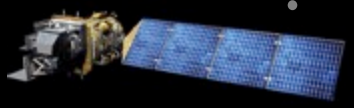


The 2016-2017 gypsy moth outbreak: Current status and continued monitoring

Valerie Pasquarella
Postdoctoral Fellow
University of Massachusetts - Amherst

WSCAC Meeting
February 13, 2018 | Southborough, MA

USGS science for a changing world

NE CSC Northeast Climate Science Center

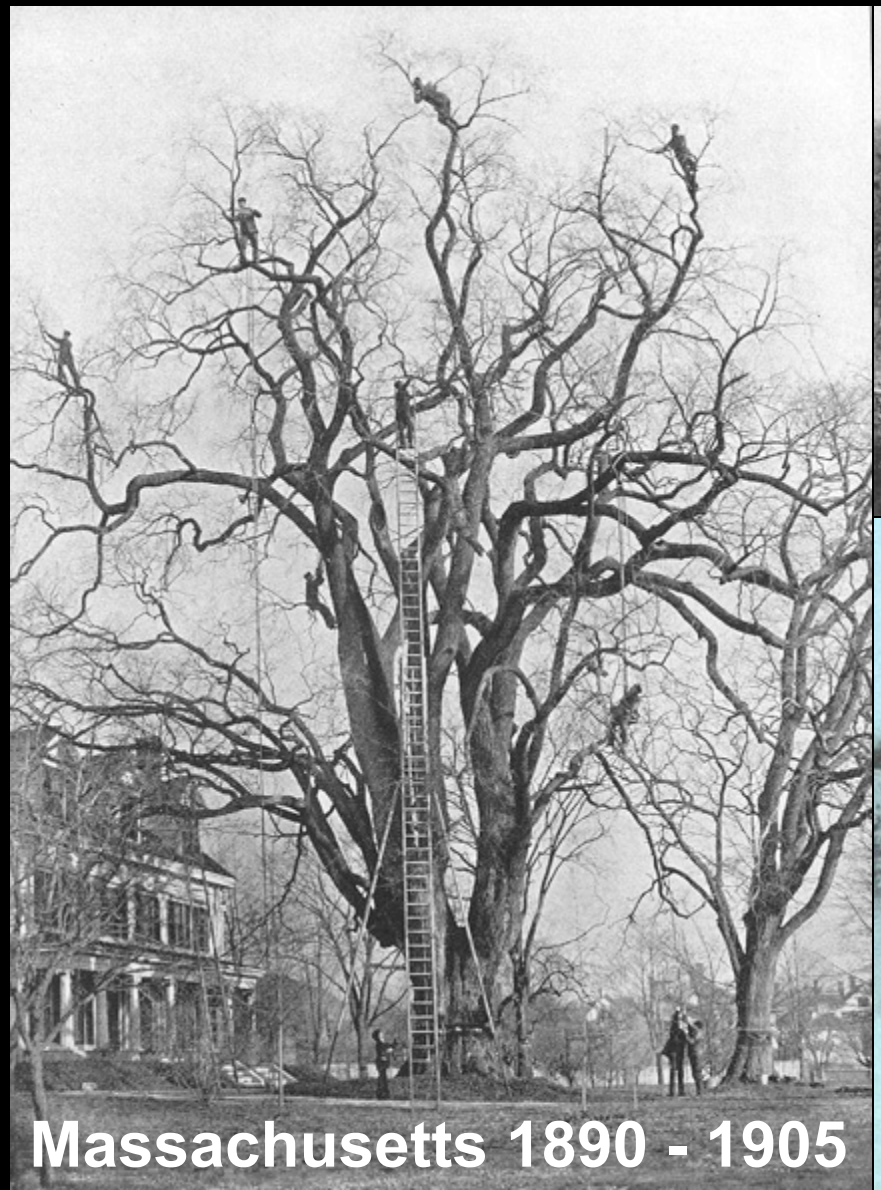
University of Massachusetts Amherst 1863

A Brief History
of Gypsy moth in New England

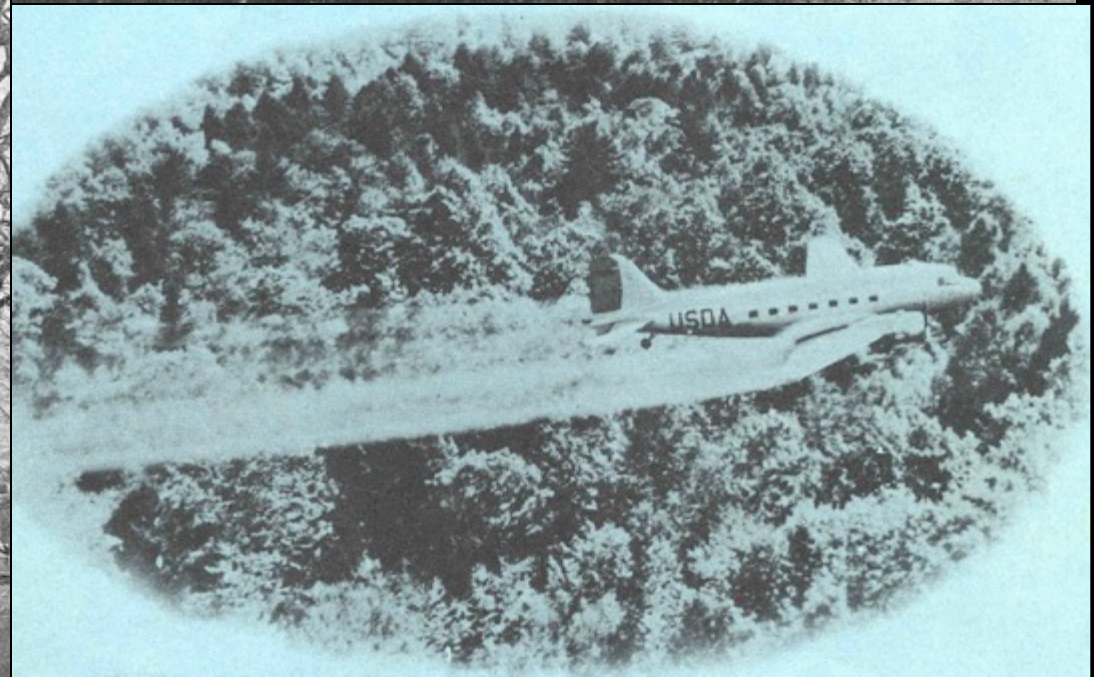
It all began in 1868 ...

Leopold Trouvelot

Early eradication efforts



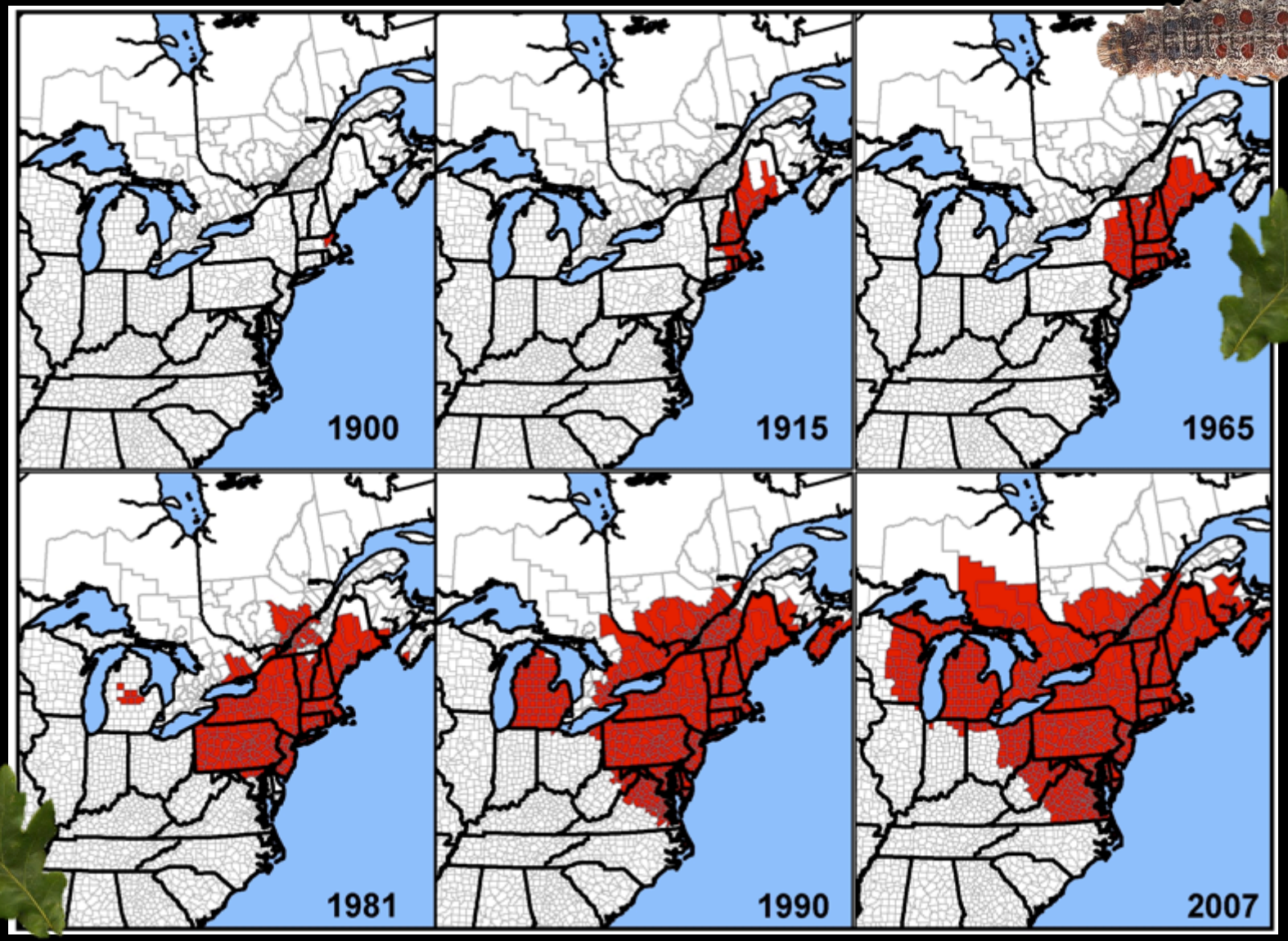
Massachusetts 1890 - 1905



Biological Control

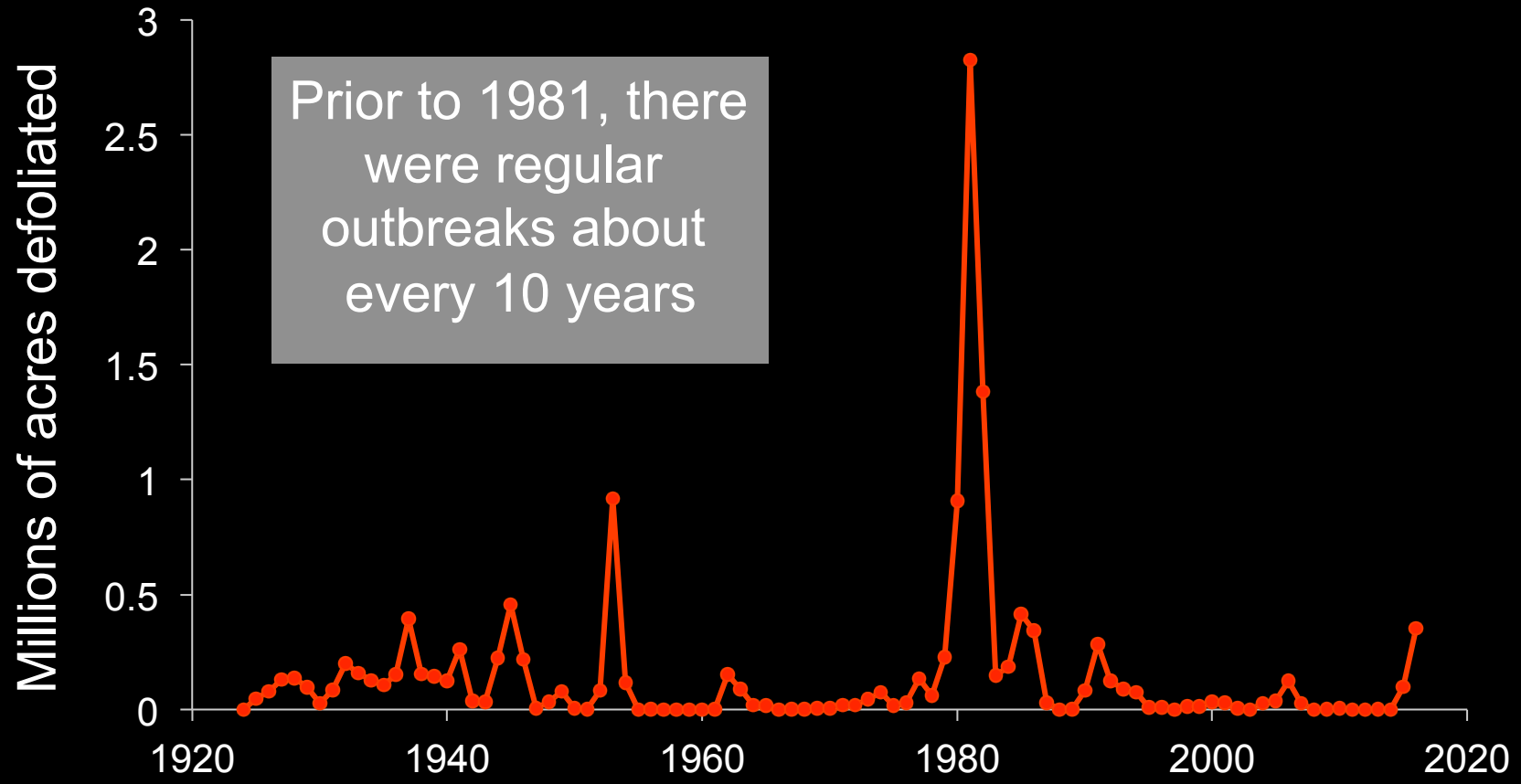
- Beginning in 1905, **ten** species of parasitoids were established in North America
- They did not, however, stop the spread or outbreaks

...so the spread continued



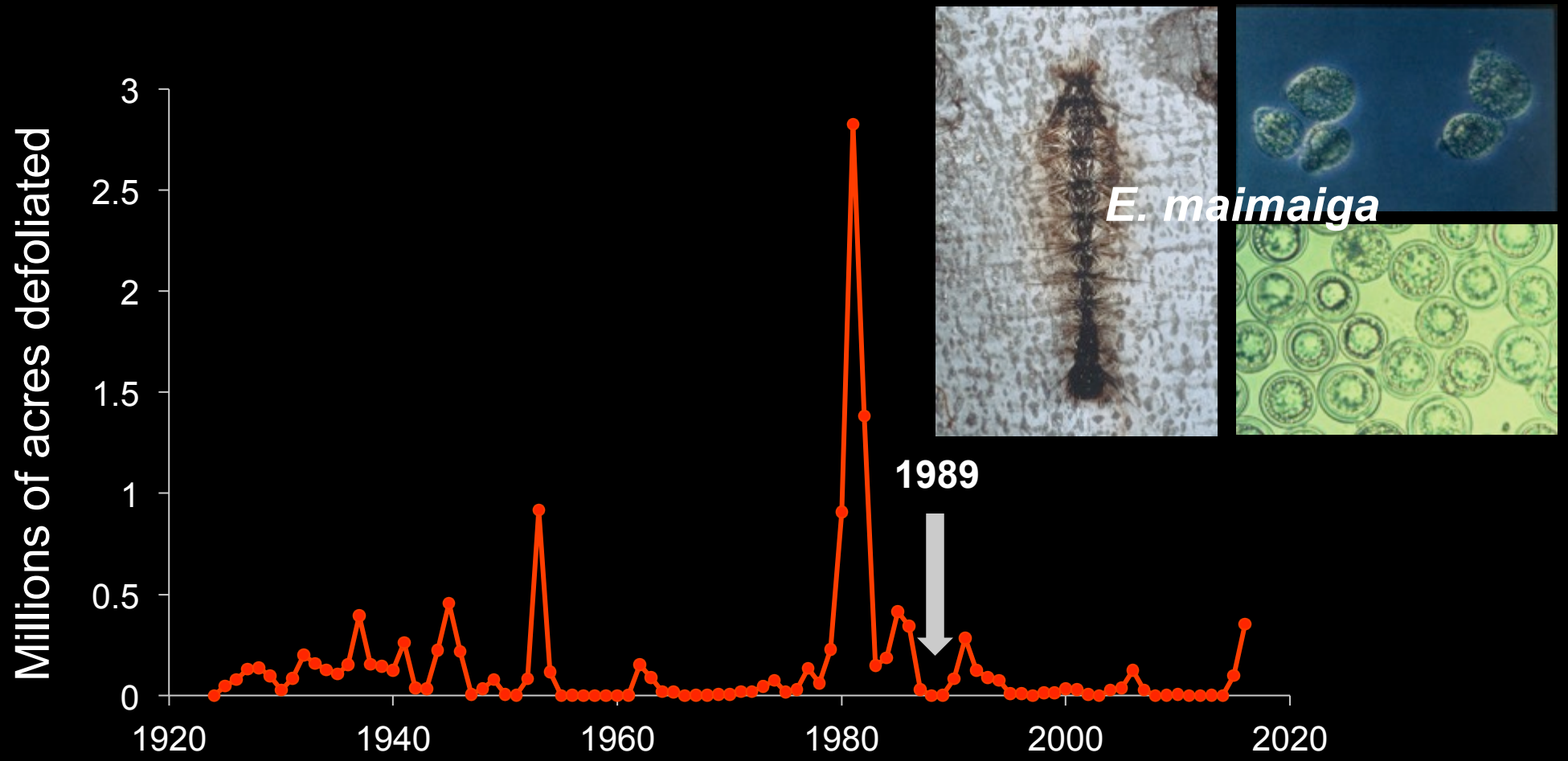
GM has cyclic outbreaks

Defoliation in Massachusetts (1924-2016)



