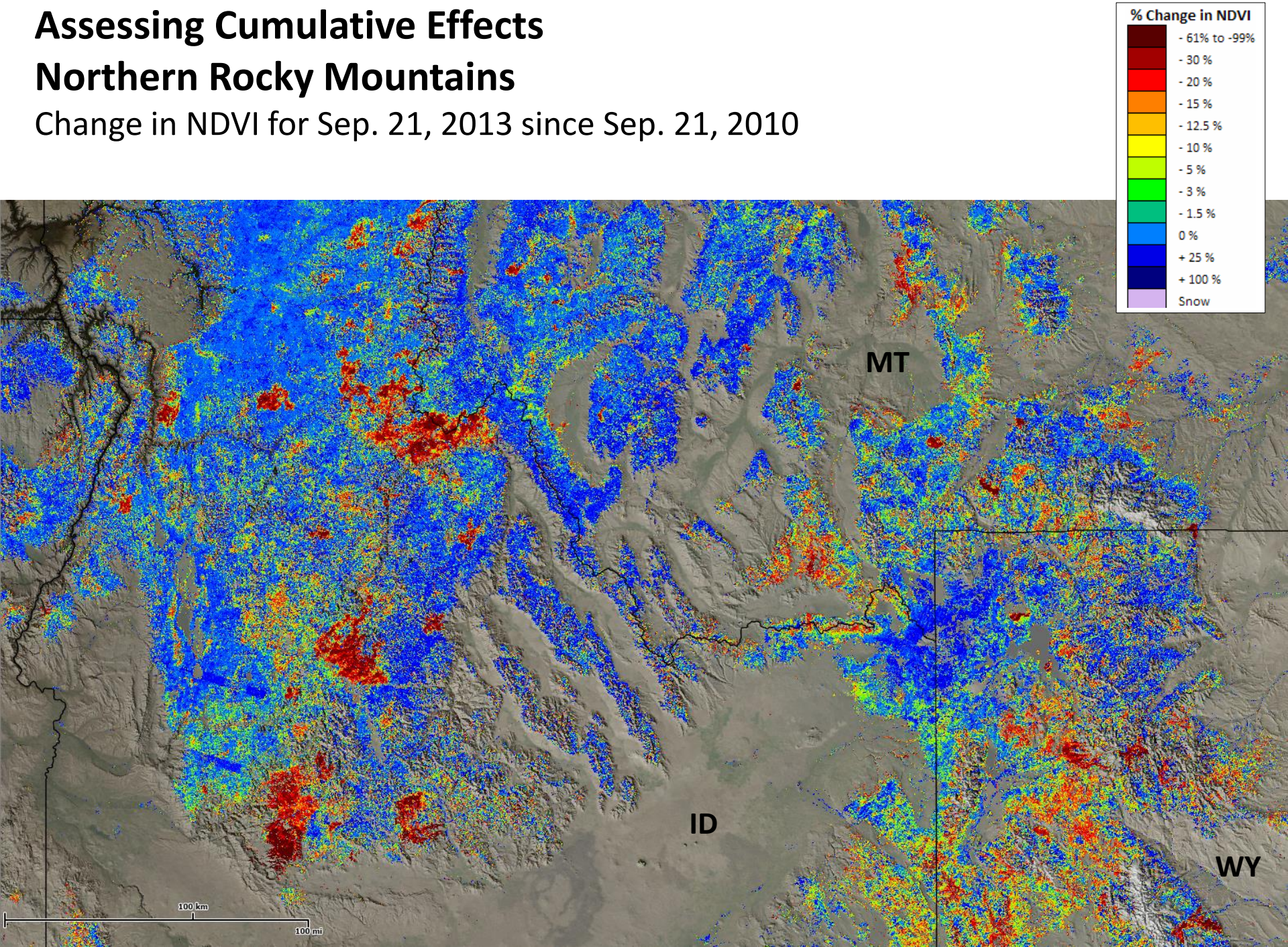
Assessing Cumulative Effects
Northern Rocky Mountains

Change in NDVI for Sep. 21, 2013 since Sep. 21, 2012



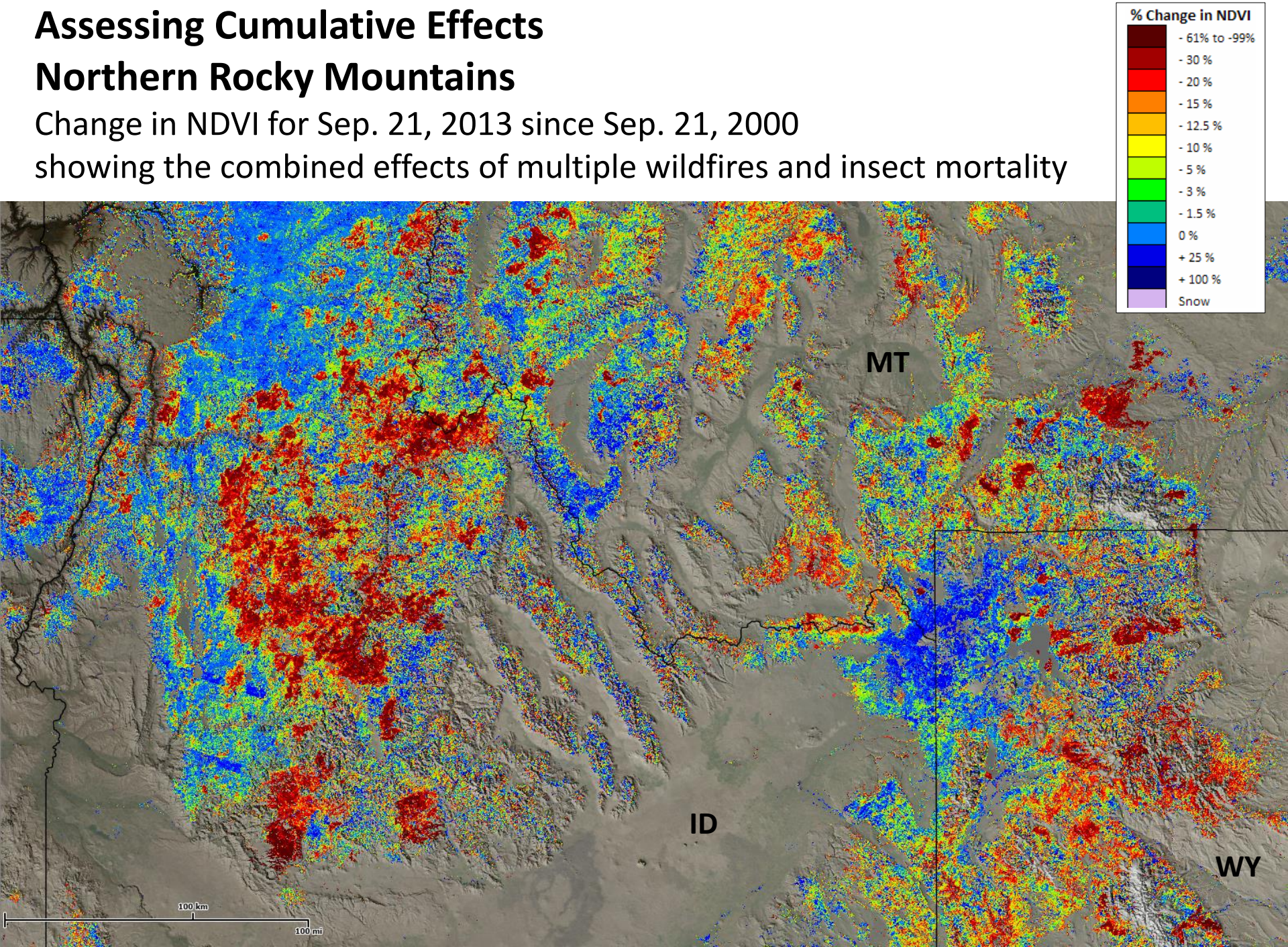
Assessing Cumulative Effects
Northern Rocky Mountains

