



Assessing MODIS-based products and techniques for detecting gypsy moth defoliation

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Project Background



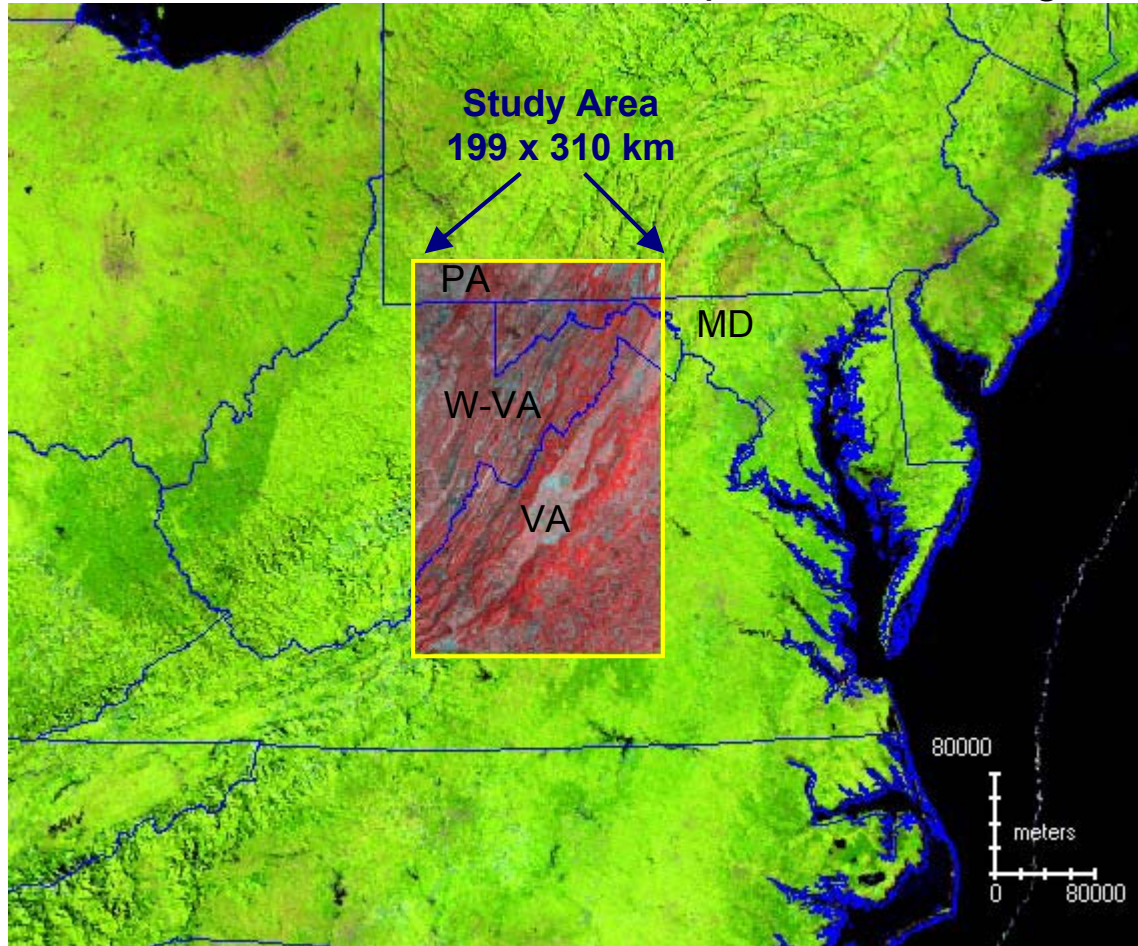
- The project addresses: What is the potential of MODIS data for monitoring historic gypsy moth defoliation?
- This project regards a NASA/USDA Forest Service (USFS) partnership
 - NASA is helping USFS to implement satellite data products into its emerging Forest Threat Early Warning System
 - The latter system is being developed by the USFS Eastern and Western Forest Threat Assessment Centers
 - The USFS Forest Threat Centers want to use MODIS time series data for regional monitoring of forest damage (e.g., defoliation), preferably in near real time

