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ENVIRONMENTAL THREAT  
ASSESSMENT CENTER

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The Eastern Threat Center hosts First Friday All Climate Change Talks, monthly information sharing forums featuring presentations about research activities focused on climate change impacts to eastern forest ecosystems.

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### LATEST NEWS

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Family forest owners may use consulting foresters or state extension foresters for advice on the technical details of land management, but many owners shy away from seeking help with how best to pass their forest land on to the next generation.




**Sunlight vs. Hemlock Woolly Adelgids**


Scientists have identified a potential new strategy for protecting hemlocks from the miniscule insect that plagues them.


### RECENT PUBLICATIONS

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*Productivity in the Conterminous United States*

 A dynamic leaf gas-exchange strategy is conserved in woody plants under changing ambient CO<sub>2</sub>: evidence from carbon isotope discrimination in paleo and CO<sub>2</sub> enrichment studies [pdf](#)

 Potential and limitations of inferring ecosystem photosynthetic capacity from leaf functional traits [pdf](#)

 A remotely sensed pigment index reveals photosynthetic phenology in evergreen conifers [pdf](#)



Southern Research Station  
*Science you can use!*

Western Wildland Environmental  
Threat Assessment Center







# A National Satellite-Based Forest Disturbance Detection System in Near-Real-Time

*Eastern Forest Environmental Threat Assessment Center  
USDA Forest Service, Southern Research Station, Asheville, NC*

## **ForWarn Team**

*William W. Hargrove, PI (USDA-FS)  
Steven P. Norman (USDA-FS)  
William M. Christie (USDA-FS)  
Joseph P. Spruce (NASA Stennis)*

## **Partners**

*USGS EROS Data Center, SD  
NASA Stennis Space Center, MS  
DOE Oak Ridge National Laboratory, TN  
UNC-Asheville, NC: NEMAC*





# **ForWarn**

Satellite-Based Change Recognition and Tracking



- What is **ForWarn** and how does it work?
- The **Forest Change Assessment Viewer**
- Website - <https://forwarn.forestthreats.org>
- Questions?



*ForWarn* Introduction Webinar  
Virginia Department of Forestry  
April 3, 2017







AQUA - MODIS

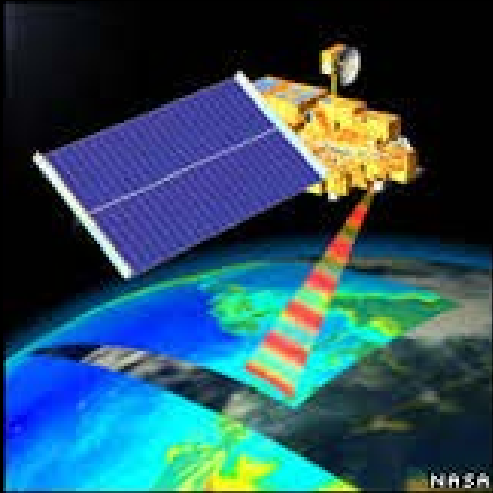


- A **national-scale near real-time** satellite-based recognition and tracking system for all land cover disturbances
- "Officially" rolled-out in 2012, but has actually been operating since January 2010
- ***ForWarn*** covers the entire lower 48 United States
- Generates new potential **disturbance maps every 8 days**, even throughout the winter
- Detects most types of regional and local land cover disturbances
  - insects, diseases, wildfires, ice and frost damage, tornadoes, hurricanes, blowdowns, harvest, urbanization, seasonal timing and drought. and landslides
- 231 meter native resolution map cells (**13-acre minimum mapping unit**)
  - It is not necessary for an entire forested pixel to be disturbed for disturbance to be detected



# Application Context

*strategic*



- The ***ForWarn*** System covers essentially 100% of the forests within the lower 48 United States every 8 days
- In 2011, airborne observers from the Aerial Disturbance Survey (ADS) program covered about 70% of forests within the lower 48 United States once with visual observations from light aircraft
- **The two tiers are complementary:**

*tactical*

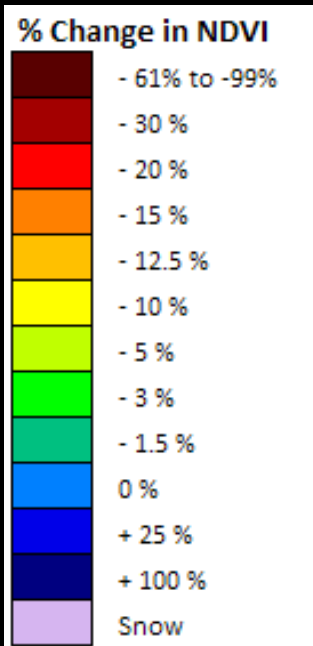


- ***ForWarn*** is coarse-scaled, automated and extensive, and has a very high repeat rate
- Aerial surveys are finer-scaled, but require experienced observers, are labor-intensive and expensive, are a safety risk, are limited in extent and are completed once-a-year
- The two different systems can support each other well



# How Does *ForWarn* Work?

- Based on a simple comparison between current greenness vs. historical greenness
- We develop this historical greenness from the 16-year historical MODIS satellite record
- The comparison is both spatially and temporally explicit – compares during the same 24-day period and for the same MODIS pixel
- **If the current NDVI value is less than 100% of the baseline used** = Potential Disturbances
  - ✓ shown as Greens, Yellows, and Reds
- **If the current NDVI value is greater than 100% of baseline greenness** = Vegetation Regrowth or Recovery
  - ✓ shown as Blues
- Only shows a Disturbance if it affects the plants - and to the degree that it affects the plants
- When first opening the 'Forest Change Assessment Viewer', only forested areas are shown by default, but ***ForWarn*** detects disturbances in all NLCD-based land use and land cover classes, including agricultural crops and rangeland forage (see the new "Masking" tool)





**ForWarn** produces seven annually-based disturbance maps every 8 days, each emphasizing the **age and magnitude** of disturbance that are displayed

Added in 2016, are four intra-annual disturbance maps produced for three timeframes during the growing season, each emphasizing the **persistence** of disturbance

## Standard Products

1. 1yr baseline '*Early Detect*' (by most recent cloud-free)
2. 1yr baseline (by NDVI max)
3. 3yr baseline “
4. 5yr baseline “
5. All year baseline “

*Seasonally Adjusted (for early / late – spring / fall )*

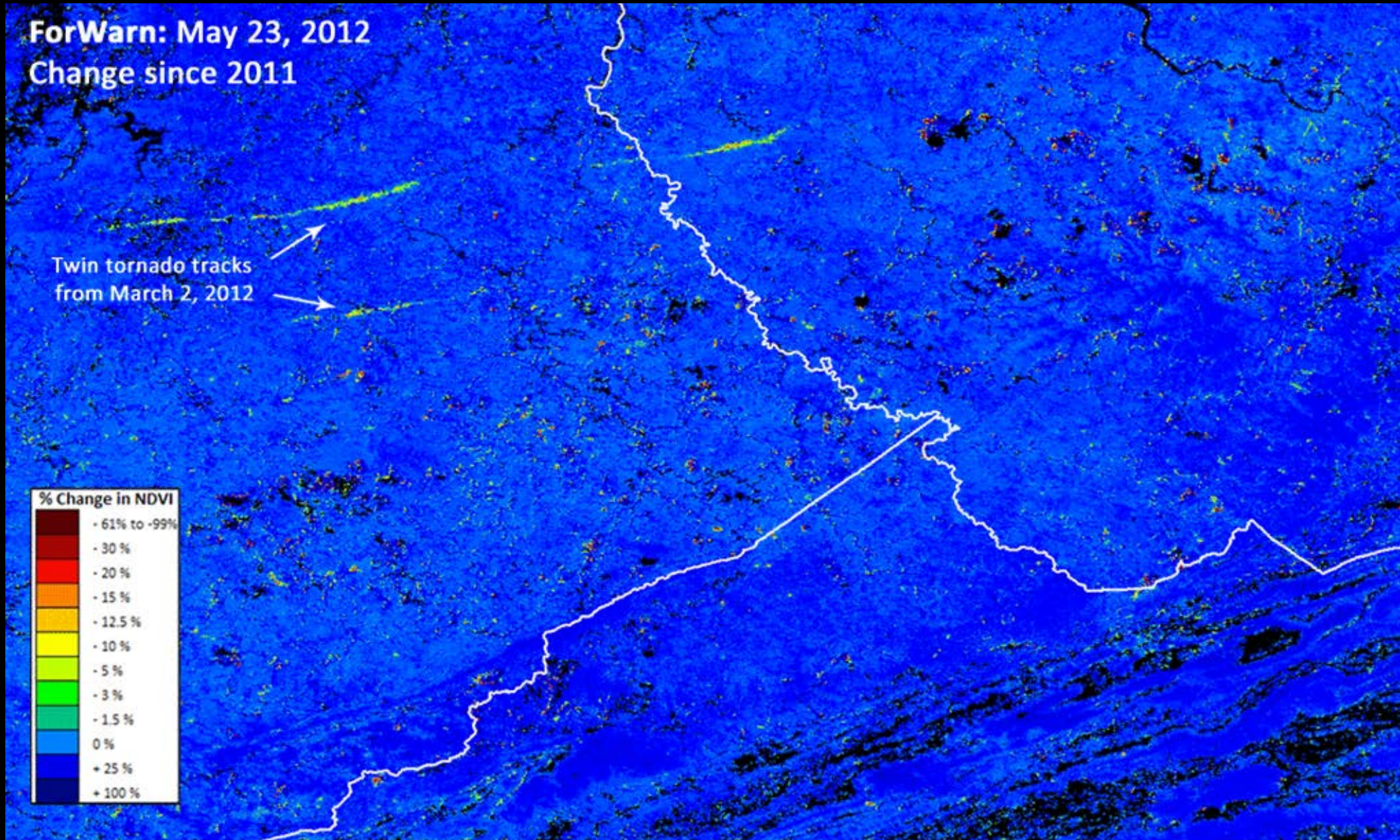
6. All year, based on Mean-of-the-Max NDVI
7. All year, based on Phenotype Mean NDVI

## Intra-Annual Duration

1. 6-period Duration, May 8 – June 17 (for western U.S.)
2. 6-period Duration, June 24 – Aug 4
3. 6-period Duration, Aug 12 – Sept 21
4. 12-period Duration, June 24 – Sept 21

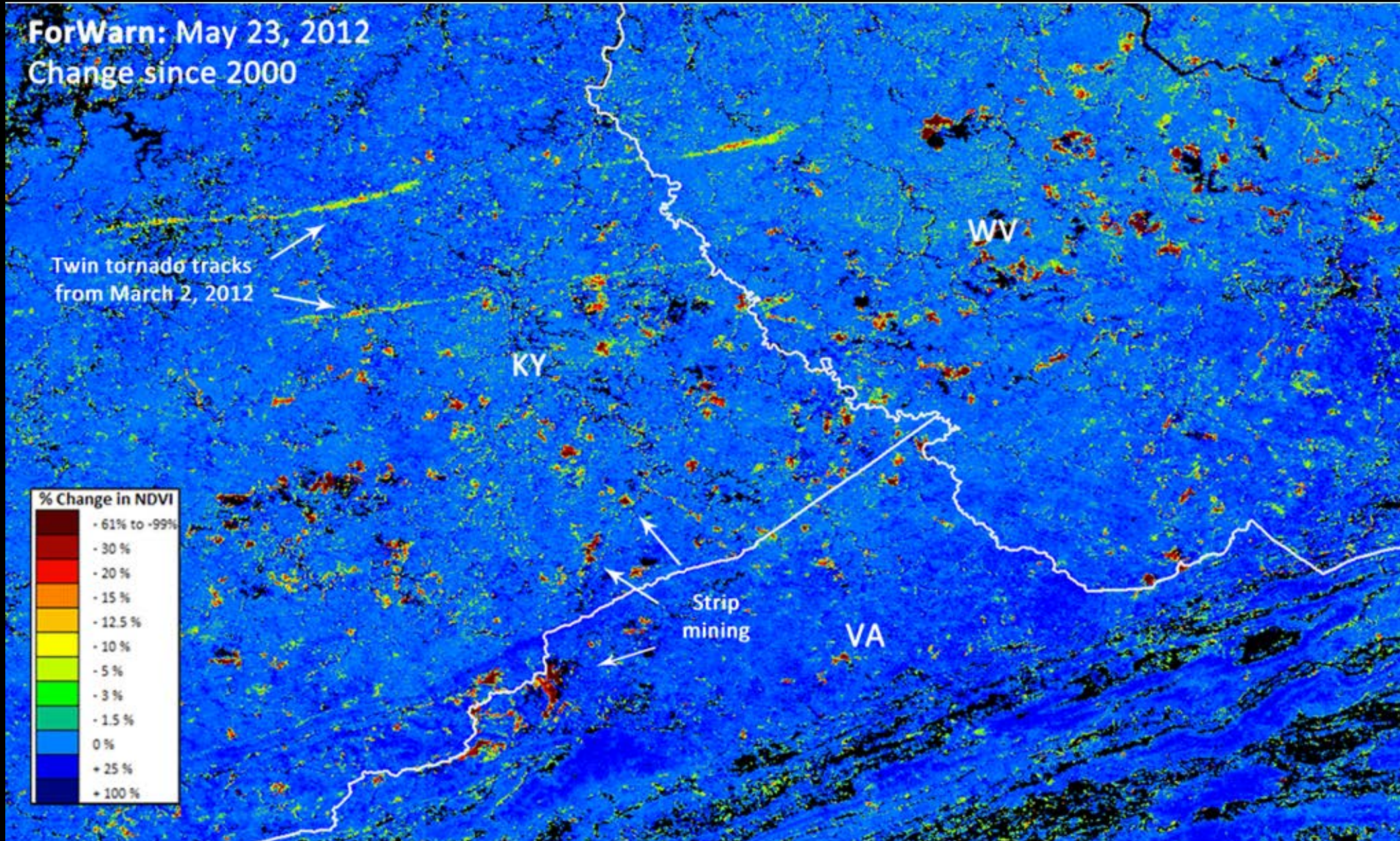


## ForWarn 1 year baseline vs. All-year baseline





## ForWarn 1 year baseline vs. All-year baseline

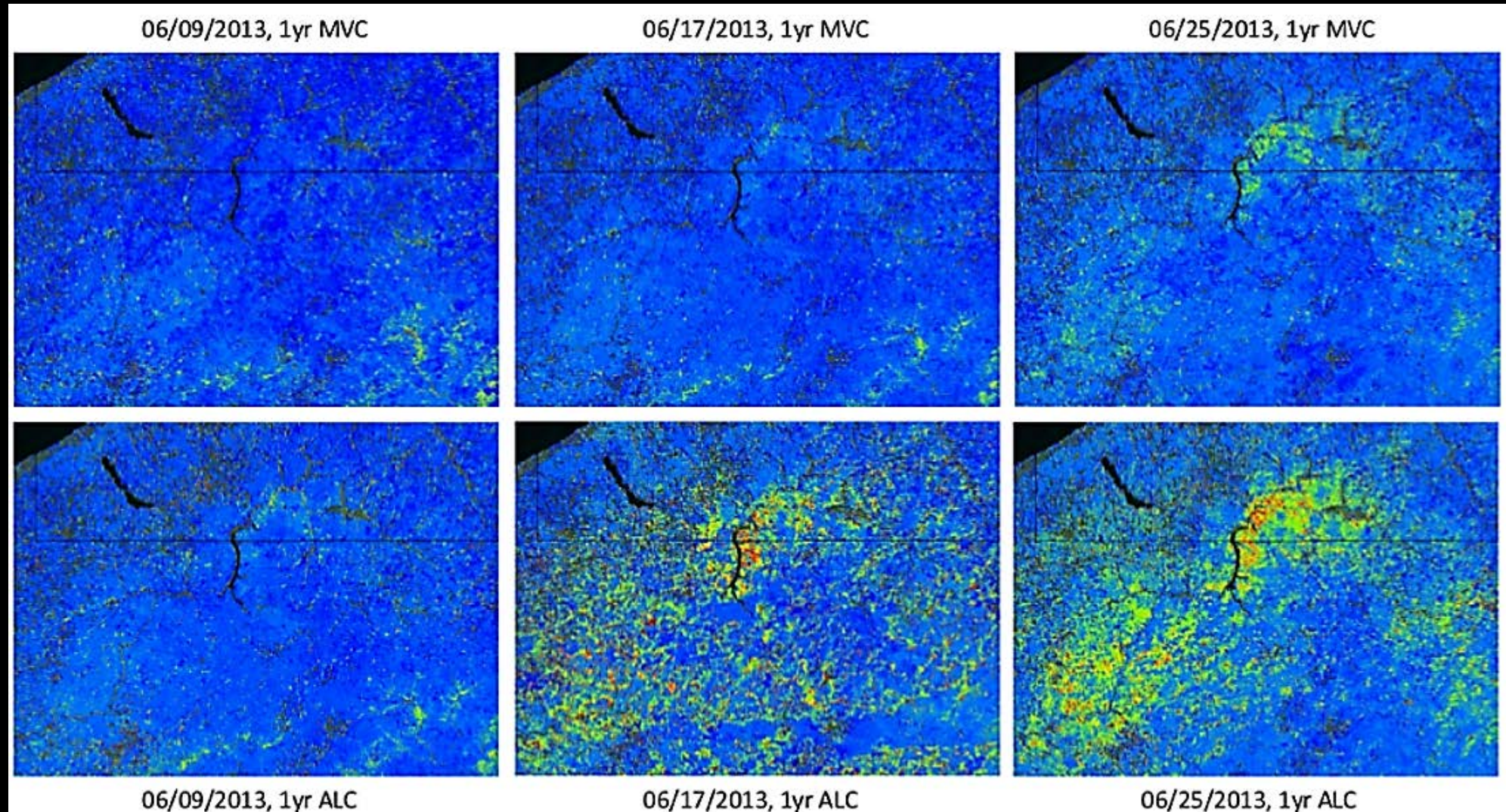




# ForWarn 1yr Baseline 'Standard' Product vs. 1yr Baseline 'Early Detect' Product



2013 Gypsy Moth Defoliation, Allegheny NF, PA-NY

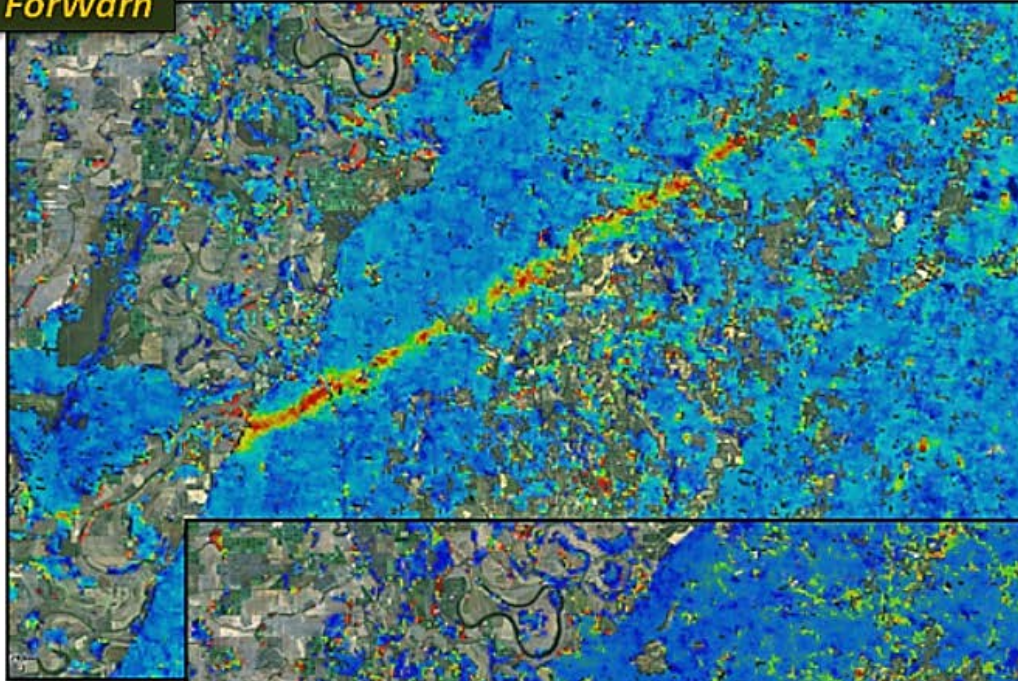


*The 'Early Detect' product dramatically reduces **ForWarn** detection speeds, allowing the detection of disturbances in as few as one 8-day period*