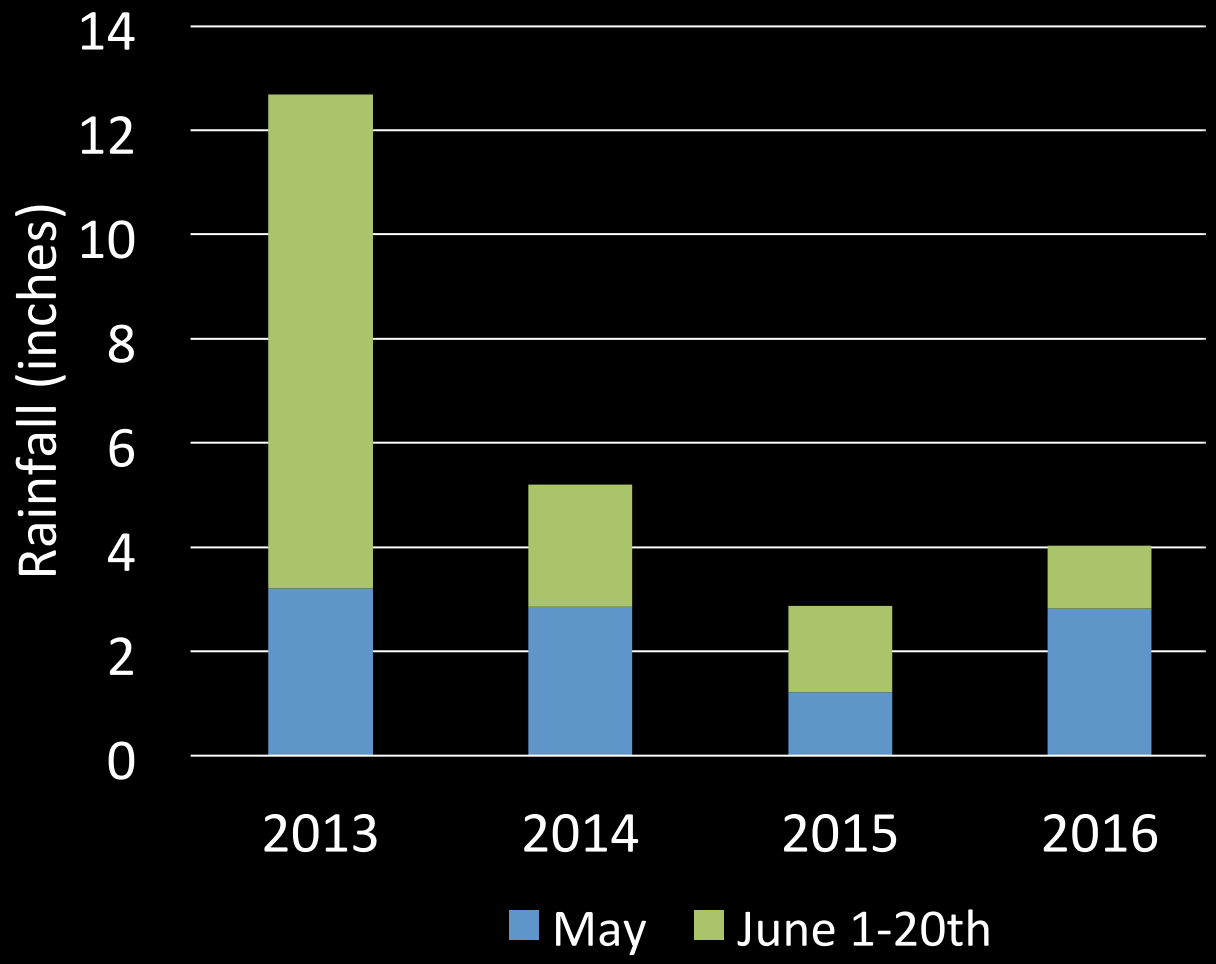
A fungal pathogen breaks the cycle

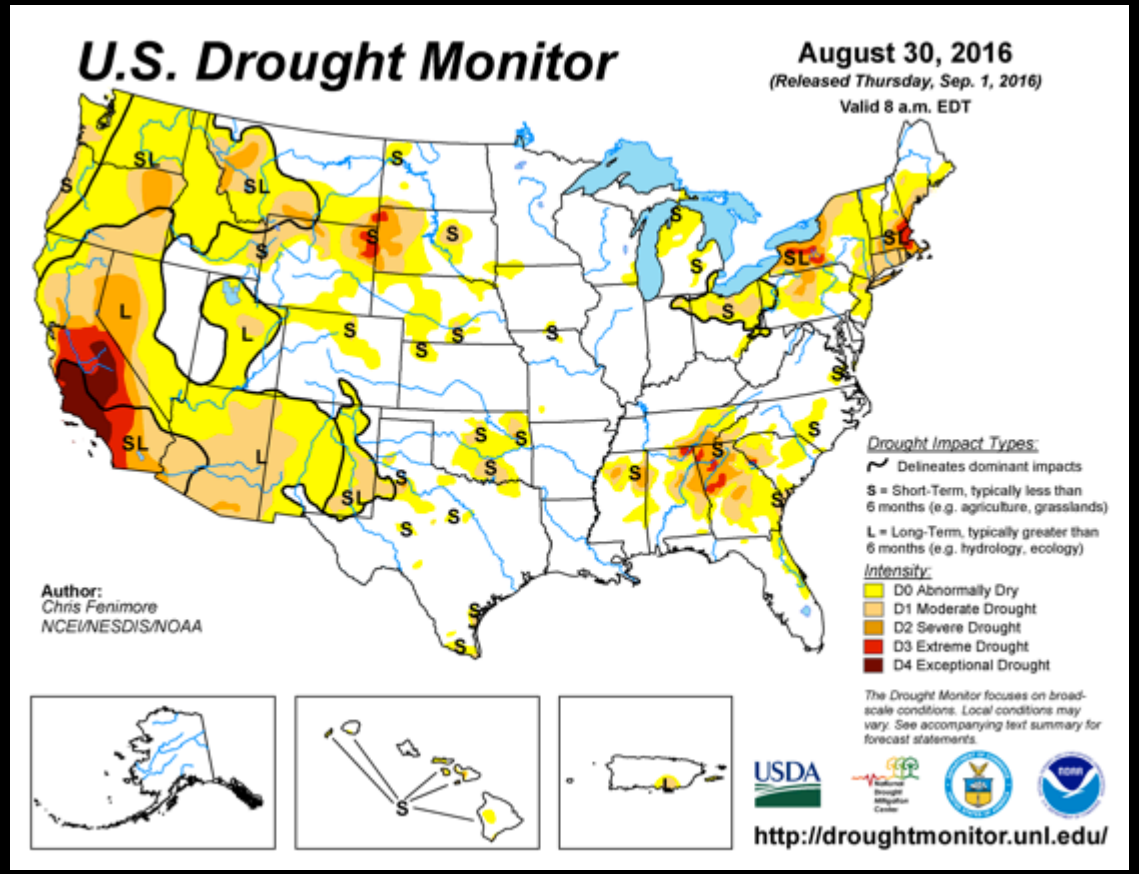
Defoliation in Massachusetts (1924-2016)




(Or so we thought)

Drought conditions in the Northeast





Summer 2016

Gypsy moth infestation expected to be exceptionally bad

Pests can do major damage to home, plants

WCVB | Updated: 11:00 PM EDT Jun 10, 2016

The Washington Post
Democracy Dies in Darkness

Morning Mix

Northeast battles gypsy moths, an insect plague stripping trees bare and delaying airplanes

Guarino July 7, 2016

For this massive caterpillar invasion, it's crunch time

By Michael Levenson | GLOBE STAFF JUNE 30, 2016

State: Gypsy moth damage nine times greater than in 2015

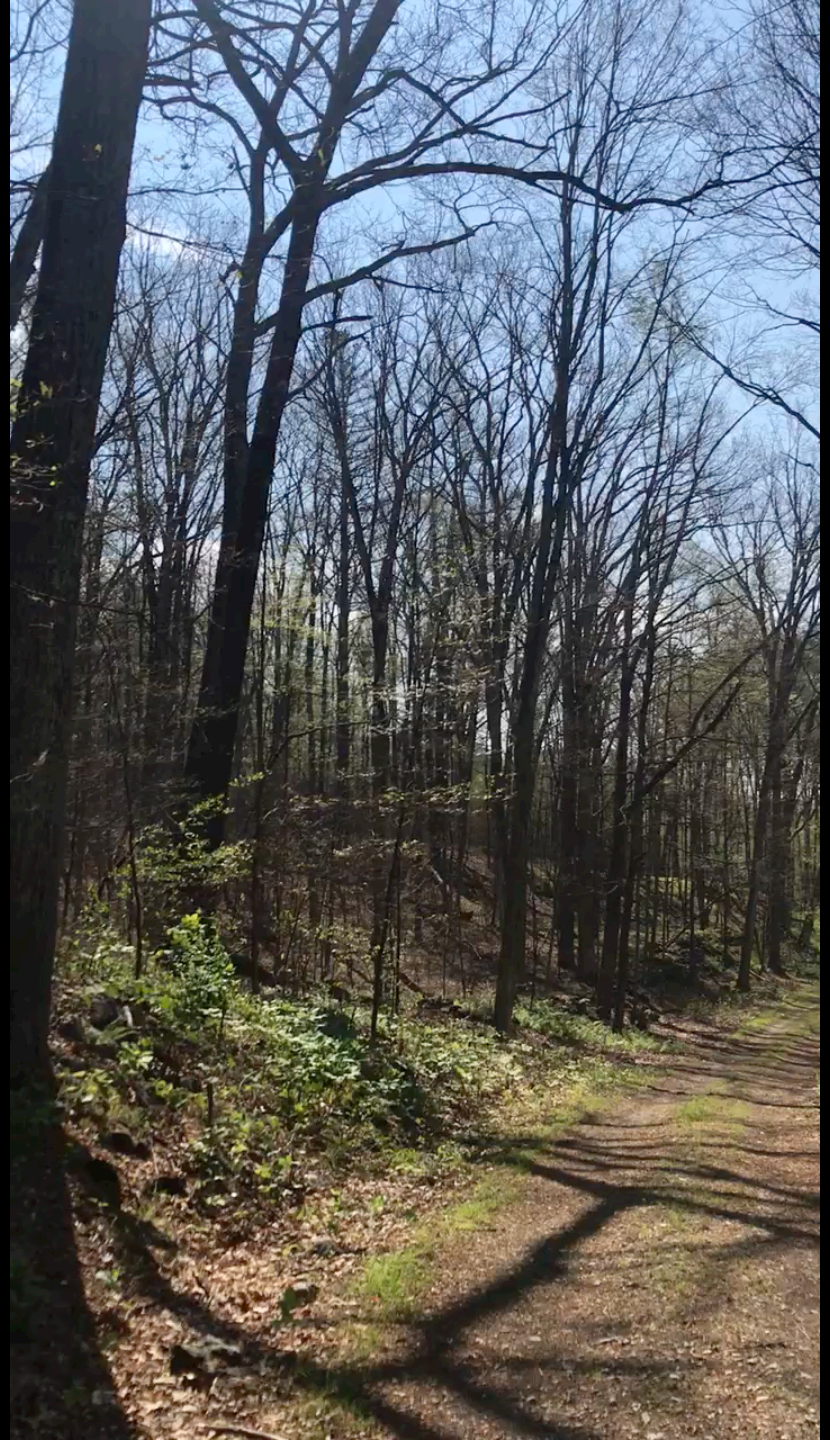
By Corin Cook, Daily News Staff

Updated: 10:04 AM EDT Aug 6, 2016

The Patriot Ledger

Losing the battle with gypsy moths and other bugs

Tuesday
Posted Jul 12, 2016 at 12:01 AM
Updated Jul 12, 2016 at 10:38 AM



Monitoring

Gypsy moth defoliation

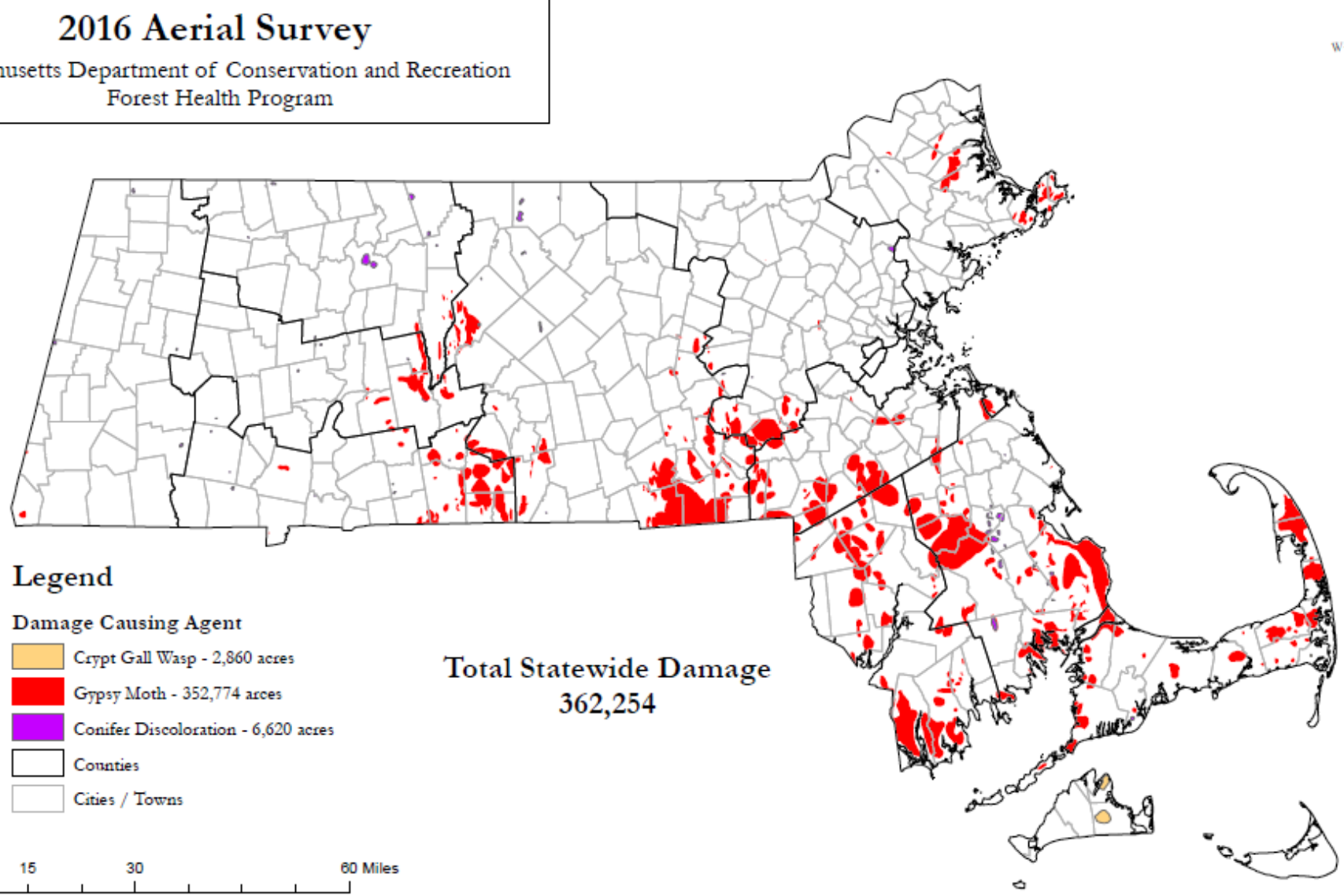
Figure 26. Defoliation of a mixed broadleaf forest by gypsy moth. Bear Brook State Park, NH.

Aerial sketch maps

Ciesla, W., Billings, R., Compton, J., Frament, W., Mech, R., & Roberts, M. (2008). Aerial signatures of forest damage in the eastern United States. The Forest Health Technology Enterprise Team (FHTET). USA.

2016 Aerial Survey

Massachusetts Department of Conservation and Recreation
Forest Health Program



Long h**istory of using satellite remote sensing to map defoliation…**

Ross F. Nelson
NASA/Goddard Space Flight Center
Greenbelt, MD 20771

Detecting Forest Canopy Change Due to Insect Activity Using Landsat MSS

A vegetative index difference (VID) transformation most accurately delineates forest canopy change.

COMPUTER ANALYSIS AND MAPPING OF GYPSY MOTH DEFOLIATION LEVELS IN PENNSYLVANIA USING LANDSAT-1 DIGITAL DATA* A-13

By Darrel L. Williams, NASA/Goddard Space Flight Center, Greenbelt, Maryland

ABSTRACT

The purpose of this study was to investigate the effectiveness of using LANDSAT-1 multispectral digital data and imagery, supplemented by ground truth and aerial photography, as a new method of surveying gypsy moth (Porthetria dispar (L.)) (Lepidoptera; Lymantriidae) defoliation, which has greatly increased in Pennsylvania in recent years. Since the acreage and severity of gypsy moth defoliation reaches a peak from mid-June through the first few days of July, the July 8, 1973, LANDSAT-1 scene was chosen for analysis. Results indicate that LANDSAT-1 data can be used to discriminate between defoliated and healthy vegetation in Pennsylvania and that digital processing methods can be used

130 IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, VOL. GE-24, NO. 1, JANUARY 1986

Use of Remotely Sensed Data for Assessing Forest Stand Conditions in the Eastern United States

DARREL L. WILLIAMS AND ROSS F. NELSON

Satellite Technology: An Improved Means For Monitoring Forest Insect Defoliation

C. Lisette Dottavio and Darrel L. Williams

THE GEOLOGICAL SOCIETY OF AMERICA

Identifying Gypsy Moth Defoliation in Ohio Using Landsat Data

ANGELA HURLEY

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Department of Geological Sciences, Wright State University, Dayton, OH 45435

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Department of Geological Sciences, Wright State University, Dayton, OH 45435

BRIAN BURKE

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Remote Sensing of Environment 112 (2008) 3983–3990

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ELSEVIER

Estimating the effect of gypsy moth defoliation using MODIS

K.M. de Beurs *, P.A. Townsend

University of Wisconsin – Madison, Department of Forest and Wildlife Ecology, 1630 Linden Drive, Madison, WI 53706, United States

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Remote Sensing of Environment 119 (2012) 255–265

Contents lists available at SciVerse ScienceDirect

Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse

ELSEVIER

A general Landsat model to predict canopy defoliation in broadleaf deciduous forests

Philip A. Townsend [a,*], Aditya Singh [a], Jane R. Foster [a], Nathan J. Rehberg [a], Clayton C. Kingdon [a], Keith N. Eshleman [b], Steven W. Seagle [c]

[a] University of Wisconsin-Madison, Department of Forest and Wildlife Ecology, 1630 Linden Drive, Madison, WI 53706, United States
[b] University of Maryland Center for Environmental Science, Appalachian Laboratory, 301 Braddock Road, Frostburg, MD 21532, United States
[c] Appalachian State University, Department of Biology, 572 Rivers Street, Boone, NC 28608, United States

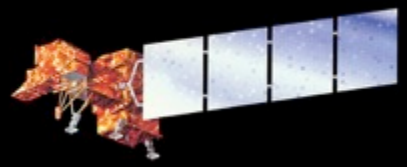
2008

Opening of USGS archives →

New opportunities to use the Landsat temporal domain to map and monitor changes in forest condition

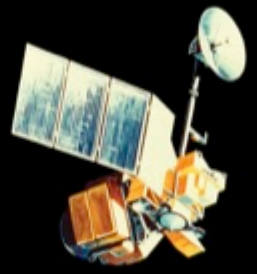
Landsat 1 – 3

Landsat 1: 1972 – 1978
Landsat 2: 1975 – 1982
Landsat 3: 1978 – 1983



Landsat 7

1999 – present

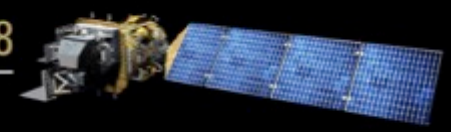


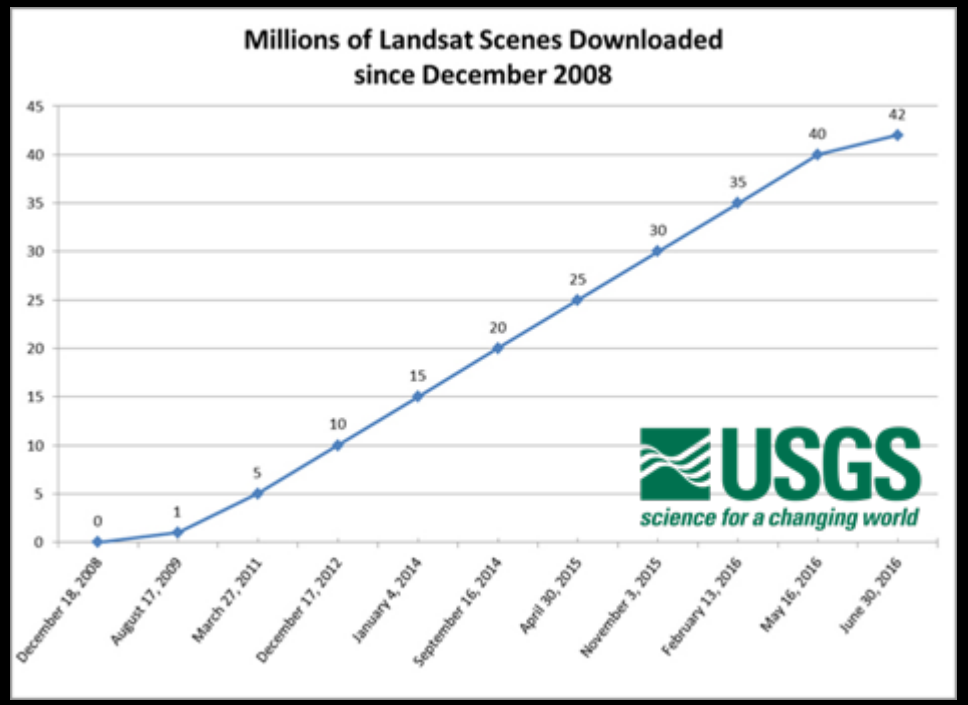
Landsat 4 – 5

Landsat 4: 1982 – 1993
Landsat 5: 1984 – 2013

Landsat 8

2013 - present

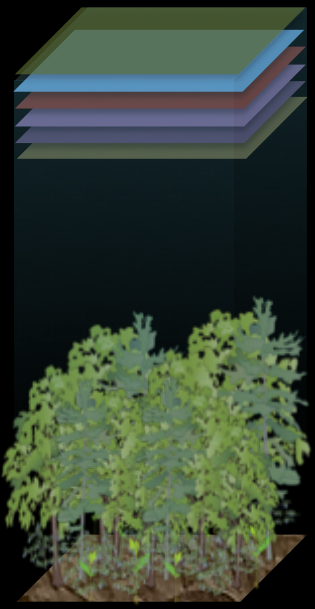




30 m spatial resolution

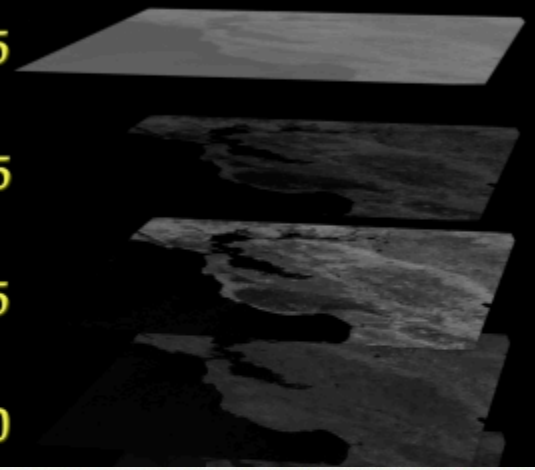
30 centimeters
(high res. imagery)

30 meters
(Landsat)



Broad multi-spectral bands

TM Band	Wavelength (*um*)	
6	10.4 - 12.5	Thermal Infrared
7	2.08 - 2.35	Shortwave Infrared
5	1.55 - 1.75	Shortwave Infrared
4	0.76 - 0.90	Near Infrared
3	0.63 - 0	
2	0.52 - 0	
1	0.45 - 0	