Change in NDVI for Sep. 21, 2013 since Sep. 21, 2010



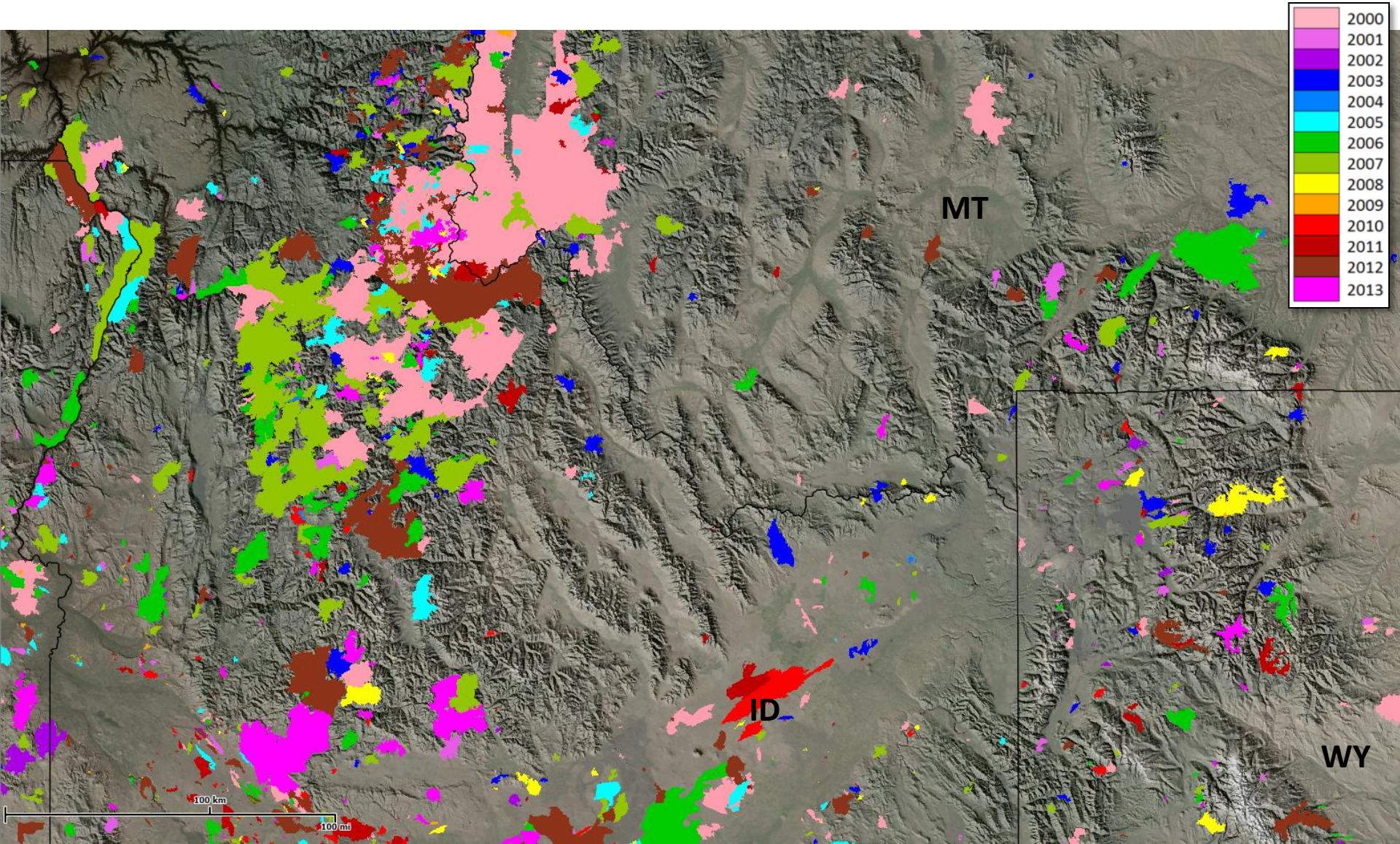
Assessing Cumulative Effects
Northern Rocky Mountains

Change in NDVI for Sep. 21, 2013 since Sep. 21, 2000
showing the combined effects of multiple wildfires and insect mortality