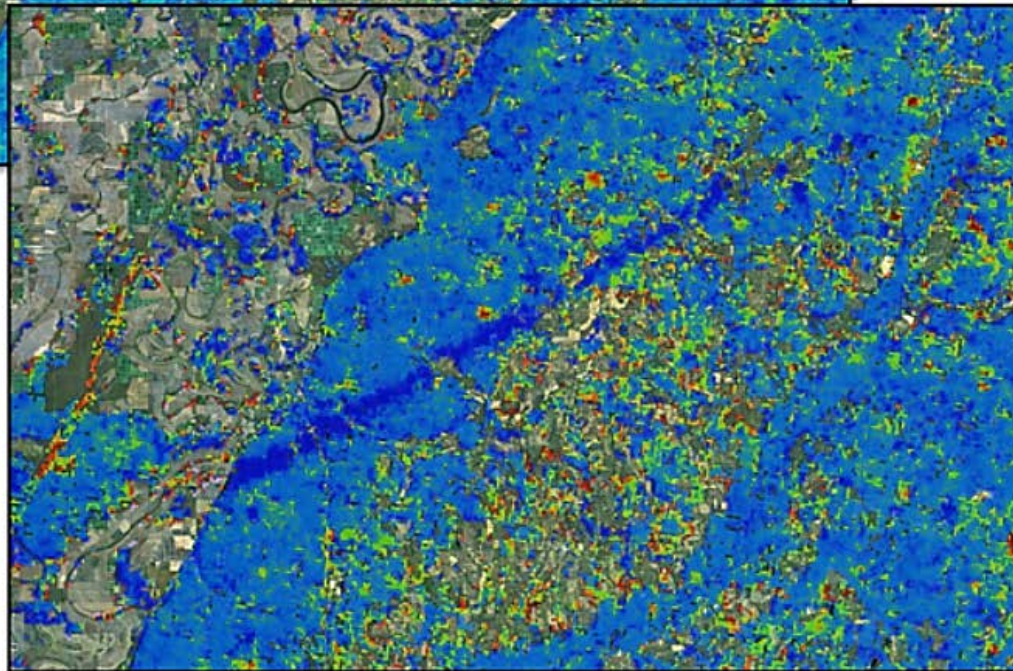


# Positive NDVI Departure = Vegetative Recovery / Re-Growth

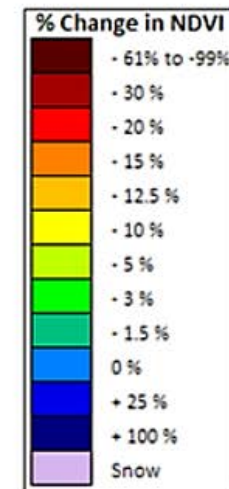
**ForWarn**



June 17, 2010  
compared to 2009



June 17, 2011  
compared to 2010



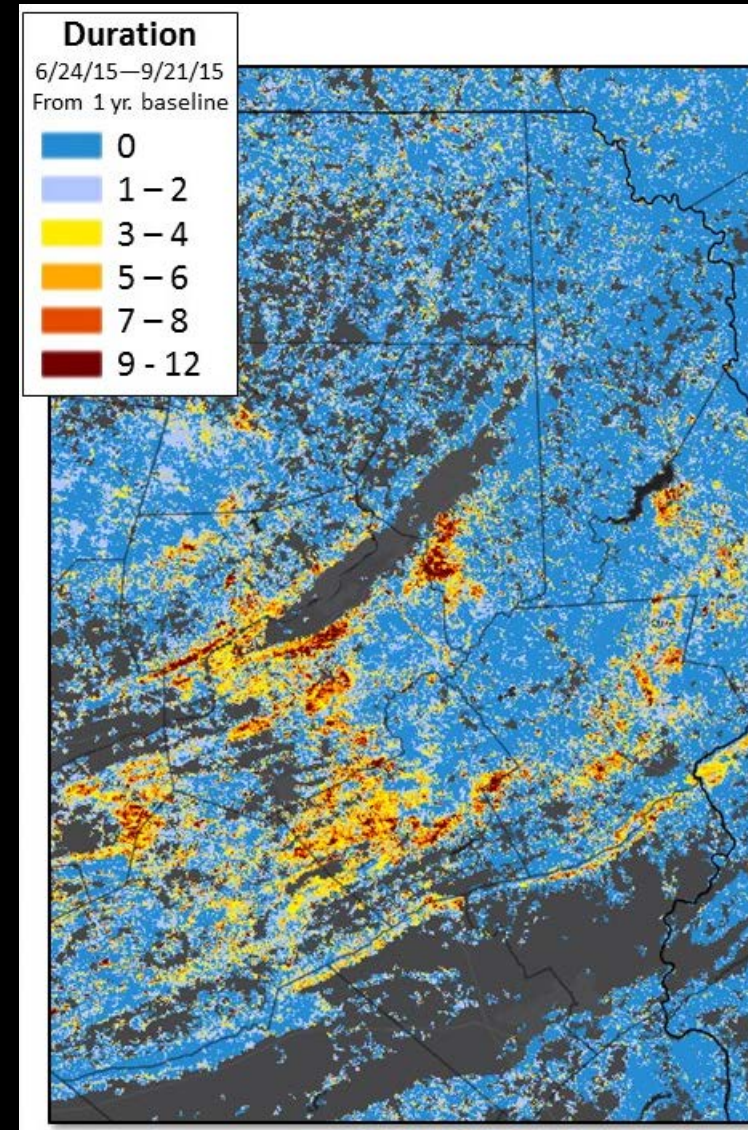
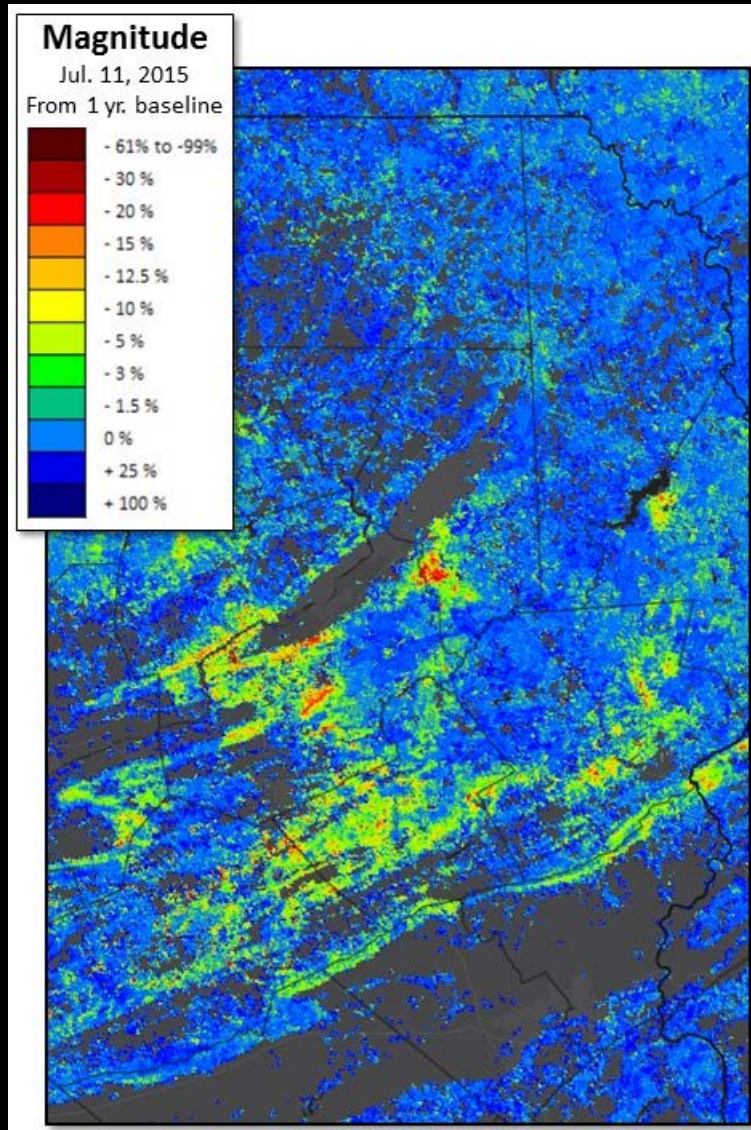
Relative to a 1-year baseline, forest vegetation is re-growing within the Yazoo, MS tornado track. **ForWarn** can easily track such recovery, and the variability in the rate of recovery.



# Tracking Gypsy Moth emergence and severity with magnitude and duration (PA, 2016)



Static images  
produced every  
8-days



(6) or (12)  
Consecutive  
image dates are  
summarized  
within the  
growing season  
for these  
timeframes:

6-period Duration  
**May 8 – June 17**

6-period Duration  
**June 24 – Aug 4**

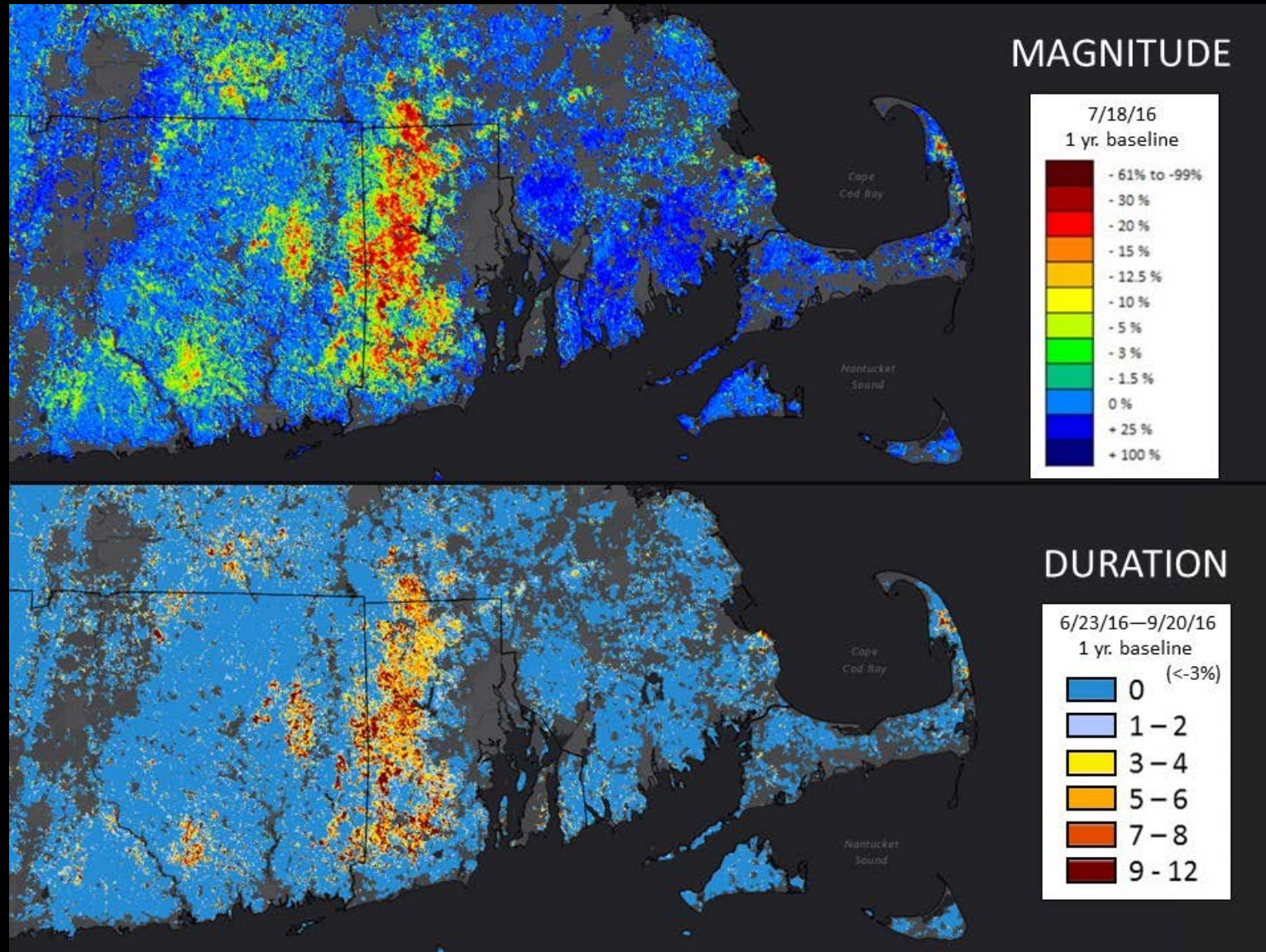
6-period Duration  
**Aug 12 – Sept 21**

12-period Duration  
**June 24 – Sept 21**

*ForWarn's* Seasonal Duration products help discriminate ephemeral from persistent impacts



# Gypsy Moth defoliation in the state of Rhode Island (2016)



Single period observations can underestimate impacts because peak defoliations may not coincide.





# ***ForWarn***

Satellite-Based Change Recognition and Tracking



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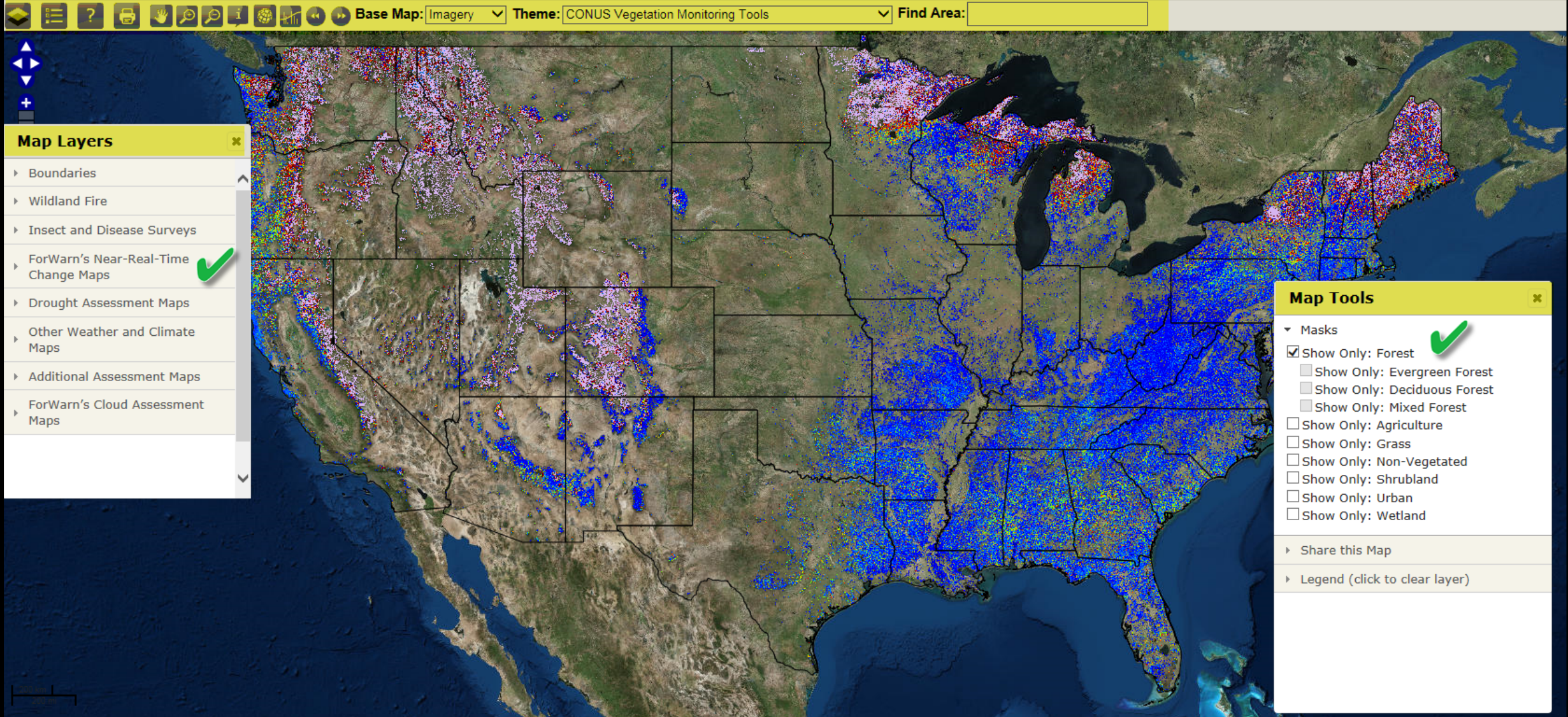




# ForWarn's Forest Change Assessment Viewer



U.S. Forest Change Assessment Viewer - New: Version 2.0 (previous version)

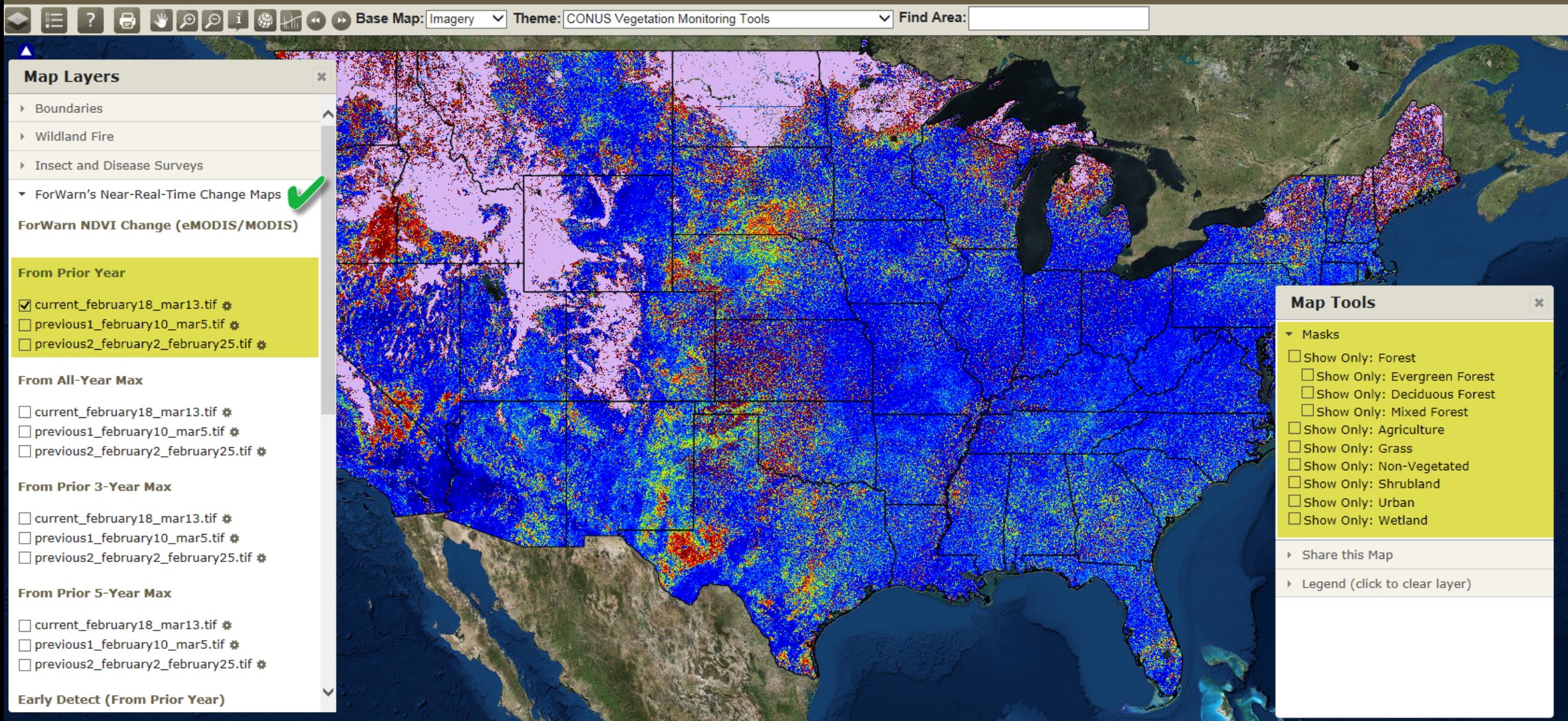




# Forest Change Assessment Viewer (FCAV): Current 1yr, 'All-Lands' (no mask)



U.S. Forest Change Assessment Viewer - New: Version 2.0 (previous version)