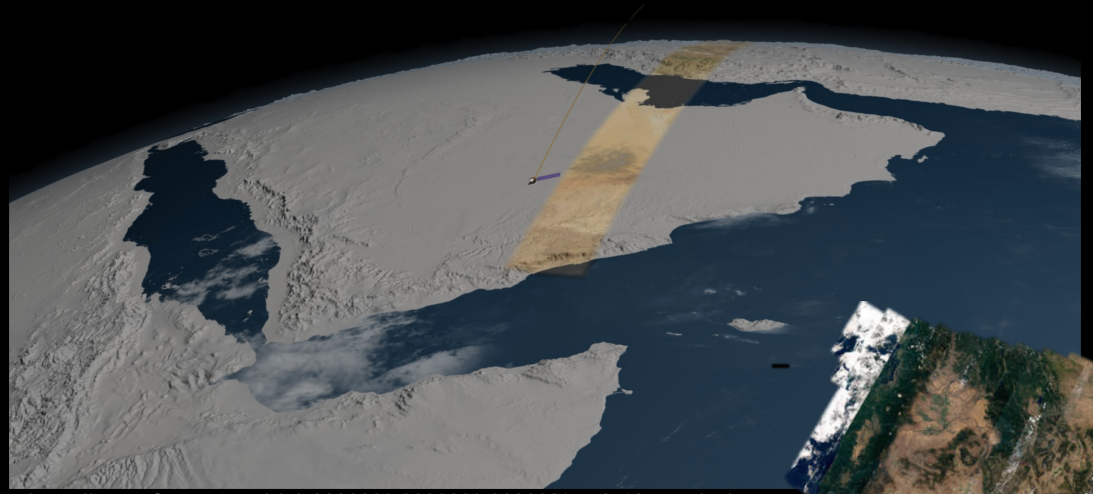


https://svs.gsfc.nasa.gov/vis/a000000/a000900/

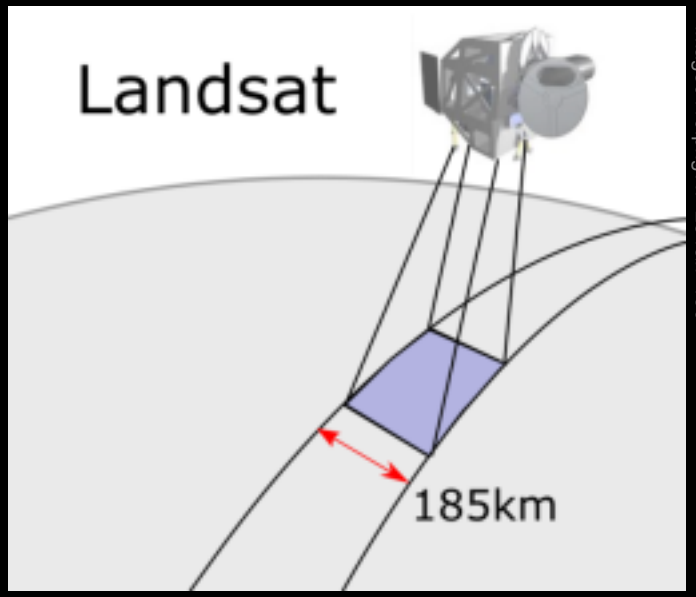
[OLI, Operational Land Imager; TIRS, Thermal Infrared Sensor; ETM+, Enhanced Thematic Mapper Plus; TM, Thematic Mapper; MSS, Multispectral Scanner; --, not applicable]

Band designations	Landsat band wavelength comparisons All bands 30-meter resolution unless noted									
	L8 OLI/TIRS		L7 ETM+		L4-5 TM		L4-5 MSS*		L1-3 MSS*	
Coastal/Aerosol	Band 1	0.43–0.45	--	--	--	--	--	--	--	--
Blue	Band 2	0.45–0.51	Band 1	0.45–0.52	Band 1	0.45–0.52	--	--	--	--
Green	Band 3	0.53–0.59	Band 2	0.52–0.60	Band 2	0.52–0.60	Band 1	0.5–0.6 *	Band 4	0.5–0.6 *
Panchromatic	Band 8**	0.50–0.68	Band 8 **	0.52–0.90	--	--	--	--	--	--
Red	Band 4	0.64–0.67	Band 3	0.63–0.69	Band 3	0.63–0.69	Band 2	0.6–0.7 *	Band 5	0.6–0.7 *
Near-Infrared	Band 5	0.85–0.88	Band 4	0.77–0.90	Band 4	0.76–0.90	Band 3	0.7–0.8 *	Band 6	0.7–0.8 *
Near-Infrared	--	--	--	--	--	--	Band 4	0.8–1.1 *	Band 7	0.8–1.1*
Cirrus	Band 9	1.36–1.38	--	--	--	--	* Acquired at 79 meters, resampled to 60 meters ** 15-meter (panchromatic) T1 = Thermal (acquired at 100 meters, resampled to 30 meters) T2 = Thermal (acquired at 120 meters, resampled to 30 meters)			
Shortwave Infrared-1	Band 6	1.57–1.65	Band 5	1.55–1.75	Band 5	1.55–1.75				
Shortwave Infrared-2	Band 7	2.11–2.29	Band 7	2.09–2.35	Band 7	2.08–2.35				
Thermal	Band 10 T1	10.60–11.19	Band 6 T2	10.40–12.50	Band 6 T2	10.40–12.50				
Thermal	Band 11 T1	11.50–12.51	--	--	--	--				

16-day revisit
(8-day with two)



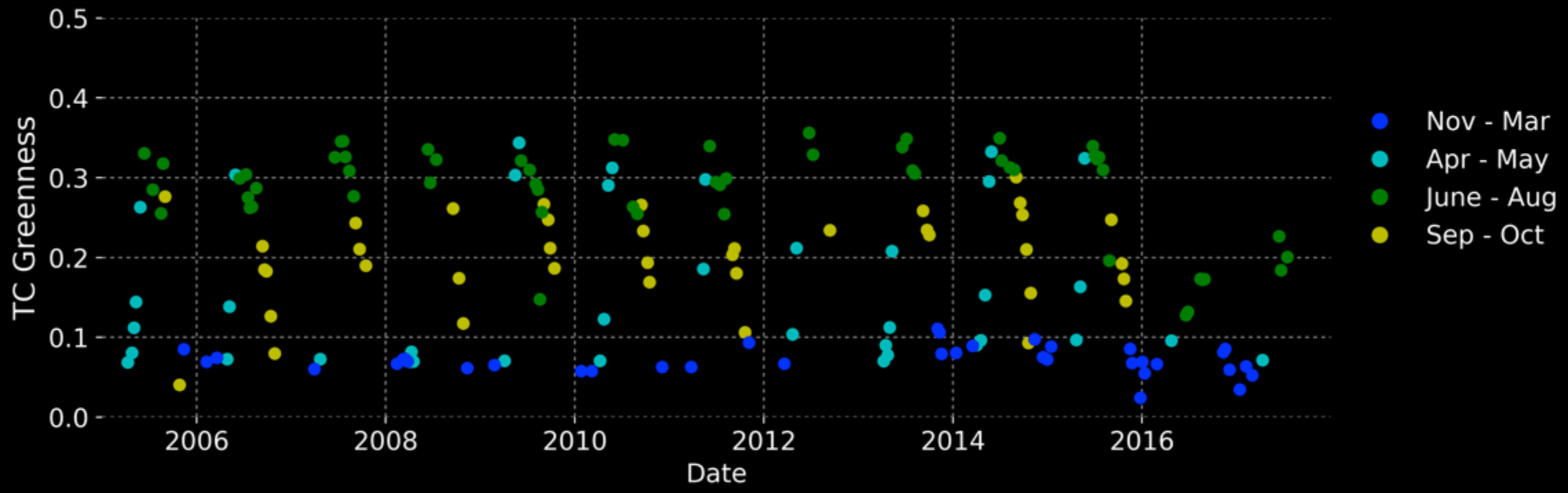
https://svs.gsfc.nasa.gov/vis/a000000/a003900/a003939/earth.1045_print.jpg



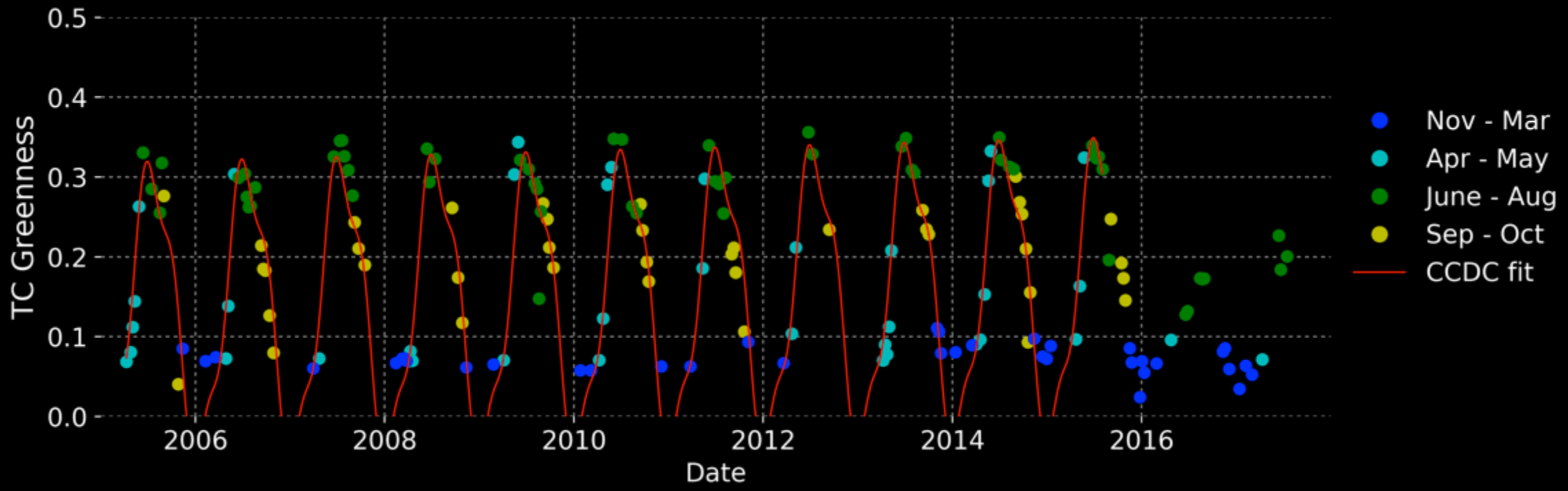
https://sagatutorials.files.wordpress.com/2016/11/image0116.png?w=254&h=190

https://www.nasa.gov/sites/default/files/styles/full_width_feature/public/usa_oli_201308_lrg.jpg?itok=FQpTt5wY

“**Greenness**” time series (for one pixel)

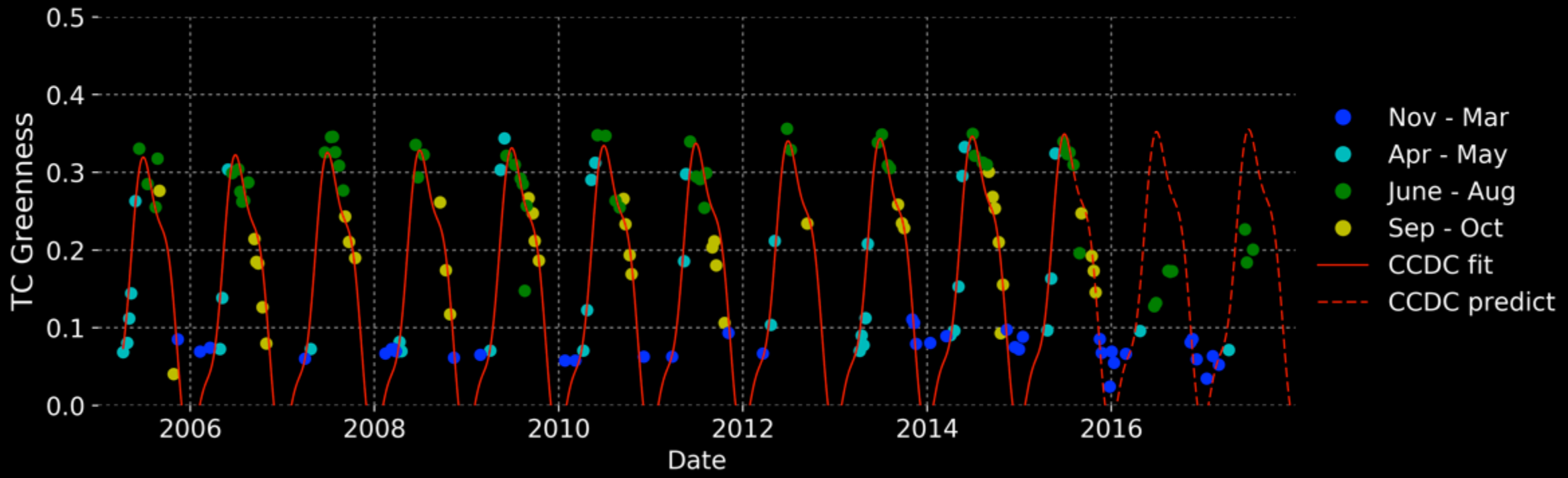


“**Greenness**” time series (for one pixel)



Use historical observations to estimate **baseline**

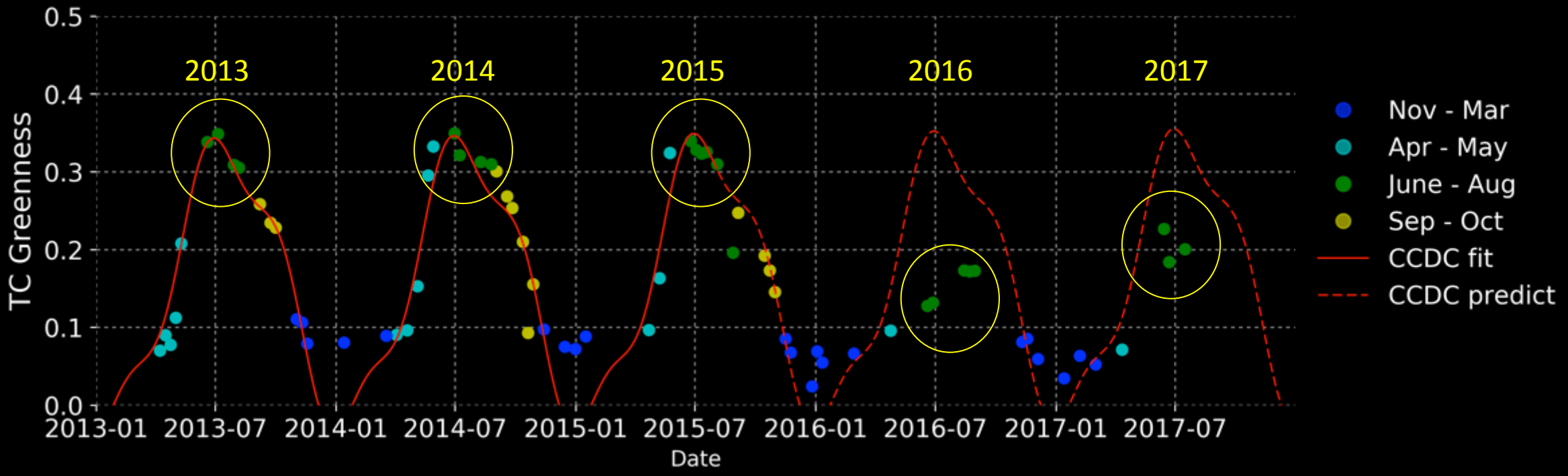
“**Greenness**” time series (for one pixel)



Use historical observations to estimate **baseline**

$$Condition = \frac{obs - pred}{RMSE}$$

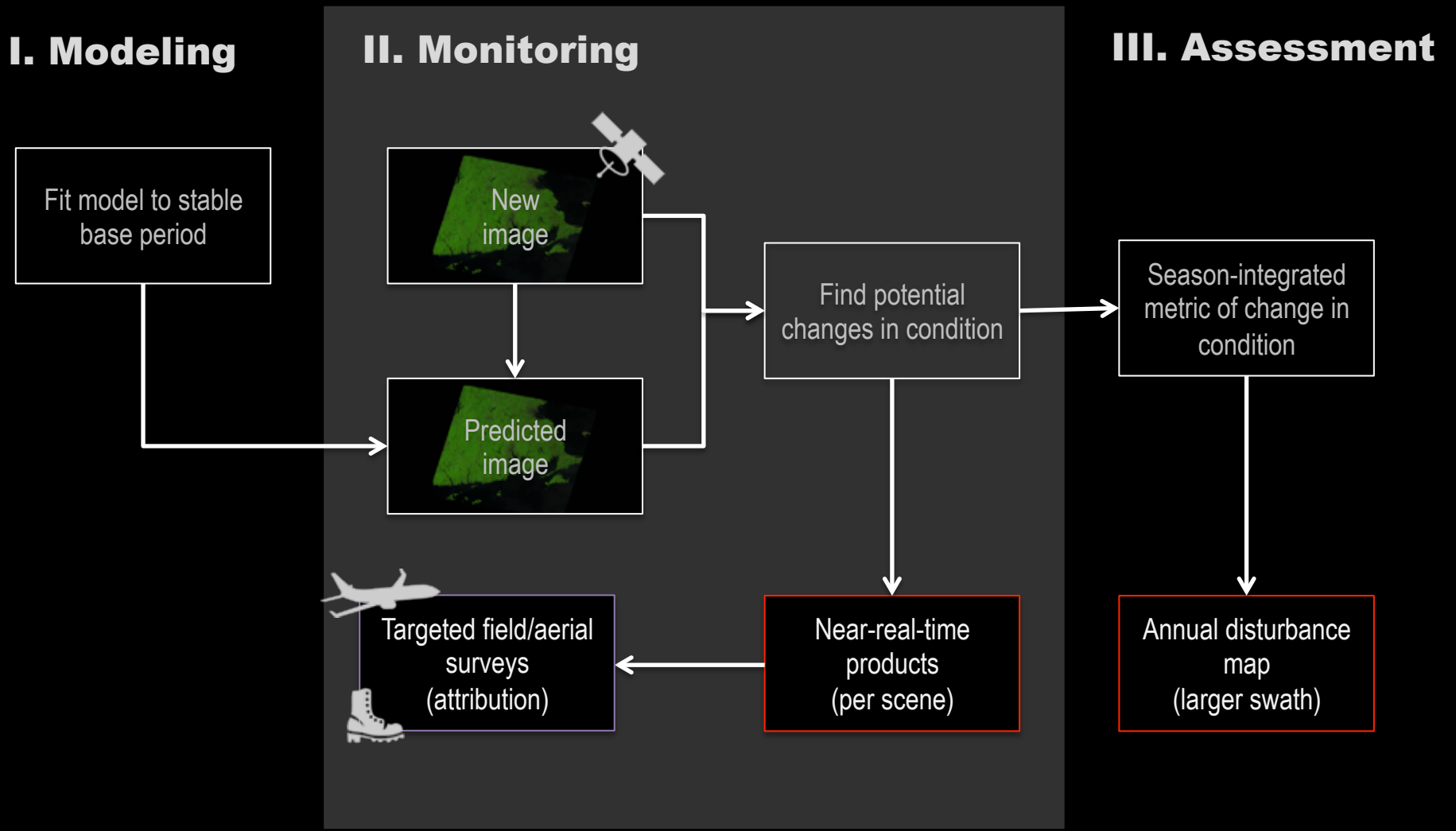
“**Greenness**” time series (for one pixel)