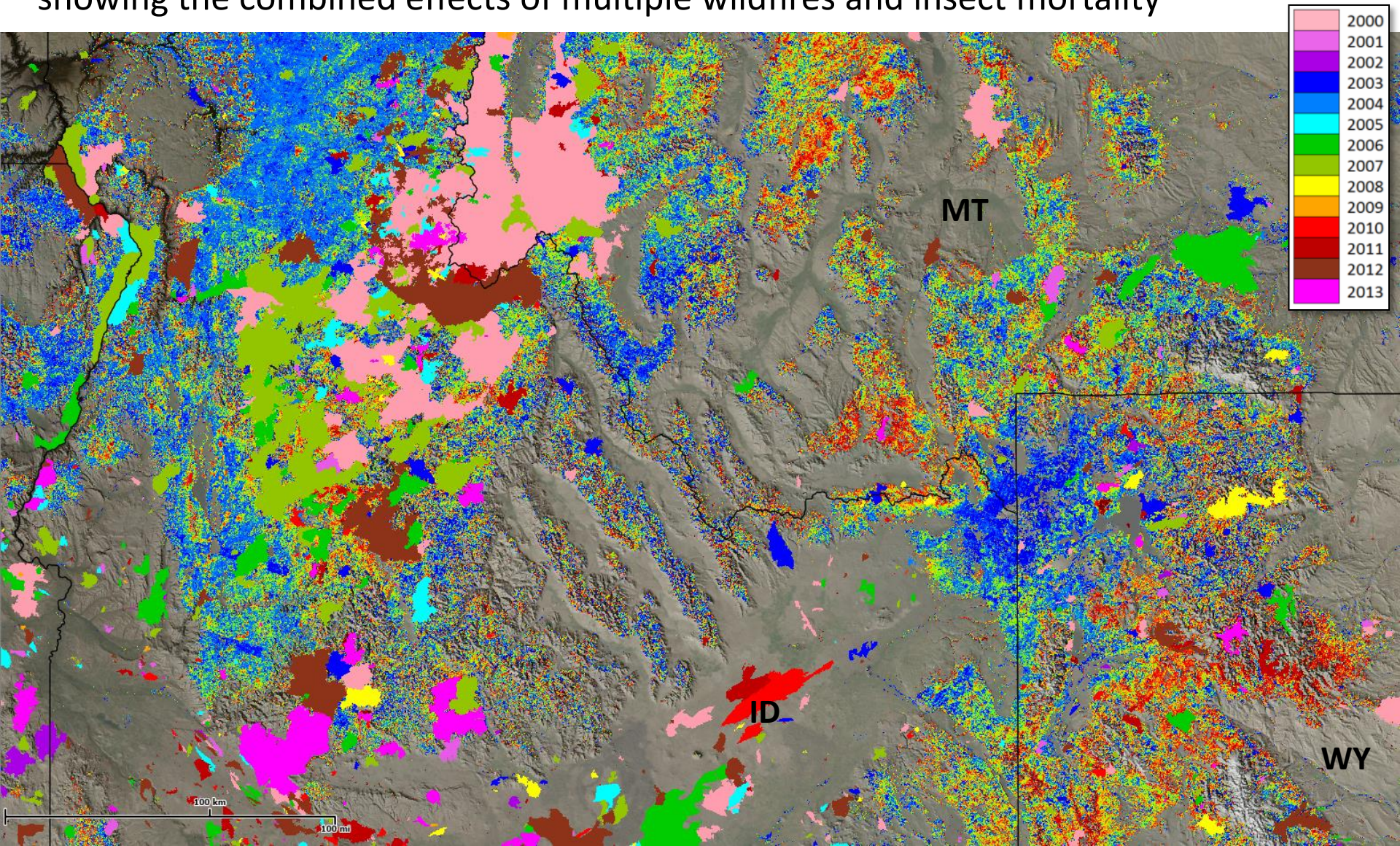
Assessing Cumulative Effects
Northern Rocky Mountains

Wildland Fires since 2000



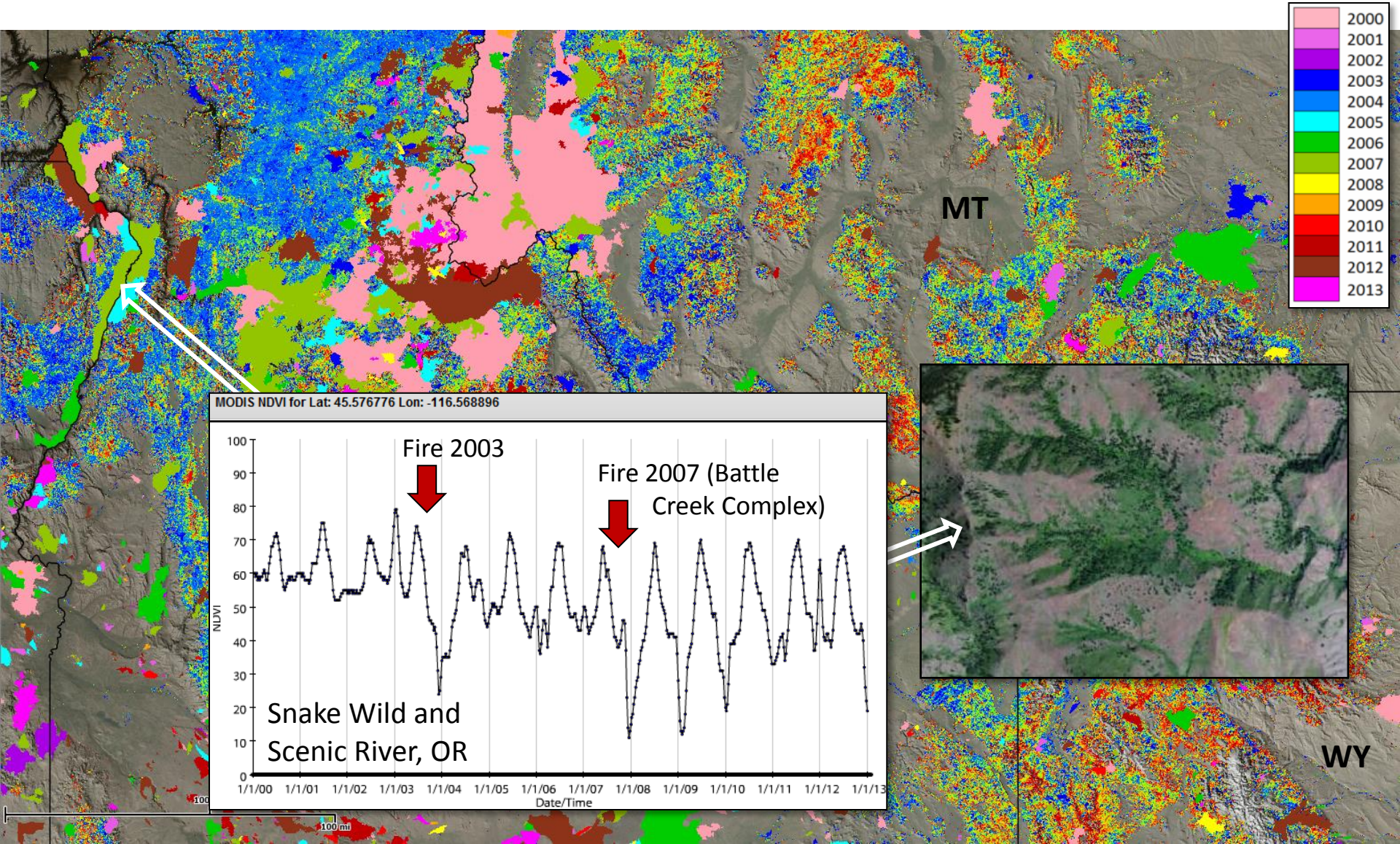
Assessing Cumulative Effects
Northern Rocky Mountains