# Forest Change Assessment Viewer (FCAV): Map Layers Window



U.S. Forest Change Assessment Viewer - New: Version 2.0 (previous version)

Base Map: Imagery Theme: Duration Products Find Area:

## Map Layers

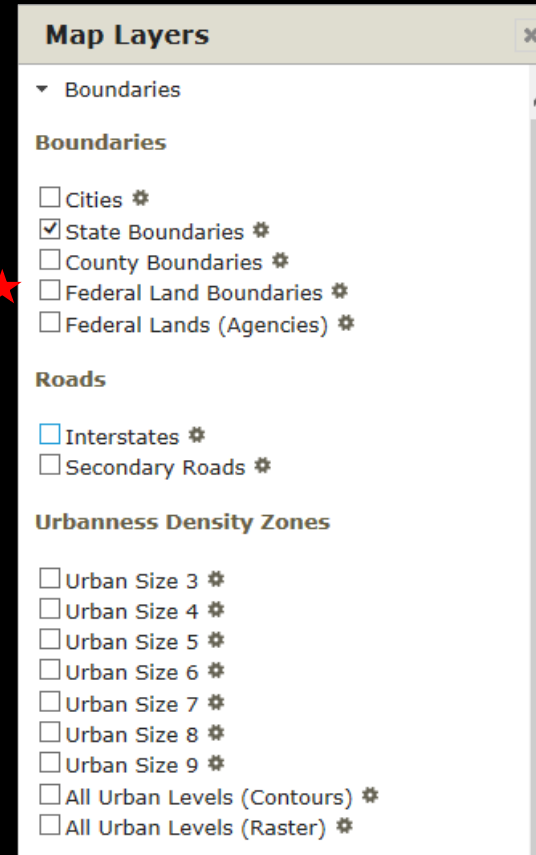
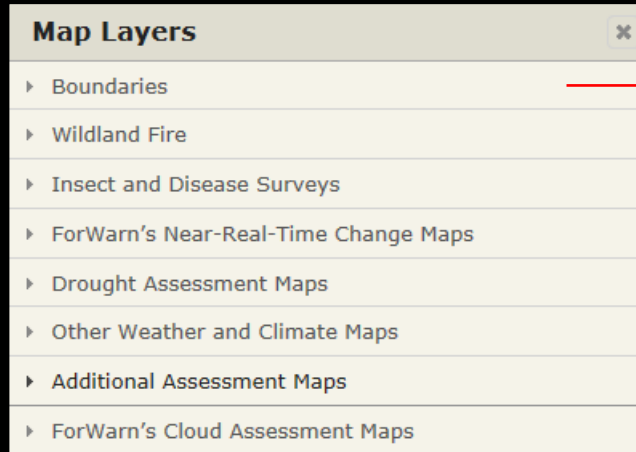
- ▶ Boundaries
- ▶ Disturbances Assessed
- ▶ Wildland Fire
- ▶ Insect and Disease Surveys
- ▶ ForWarn's Near-Real-Time Change Maps ★
- ▶ Archived ForWarn Change Maps
- ▶ Duration Products (at -3% departure)
- ▶ Archived RSAC-FHTET Change Maps
- ▶ Drought Assessment Maps
- ▶ Other Weather and Climate Maps
- ▶ Additional Assessment Maps
- ▶ ForWarn's Cloud Assessment Maps

## Map Tools

- ▶ Masks
  - ▶ Share this Map
  - ▶ 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          |
- States

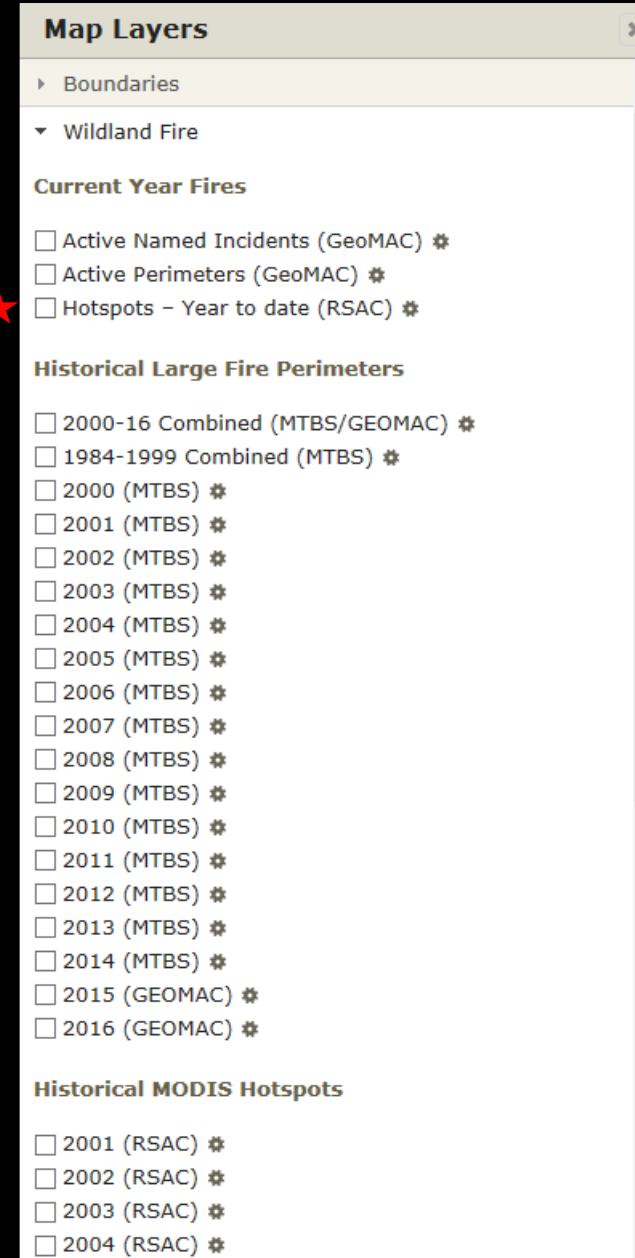
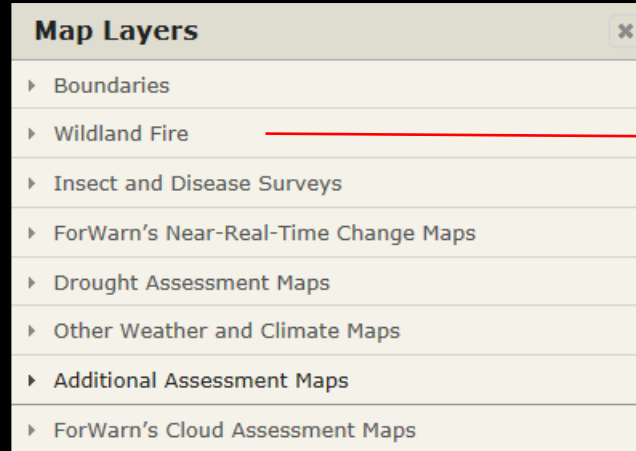


# Forest Change Assessment Viewer (FCAV) Layers: Boundaries



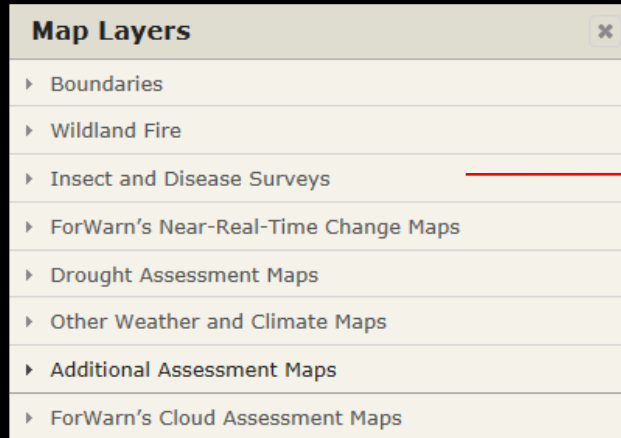


# Forest Change Assessment Viewer (FCAV) Layers: Wildland Fire





# Forest Change Assessment Viewer (FCAV) Layers: ADS, PEST PROXIMITY



## Pest Proximity Feature

- Pest Proximity shows a list of all of the "Usual Suspects" -- all insects and diseases that have been found by the Aerial Disturbance Survey program -- near any point where the user clicks with the mouse
- Shown in order of greatest likelihood, by area affected
- **'Pest-Prox'** is designed to help you think of all of the likely possible causative disturbance agents

U.S. Forest Change Assessment Viewer - New: Version 2.0 (previous version)

Base Map: Imagery Theme: CONUS Vegetation Monitoring Tools Find Area:

**Map Layers**

- Boundaries
- Wildland Fire
- Insect and Disease Surveys
- ForWarn's Near-Real-Time Change Maps
- Drought Assessment Maps
- Other Weather and Climate Maps
- Additional Assessment Maps
- ForWarn's Cloud Assessment Maps

**USDA FS Forest Health (aerial detections)**

- ☐ 2000 surveys \*
- ☐ 2001 surveys \*
- ☐ 2002 surveys \*
- ☐ 2003 surveys \*
- ☐ 2004 surveys \*
- ☐ 2005 surveys \*
- ☐ 2006 surveys \*
- ☐ 2007 surveys \*
- ☐ 2008 surveys \*
- ☐ 2009 surveys \*
- ☐ 2010 surveys \*
- ☐ 2011 surveys \*
- ☐ 2012 surveys \*
- ☐ 2013 surveys \*
- ☐ 2014 surveys \*
- ☐ 2015 surveys \*
- ☐ EFETAC Pest Proximity (from ADS polygons, 2003-2010) \*

**Identify Results**

agents:

- ★ **FOREST TENT CATERPILLAR** | Closest Agent (km): 12.50 | Acres: 25875700.00 | Host: hardwoods | Count: 5775 | Yr: 2010 | Prob: 0.94
- BALDCYPRESS LEAFROLLER** | Closest Agent (km): 21.40 | Acres: 1677020.00 | Host: baldcypress | Count: 650 | Yr: 2010 | Prob: 0.06 IPS | Closest Agent (km): 48.80 | Acres: 2.20 | Host: No data | Count: 12 | Yr: 2010 | Prob: 0.00
- SAWFLIES** | Closest Agent (km): 10.60 | Acres: 4872.20 | Host: softwoods | Count: 4 | Yr: 2010 | Prob: 0.00
- SOUTHERN PINE BEETLE** | Closest Agent (km): 65.30 | Acres: 171.20 | Host: No data | Count: 29 | Yr: 2007 | Prob: 0.00

forwarn.forestthreats.org | Data Disclaimer | FCAV Users Guide | Change Product Descriptions | Previous Version



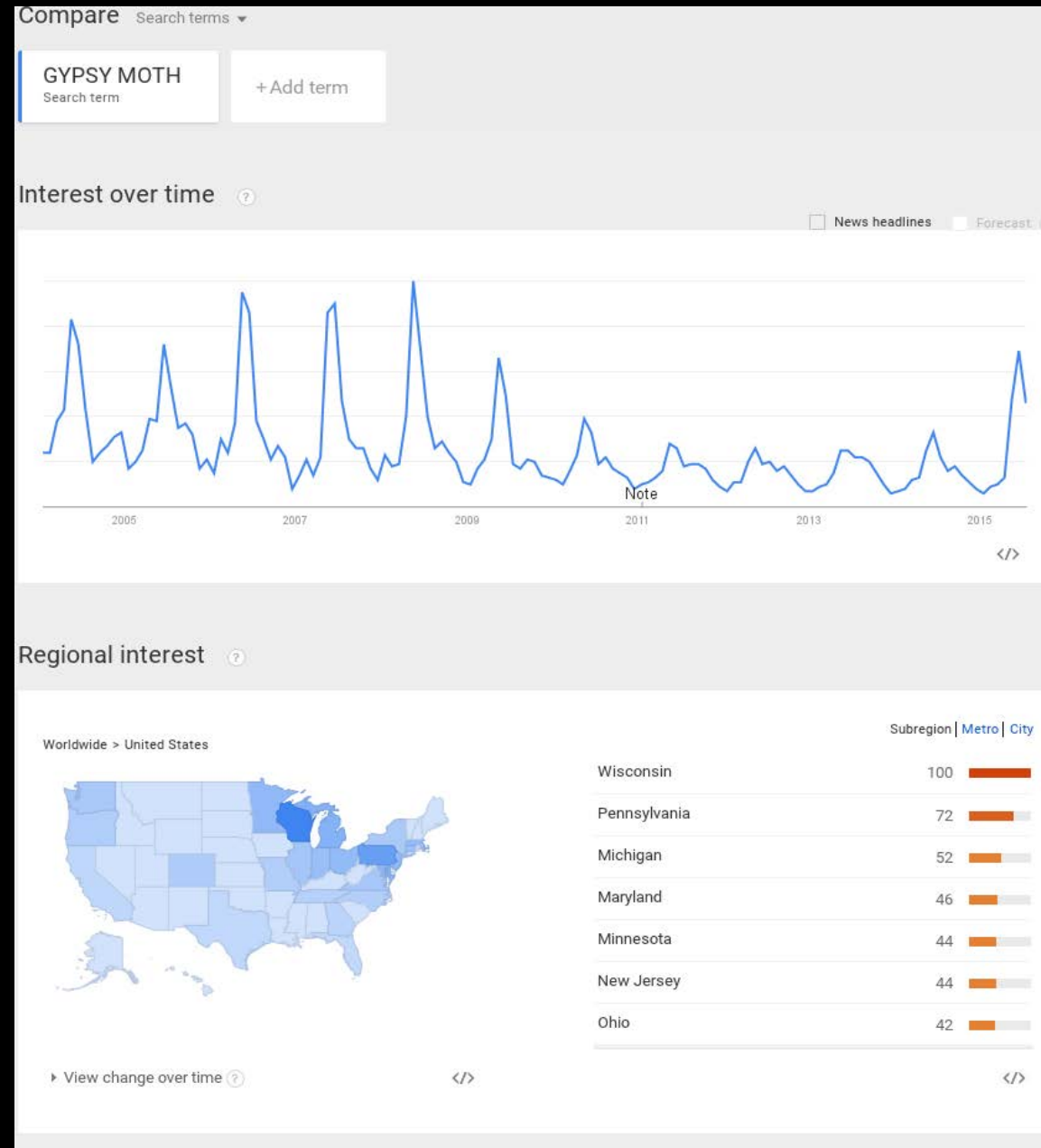
# FCAV Layer PEST-PROX, Google Trends: Social "Crowd-Sourcing"



## Google Trends Pest-Prox Feature

Clicking on a Pest in **Pest-Prox** list does a Google Trends search, shows how frequently people have done a Google search on that Pest since 2004 – May, show:

- (1) historical seasonality of attack, and
- (2) relative magnitude / importance/interest of the attack this year, via indirect use of "Citizen Science."
- (3) interesting feature, though all of you are the experts





# FCAV Layers: Near-Real-Time Change Maps

**Map Layers** ✕


- ▶ Boundaries
- ▶ Wildland Fire
- ▶ Insect and Disease Surveys
- ▶ ForWarn's Near-Real-Time Change Maps
- ▶ Drought Assessment Maps
- ▶ Other Weather and Climate Maps
- ▶ Additional Assessment Maps
- ▶ ForWarn's Cloud Assessment Maps

**Map Layers** ✕

- ▶ Boundaries
- ▶ Wildland Fire
- ▶ Insect and Disease Surveys
- ▼ ForWarn's Near-Real-Time Change Maps

**ForWarn NDVI Change (eMODIS/MODIS)**

**From Prior Year**

☒ current\_february26\_mar21.tif # (m) 

☐ previous1\_february18\_mar13.tif #

☐ previous2\_february10\_mar5.tif #

**From All-Year Max**

☐ current\_february26\_mar21.tif #

☐ previous1\_february18\_mar13.tif #

☐ previous2\_february10\_mar5.tif #

**From Prior 3-Year Max**

☐ current\_february26\_mar21.tif #

☐ previous1\_february18\_mar13.tif #

☐ previous2\_february10\_mar5.tif #

**From Prior 5-Year Max**

☐ current\_february26\_mar21.tif #

☐ previous1\_february18\_mar13.tif #

☐ previous2\_february10\_mar5.tif #

**Early Detect (From Prior Year)**

☐ current\_february26\_mar21.tif #

☐ previous1\_february18\_mar13.tif #

☐ previous2\_february10\_mar5.tif #

**From All-Year Phenotype Max**



# Forest Change Assessment Viewer (FCAV) Layers: Drought Monitor Maps



The screenshot displays the 'Map Layers' panel of the Forest Change Assessment Viewer (FCAV). The panel is divided into two sections. The left section shows a list of map layers, with 'Drought Assessment Maps' highlighted by a red arrow. The right section shows the expanded 'Drought Assessment Maps' layer, which includes a yellow highlight for 'US Drought Monitor (NDMC)'. Below this, a list of dates is shown, each preceded by an unchecked checkbox and followed by a star icon. A red star icon is also visible next to the 'US Drought Monitor (NDMC)' header.