Use historical observations to estimate **baseline**

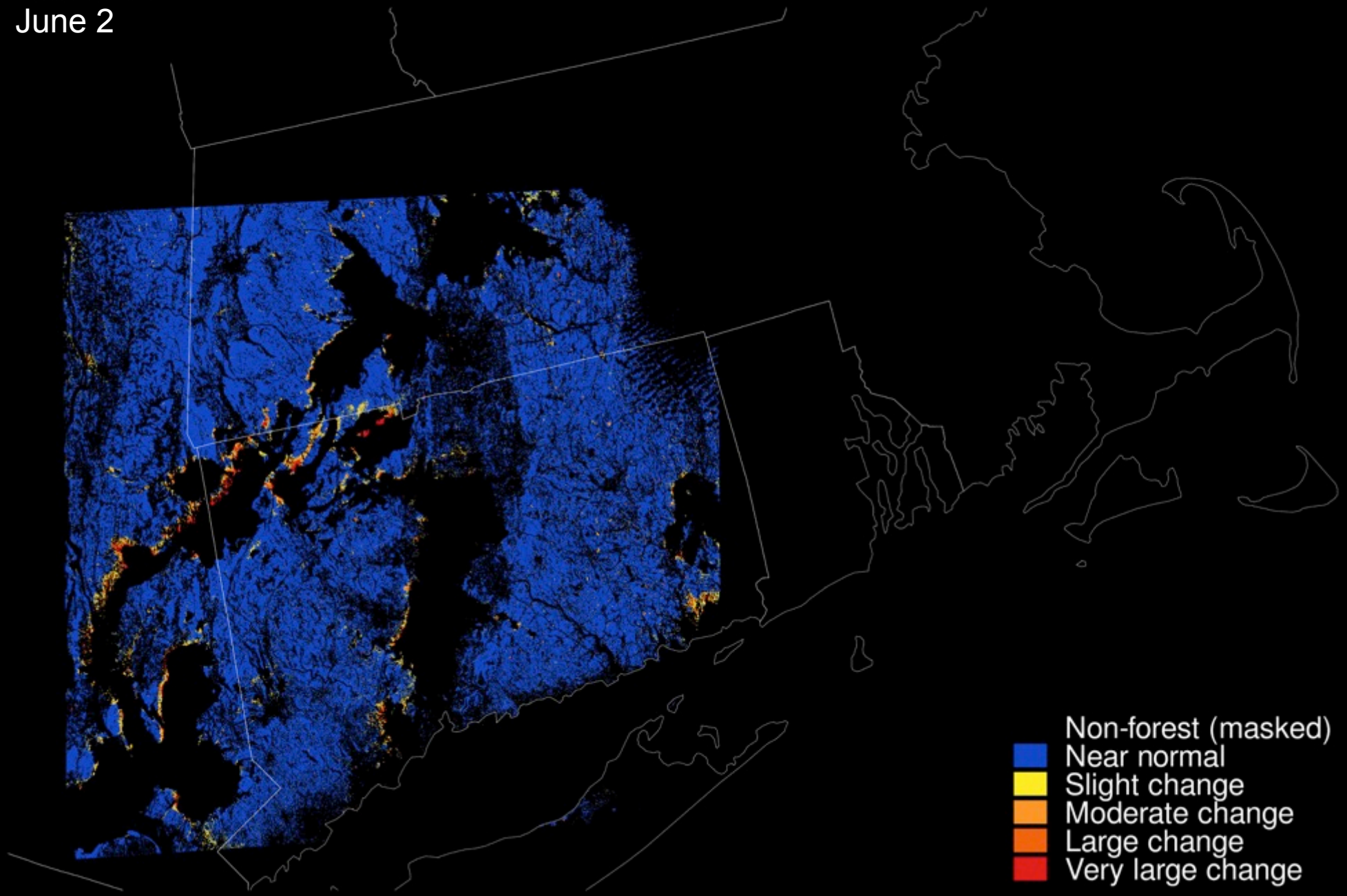
$$Condition = \frac{obs - pred}{RMSE}$$

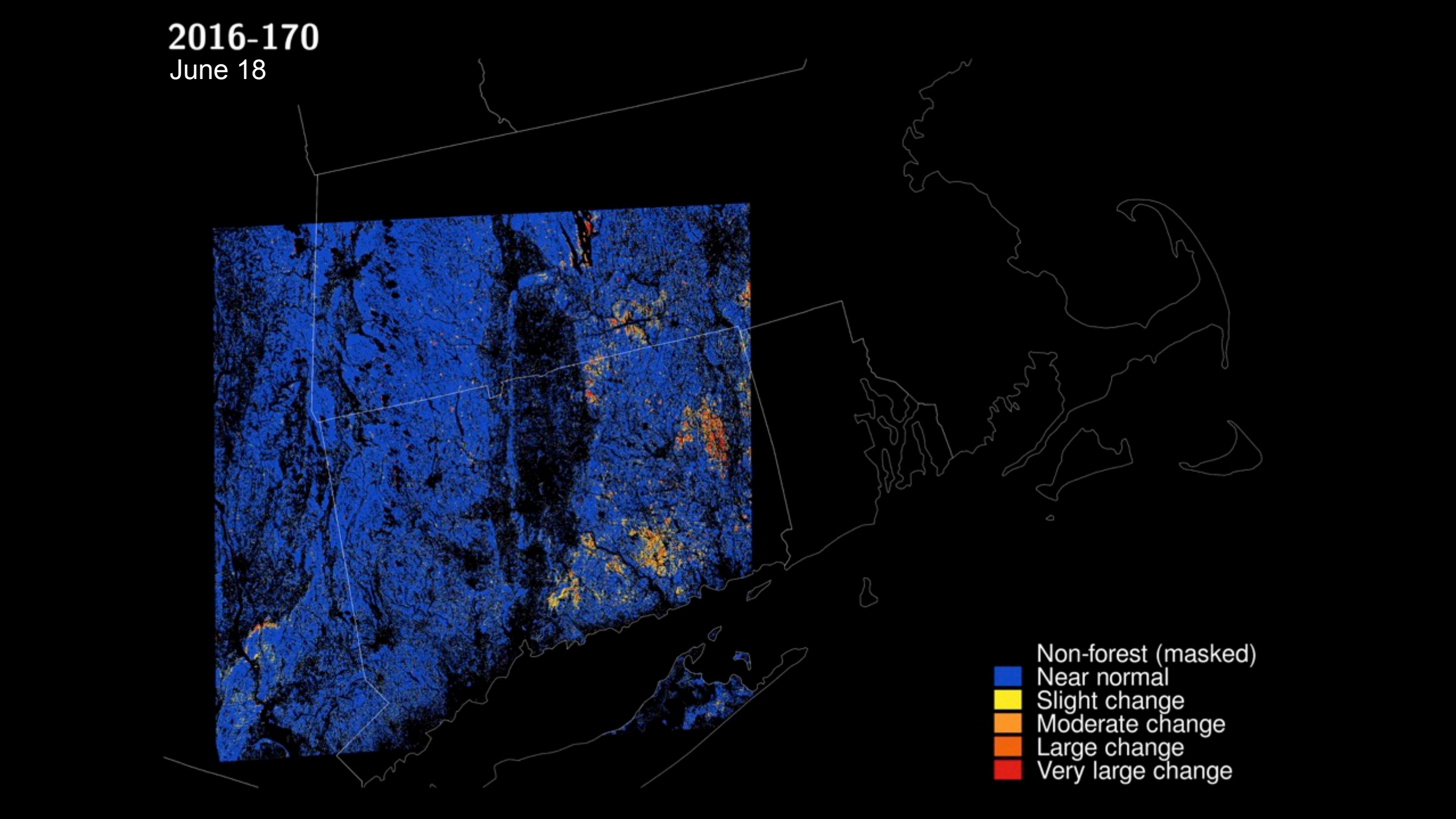
Forest disturbance monitoring system

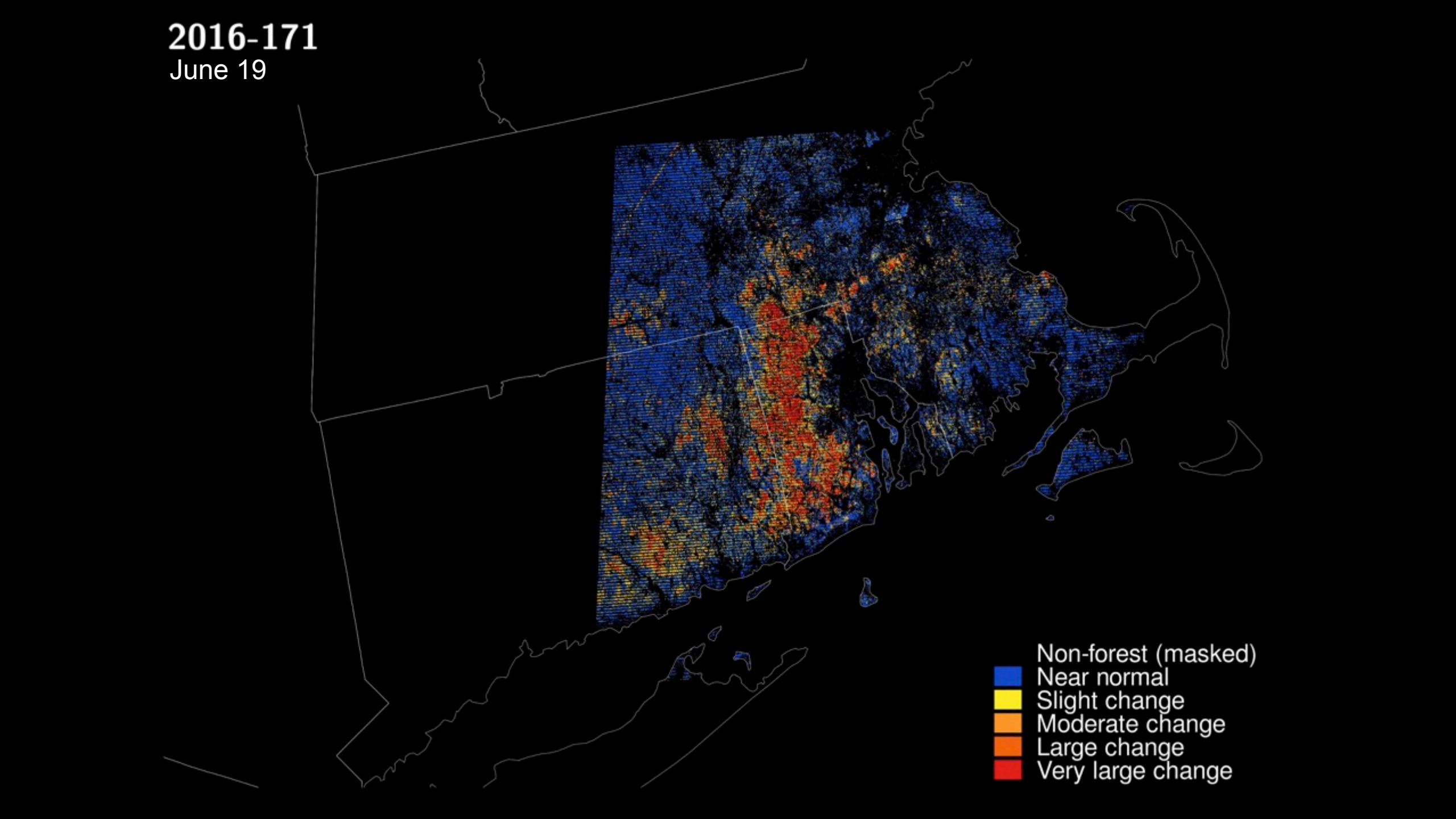


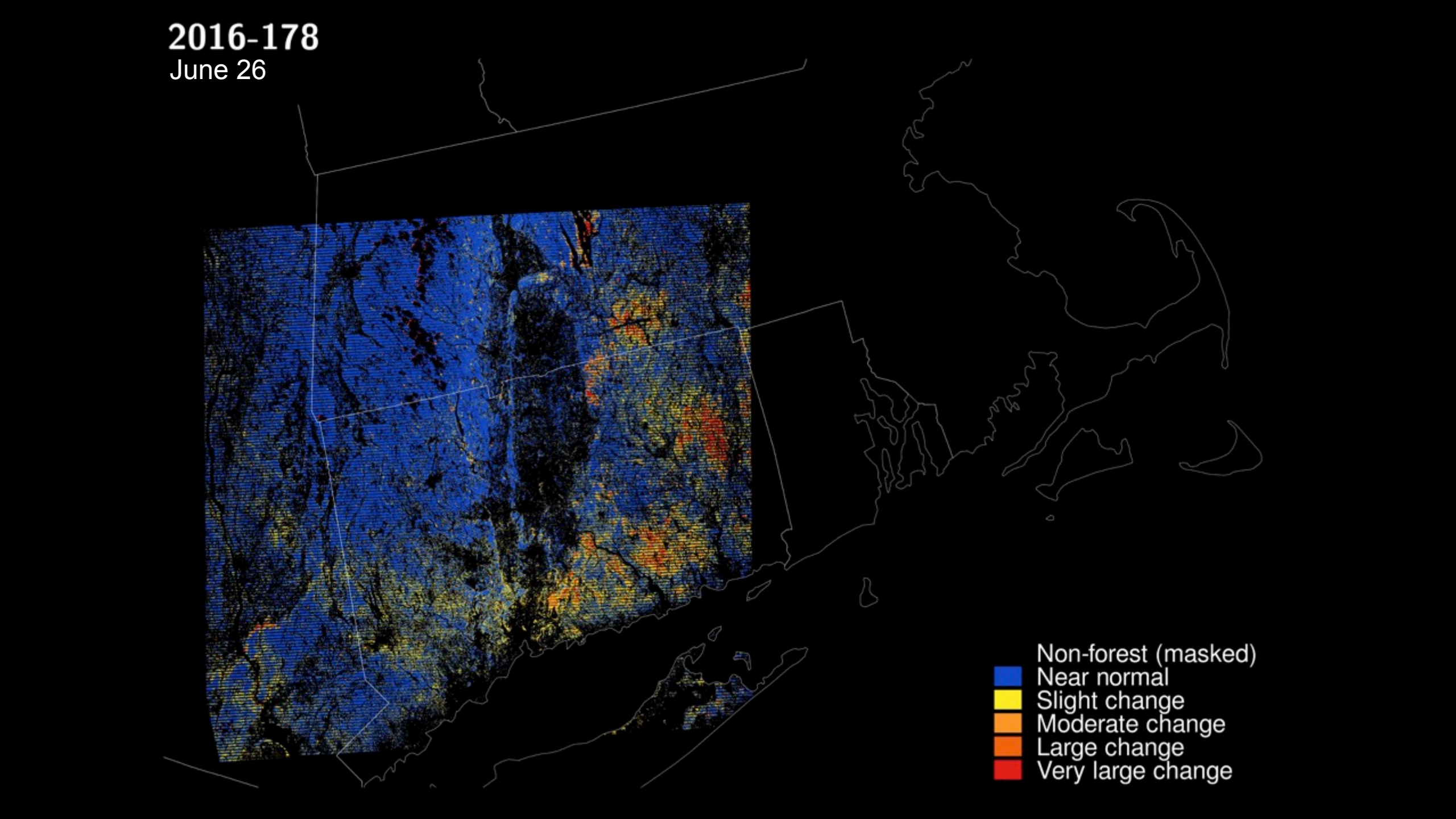
2016:
Near-real-time pilot

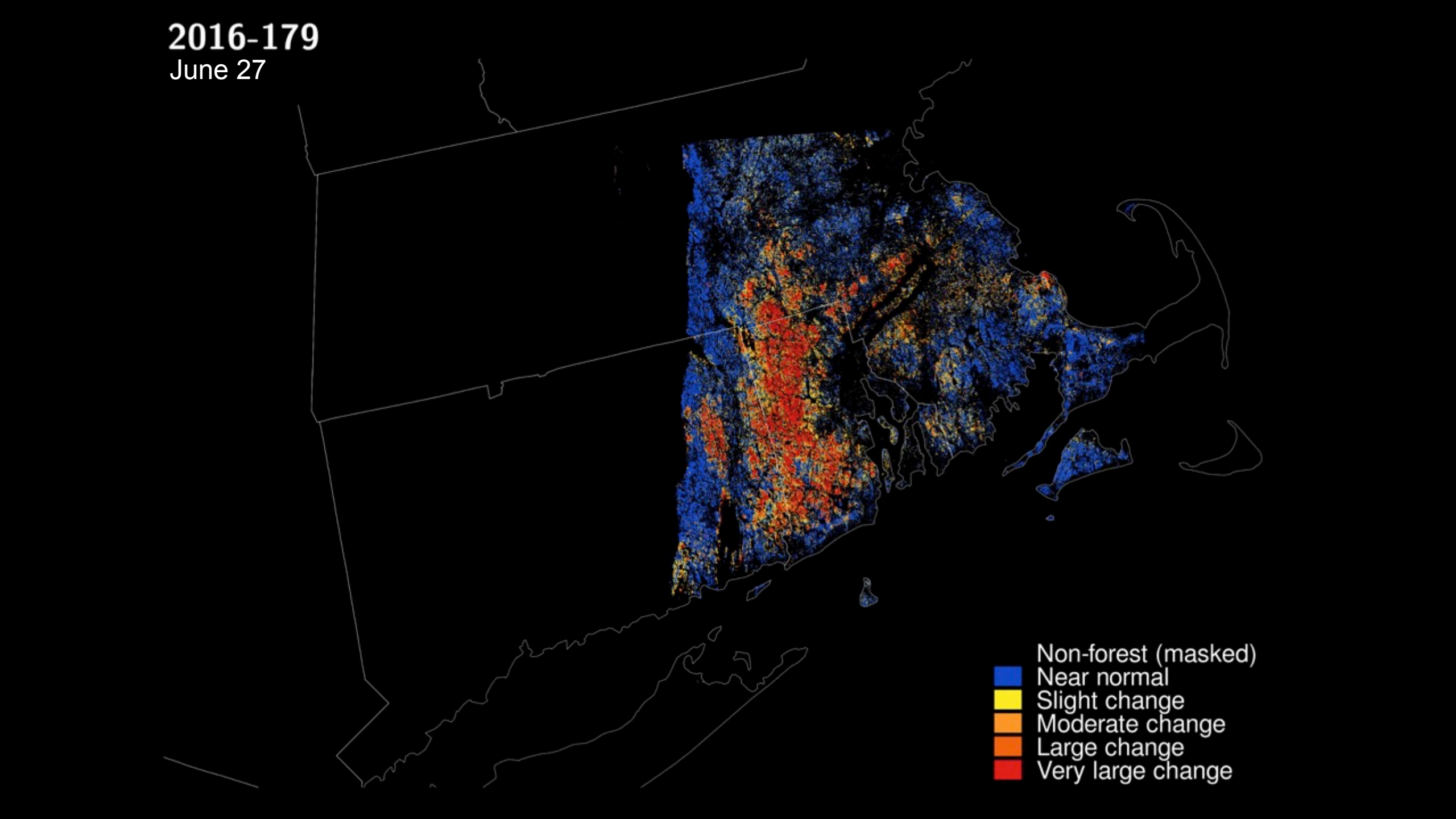
2016-154
June 2

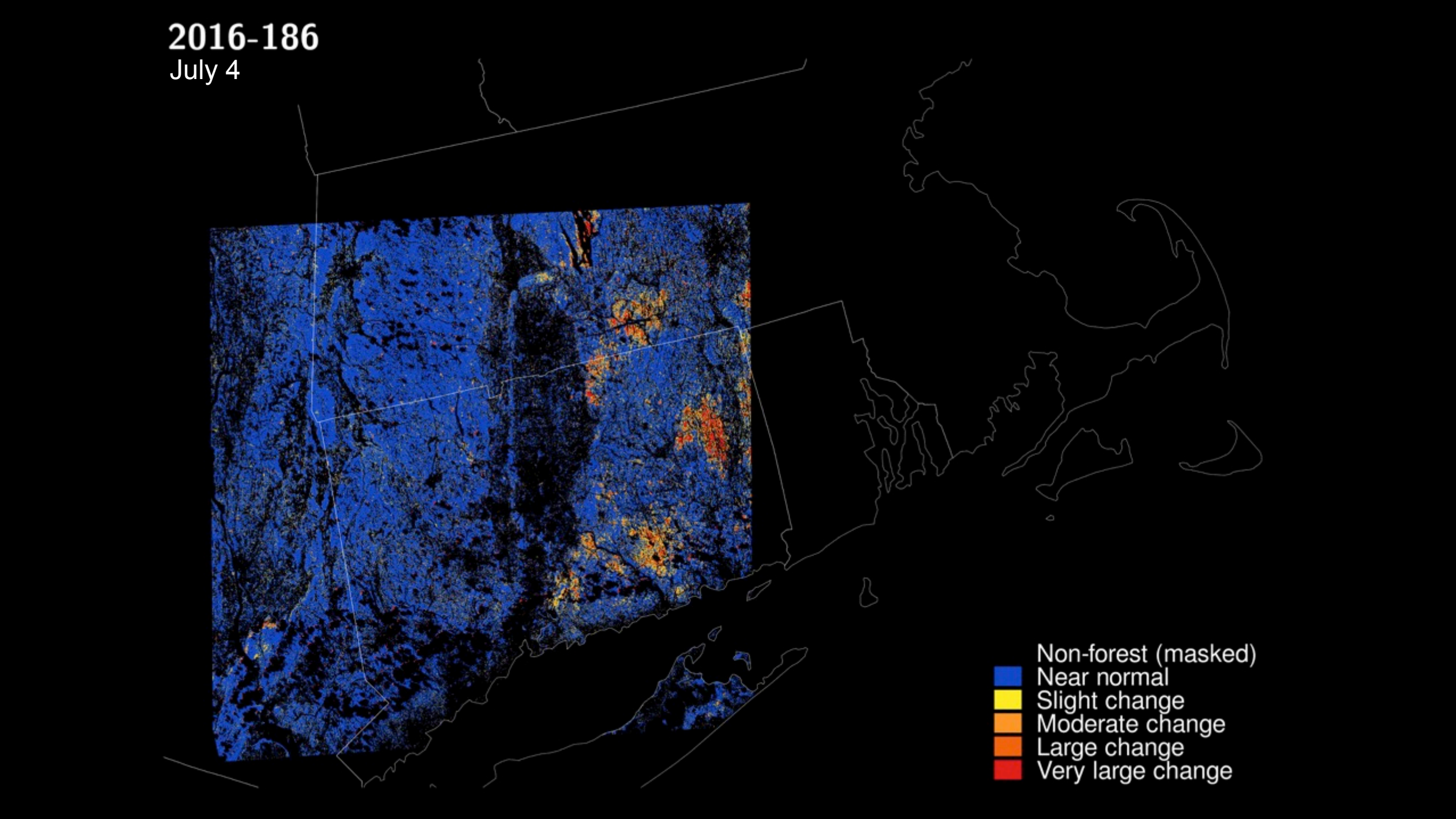


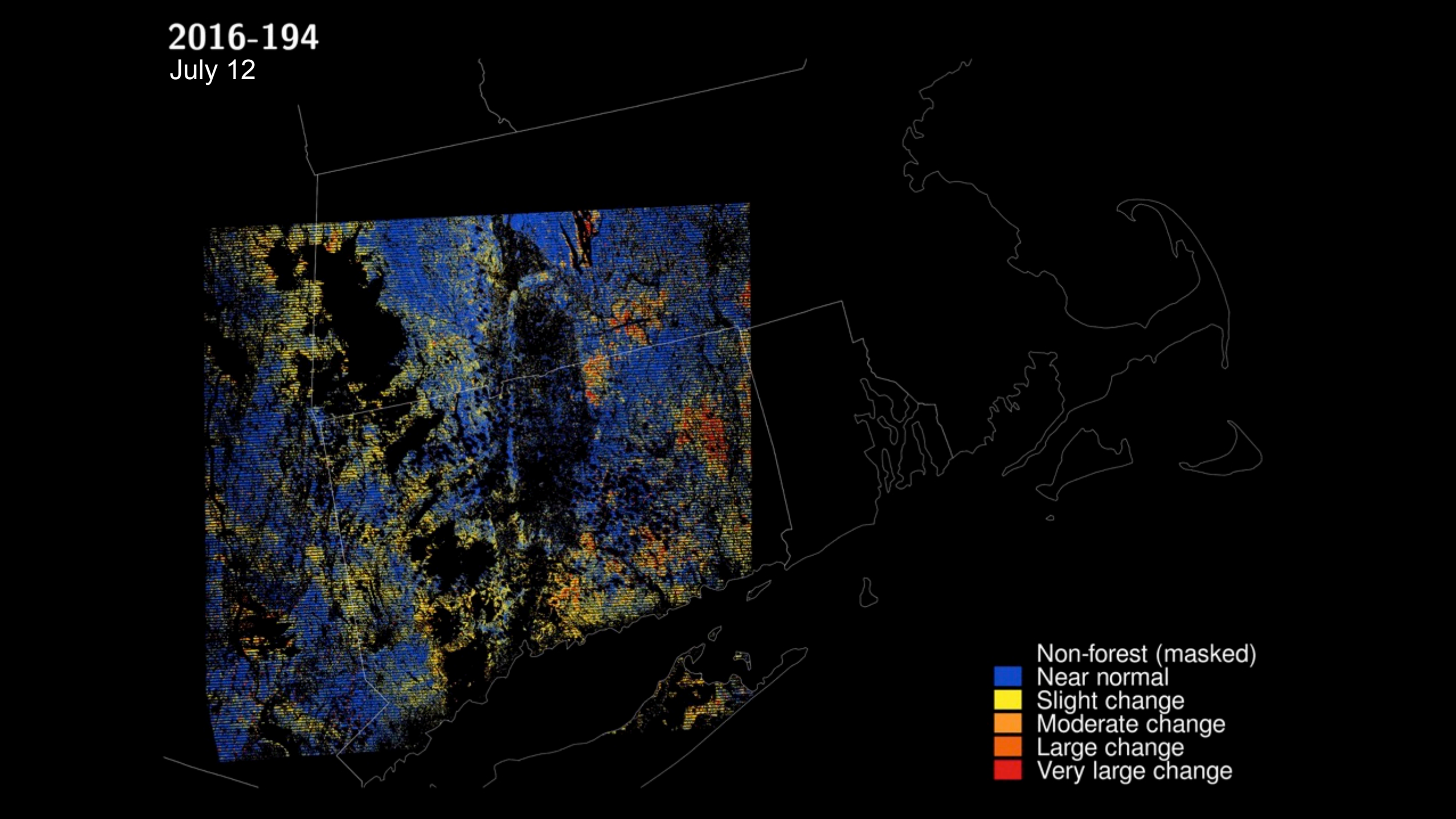

2016-170
June 18
Non-forest (masked)
Near normal
Slight change
Moderate change
Large change
Very large change