Change in NDVI for Sep. 21, 2013 since Sep. 21, 2000 and **Wildland Fires** since 2000 showing the combined effects of multiple wildfires and insect mortality

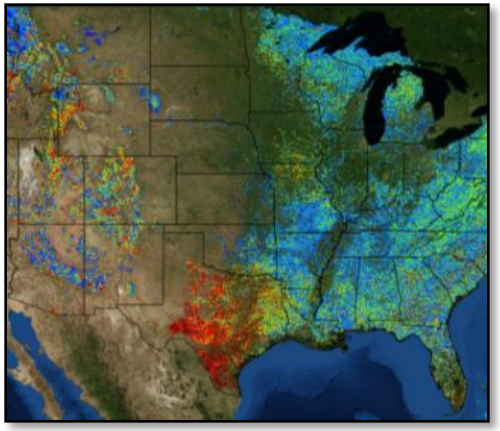


Assessing Cumulative Effects
Northern Rocky Mountains

Change in NDVI for Sep. 21, 2013 since Sep. 21, 2000 and **Wildland Fires** since 2000



Five Applications of the *ForWarn* System for Monitoring, Assessment and Prediction



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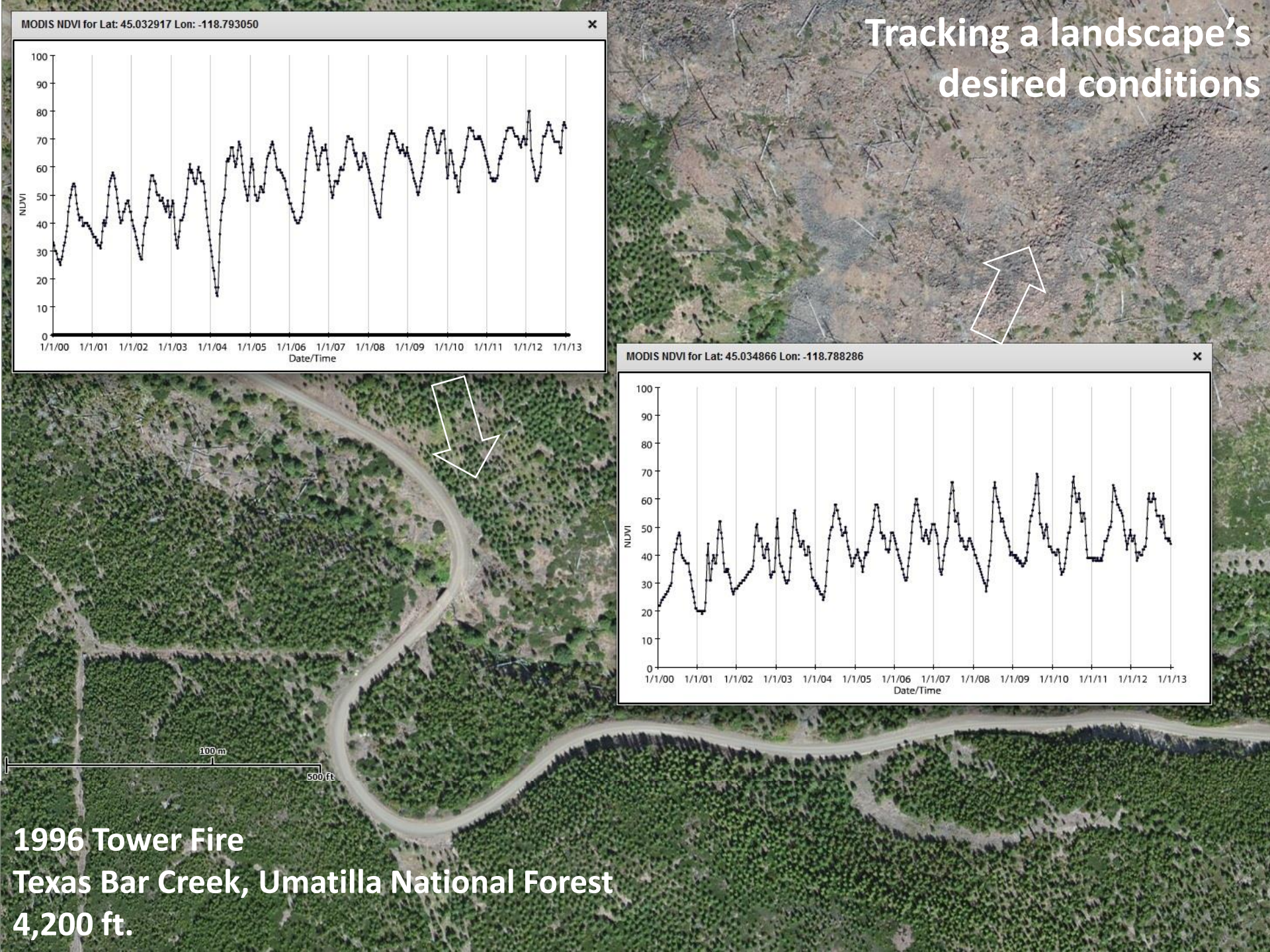
Tracking a landscape's desired conditions