Map Layers	
▶ Boundaries	
▶ Wildland Fire	
▶ Insect and Disease Surveys	
▶ ForWarn's Near-Real-Time Change Maps	
▶ Drought Assessment Maps	▼ Drought Assessment Maps
▶ Other Weather and Climate Maps	<b>US Drought Monitor (NDMC)</b>
▶ Additional Assessment Maps	<input type="checkbox"/> Current Drought Monitor *
▶ ForWarn's Cloud Assessment Maps	<input type="checkbox"/> 03/28/2017 *
	<input type="checkbox"/> 03/21/2017 *
	<input type="checkbox"/> 03/14/2017 *
	<input type="checkbox"/> 03/07/2017 *
	<input type="checkbox"/> 02/28/2017 *
	<input type="checkbox"/> 02/21/2017 *
	<input type="checkbox"/> 02/14/2017 *
	<input type="checkbox"/> 02/07/2017 *
	<input type="checkbox"/> 01/31/2017 *
	<input type="checkbox"/> 01/24/2017 *
	<input type="checkbox"/> 01/17/2017 *
	<input type="checkbox"/> 01/10/2017 *
	<input type="checkbox"/> 01/03/2017 *
	<input type="checkbox"/> 12/27/2016 *
	<input type="checkbox"/> 12/20/2016 *
	<input type="checkbox"/> 12/13/2016 *
	<input type="checkbox"/> 12/06/2016 *
	<input type="checkbox"/> 11/29/2016 *
	<input type="checkbox"/> 11/22/2016 *
	<input type="checkbox"/> 11/15/2016 *
	<input type="checkbox"/> 11/08/2016 *



# Forest Change Assessment Viewer (FCAV) Layers: Additional Assessment Maps



**Map Layers** ✕

- Boundaries
- Wildland Fire
- Insect and Disease Surveys
- ForWarn's Near-Real-Time Change Maps
- Drought Assessment Maps
- Other Weather and Climate Maps
- **Additional Assessment Maps** →
- ForWarn's Cloud Assessment Maps

**Map Layers**

- Insect and Disease Surveys
- ForWarn's Near-Real-Time Change Maps
- Drought Assessment Maps
- Other Weather and Climate Maps
- ▼ **Additional Assessment Maps**
  - ☐ 2000-2017 Combined (FS) \*
  - ☐ 2000 (FS) \*
  - ☐ 2001 (FS) \*
  - ☐ 2002 (FS) \*
  - ☐ 2003 (FS) \*
  - ☐ 2004 (FS) \*
  - ☐ 2005 (FS) \*
  - ☐ 2006 (FS) \*
  - ☐ 2007(FS) \*
  - ☐ 2008 (FS) \*
  - ☐ 2009 (FS) \*
  - ☐ 2010 (FS) \*
  - ☐ 2011 (FS) \*
  - ☐ 2012 (FS) \*
  - ☐ 2013 (FS) \*
  - ☐ 2014 (FS) \*
  - ☐ 2015 (FS) \*
  - ☐ 2016 (FS) \*
  - ☐ 2017 (FS) \*

**Map Layers** ★

**USFS Logging Activity**

- ☐ 2000-2017 Combined (FS) \*
- ☐ 2000 (FS) \*
- ☐ 2001 (FS) \*
- ☐ 2002 (FS) \*
- ☐ 2003 (FS) \*
- ☐ 2004 (FS) \*
- ☐ 2005 (FS) \*
- ☐ 2006 (FS) \*
- ☐ 2007(FS) \*
- ☐ 2008 (FS) \*
- ☐ 2009 (FS) \*
- ☐ 2010 (FS) \*
- ☐ 2011 (FS) \*
- ☐ 2012 (FS) \*
- ☐ 2013 (FS) \*
- ☐ 2014 (FS) \*
- ☐ 2015 (FS) \*
- ☐ 2016 (FS) \*
- ☐ 2017 (FS) \*

**USDA Agriculture**

- ☐ 2013 Cropland Data Layer \*
- ☐ 2014 Cropland Data Layer \*
- ☐ 2015 Cropland Data Layer \*

**Elevation Products**

- ☐ Elevation (SRTM 231m DEM) \*
- ☐ Aspect (SRTM 231m) \*
- ☐ Hillshading (SRTM 231m) \*

**Map Layers** ✕

**Hydrography**

- ☐ 7 Day Avg. Streamflow (USGS WaterWatch) \*
- ☐ Streams and Water Features \*
- ☐ Major River Basins (HUC 6) \*
- ☐ Major River Basins (HUC 8) \*

**Decadal Change**

- ☐ Deciduous Thrive \*
- ☐ Deciduous Decline \*
- ☐ Evergreen Thrive \*
- ☐ Evergreen Decline \*

**Phenological Regions**

- ☐ Phenoregions 50 MaxMode \*
- ☐ Phenoregions 100 MaxMode \*
- ☐ Phenoregions 200 MaxMode \*
- ☐ Phenoregions 500 MaxMode \*
- ☐ Phenoregions 1000 MaxMode \*
- ☐ Phenoregions 5000 MaxMode \*

**Landcover** ★

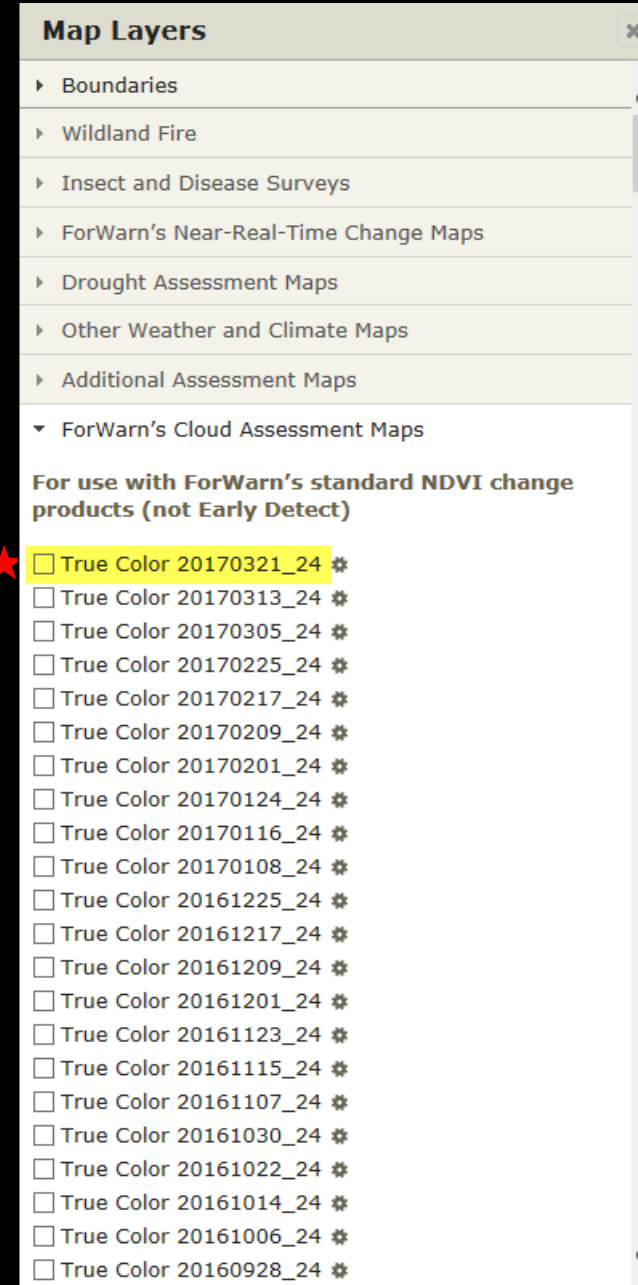
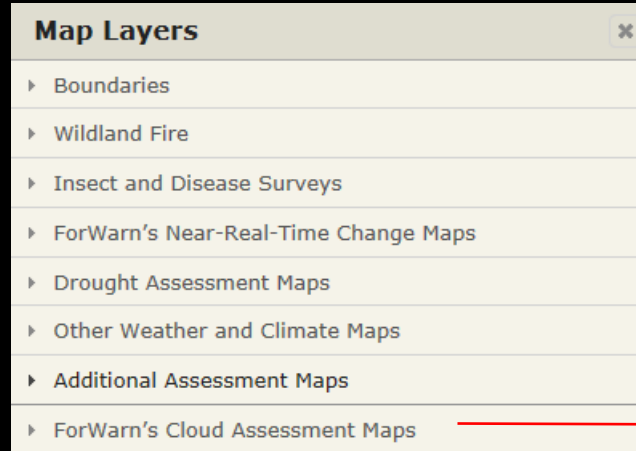
- ★ ☐ Forest Type (USFS FIA-RSAC) \*
- ★ ☐ Major Forest Group (USFS FIA-RSAC) \*
- ☐ Forest Biomass (USFS FIA-RSAC) \*
- ☐ Carbon Stock 2009 \*
- ☐ NLCD 2006 \*
- ☐ 2001 GAP Landfire CONUS \*
- ☐ Land Cover 2005 (NALCMS) \*
- ☐ Land Cover 2010 (NALCMS) \*
- ☐ LANDFIRE Fuel Mode 40 \*
- ☐ LANDFIRE Vegetation \*

**Ecoregions**

- ☐ Bailey's Ecoregions \*
- ☐ Omernik Ecoregions \*



# FCAV Layers: **Cloud Assessment Maps** (available from 01/08/06 through 09/29/15)

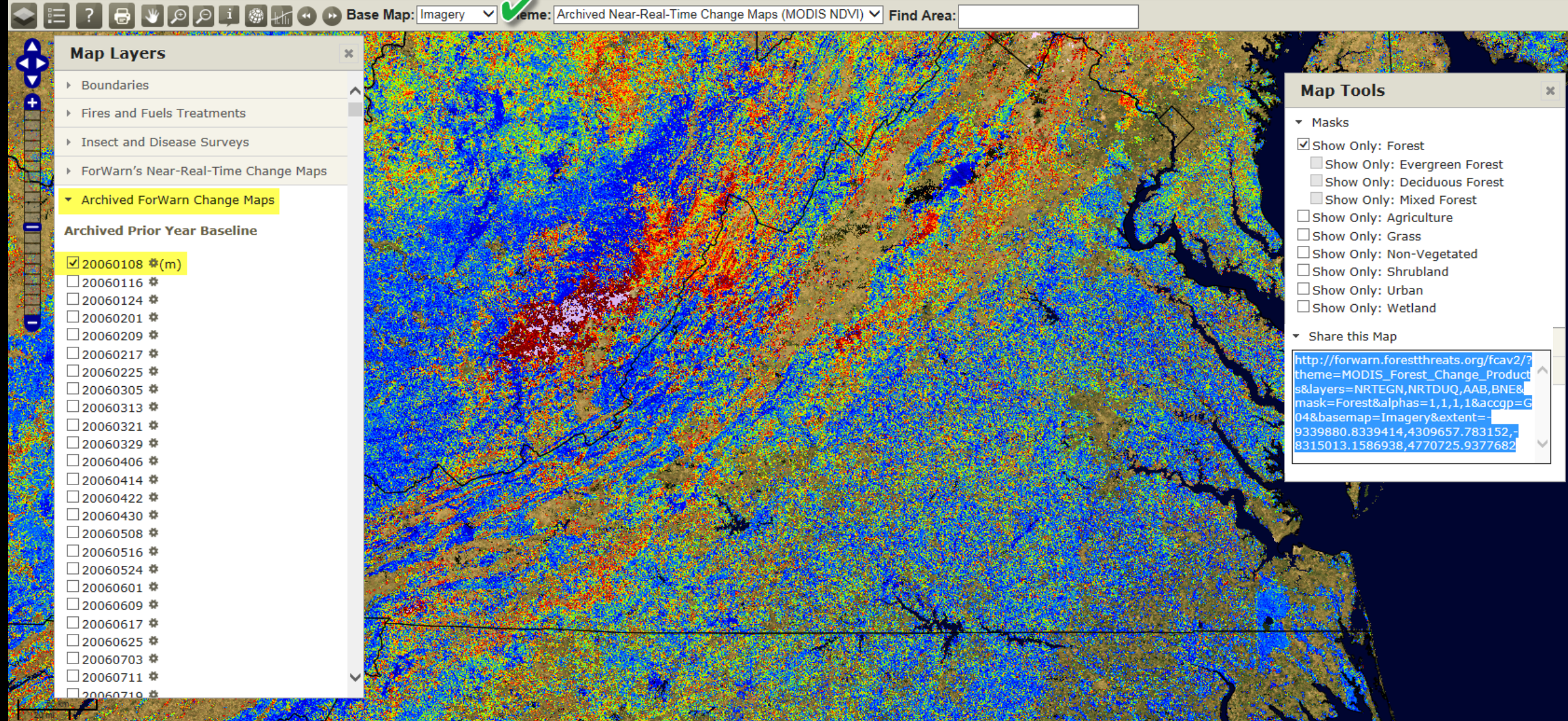




# FCAV Layers: Cloud Assessment Maps (available from 01/08/06 through 09/29/15)



U.S. Forest Change Assessment Viewer - New: Version 2.0 (previous version)





# FCAV Layers: Cloud Assessment Maps (available from 01/08/06 through 09/29/15)



U.S. Forest Change Assessment Viewer - New: Version 2.0 (previous version)

Base Map: Imagery Theme: Archived Near-Real-Time Change Maps (MODIS NDVI) Find Area:

**Map Layers**

- Boundaries
- Fires and Fuels Treatments
- Insect and Disease Surveys
- ForWarn's Near-Real-Time Change Maps
- Archived ForWarn Change Maps
- ForWarn's Cloud Assessment Maps
  - ☒ True Color 20060108\_24
  - ☐ True Color 20060116\_24
  - ☐ True Color 20060124\_24
  - ☐ True Color 20060201\_24
  - ☐ True Color 20060209\_24
  - ☐ True Color 20060217\_24
  - ☐ True Color 20060225\_24
  - ☐ True Color 20060305\_24
  - ☐ True Color 20060313\_24
  - ☐ True Color 20060321\_24
  - ☐ True Color 20060329\_24
  - ☐ True Color 20060406\_24
  - ☐ True Color 20060414\_24
  - ☐ True Color 20060422\_24
  - ☐ True Color 20060430\_24
  - ☐ True Color 20060508\_24
  - ☐ True Color 20060516\_24
  - ☐ True Color 20060524\_24
  - ☐ True Color 20060601\_24
  - ☐ True Color 20060609\_24
  - ☐ True Color 20060617\_24
  - ☐ True Color 20060625\_24

For use with ForWarn's standard NDVI change products (not Early Detect)

**Map Tools**

Masks

- ☒ Show Only: Forest
  - ☐ Show Only: Evergreen Forest
  - ☐ Show Only: Deciduous Forest
  - ☐ Show Only: Mixed Forest
- ☐ Show Only: Agriculture
- ☐ Show Only: Grass
- ☐ Show Only: Non-Vegetated
- ☐ Show Only: Shrubland
- ☐ Show Only: Urban
- ☐ Show Only: Wetland

Share this Map

Legend (click to clear layer)



# FCAV Feature: “Share this Map” (*share potential disturbances with your colleagues*)



U.S. Forest Change Assessment Viewer – New: Version 2.0 (previous version)

The screenshot shows the U.S. Forest Change Assessment Viewer interface. The main map area displays a satellite image of a forested region with various colored overlays representing different forest change metrics. On the left, there is a 'Map Layers' panel with several categories: 'Boundaries' (including Cities, State Boundaries, County Boundaries, Federal Land Boundaries, and Federal Lands (Agencies)), 'Roads' (including Interstates and Secondary Roads), 'Urbanness Density Zones' (including Urban Size 3 through 9, All Urban Levels (Contours), and All Urban Levels (Raster)), and a list of other maps (Wildland Fire, Insect and Disease Surveys, ForWarn's Near-Real-Time Change Maps, and Drought Assessment Maps). At the top, there is a toolbar with various icons for map navigation and a 'Find Area' search bar. The 'Base Map' is set to 'Imagery' and the 'Theme' is 'CONUS Vegetation Monitoring Tools'. On the right, there is a 'Map Tools' panel with a 'Share this Map' button highlighted in yellow. An arrow points from the 'Share this Map' text in the center to this button. Below the button, a URL is displayed: [https://forwarn.forestthreats.org/fcav2?theme=CONUS\\_Vegetation\\_Monitoring\\_Tools&layers=AD,AAC,AAB&mask=&allphas=1,1,1&accgp=G04&basemap=Imagery&extent=-9445780.5058958,4178505.8590374,-9188952.0908576,4291326.9127864](https://forwarn.forestthreats.org/fcav2?theme=CONUS_Vegetation_Monitoring_Tools&layers=AD,AAC,AAB&mask=&allphas=1,1,1&accgp=G04&basemap=Imagery&extent=-9445780.5058958,4178505.8590374,-9188952.0908576,4291326.9127864). Below the URL, there is a 'Legend (click to clear layer)' section.

**Share this Map**

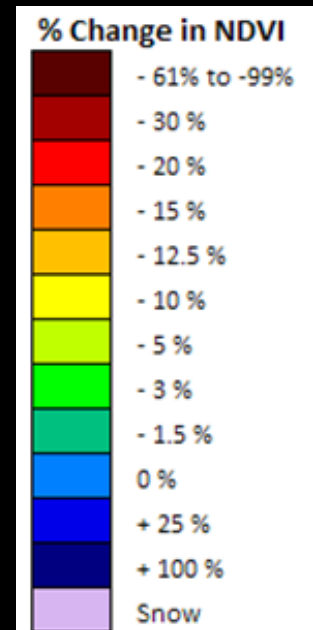
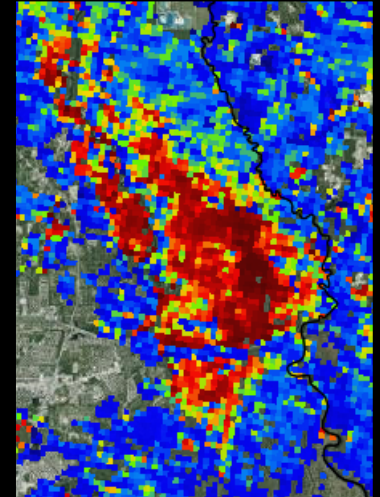
- **Copy and email this URL** to a colleague. The Viewer will open and display the exact extent and layers from which it was created.
- **Create a bookmark** in your browser to quickly return to, and monitor your area of interest, pre-loaded with the change product and layers of your choice



# Identifying and Interpreting Forest Disturbance

(locate, characterize and assess)

- *Where is the Disturbance Located?* (geographic site and situation)
  - ✓ Land cover / Land Use (image basemap, NLCD masks, FS/GAP veg maps)
  - ✓ Topographic position (elevation, slope and aspect, USGS topo's are available in Viewer under 'Base maps', wet/dry – USGS Stream Gauges, amount of mix?)
- *What is the character of the NDVI departure?*
  - ✓ Progression speed (use the 3 most recent, fast vs. slow, on in 1/off in next = clouds)
  - ✓ Severity, percent NDVI change (pos./neg., low/high departure, climate affects?)
  - ✓ Spatial extent (large area or localized)
  - ✓ Pattern and shape (spotty/scattered, bulls-eye, target-like, linearity)
  - ✓ Edges (hard/well defined or bulls-eye – trails-off showing less departure)
  - ✓ Seasonality (spring, fall, snow: local and regional variation in annual phenology can causes NDVI departure (+/-); two new forest change products attempt to mitigate the effects in the variability of the start and stop of spring and fall from year to year)





# Examples of forest disturbance, or recovery, seen in the *ForWarn* forest change images

## Natural Disturbance

Severe weather (tornadoes, wind, hail, ice)