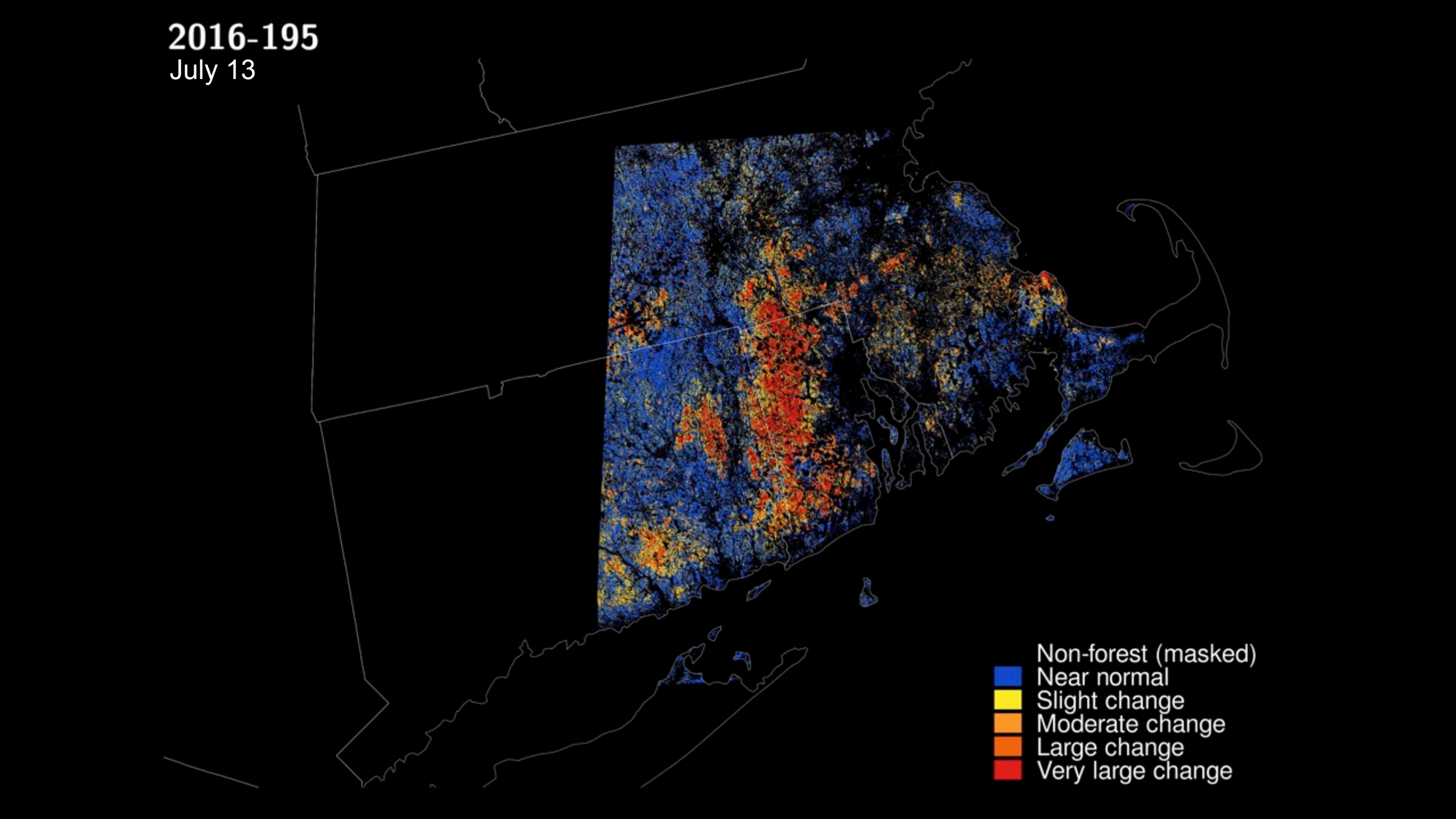

2016-171
June 19
Non-forest (masked)
Near normal
Slight change
Moderate change
Large change
Very large change

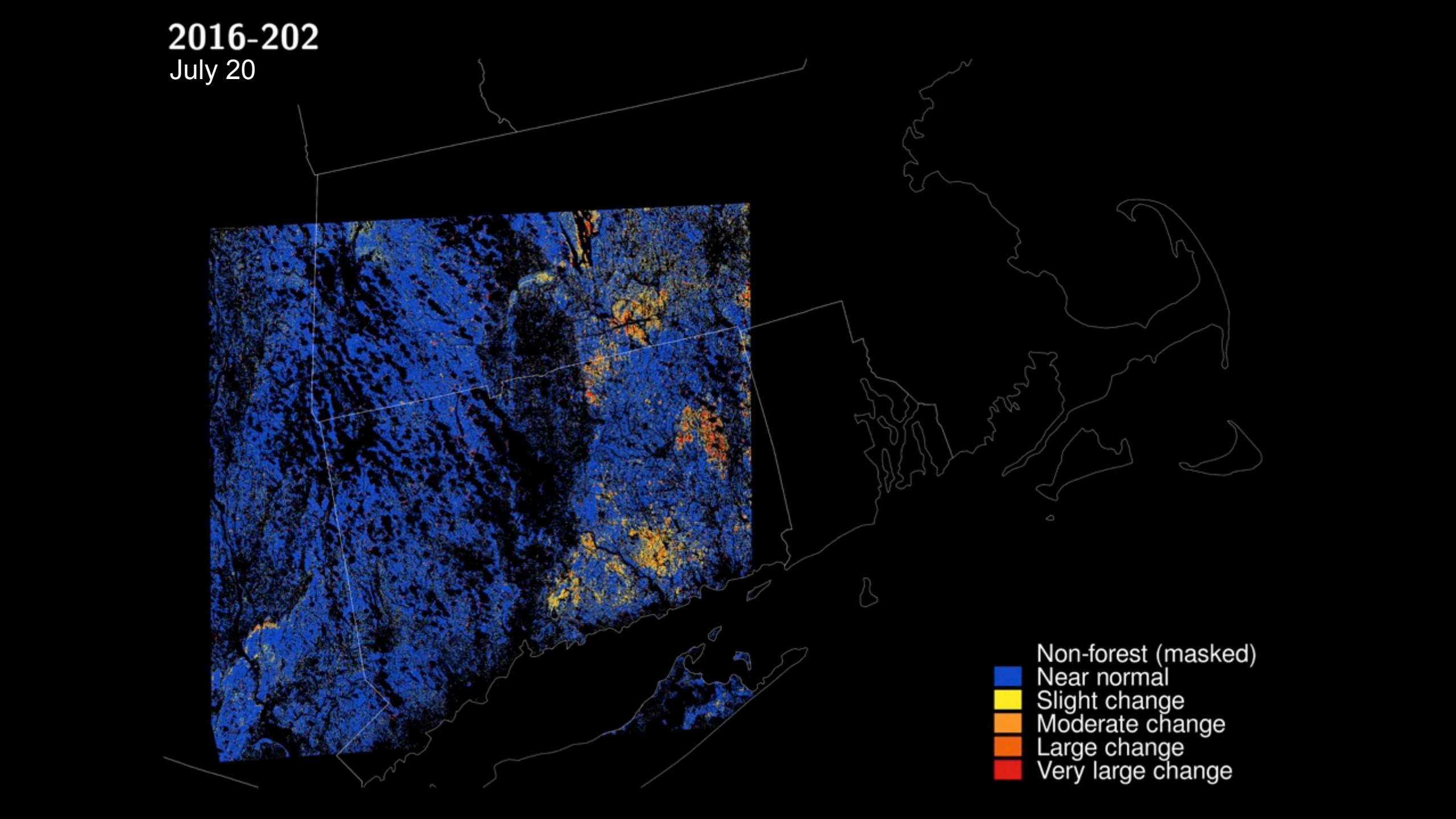

2016-178
June 26
Non-forest (masked)
Near normal
Slight change
Moderate change
Large change
Very large change

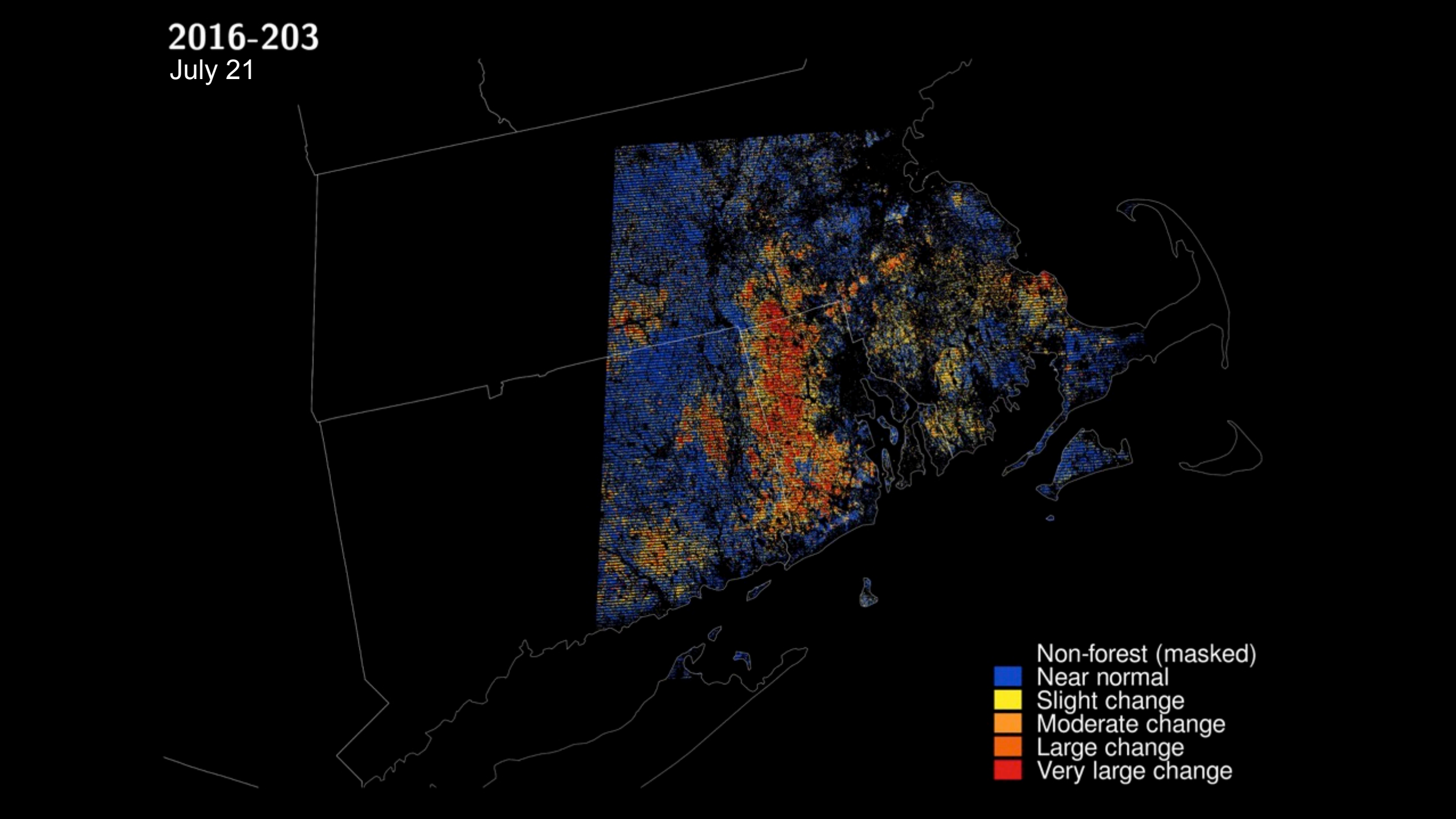

2016-179
June 27
Non-forest (masked)
Near normal
Slight change
Moderate change
Large change
Very large change

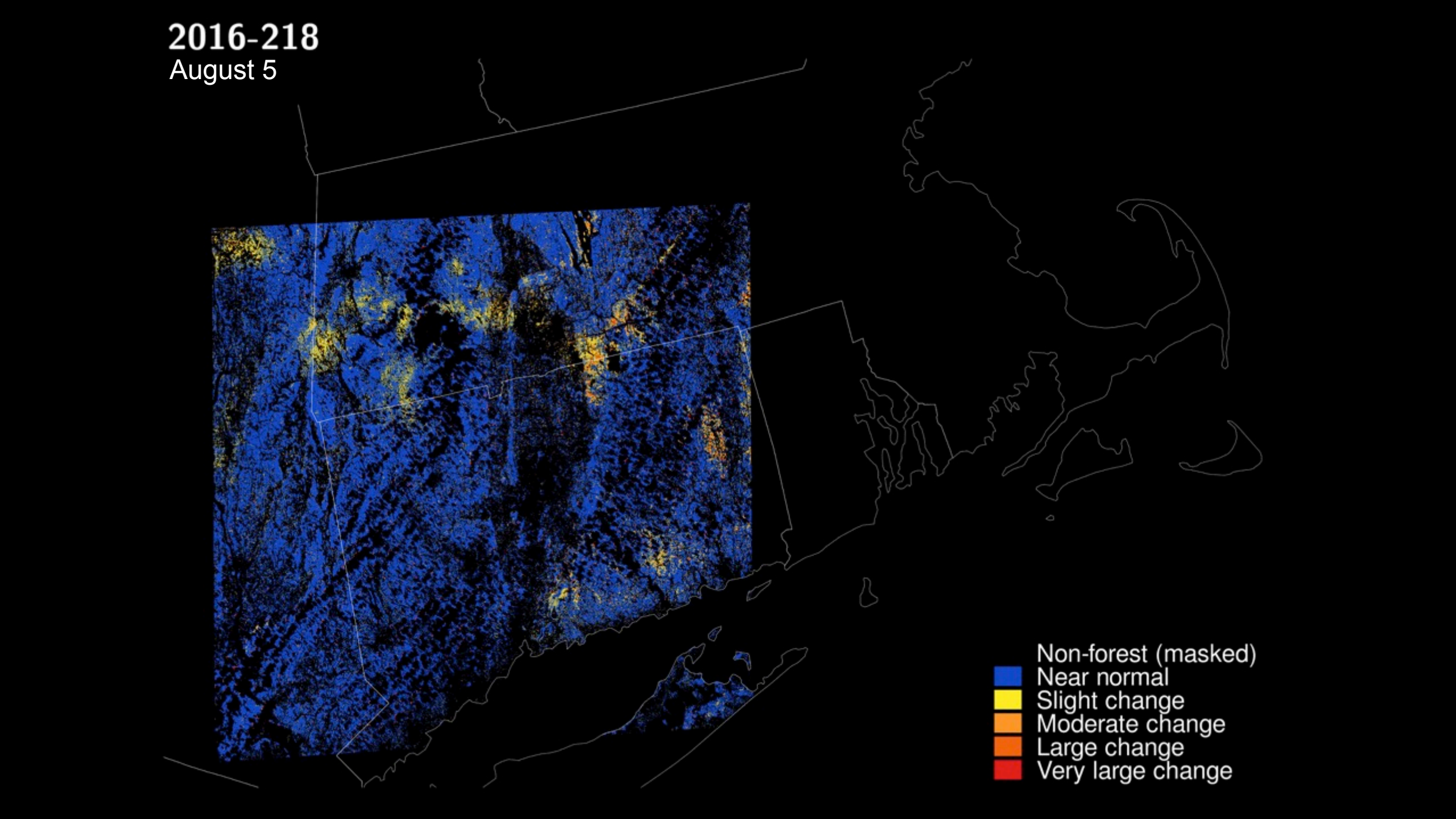

2016-186
July 4
Non-forest (masked)
Near normal
Slight change
Moderate change
Large change
Very large change

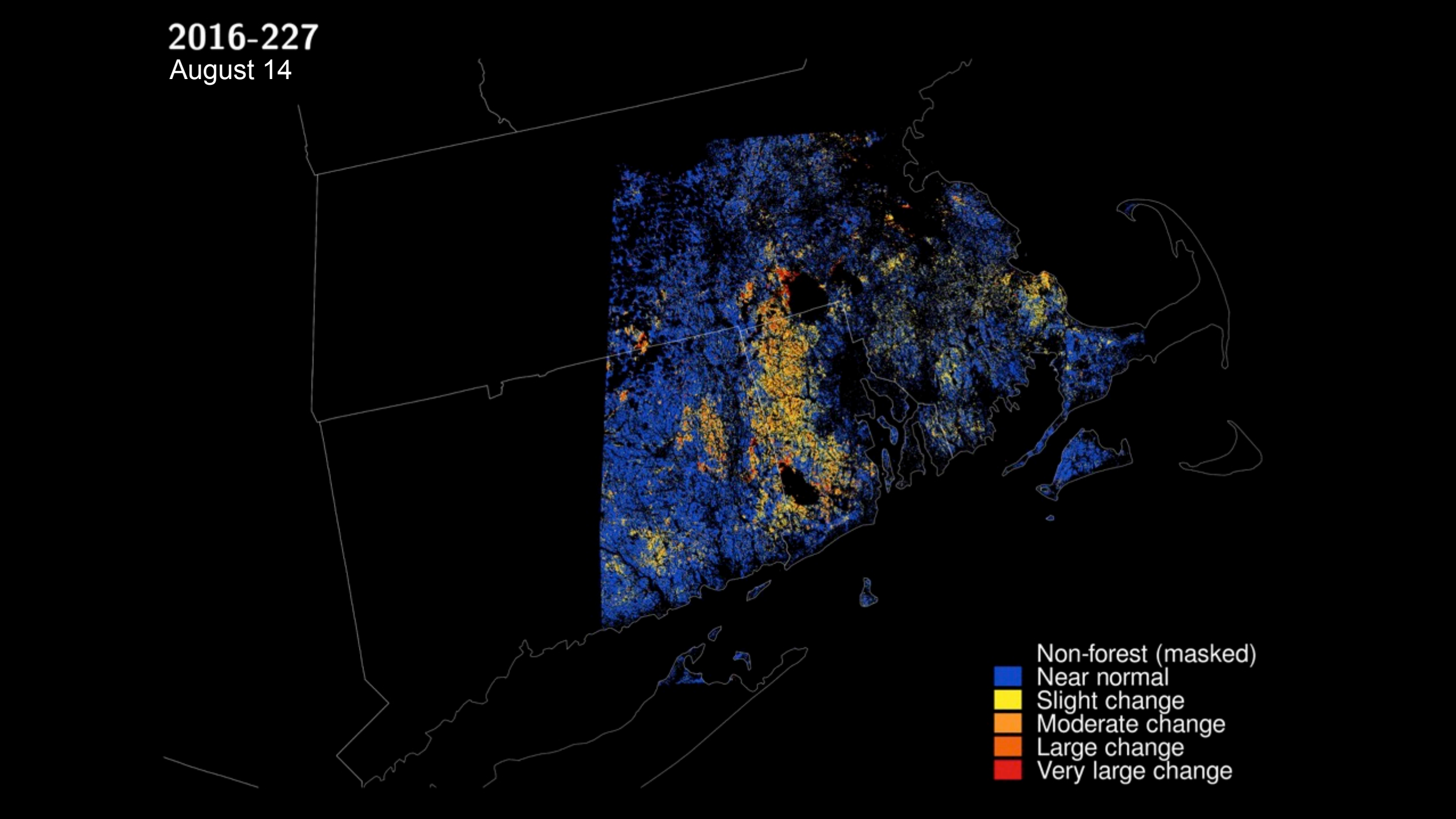

2016-194
July 12
Non-forest (masked)
Near normal
Slight change
Moderate change
Large change
Very large change