1996 Tower Fire
Texas Bar Creek, Umatilla National Forest
4,200 ft.

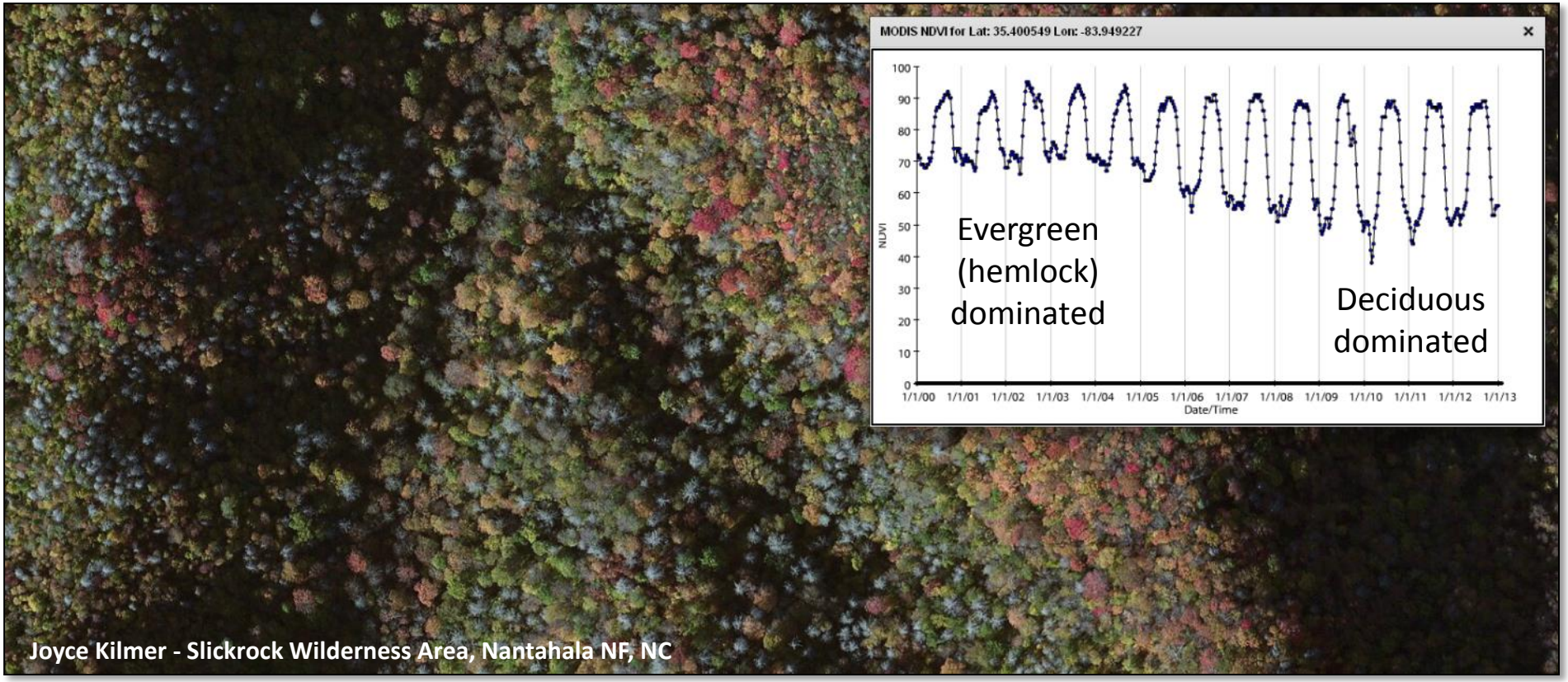
Tracking a landscape's desired conditions

Shifts in annual phenology profiles track certain changes in vegetation composition and structure

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.