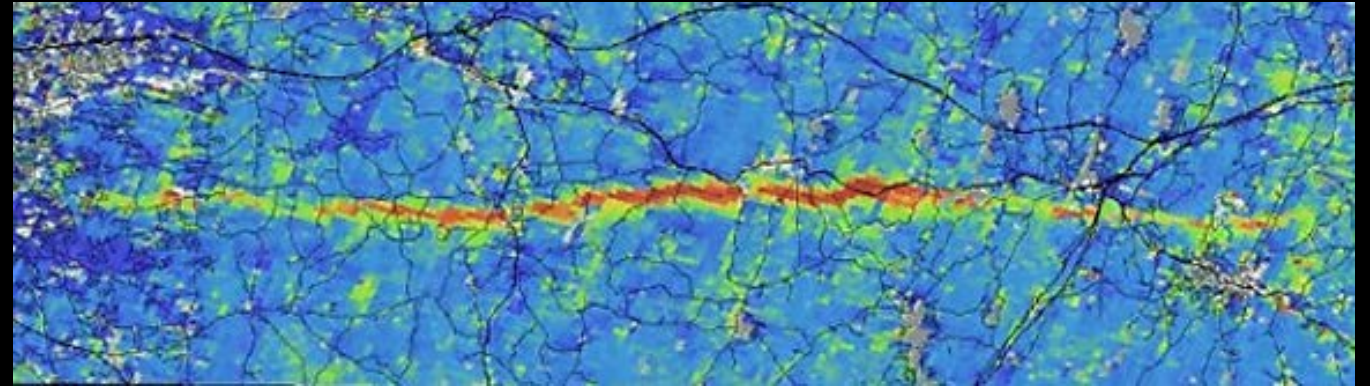
Drought and flood events

Insects and disease outbreaks

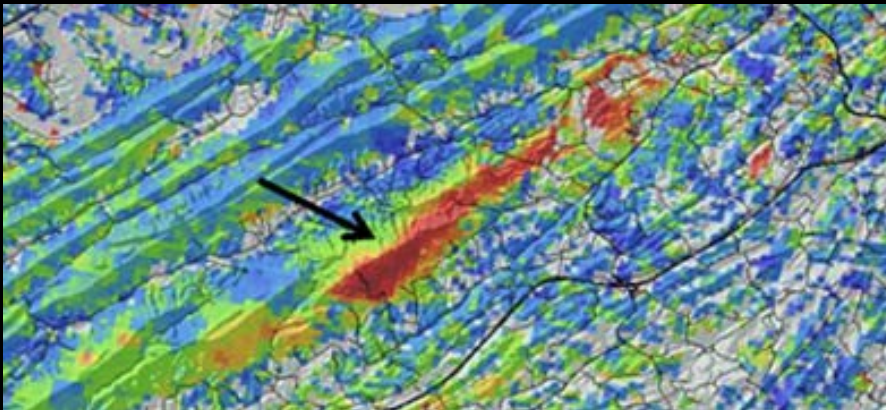
Early/late – spring/fall timing

Snow

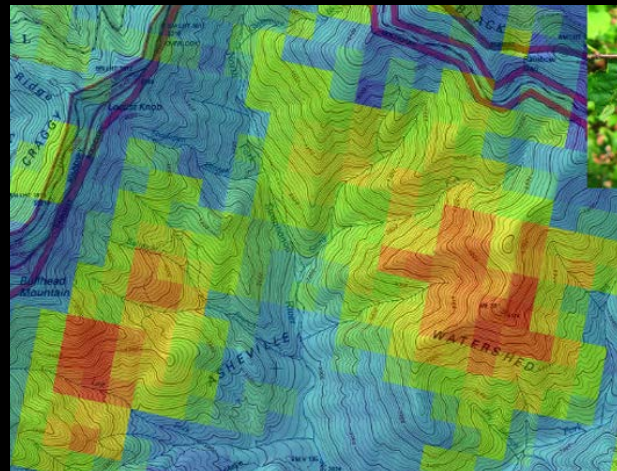
Wildfire events



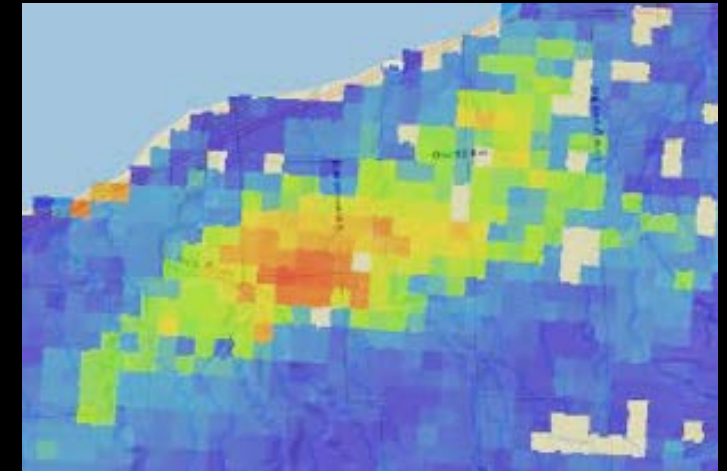
Tornado (MA)



Severe Wind, Leaf Stripping (TN)



Hail Damage (NC)



Severe Weather (MI)



# Examples of forest disturbance, or recovery, seen in the *ForWarn* forest change images

## Natural Disturbance

Severe weather (tornadoes, wind, hail, ice)

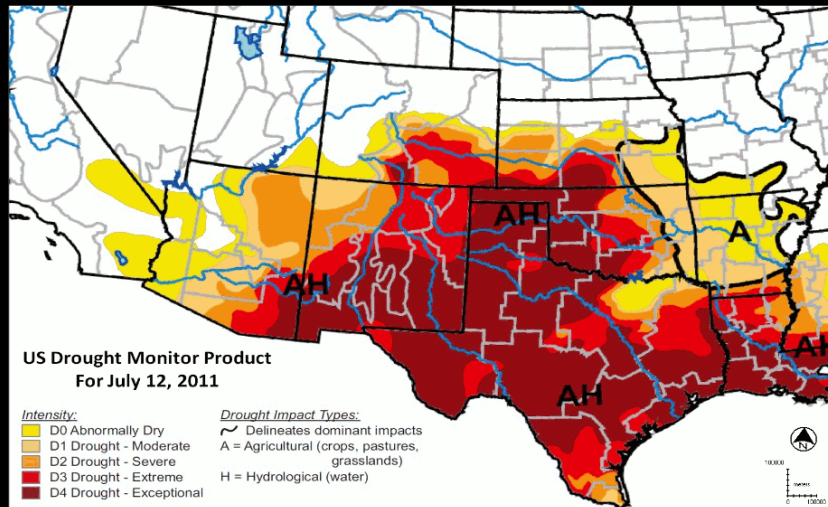
Drought and flood events

Insects and disease outbreaks

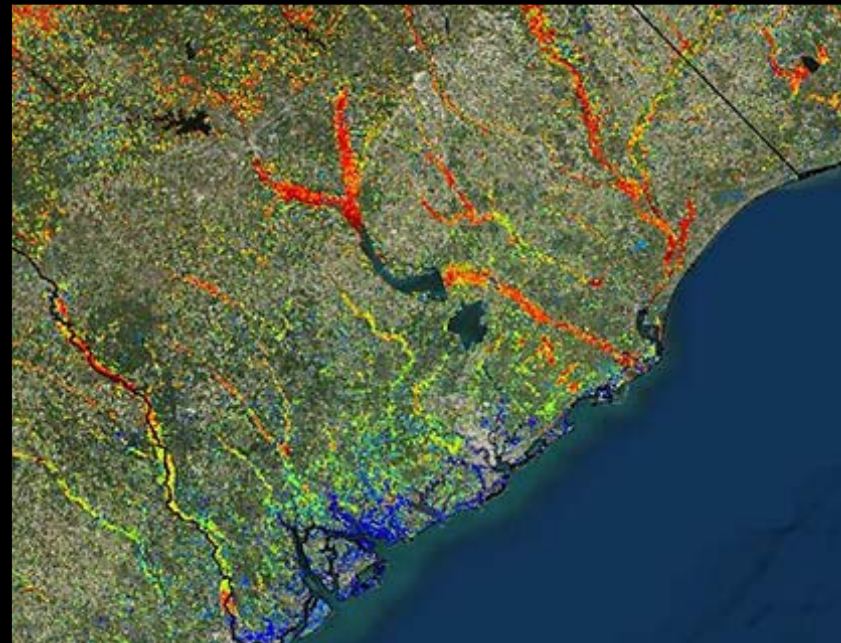
Early/late – spring/fall timing

Snow

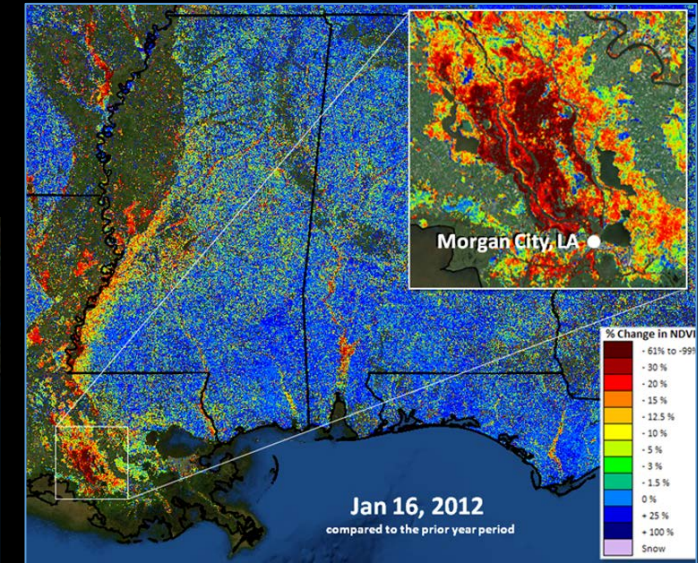
Wildfire events



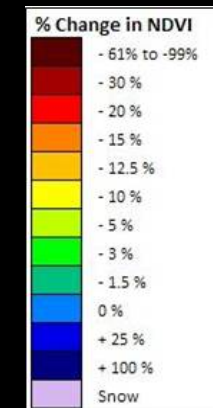
Texas Drought Monitor Comparison, 2011



Bottomland Hardwood Flooding (SC)



Flooding (Atchafalaya Basin, LA)





# Examples of forest disturbance, or recovery, seen in the *ForWarn* forest change images

## Natural Disturbance

Severe weather (tornadoes, wind, hail, ice)

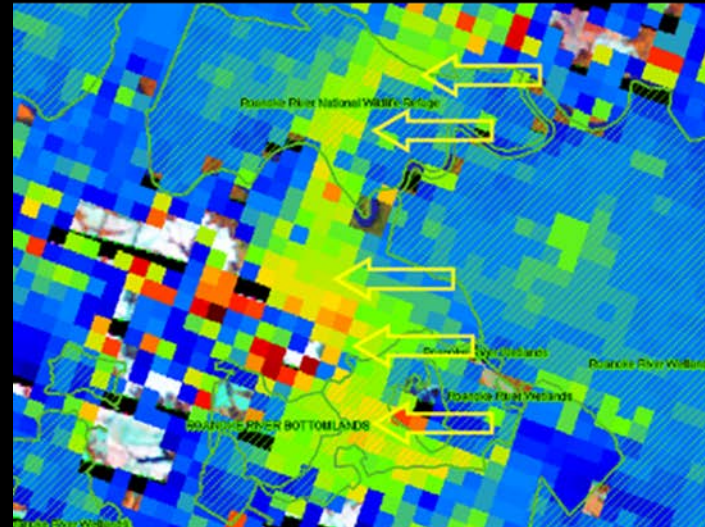
Drought and flood events

Insects and disease outbreaks

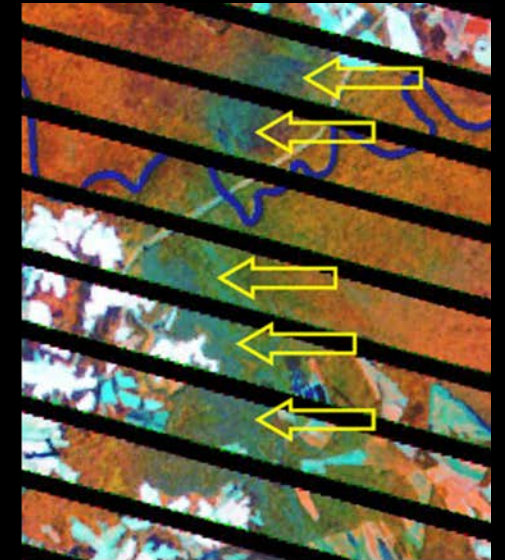
Early/late – spring/fall timing

Snow

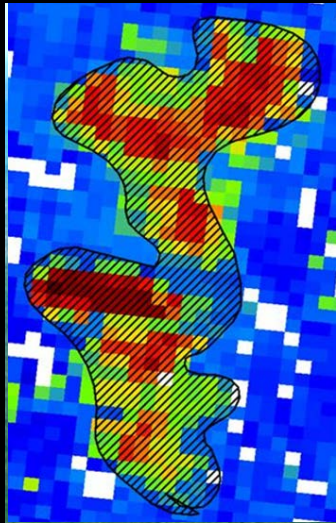
Wildfire events



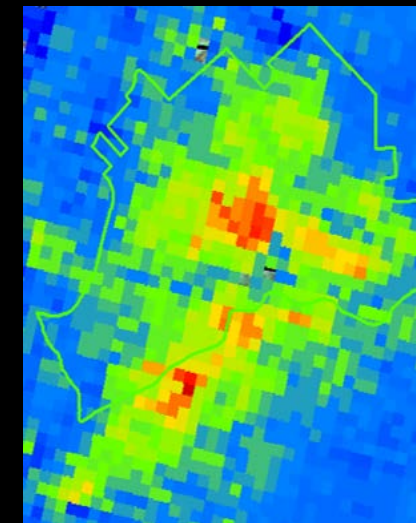
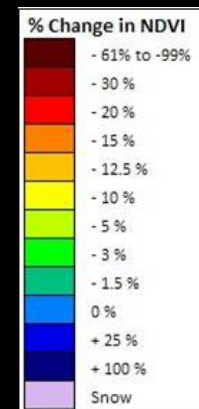
Forest Tent Caterpillar (NC)



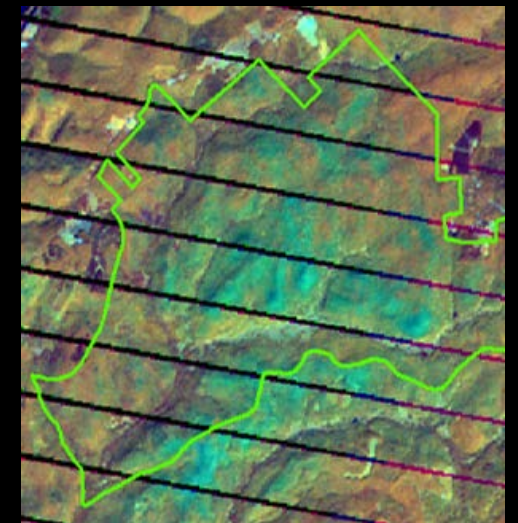
Landsat



Forest Tent Caterpillar (MS)



Fall Webworm (PA)



Landsat



# Examples of forest disturbance, or recovery, seen in the *ForWarn* forest change images

## Natural Disturbance

Severe weather (tornadoes, wind, hail, ice)

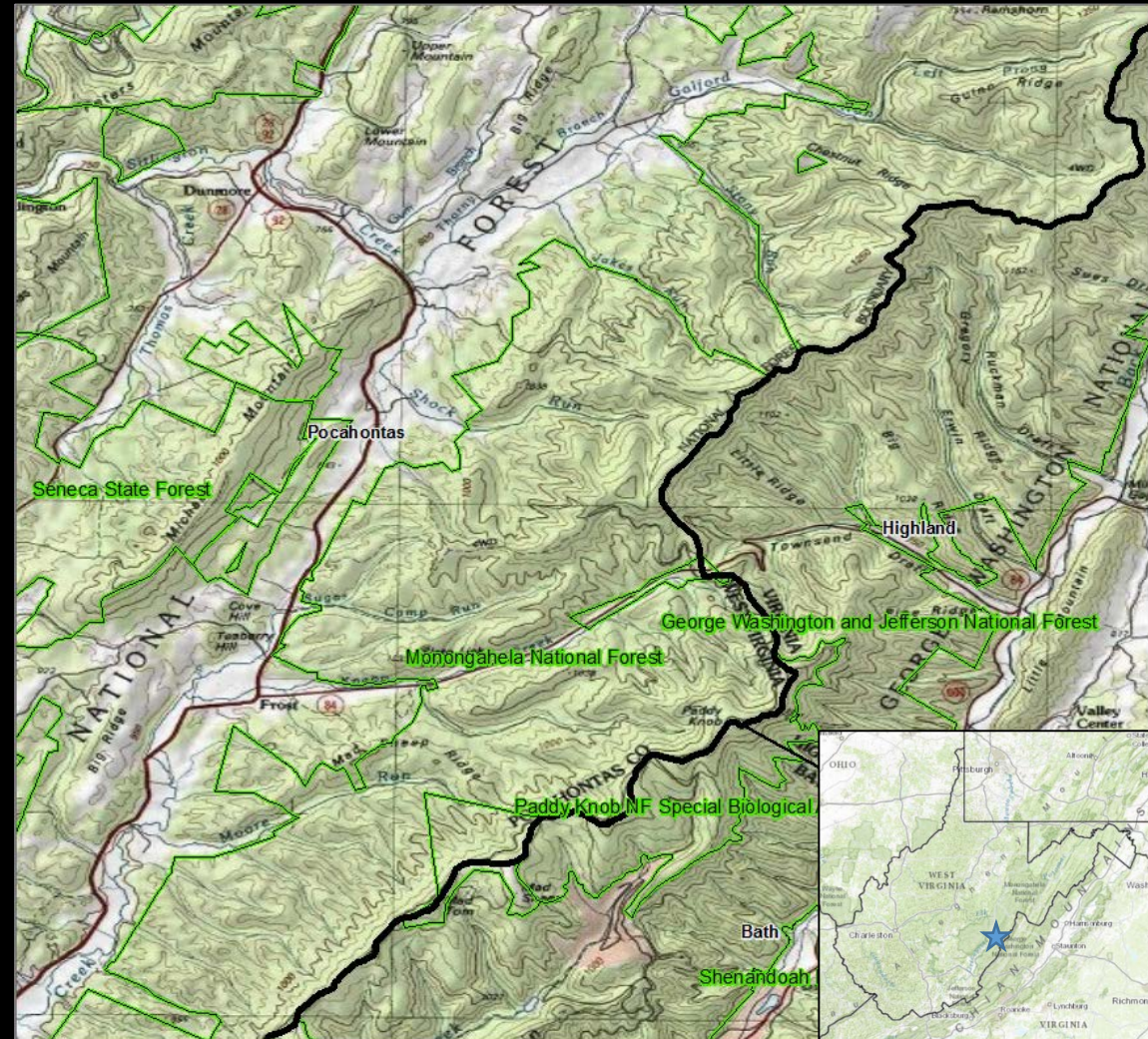
Drought and flood events

Insects and disease outbreaks

Early/late – spring/fall timing

Snow

Wildfire events



Monongahela National Forest, Pocahontas County, WV and  
George Washington National Forest, Highland County, VA



# Examples of forest disturbance, or recovery, seen in the *ForWarn* forest change images

## Natural Disturbance

Severe weather (tornadoes, wind, hail, ice)