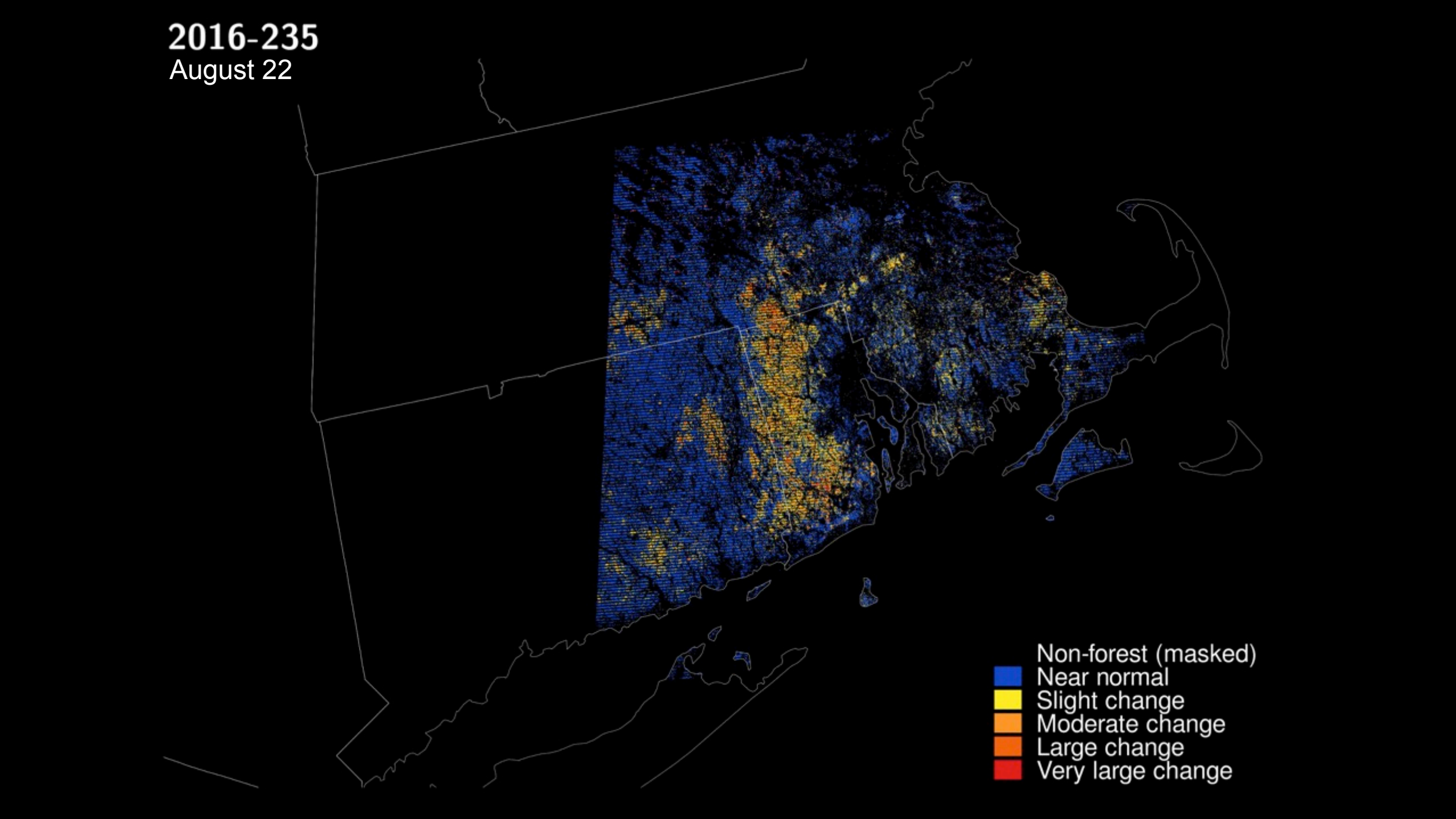

2016-195
July 13
Non-forest (masked)
Near normal
Slight change
Moderate change
Large change
Very large change

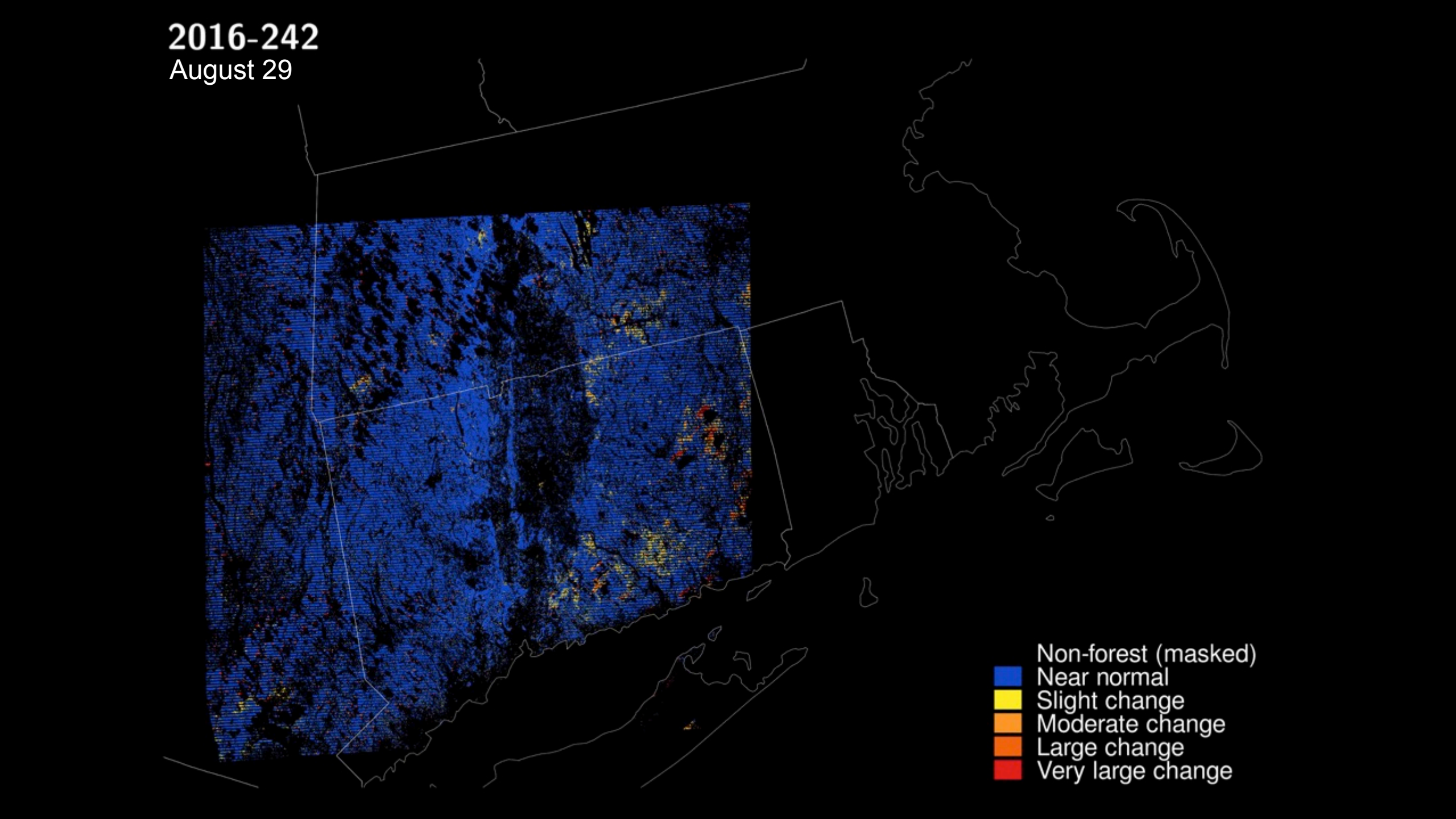

2016-202
July 20
Non-forest (masked)
Near normal
Slight change
Moderate change
Large change
Very large change

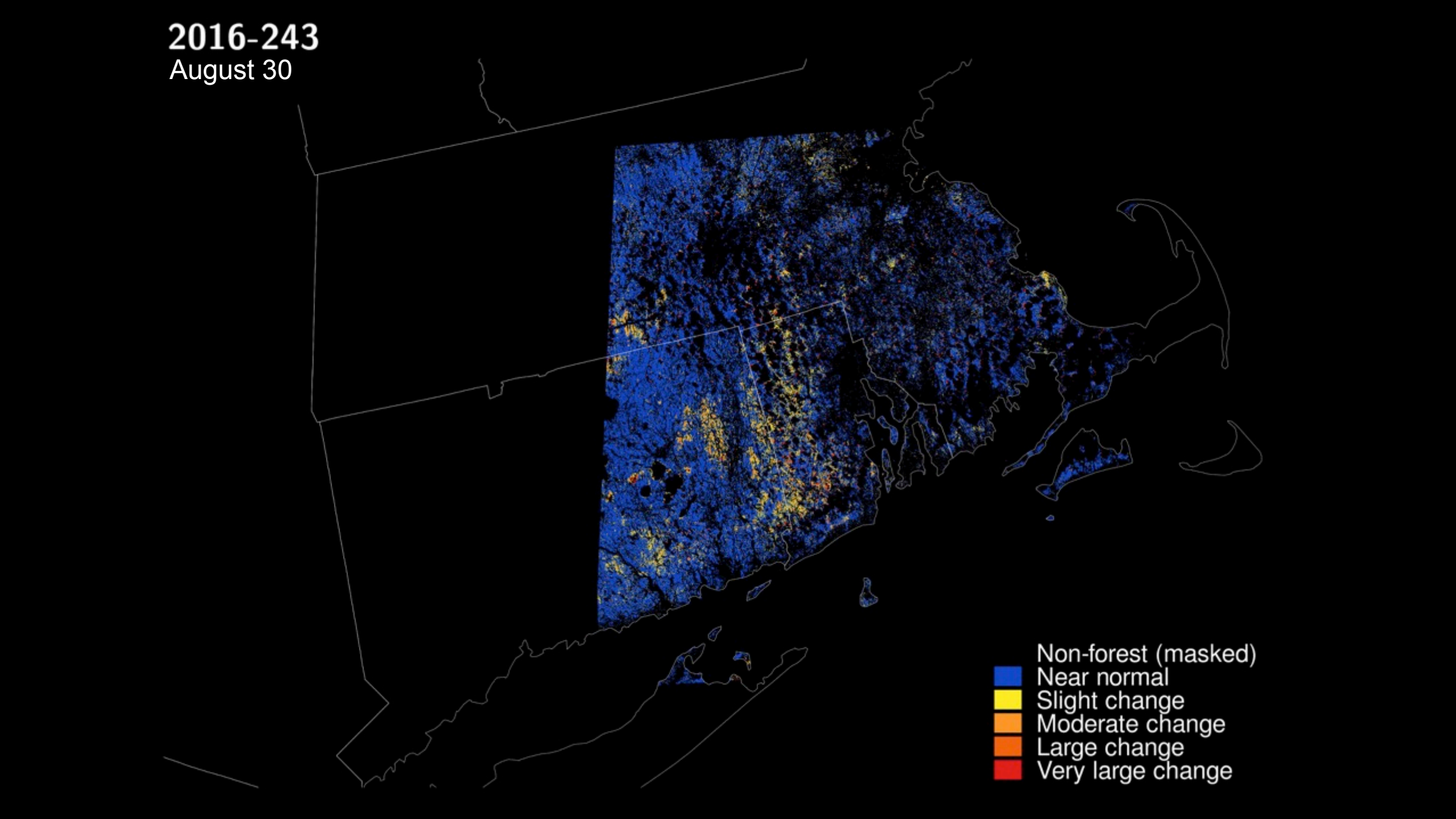

2016-203
July 21
Non-forest (masked)
Near normal
Slight change
Moderate change
Large change
Very large change

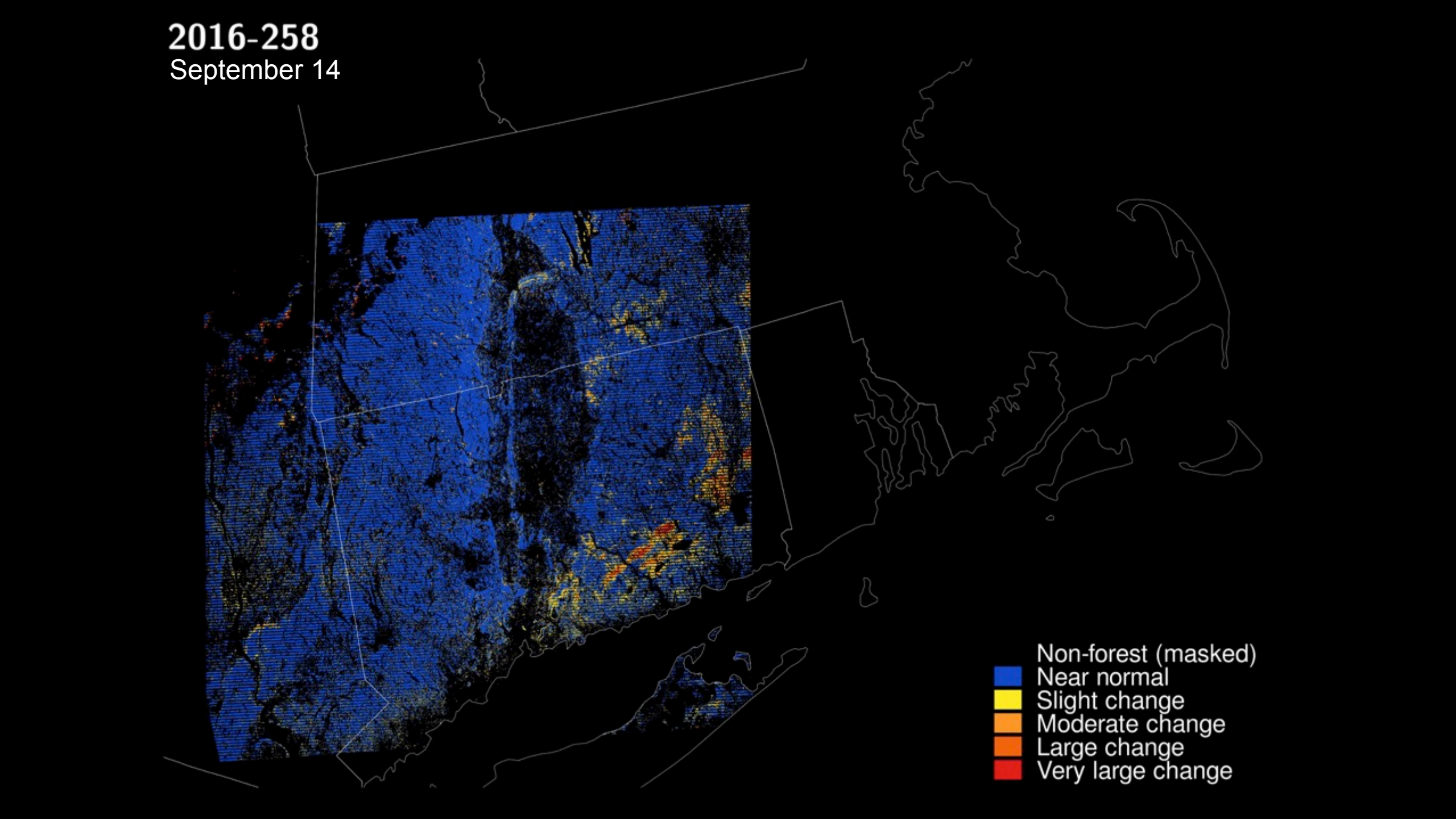

2016-218
August 5
Non-forest (masked)
Near normal
Slight change
Moderate change
Large change
Very large change

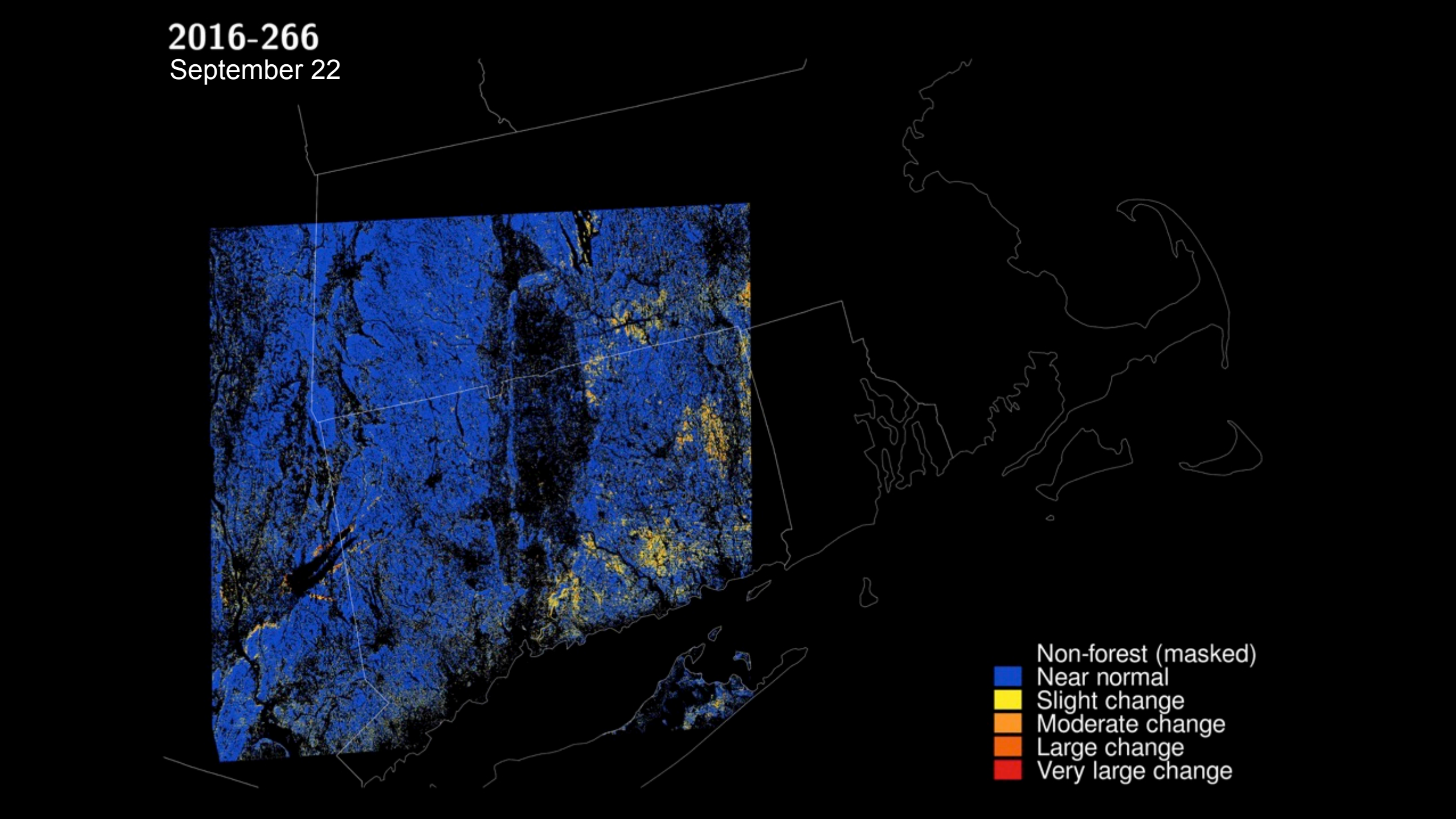

2016-227
August 14
Non-forest (masked)
Near normal
Slight change
Moderate change
Large change
Very large change


2016-235
August 22
Non-forest (masked)
Near normal
Slight change
Moderate change
Large change
Very large change


2016-242
August 29
Non-forest (masked)
Near normal
Slight change
Moderate change
Large change
Very large change