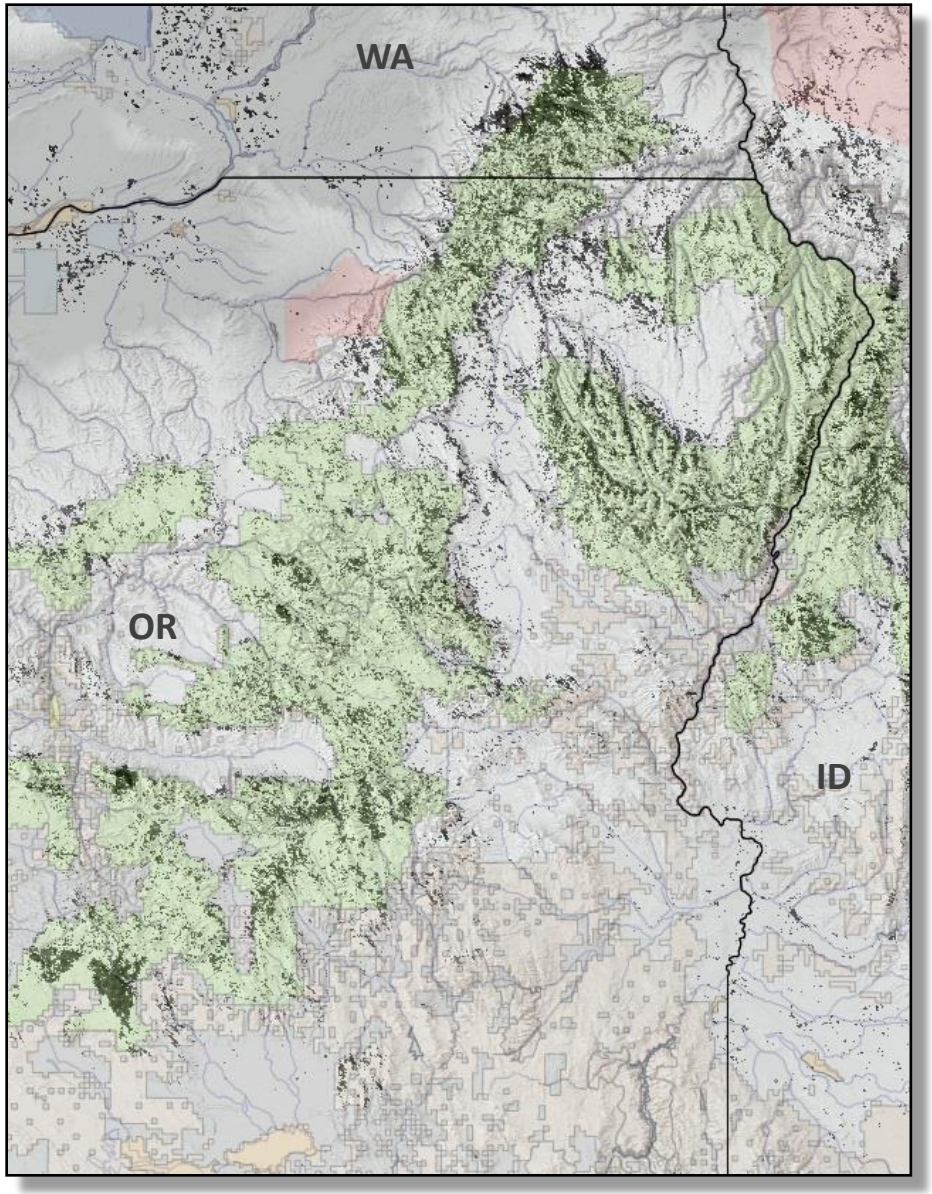


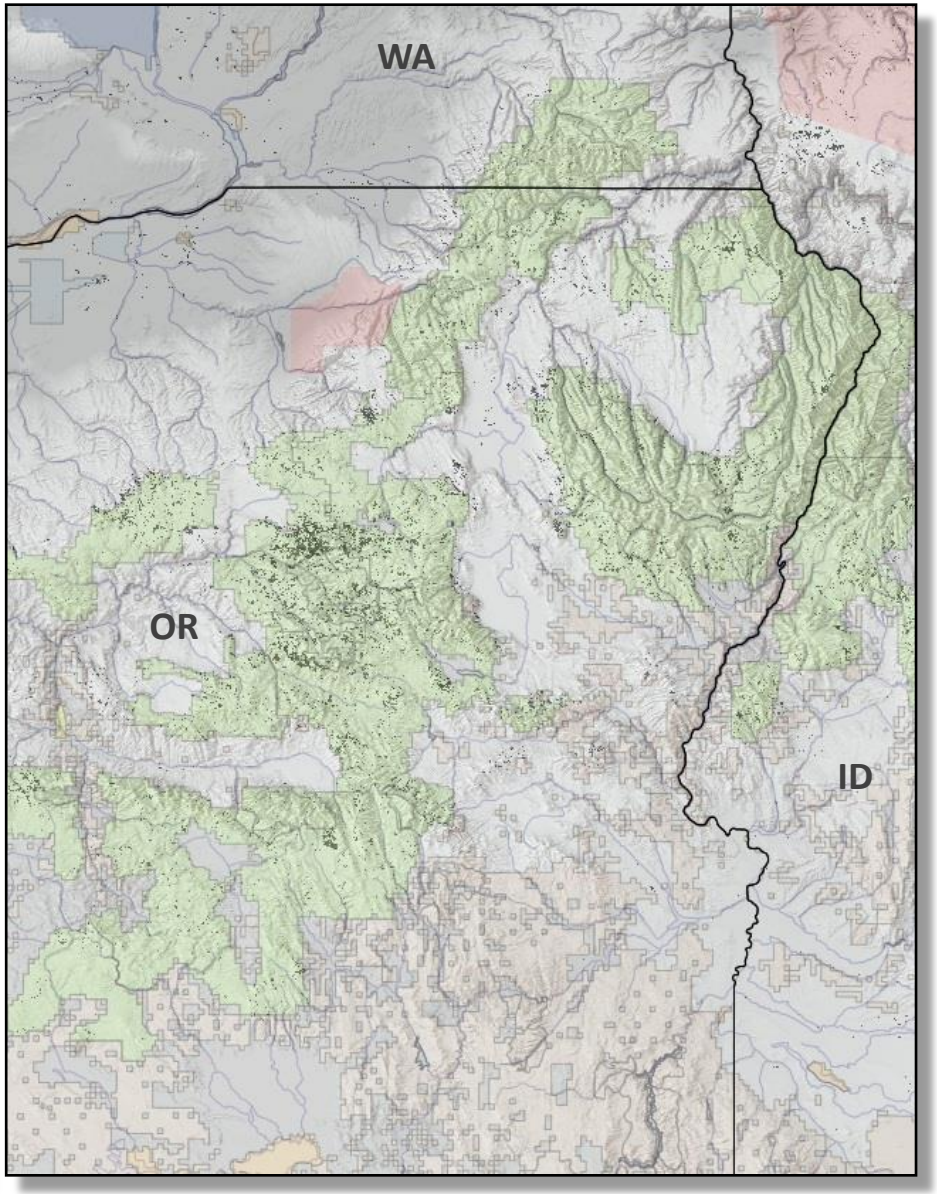
Joyce Kilmer - Slickrock Wilderness Area, Nantahala NF, NC