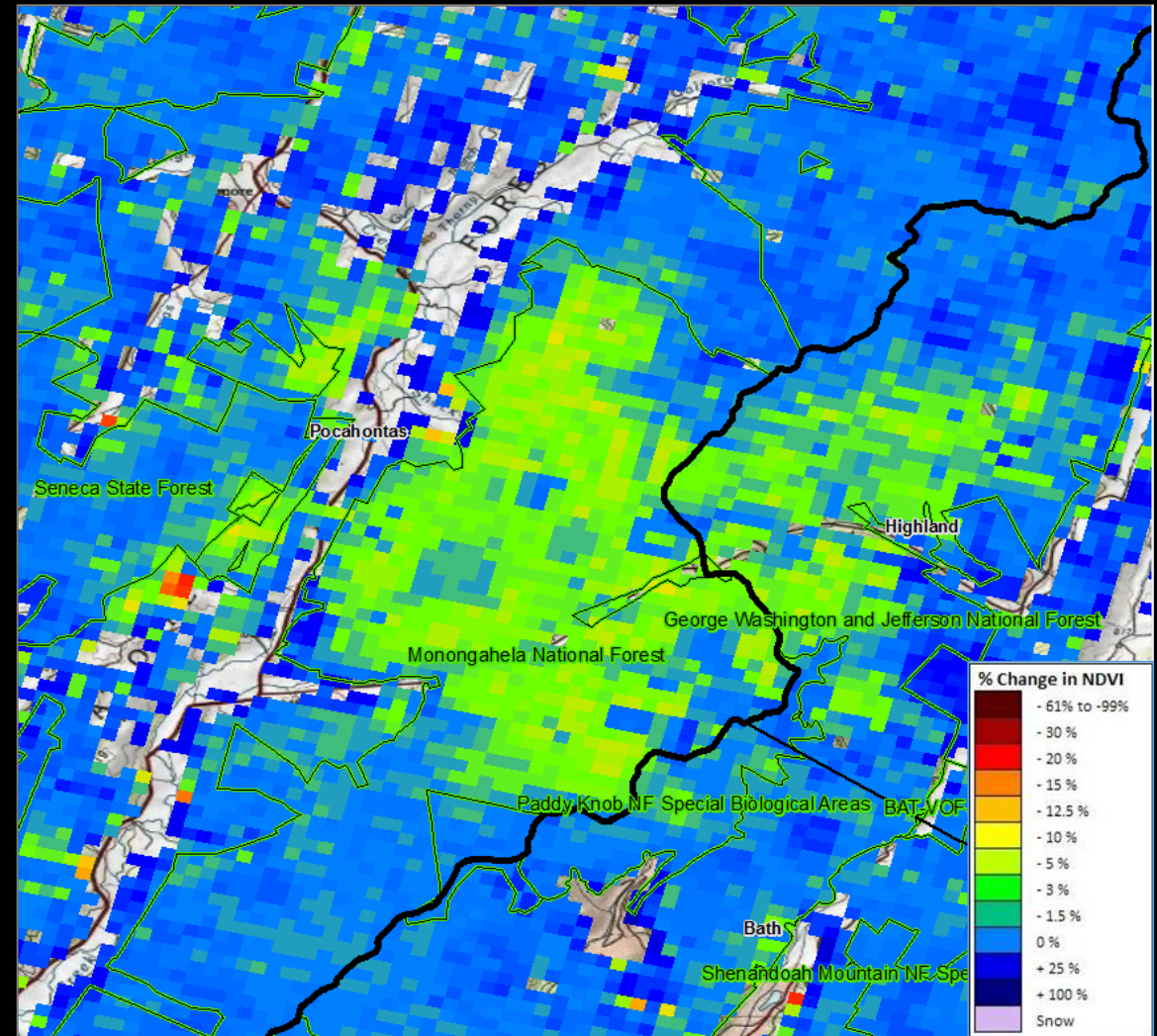
Drought and flood events

Insects and disease outbreaks

Early/late – spring/fall timing

Snow

Wildfire events



*ForWarn* 07/27/2015, 1-year baseline



# Examples of forest disturbance, or recovery, seen in the *ForWarn* forest change images

## Natural Disturbance

Severe weather (tornadoes, wind, hail, ice)

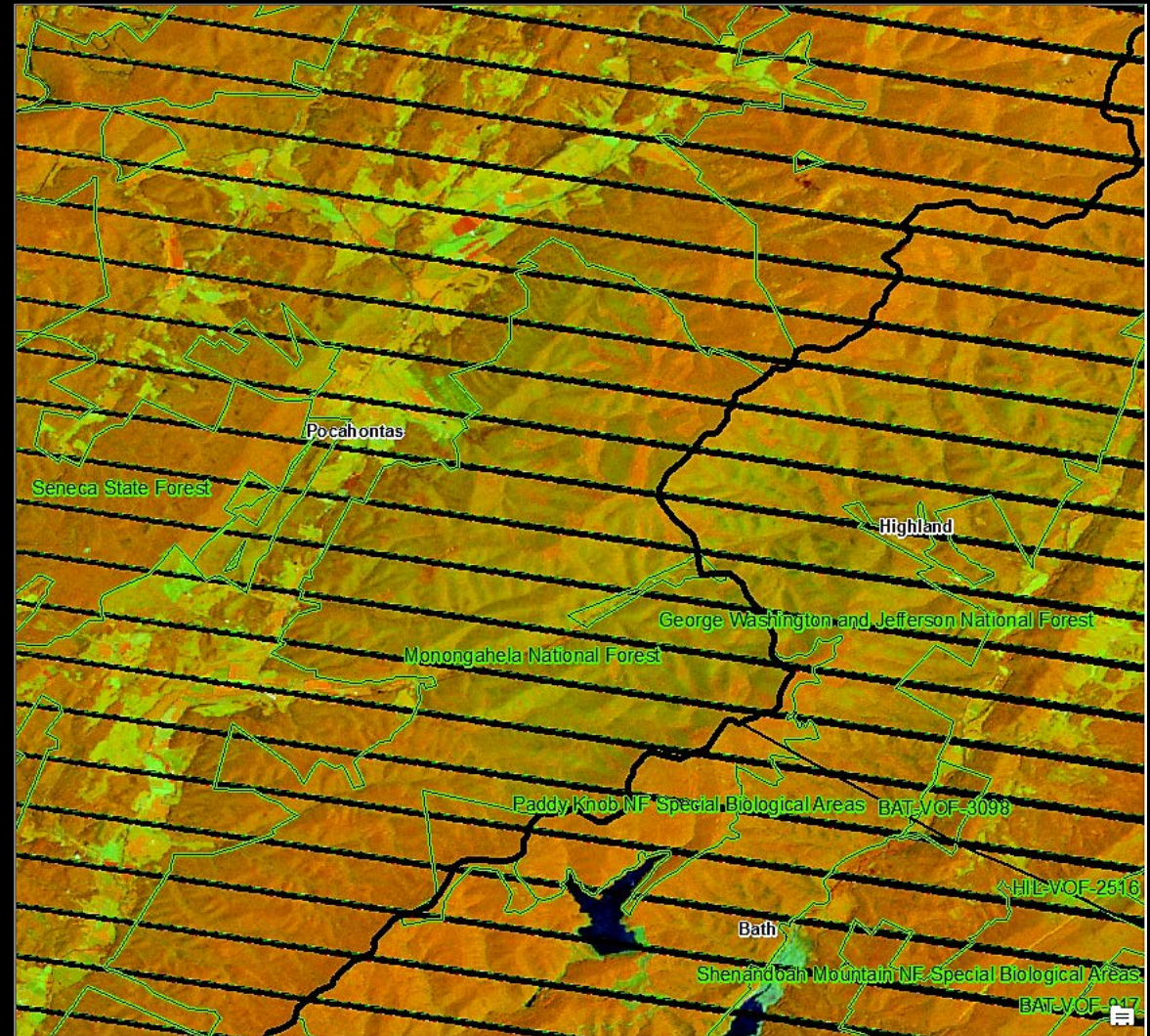
Drought and flood events

Insects and disease outbreaks

Early/late – spring/fall timing

Snow

Wildfire events



Landsat 7, 07/22/2015, 452rgb



# Examples of forest disturbance, or recovery, seen in the *ForWarn* forest change images

## Natural Disturbance

Severe weather (tornadoes, wind, hail, ice)

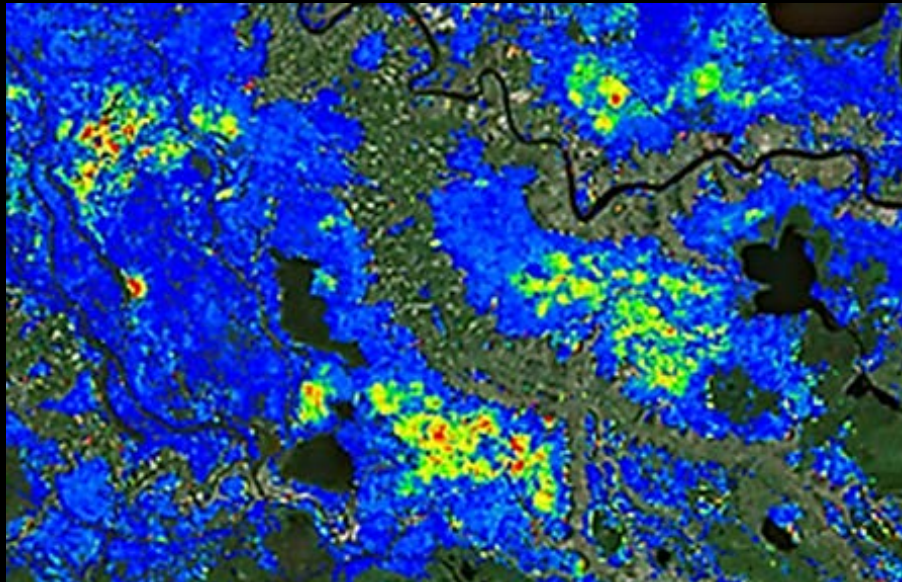
Drought and flood events

Insects and disease outbreaks

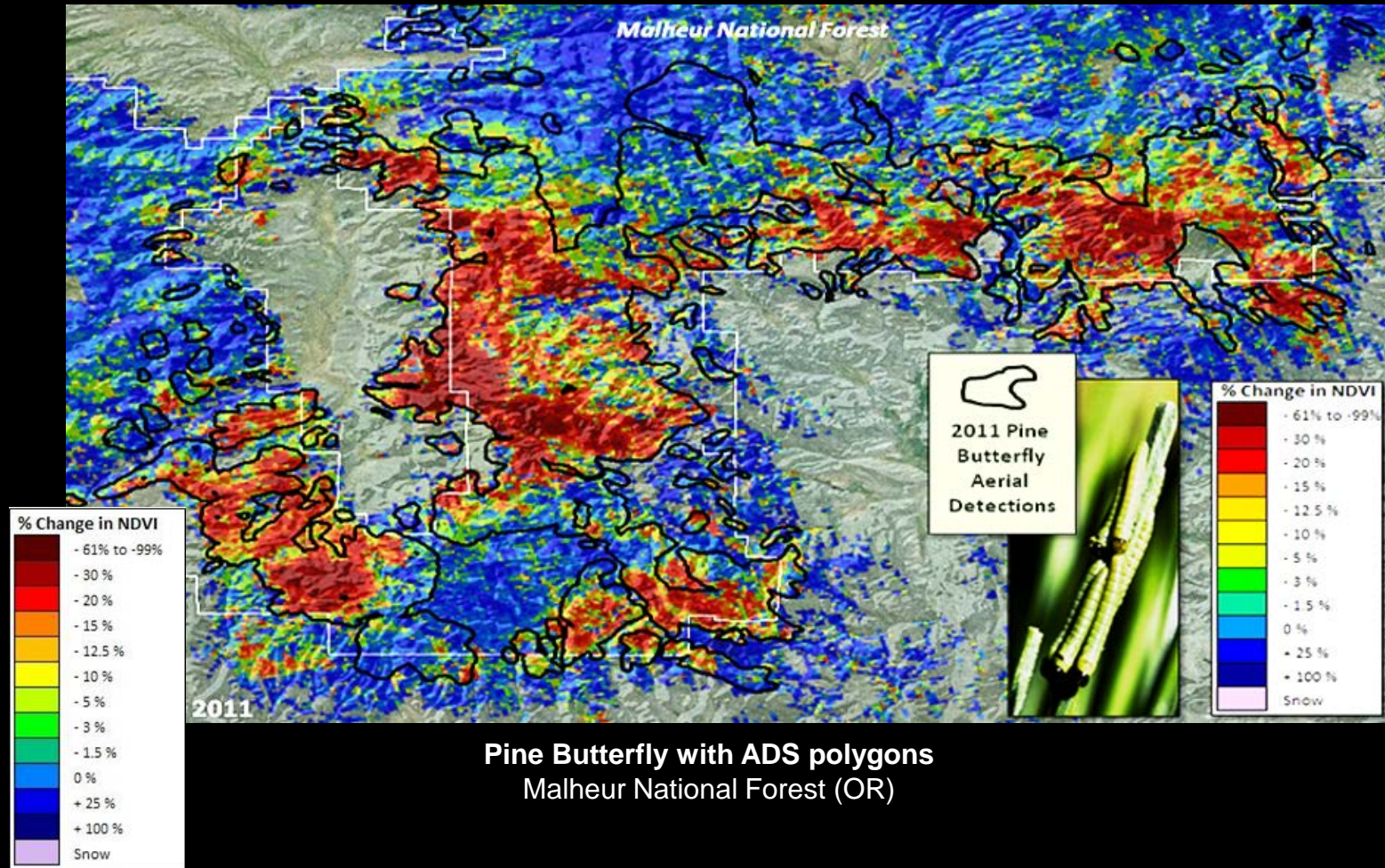
Early/late – spring/fall timing

Snow

Wildfire events



Cypress Leaf roller – Forest Tent Caterpillar (LA)



Pine Butterfly with ADS polygons  
Malheur National Forest (OR)



# Examples of forest disturbance, or recovery, seen in the *ForWarn* forest change images

## Natural Disturbance

Severe weather (tornadoes, wind, hail, ice)

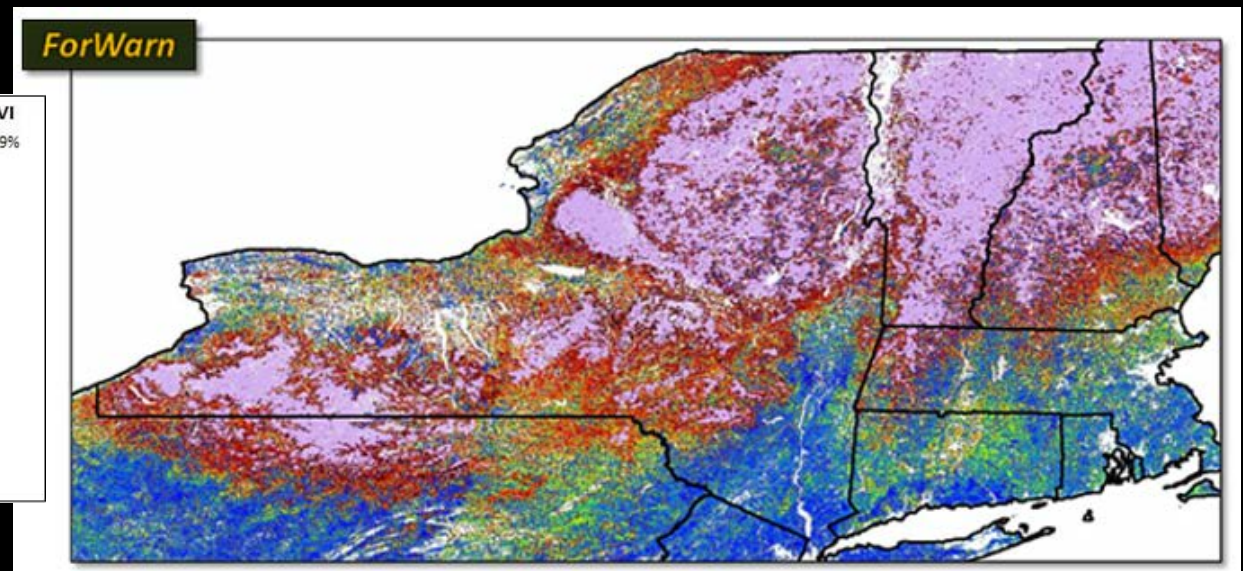
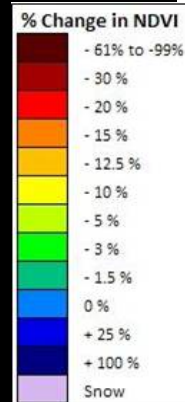
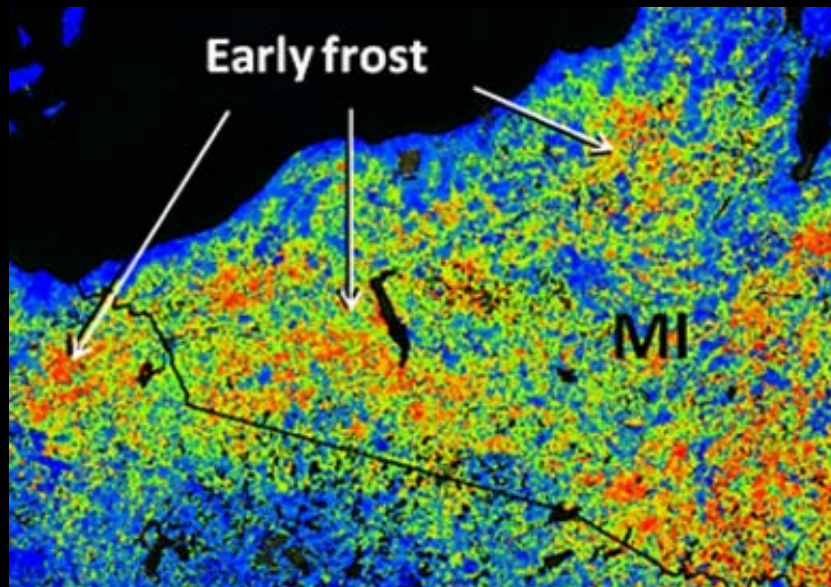
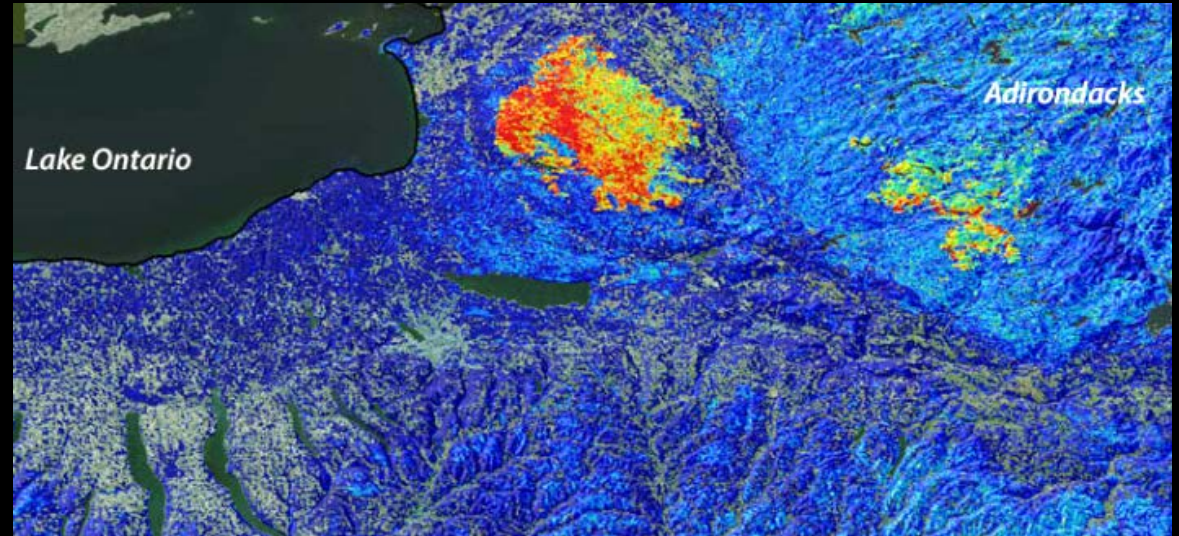
Drought and flood events

Insects and disease outbreaks

Early/late – spring/fall timing

Snow, frost

Wildfire events





# Examples of forest disturbance, or recovery, seen in the *ForWarn* forest change images

## Natural Disturbance

Severe weather (tornadoes, wind, hail, ice)