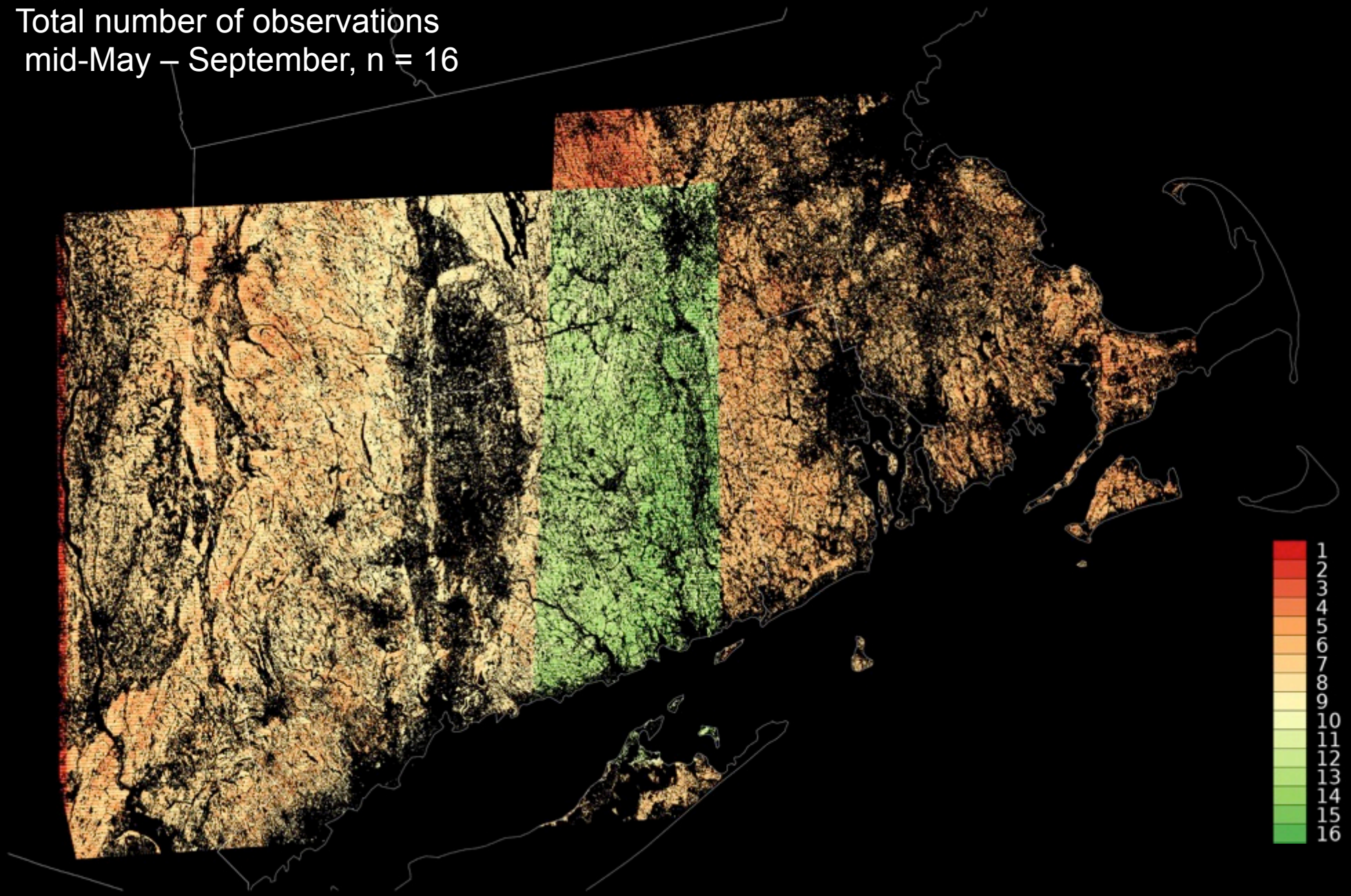

2016-243
August 30
Non-forest (masked)
Near normal
Slight change
Moderate change
Large change
Very large change


2016-258
September 14
Non-forest (masked)
Near normal
Slight change
Moderate change
Large change
Very large change


2016-266
September 22
Non-forest (masked)
Near normal
Slight change
Moderate change
Large change
Very large change

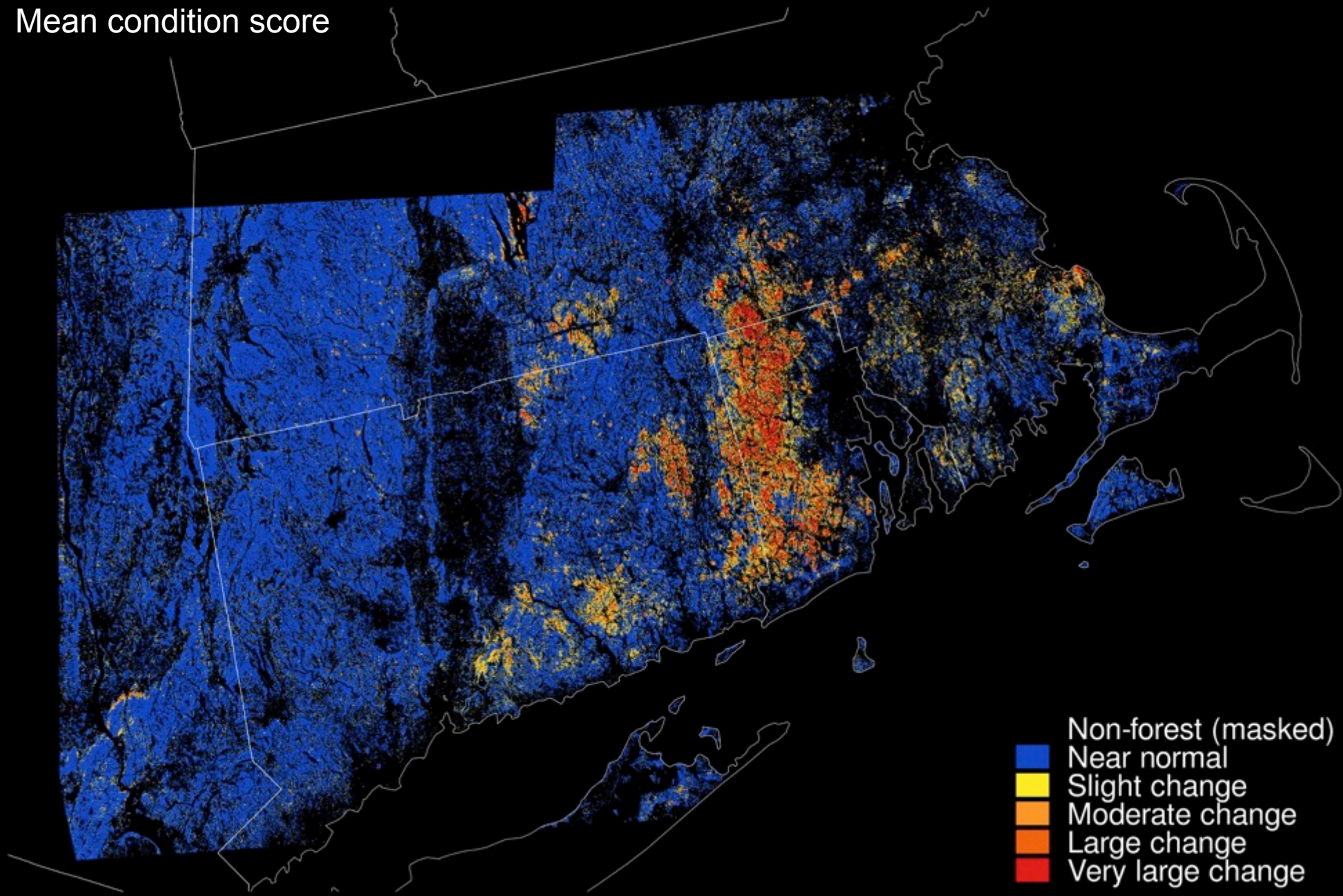
2016

Total number of observations
mid-May – September, n = 16

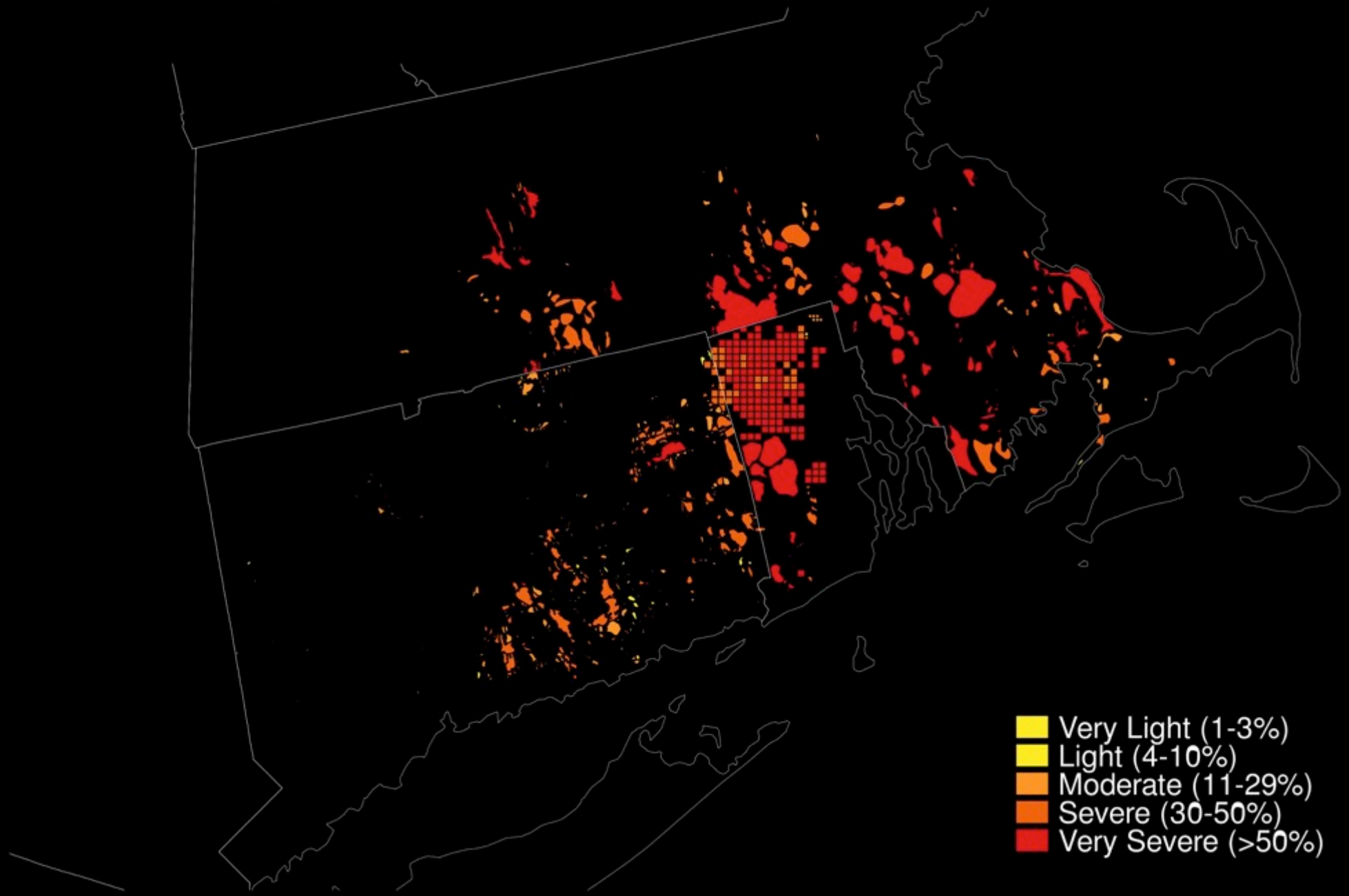


2016

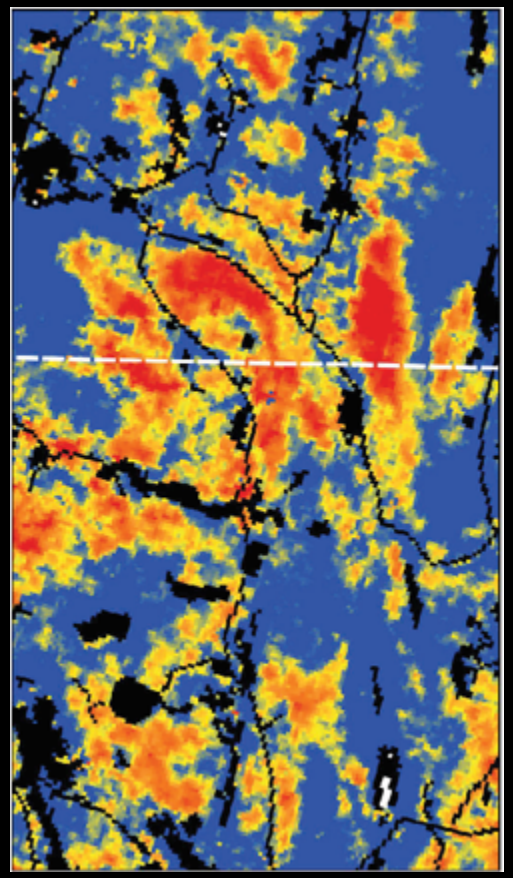
Mean condition score



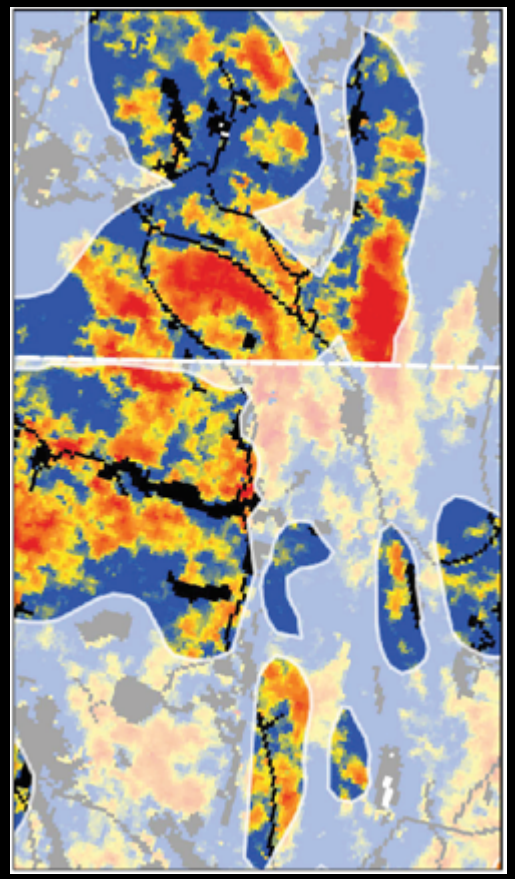
2016 aerial sketch



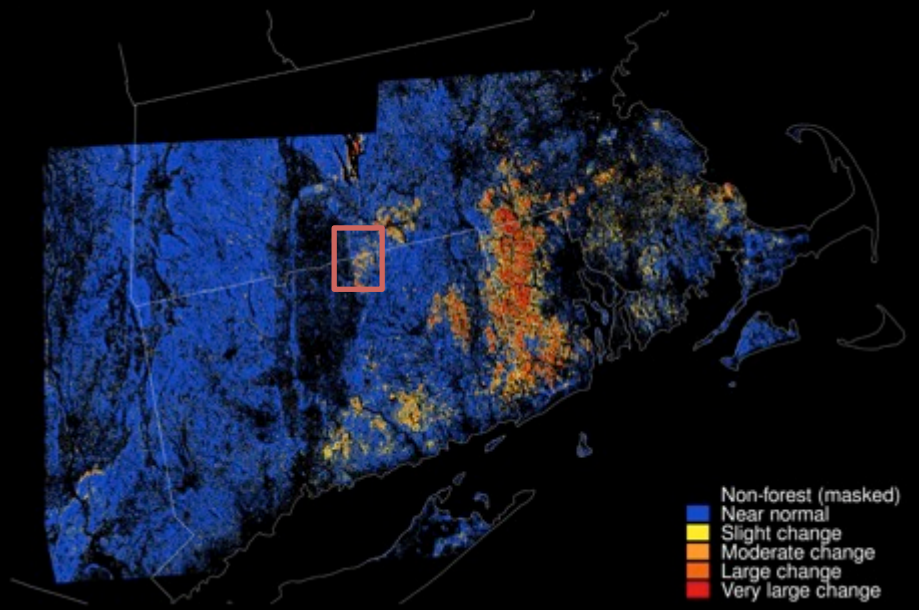
Landsat time series



Aerial sketch overlay



Non-forest (masked)
Near normal
Slight change
Moderate change
Large change
Very large change



forests

MDPI

Article

Near-Real-Time Monitoring of Insect Defoliation Using Landsat Time Series

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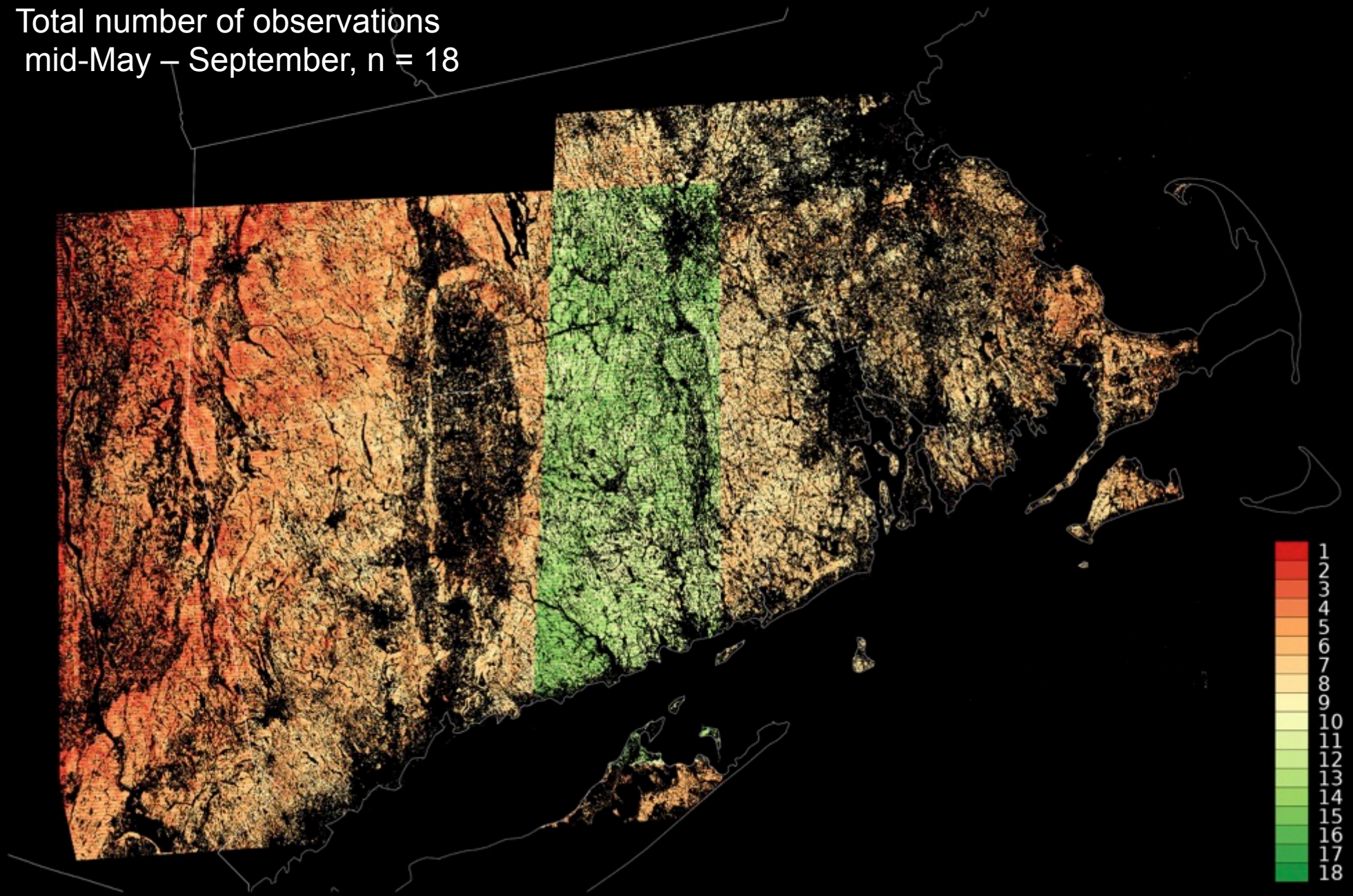
2017:
Continued monitoring