Tracking a landscape's desired conditions

NDVI-derived trends in the Blue Mountains

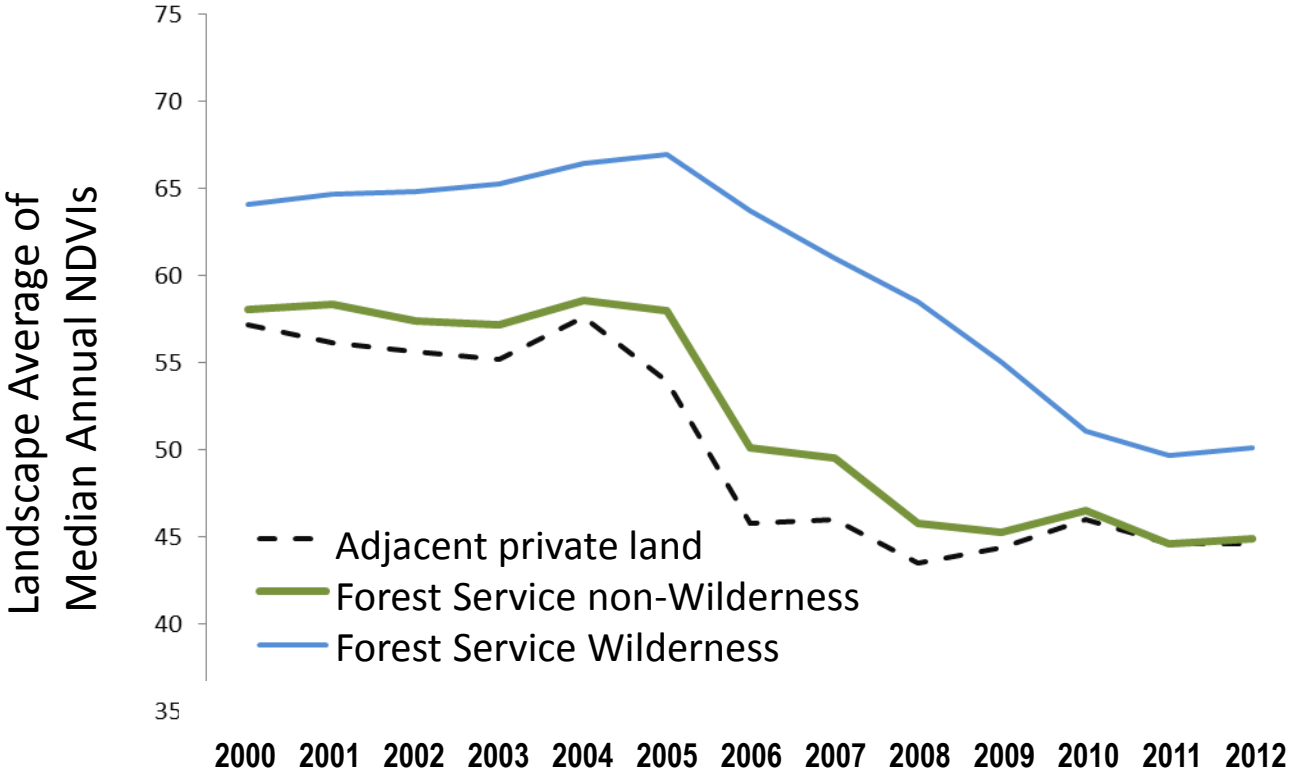
ForWarn's Evergreen Decline (left) and Evergreen Thrive (Right), 2000-2011





Tracking a landscape's desired conditions
Umatilla National Forest

Change in NDVI for all lands that burned at least once between 2000 and 2012



Adjacent private: 329/7,954 (04%)
FS non-Wilderness: 7,915/82,980 (10%)
FS Wilderness: 2,121/22,827 (09%)

Tracking a landscape's desired conditions

Transition matrix of 454 random MODIS cells that burned in 2002, CONUS

NDVI group in 2003 (post-fire)

grass dominated → *sparse trees* → *dense trees*

NDVI group in 2001 (pre-fire)

grass dominated ↓ *sparse trees* ↓ *dense trees*

	0	19	22	23	25	25	30	31	31	32	34	36	37	37	38	38	39	40	42	43	43	44	45	45	46	48	49	51	51	52	53	55	55	56	57	61	61	62	64	65	67	68	70	71	74	80	Grand To
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19																																															
22																																															
23		2		5						5																																					10
25		1			3																																										4
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30				3			4		1																																						8
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31					1	1			2																																						4
32				3			2			2					1																																8
34					1						1																																				2
36							3					4																																			7
37												5																	1																		6
37		2			1	2	1	2	2			3		1	1																																15
38				3			1	1	2	1														1																							9
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45																							1						1																		2
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55							1		1						1						1										2																	6
55																							1																									1
56																						1																										1
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60				1	2	1			2					2					1			2			1			3			2																17
61																																				3											3
62		2		2	4	1			7		1			5	5							1		1	6			2	3		4						2							1			47
64																																								1							1
65																																					1			2							3
67																			1									1												1							3
68																								2	1				1														1					5
70																																													1		1
71				1	1				4						1										4					1	2						2							1			17
74																																												1			1
80									3						4										4			1			4				1			10						20		13	60
Total	0	17	3	25	25	12	21	12	58	9	8	17	4	21	34	5	6		4	4	1	20	3	8	38	2	1	10	7	1	15	0		0	1	3	1	14	2	4			1	23	1	13	454

Tracking a landscape's desired conditions

Transition matrix of 454 random MODIS cells that burned in 2002, CONUS

NDVI group in 2012 (long post-fire)

grass dominated → *sparse trees* → *dense trees*

NDVI group in 2001 (pre-fire)