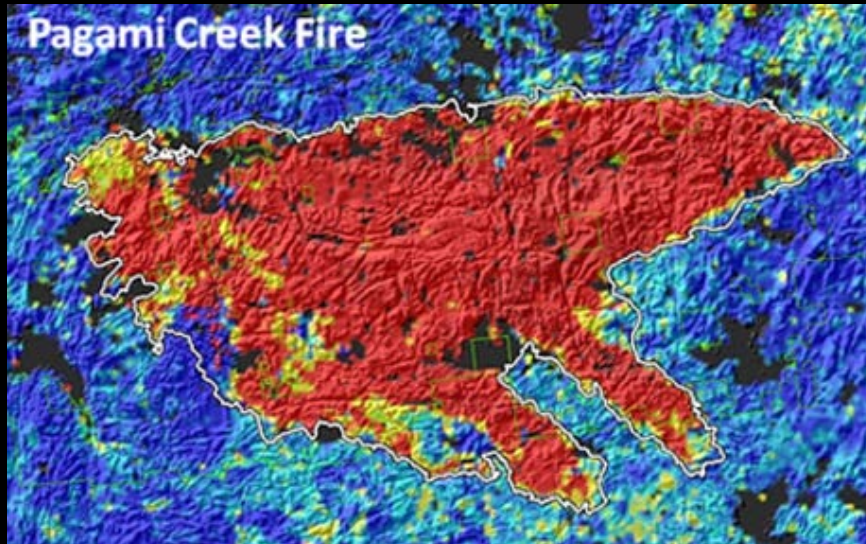
Drought and flood events

Insects and disease outbreaks

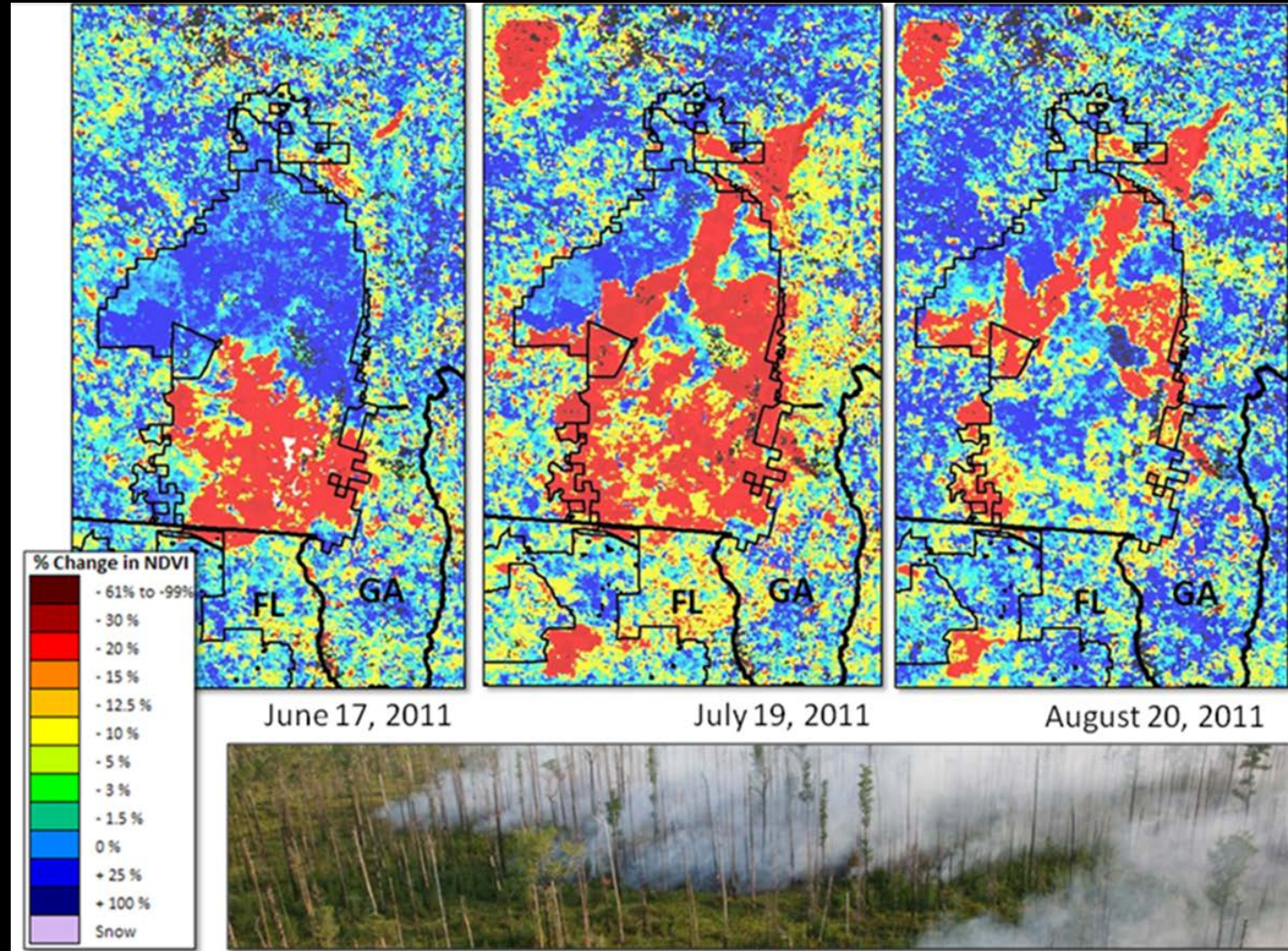
Early/late – spring/fall timing

Snow

Wildfire events



Okefenokee Swamp (GA)





# Examples of forest disturbance, or recovery, seen in the *ForWarn* forest change images

## Natural Disturbance

Severe weather (tornadoes, wind, hail, ice)

Drought and flood events

Insects and disease outbreaks

Early/late – spring/fall timing

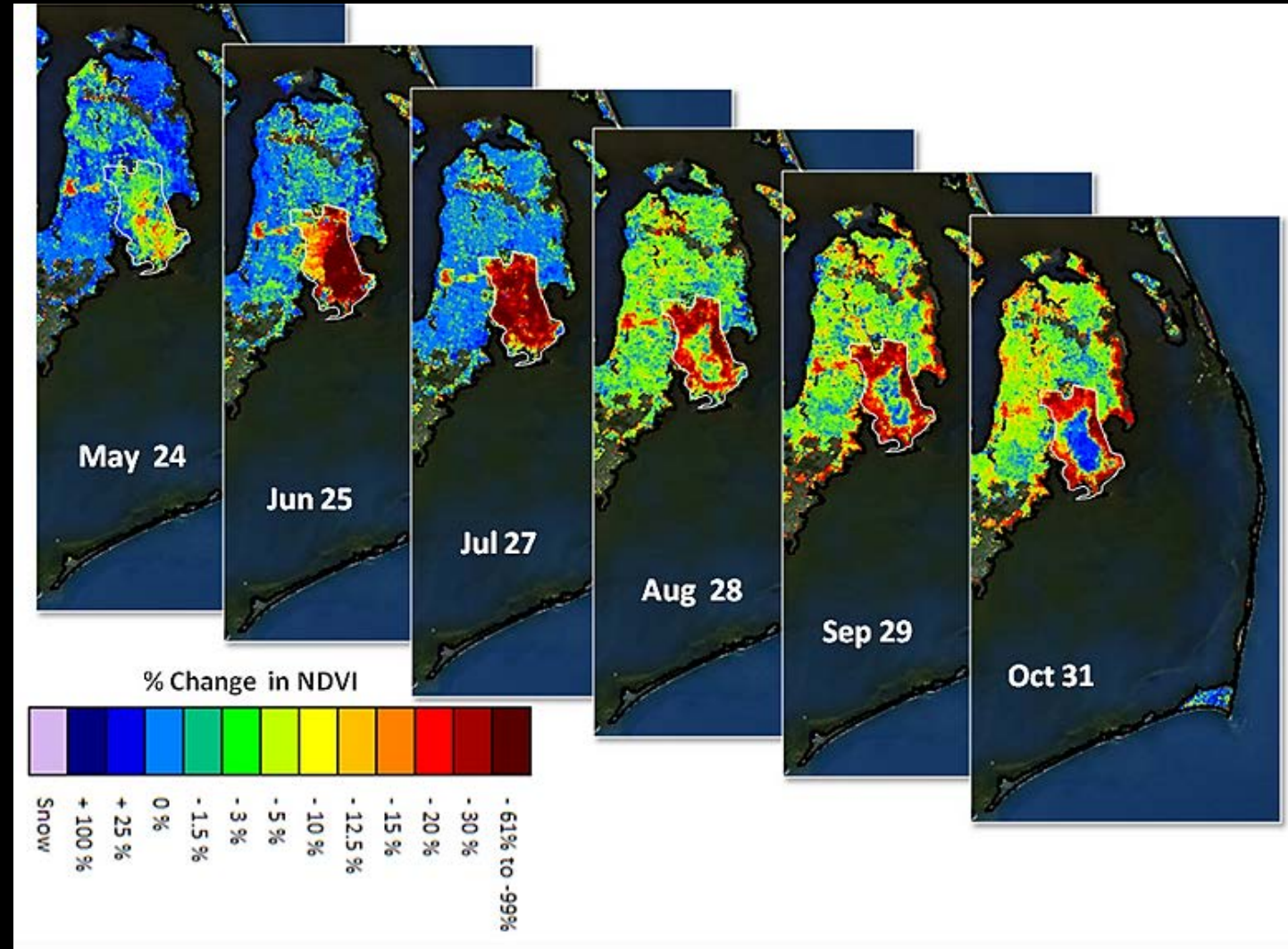
Snow

Wildfire events

*Forest disturbance events often display degrees of severity.*

*Variation in rates of recovery can relate to vegetative resilience.*

Pains Bay Wildfire (NC)

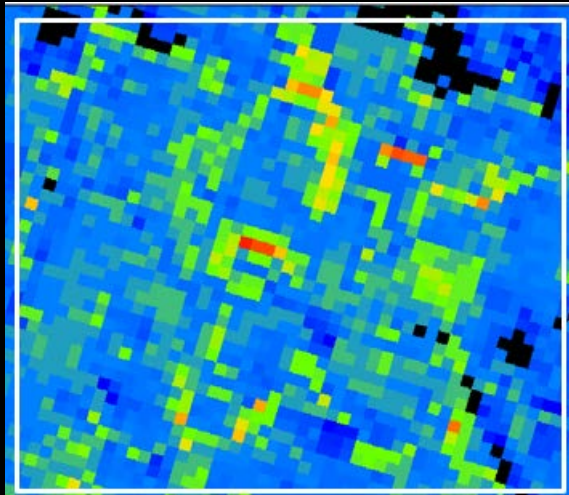




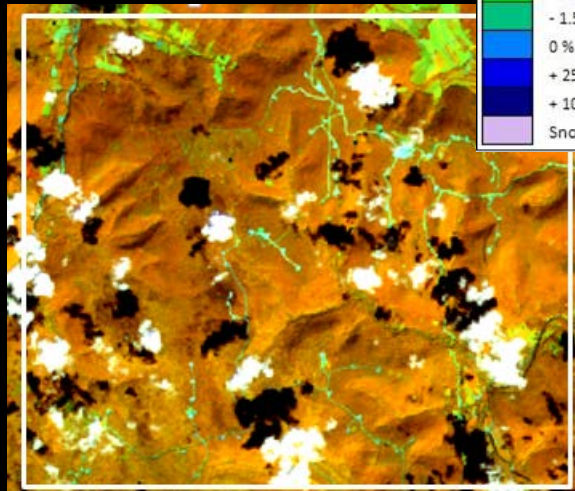
# Examples of forest disturbance, or recovery, seen in the *ForWarn* forest change images

## Anthropogenic Disturbance

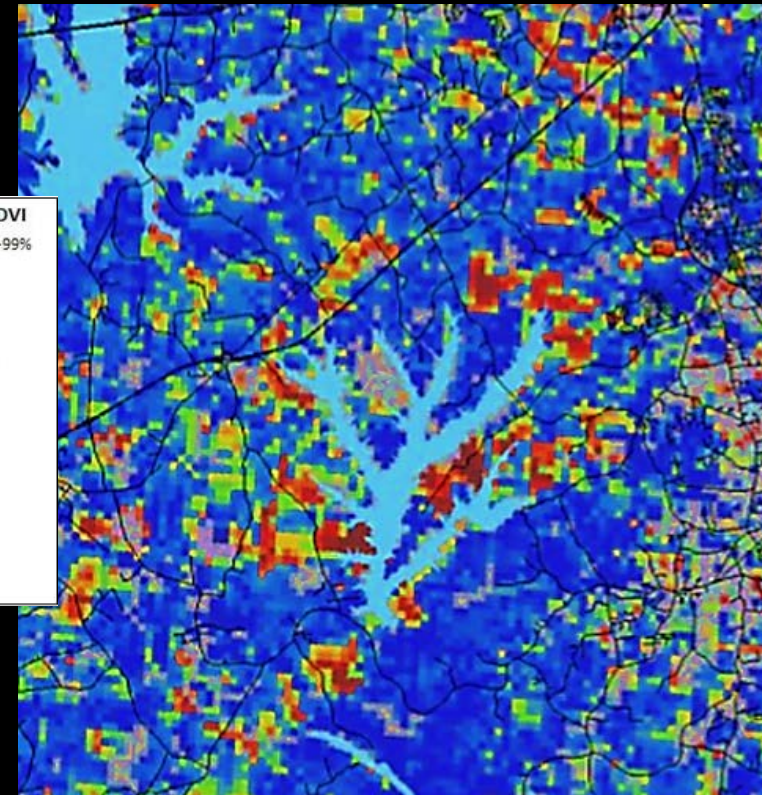
Forest Fragmentation, conversion and urban sprawl  
Forest clear cutting, Rx and silvicultural operations  
Mining, oil and gas activities  
Climate variability  
Arson wildfire



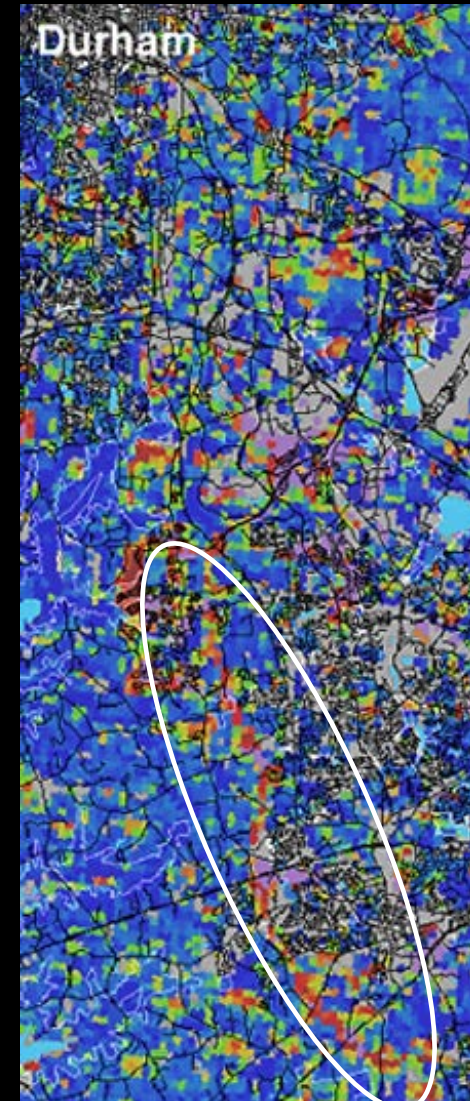
Oil and gas well construction (PA)



Landsat



Forest management (NC)



Road construction (NC)

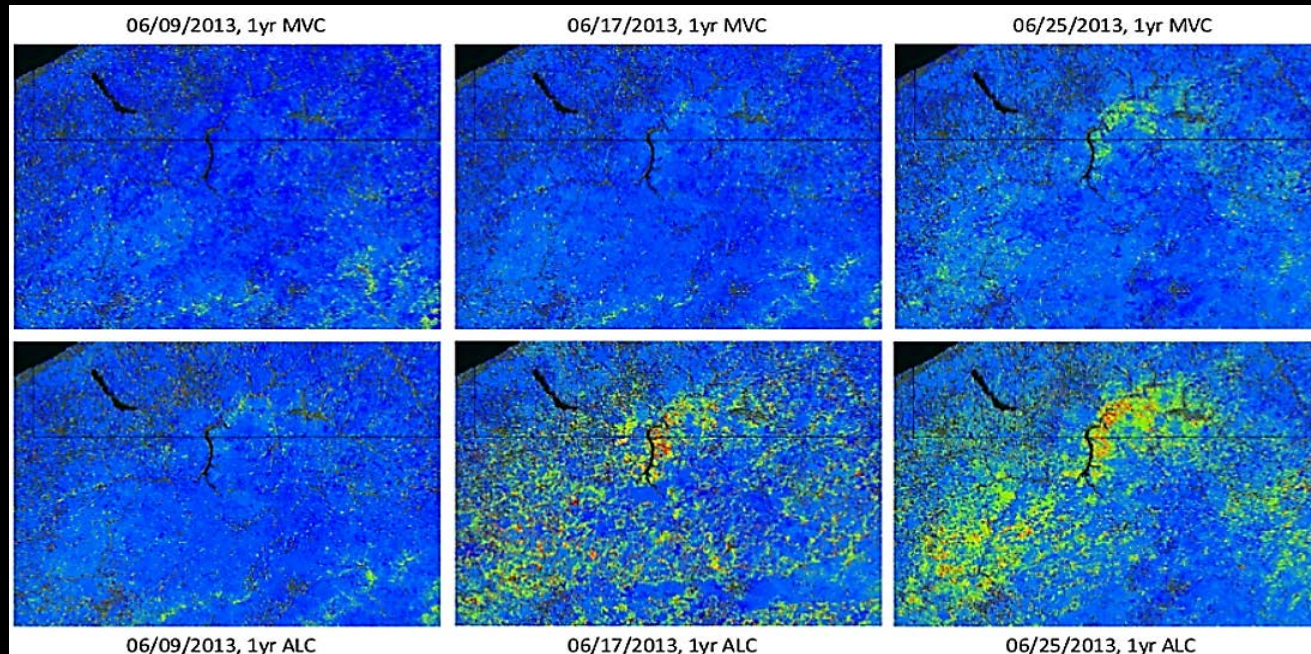


# Application Limitation

## Detection Delay

24-day detection delay in the 'max-NDVI' standard products, except...