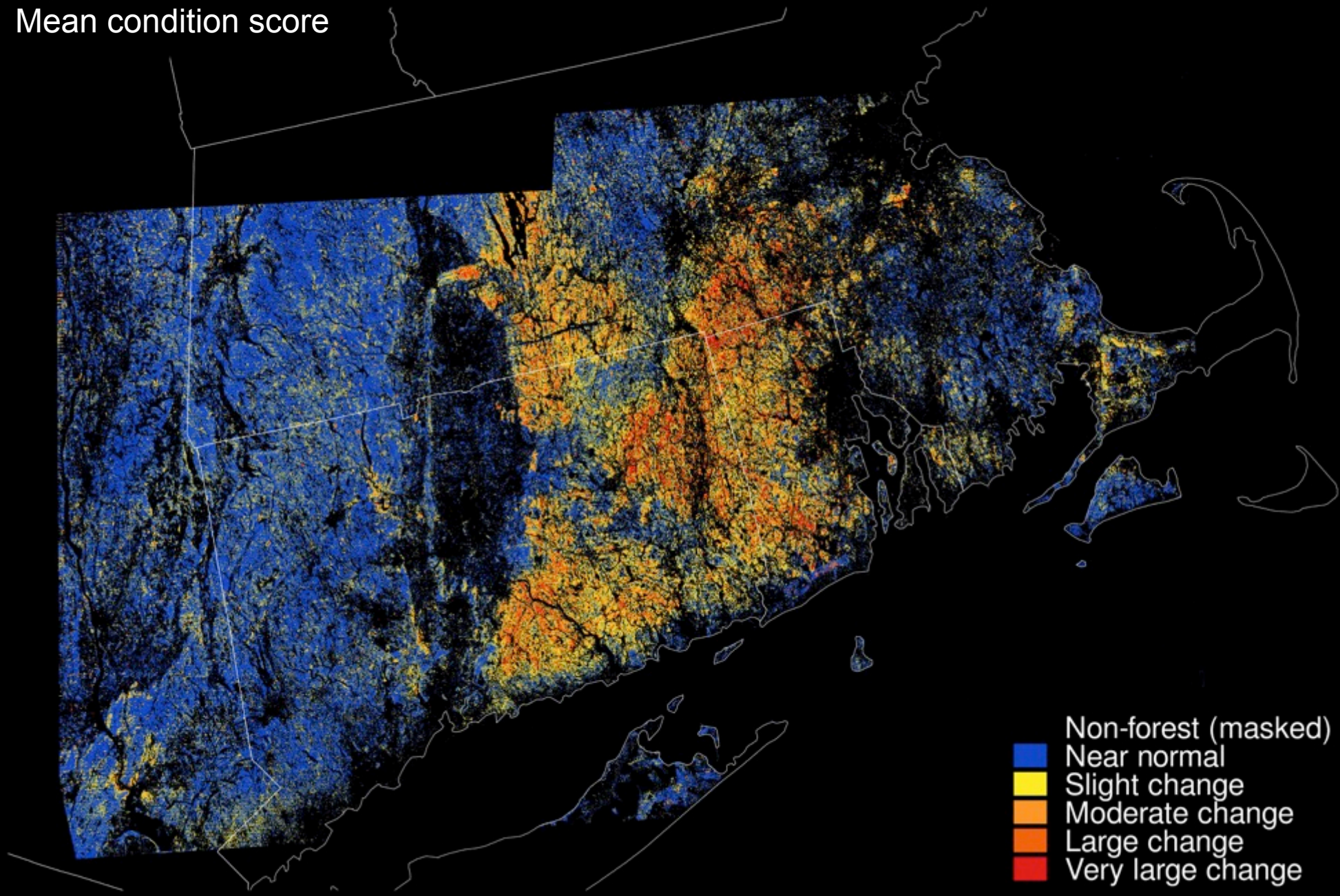
2017

Total number of observations
mid-May – September, n = 18

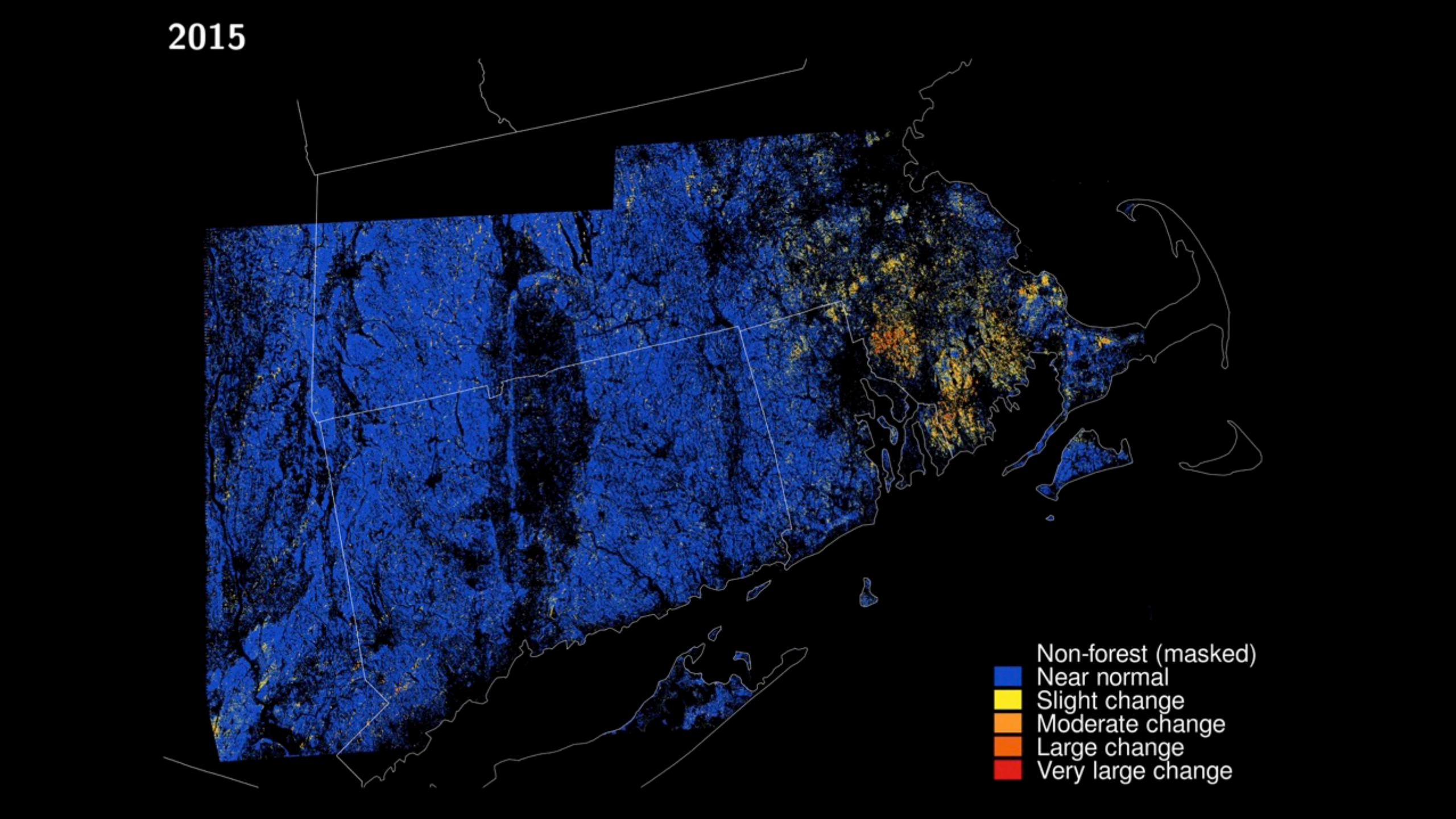


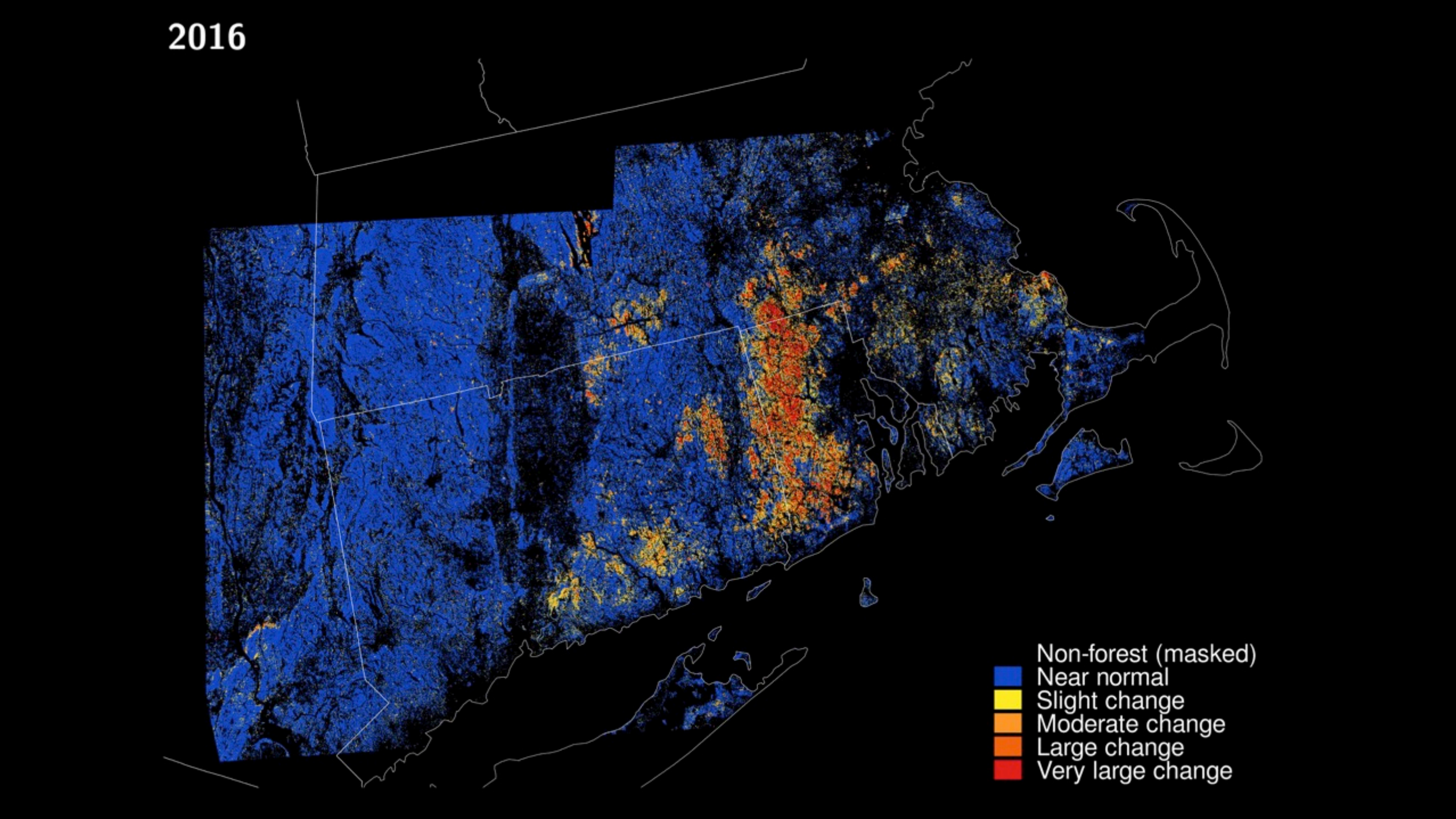
2017

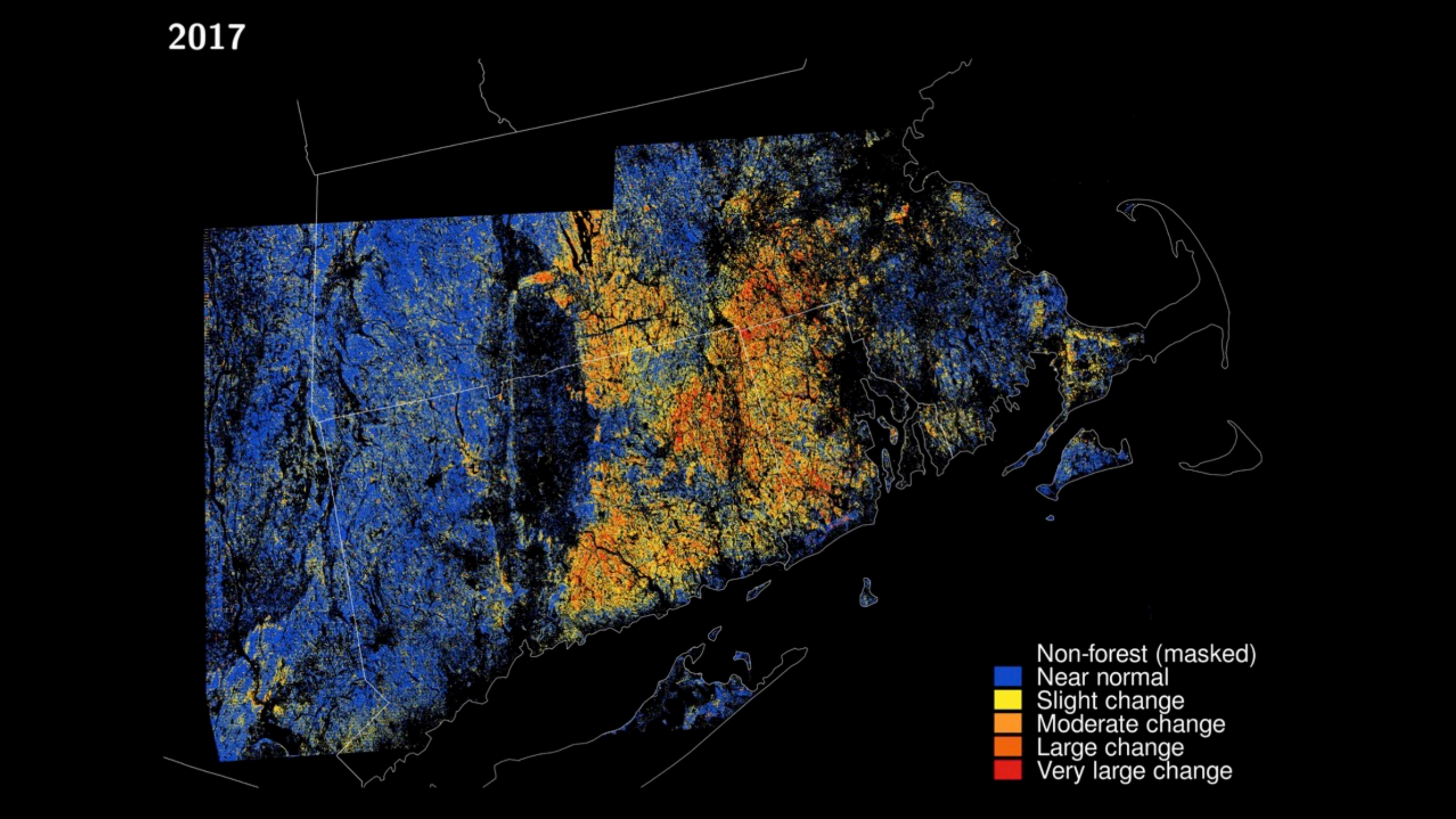
Mean condition score

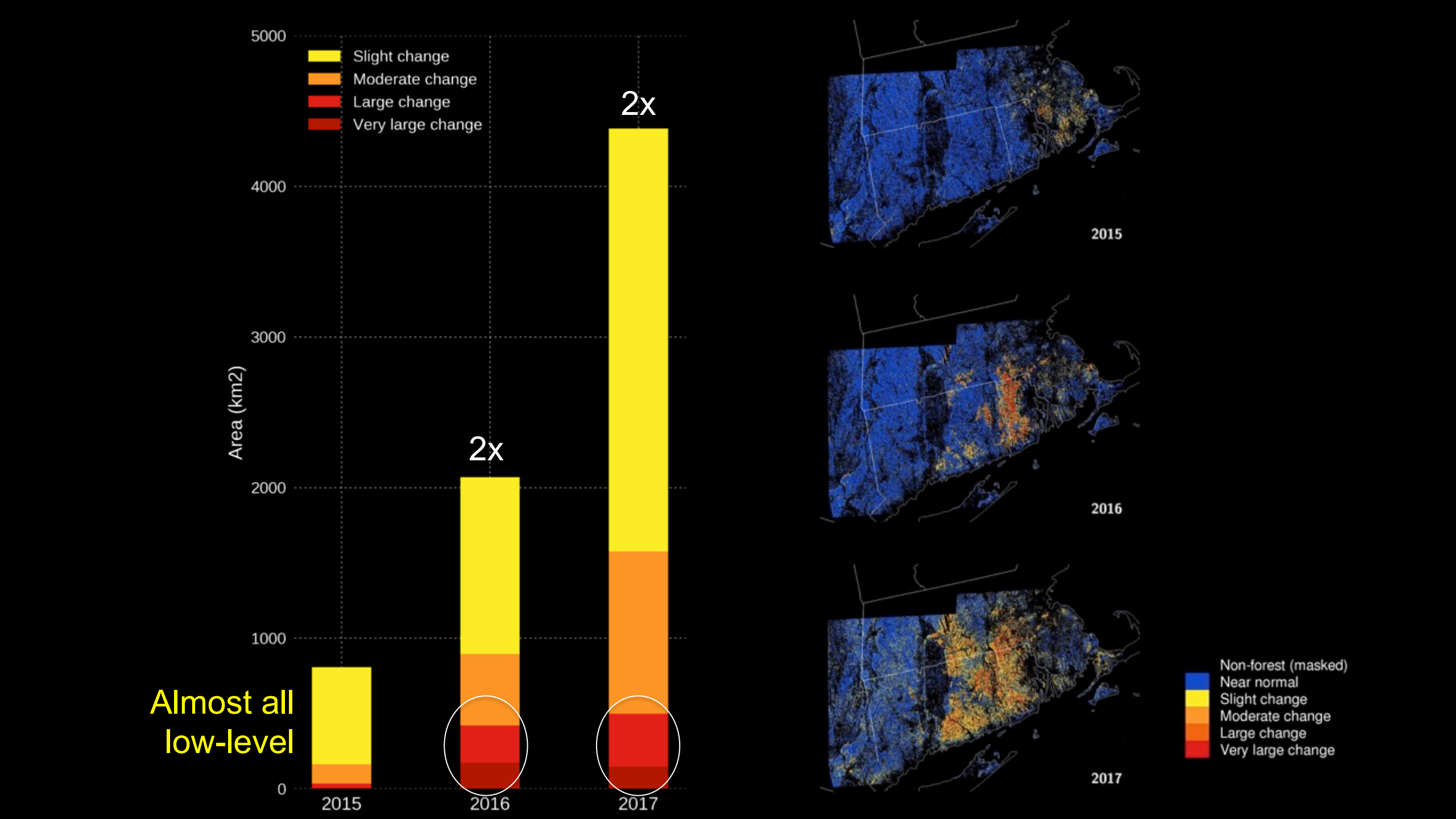


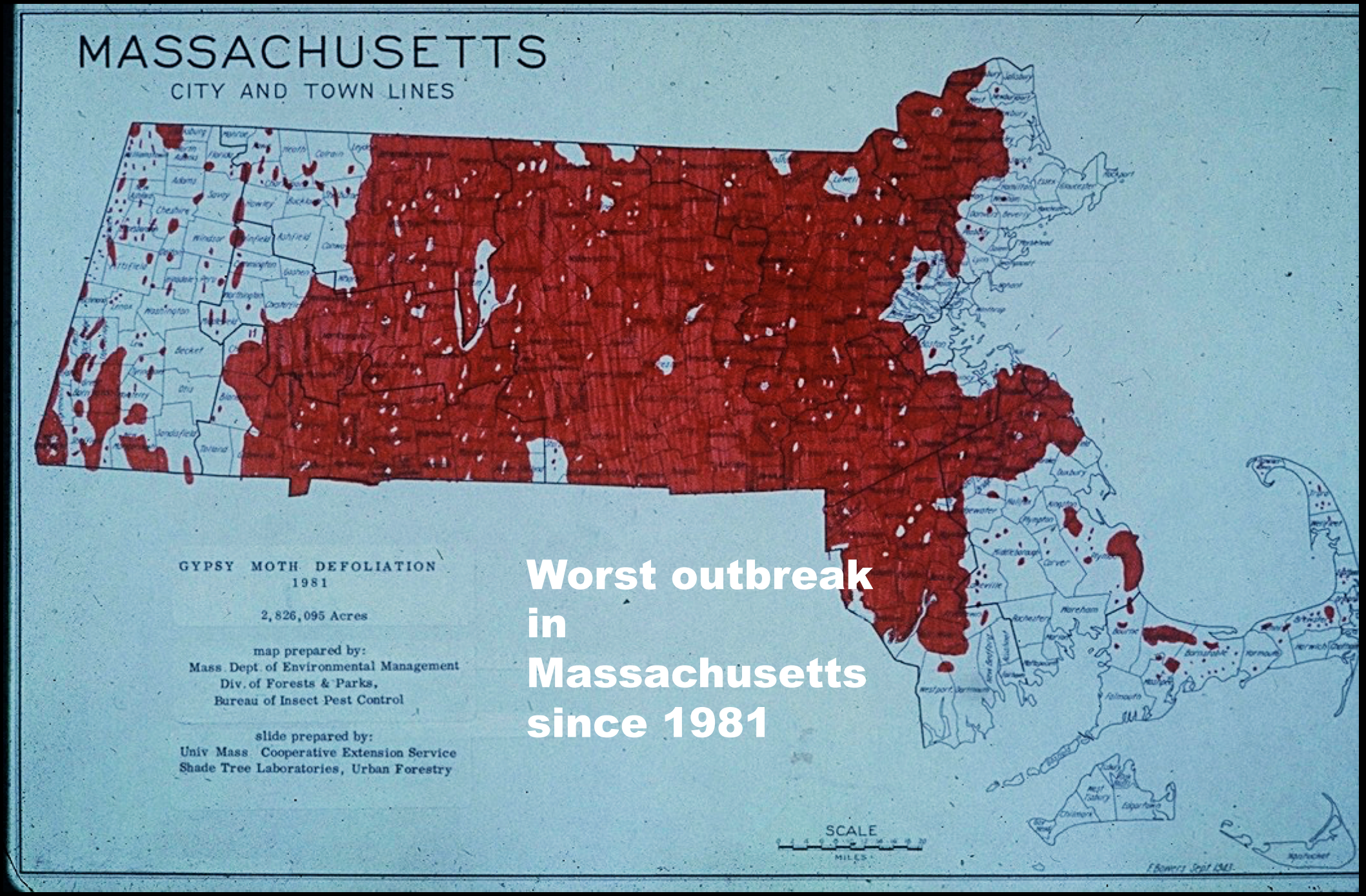
Year-to-year comparison


2015
Non-forest (masked)
Near normal
Slight change
Moderate change
Large change
Very large change


2016
Non-forest (masked)
Near normal
Slight change
Moderate change
Large change
Very large change


2017
Non-forest (masked)
Near normal
Slight change
Moderate change
Large change
Very large change


5000
4000
3000
2000
1000
0
Area (km2)
Slight change
Moderate change
Large change
Very large change
2x
2x
2015
2016
2017
Almost all low-level
2015
2016
2017
Non-forest (masked)
Near normal
Slight change
Moderate change
Large change
Very large change


MASSACHUSETTS
CITY AND TOWN LINES
GYPSY MOTH DEFOLIATION
1981
2,826,095 Acres
map prepared by:
Mass. Dept. of Environmental Management
Div. of Forests & Parks,
Bureau of Insect Pest Control
slide prepared by:
Univ Mass Cooperative Extension Service
Shade Tree Laboratories, Urban Forestry
Worst outbreak
in
Massachusetts
since 1981
SCALE
MILES

Summary

- Gypsy moth have reclaimed their role as a **major forest pest** in Southern New England
- **Outbreaks** may be linked to extreme weather events, i.e. **drought**
- **Expect continued defoliation in 2018** – but location and severity will depend on mortality this year and weather next spring
- **Satellite-based monitoring** provides a valuable tool for tracking outbreak patterns

Questions?

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forests

MDPI

Article

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University of Massachusetts Amherst 1863

Boston University

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USGS science for a changing world