grass dominated ↓ *sparse trees* ↓ *dense trees*

	13	19	22	23	25	25	30	31	31	32	34	36	37	37	38	38	39	42	42	43	43	44	45	45	46	48	49	51	51	52	53	55	55	56	57	60	61	62	64	65	67	68	70.13	71.2	74.2	79.9	Grand Tot
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36						1	3	3																																							7
37							1	4																	1																						6
37						3	4	3	3		1			1																																	15
38		1		1					3	1					2									1																								9
38																																															
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43								2				2	1	5			1			1																											12
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46				3		1	1	4	4				1	2	11							3		1	6																						37
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51												2								5		3		1																							11
52								1						1	1							6								1																	10
53				1	3	2		2	7		1			7	11					1		14			19			1	1		4																74
55														1							1										3	1																6
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56			1																																												1
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60								3					1	2					3	1		4			1			2																			17
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62						1		3					3	4	2					1		5	1		9			1	1		12	1					2							1			47
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74																																												1			1
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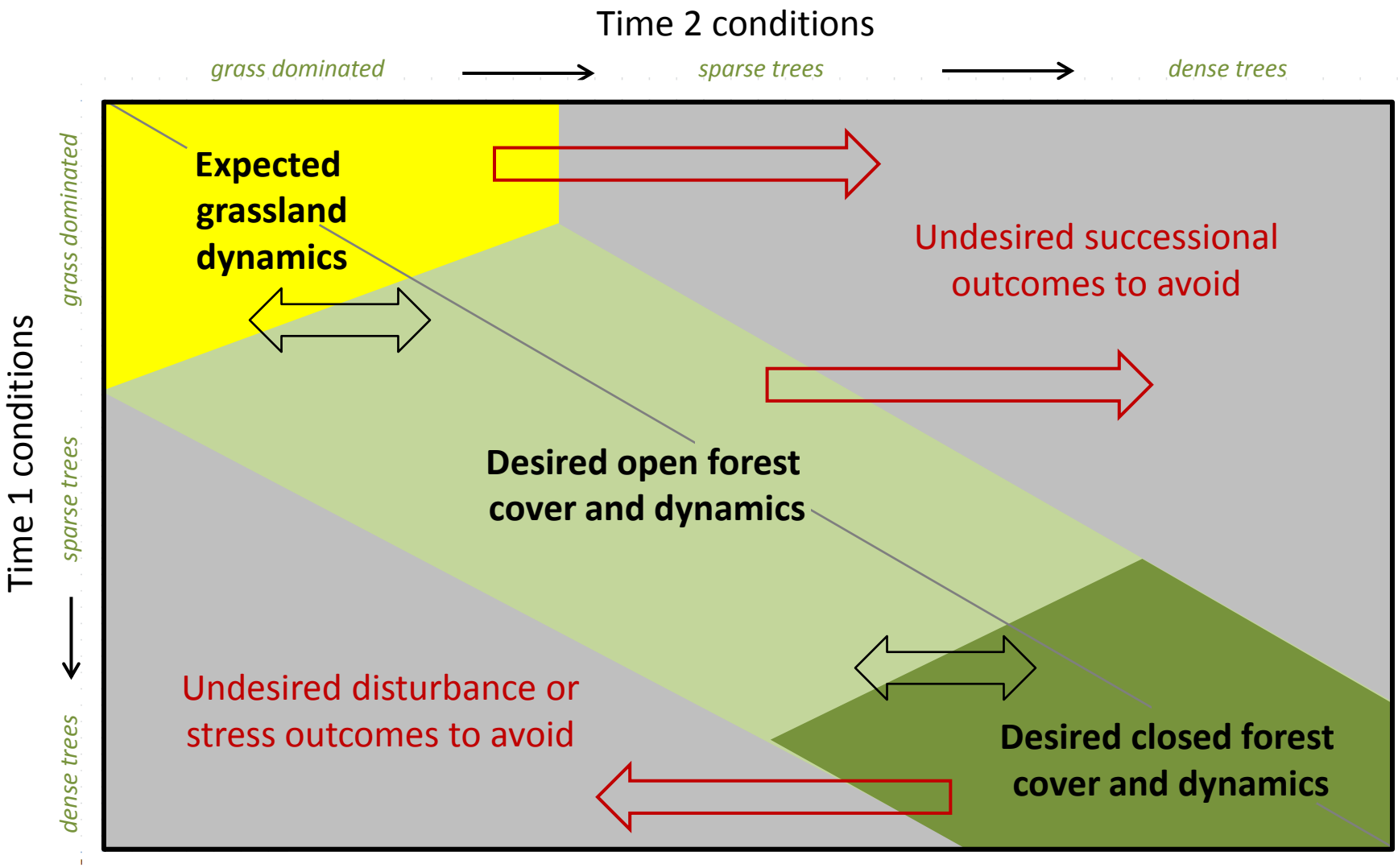
nd To	1	10	1	14	7	22	22	30	23	2	11	6	7	30	32	2	2	1	5	13	2	40	1	3	43	0	1	7	6	2	23	3		0	0	4	2	17		2		1	4	25	2	25	454

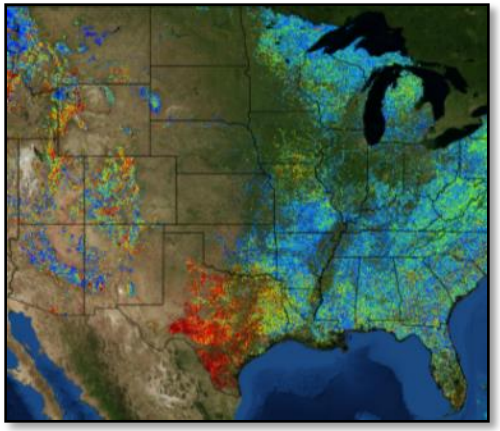
Tracking a landscape's desired conditions (and desired dynamics)

Setting preferences and tolerances for future disturbances and outcomes



Five Applications of the *ForWarn* System for Monitoring, Assessment and Prediction

…in summary



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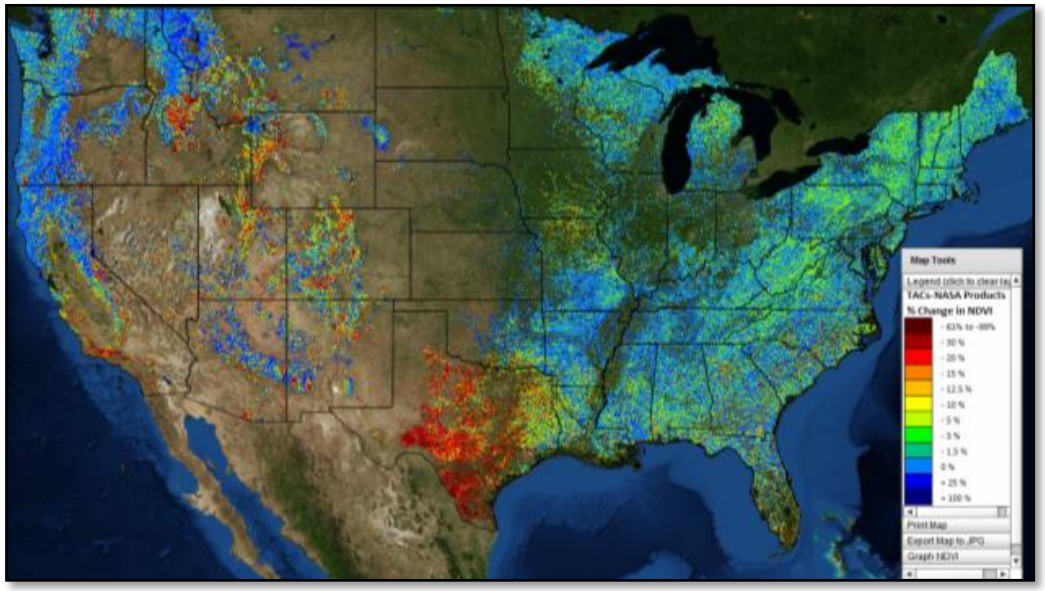
Thank You



stevenorman@fs.fed.us

http://forwarn.forestthreats.org