*ForWarn* 1yr Baseline 'Standard' Product vs. 1yr Baseline 'Early Detect' Product



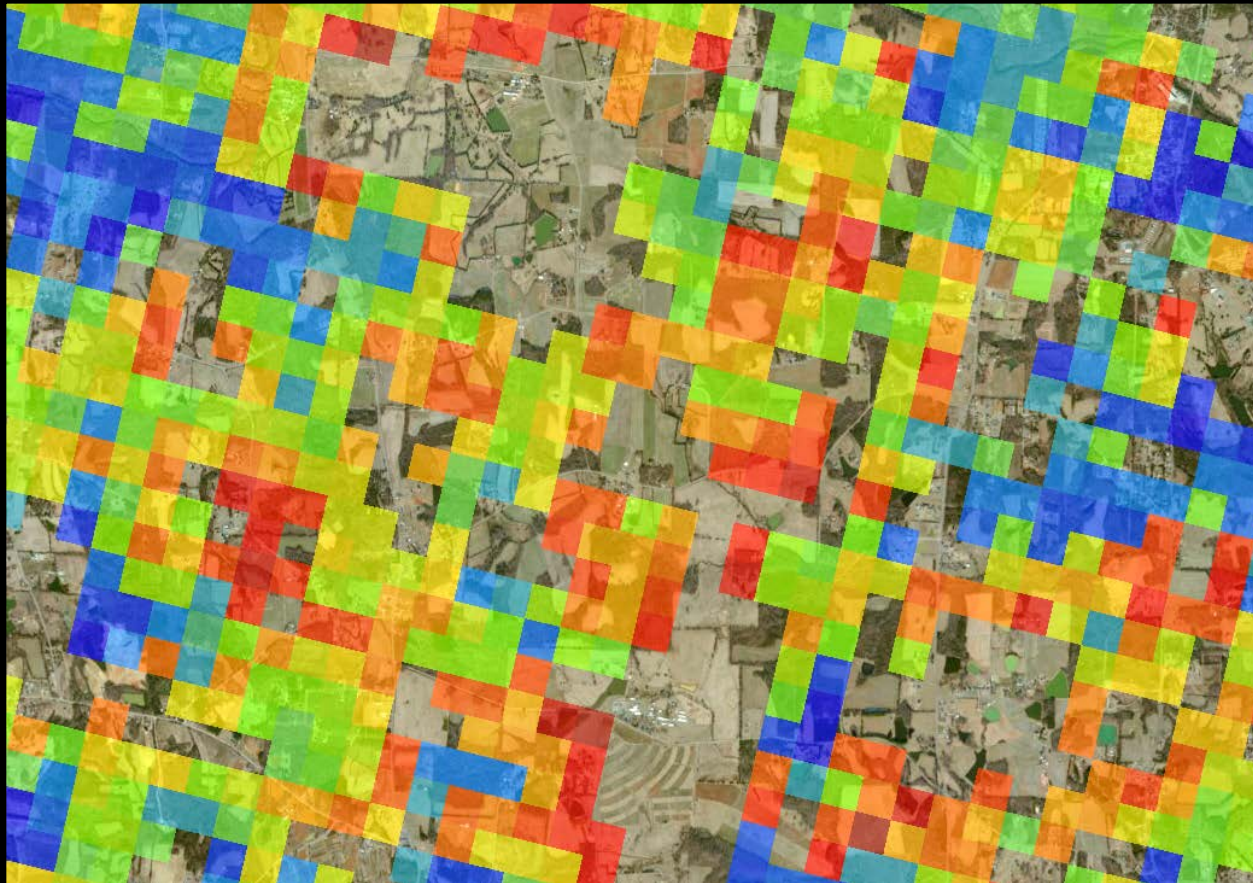
*The 'Early Detect' product dramatically reduces **ForWarn** detection speeds, allowing the detection of disturbances in as few as one 8-day period*



# Application Limitations

## 'Edge-of-the-mask'

low density, mixed composition forest  
pixels are subject to show drought



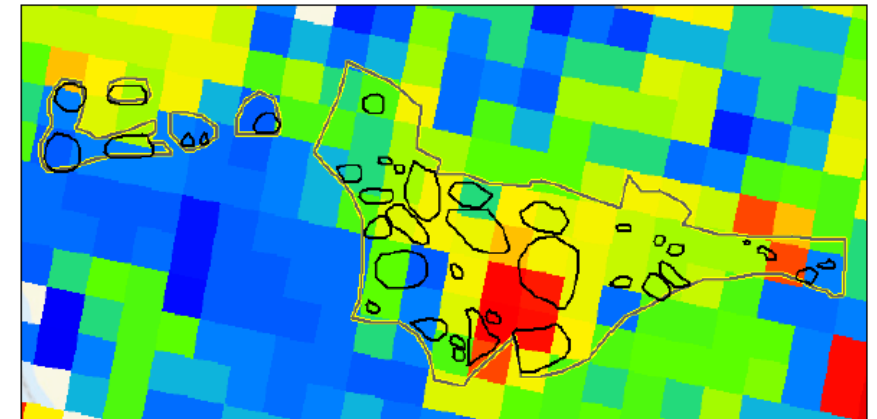
## Spatial Resolution

SPB and IPS have been difficult to detect

08/14/2012  
Landsat 453



08/19/2012  
ForWarn 11yr







# **ForWarn**

Satellite-Based Change Recognition and Tracking



- What is *ForWarn* and how does it work?
- The *Forest Change Assessment Viewer*
- Website - <https://forwarn.forestthreats.org>
- Questions?



*ForWarn* Introduction Webinar  
Virginia Department of Forestry  
April 3, 2017





[forwarn.forestthreats.org](http://forwarn.forestthreats.org)

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ForWarn

Satellite-Based Change Recognition and Tracking

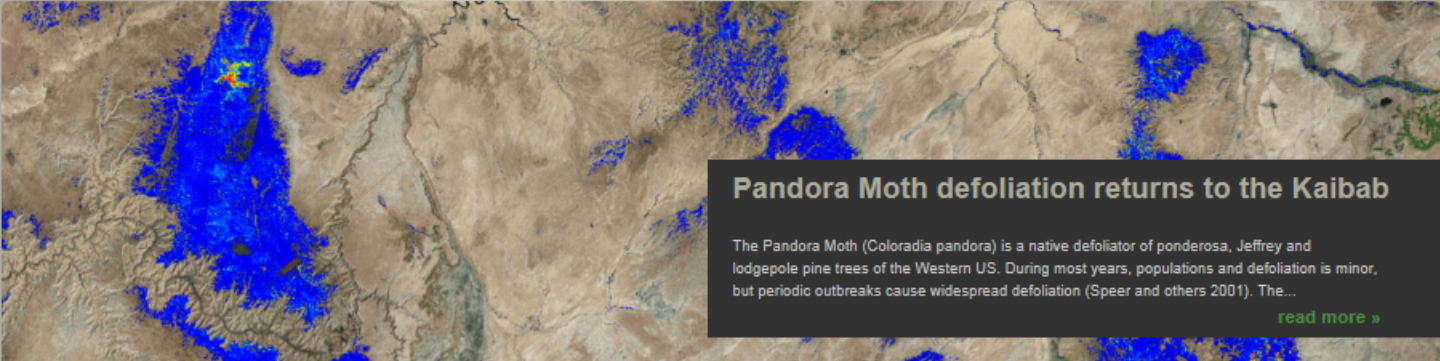
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Pandora Moth defoliation returns to the Kaibab

The Pandora Moth (*Coloradia pandora*) is a native defoliator of ponderosa, Jeffrey and lodgepole pine trees of the Western US. During most years, populations and defoliation is minor, but periodic outbreaks cause widespread defoliation (Speer and others 2001). The...

[read more »](#)

2 OF 7

PREVIOUS PAUSE NEXT

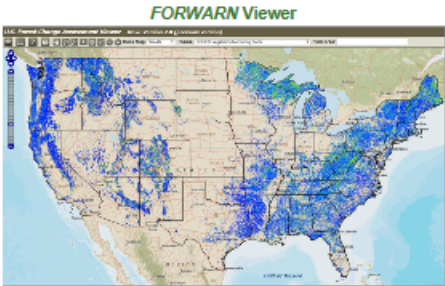
Get Started

ForWarn provides near-real-time tracking of vegetation changes across landscapes in the United States. Useful for both monitoring disturbance events as well as year-to-year variability, derived products can also be used to develop insights into seasonal and inter-annual dynamics.

- » [Introduction to ForWarn](#)
- » [Data Access](#)
- » [Sign up for updates](#)
- » [Contact Us](#)

Forest Change Assessment Viewer

The Forest Change Assessment Viewer provides a vegetation change recognition and tracking system for ForWarn that uses high-frequency, moderate resolution satellite data.



Recent News

[ForWarn featured in NASA Earth Observatory](#)

11/16/2016 - 11:03 Sap-sucking insects called hemlock woolly adelgids are draining the life from a common evergreen tree in the eastern United States. Once the non-native bugs become well-established, the consequences...

[Featured in Compass Magazine: Here Today or Here to Stay?](#)

09/22/2016 - 09:47 Some disturbances come and go, leaving forests no worse for the wear. Hailstorms, insect defoliations, and light prescribed fires, for example, commonly occur early in the growing season, but,...

[ForWarn data on Okefenokee National Wildlife Refuge presented at Texas fire conference](#)

11/23/2015 - 13:49 ForWarn team members attended the 2015 Association for Fire Ecology Meeting in San Antonio, TX in November 2015 to present research on long-term monitoring based on ForWarn's NDVI products. You can...

[more news »](#)

USDA Forest Service

EFETAC

WWETAC

Policies and Links

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Accessibility Statement

FOIA

Non-discrimination Statement

White House

usa.gov

Log In



Keyword

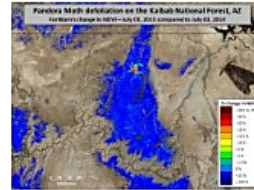
Disturbance Type

- Any -



APPLY

## Highlights



### Pandora Moth defoliation returns to the Kaibab

07/14/2015 - 14:45 The Pandora Moth (*Coloradia pandora*) is a native defoliator of ponderosa, Jeffrey and lodgepole pine trees of the Western US. During most years, populations and defoliation is minor, but periodic outbreaks cause widespread defoliation (Speer and others 2001). The outbreak shown here in Arizona's Kaibab National Forest first caused significant defoliation in June-July of 2013 and defoliating caterpillars have now returned in 2015.

One of the more peculiar aspects of outbreaks is that... [\(read more\)](#)



### Mapping the urban phenological footprint

03/18/2015 - 21:44 Urban areas are renowned for their admixture of species and vegetation types that can change from one parcel to the next. Yards and woodland parks intermix with road medians—all of which may be dominated by an irregular mix of native and exotic trees, shrubs, herbs and grasses. In cities, the vegetation of nearly every block is compositionally complex.

These species green up at different times and at different rates. Because of this, it can be difficult to decide when spring occurs... [\(read more\)](#)



### The typical start of greenup on agricultural lands

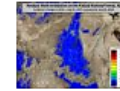
03/18/2015 - 09:56 Understanding the normal start of greenup for croplands is important because it provides a baseline to compare year to year conditions. The date of greenup for agricultural lands varies based on year-to-year climate factors, the unique responses of the specific crop or vegetation type planted, and farmers' management practices. For areas that need to be planted in the spring, wet late winters can delay planting. Cool springs can delay growth. Either can potentially influence seasonal growth... [\(read more\)](#)



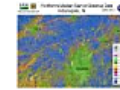
### The typical start of greenup in natural vegetation

## Highlights

Pandora Moth defoliation returns to the Kaibab



Mapping the urban phenological footprint



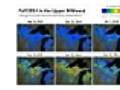
The typical start of greenup on agricultural lands



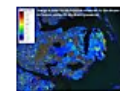
The typical start of greenup in natural vegetation



Autumnal Hail and Early Browndown in the Upper Midwest



Coastal pocosins respond to hurricanes and fire



[more highlights »](#)



# ForWarn

Satellite-Based Change Recognition and Tracking

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## Products

Near-Real-Time Products

Long-Term Monitoring

Products

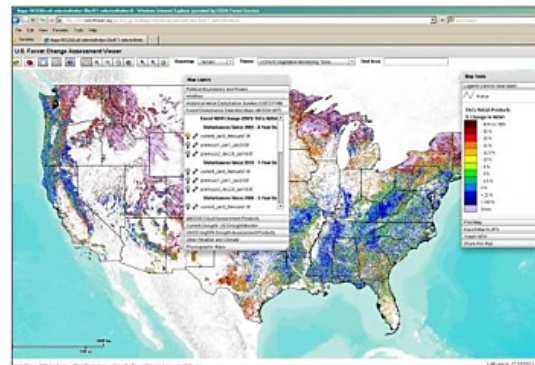
[Data Access](#)

## Data Access

ForWarn data are readily accessed through the project's [Forest Change Assessment Viewer](#) using a standard internet browser. To learn more about the functions and features of the Assessment Viewer, please read the [Forest Change Assessment Viewer Users Guide](#)

### Web Map Service (WMS) Access

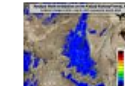
WMS allows access to the ForWarn vegetation change images using your desktop GIS or mobile mapping application software. The advantages of viewing the forest change images locally are: (1) to overlay with your GIS layers, (2) to screen-digitize disturbance extent and severity, (3) the increased use and functionality of a desktop GIS, and (4) to view the change images via mobile devices (such as using OruxMaps with Droid-based handhelds). Use the following WMS connection strings to access the ForWarn data products:



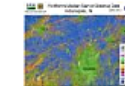
WMS Dataset	Contents	Connection URL (ArcGIS users denote version 1.0.0)
All-Year baseline forest change images (Web Mercator)	Begins 01/08/2010 for all-year baseline-only; current, previous 1 and previous 2 available for all baseline periods, disregard 16-day composite products	<a href="http://wms.forwarn.forestthreats.org/ews">http://wms.forwarn.forestthreats.org/ews</a> <a href="#">[GetCapabilities]</a>
All-Year baseline forest change images (WGS84)	Begins 01/08/2010 for all-year baseline-only; current, previous 1 and previous 2 available for all baseline periods, disregard 16-day composite products	<a href="http://wms.forwarn.forestthreats.org/ewswgs84">http://wms.forwarn.forestthreats.org/ewswgs84</a> <a href="#">[GetCapabilities]</a>
1-year baseline forest change images	Begins 01/08/2010 through current for 1-year baseline-only	<a href="http://wms.forwarn.forestthreats.org/ews1year">http://wms.forwarn.forestthreats.org/ews1year</a> <a href="#">[GetCapabilities]</a>
3-year baseline forest change images	Begins 01/08/2010 through current for 3-year baseline only	<a href="http://wms.forwarn.forestthreats.org/ews3year">http://wms.forwarn.forestthreats.org/ews3year</a> <a href="#">[GetCapabilities]</a>
Cloud Product, MODIS True Color Composites	Begins 01/08/2010 through current	<a href="http://wms.forwarn.forestthreats.org/ewstruecolor">http://wms.forwarn.forestthreats.org/ewstruecolor</a> <a href="#">[GetCapabilities]</a>

## Highlights

Pandora Moth defoliation returns to the Kaibab



Mapping the urban phenological footprint



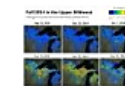
The typical start of greenup on agricultural lands



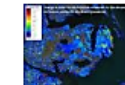
The typical start of greenup in natural vegetation



Autumnal Hail and Early Browndown in the Upper Midwest



Coastal pocosins respond to hurricanes and fire



[more highlights »](#)

If you need a quick shapefile of a forest disturbance, you can load **ForWarn** imagery to your desktop GIS and screen-digitize the extent, and if present, depict zones of severity.



# ForWarn

Satellite-Based Change Recognition and Tracking

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## Resources

### Selected Publications

- [Toward a national early warning system for forest distances using remotely sensed canopy phenology](#), *Photogrammetric Engineering and Remote Sensing*, October 2009.
- [Highlights of satellite-based forest change recognition and tracking using the ForWarn System](#) (Steve Norman, 2013)

### Presentations

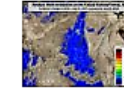
- [Toward a national Early Warning System for forest disturbances using remotely sensed land-surface phenology](#) (Bill Hargrove, et al. 2012)
- [Using land surface phenology for national mapping of the occurrence and health of evergreen and deciduous forests \(evergreen/deciduous thrive/decline\)](#) (Bill Hargrove et al., International Association for Landscape Ecology Meeting, Apr. 2013)
- [Predicting long-term wildfire effects across complex landscapes](#) (Steve Norman, et al. USDA Forest Service Landscape Science Webinar, Oct. 2013)
- [Detecting and tracking forest change in the Blue Mountains of Oregon and Washington using the ForWarn system](#) (Steve Norman et al., Blue Mountains Forest Vegetation Workshop, Apr. 2014)
- [Tracking forest and landscape change from space using the ForWarn system](#) (Steve Norman et al., Southern Regional Forestry Extension Webinar, Oct. 2014) View this archived webinar at any time through forestrywebinars.net.
- [Five applications of the ForWarn System for wildland fire management](#) (Steve Norman et al., USDA Forest Service Rocky Mountain Research Station Webinar, May 2014)
- [Recognizing gradual loss of forest resilience using continuous satellite-based monitoring](#) (Steve Norman et al., Appalachian Society of American Foresters Meeting, Jan. 2015)
- [The use of phenological completion milestones for determining day-of-year of Start-of-Greenup and Start-of-Senescence](#) (Bill Hargrove, et al., Blue Ridge Parkway Science Meeting, Apr. 2015)
- [Satellite-based monitoring of seasonal, successional and event fuels for fire planning](#) (Steve Norman et al., Southern Blue Ridge Fire Learning Network Workshop, May 2015)

### Posters

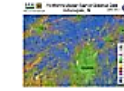
- [High Frequency Monitoring of Fire Regimes and Ecological Resilience across the Okefenokee National Wildlife Refuge](#), 2015
- [The tornado outbreak of April, 2011 recorded by the USDA Forest Service's "Forest Change Assessment Viewer"](#)
- [A framework for predicting post-wildfire trajectories with desired conditions using NDVI time series](#)
- [Mapping hemlock decline in the Southern Appalachians using high and moderate resolution imagery](#)

## Highlights

Pandora Moth defoliation returns to the Kaibab



Mapping the urban phenological footprint



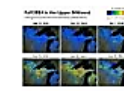
The typical start of greenup on agricultural lands



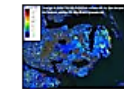
The typical start of greenup in natural vegetation



Autumnal Hail and Early Browndown in the Upper Midwest



Coastal pocosins respond to hurricanes and fire



[more highlights »](#)



# ForWarn General Technical Report



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Caring for the land and serving people  
United States Department of Agriculture

Sarah Farmer, Multimedia Information Specialist

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## Publications

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SRS Publications Highlights of satellite-based forest change recognition and tracking using the ForWarn Sys...

### Highlights of satellite-based forest change recognition and tracking using the ForWarn System

**Author(s):** Norman, Steven P.; Hargrove, William W.; Spruce, Joseph P.; Christie, William M.; Schroeder, Sean W.

**Date:** 2013

**Source:** Gen. Tech. Rep. SRS-GTR-180. Asheville, NC: USDA-Forest Service, Southern Research Station. 30 p.

**Station ID:** GTR-SRS-180

**Abstract**

For a higher resolution version of this file, please use the following link:  
[www.geobabble.org](http://www.geobabble.org)

Satellite-based remote sensing can assist forest managers with their need to recognize disturbances and track recovery. Despite the long standing availability of raw imagery, the systematic delivery of spatially continuous, ready-to-use, processed products has evaded us until recently. The web-based ForWarn system moves us a step forward by generating forest change maps at high frequency in a format that is usable to forest managers, planners, and the public. The ForWarn system shows change in the Normalized Difference Vegetation Index derived from moderate resolution imagery according to a range of baseline normals. Expectations of normal derive from previously observed changes in seasonal leaf phenology; this adjustment is critical for forests dominated by deciduous vegetation that vary in greenness through the year. After these seasonal adjustments are made behind the scene, the remaining forest change that ForWarn users see may result from an array of climatic and disturbance causes. These include insects and disease, wildland fire, wind, hail, human development, drought, or variation in the timing of spring and fall. This publication outlines the data and methods that underlie this technology, and provides examples that illustrate selected capabilities of this system for coarse-scale forest monitoring.

**Citation:** Norman, Steven P.; Hargrove, William W.; Spruce, Joseph P.; Christie, William M.; Schroeder, Sean W. 2013. Highlights of satellite-based forest change recognition and tracking using the ForWarn System. Gen. Tech. Rep. SRS-GTR-180. Asheville, NC: USDA-Forest Service, Southern Research Station. 30 p.

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[http://www.srs.fs.fed.us/pubs/gtr/gtr\\_srs180.pdf](http://www.srs.fs.fed.us/pubs/gtr/gtr_srs180.pdf)





**EASTERN THREAT CENTER:** <https://forestthreats.org/>

***ForWarn:*** <https://forwarn.forestthreats.org>

**Forest Change Assessment Viewer:** <https://forwarn.forestthreats.org/fcav2>

**Bill Christie, Biological Scientist:** [wchristie@fs.fed.us](mailto:wchristie@fs.fed.us)



*ForWarn* Introduction Webinar  
Virginia Department of Forestry  
April 3, 2017







# **ForWarn**

Satellite-Based Change Recognition and Tracking



- What is *ForWarn* and how does it work?
- The *Forest Change Assessment Viewer*
- Website - <https://forwarn.forestthreats.org>
- Questions?



*ForWarn* Introduction Webinar  
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April 3, 2017