Initial Study Area – Mid-Appalachian Highlands

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Study Area Outlined in Yellow Below (Total ~15.5 Million Acres)
Gypsy Moth Defoliation Occurred on Multiple Years During MODIS Era



Note: This Area Encompasses Several Landsat Scenes

Project Objectives



1. Assess 250-meter MODIS time series data for mapping historic gypsy moth defoliation
 - Assess accuracy of detection products compared to reference data
 - Initial focus on 2001 due to known extensive defoliation and available reference data
 - 2001 Landsat and ASTER imagery
 - 2001 USFS defoliation sketch maps

2. Assess simulated VIIRS time series data for mapping historic gypsy moth defoliation
 - VIIRS will be the follow-on to MODIS
 - VIIRS will have 400-meter resolution
 - VIIRS data is being simulated mainly from MODIS imagery

Reducing Noise in the MODIS and VIIRS Time Series Data

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- Data from each MODIS-based product was independently preprocessed to reduce inclusion of clouds and other low-quality data
 - MODIS MOD02 (planetary reflectance data) and MOD13 (atmospherically corrected NDVI)
- The Time Series Product Tool (TSPT) software was used to derive “cleaned” MODIS and VIIRS time series data
 - TSPT outputs vegetation index products (e.g., NDVI)

Computing Maximum NDVI Composites for the Defoliation Time Frame

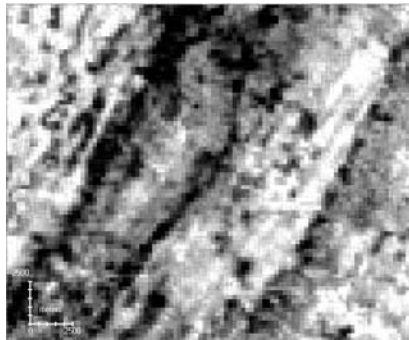


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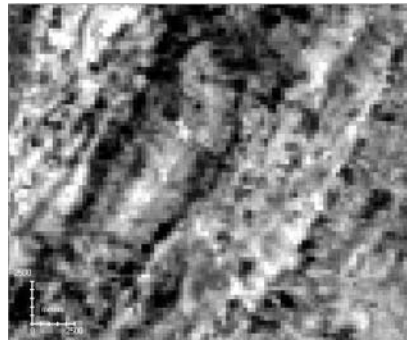
- Computed a maximum NDVI composite for the gypsy moth defoliation period of each year (June 10–July 27)
 - Time series includes defoliated and non-defoliated years
- Stacked maximum NDVI during defoliation image for 2001 with maximum NDVI image during the defoliation period over the whole 2000–2006 time series
- Used data stack to compute defoliation detection products

MODIS Maximum NDVI

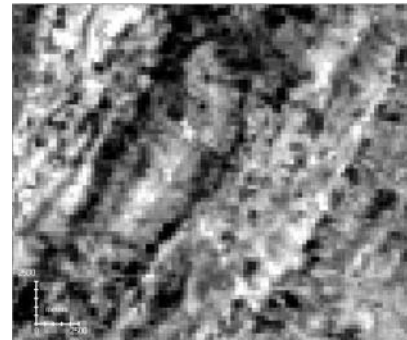
Defoliation Time Frame (DTF)
for 2000–2006 (Red)



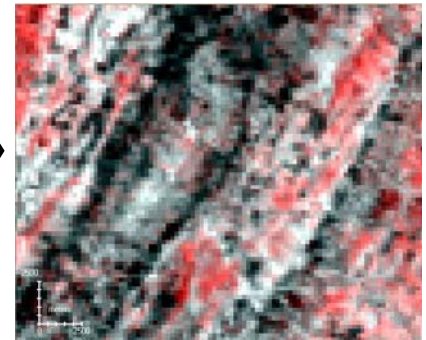
Maximum NDVI DTF
2001 (Green)



Maximum NDVI DTF
2001 (Blue)



Defoliation RGB - Based
on Maximum NDVI DTF
for All Years vs. 2001



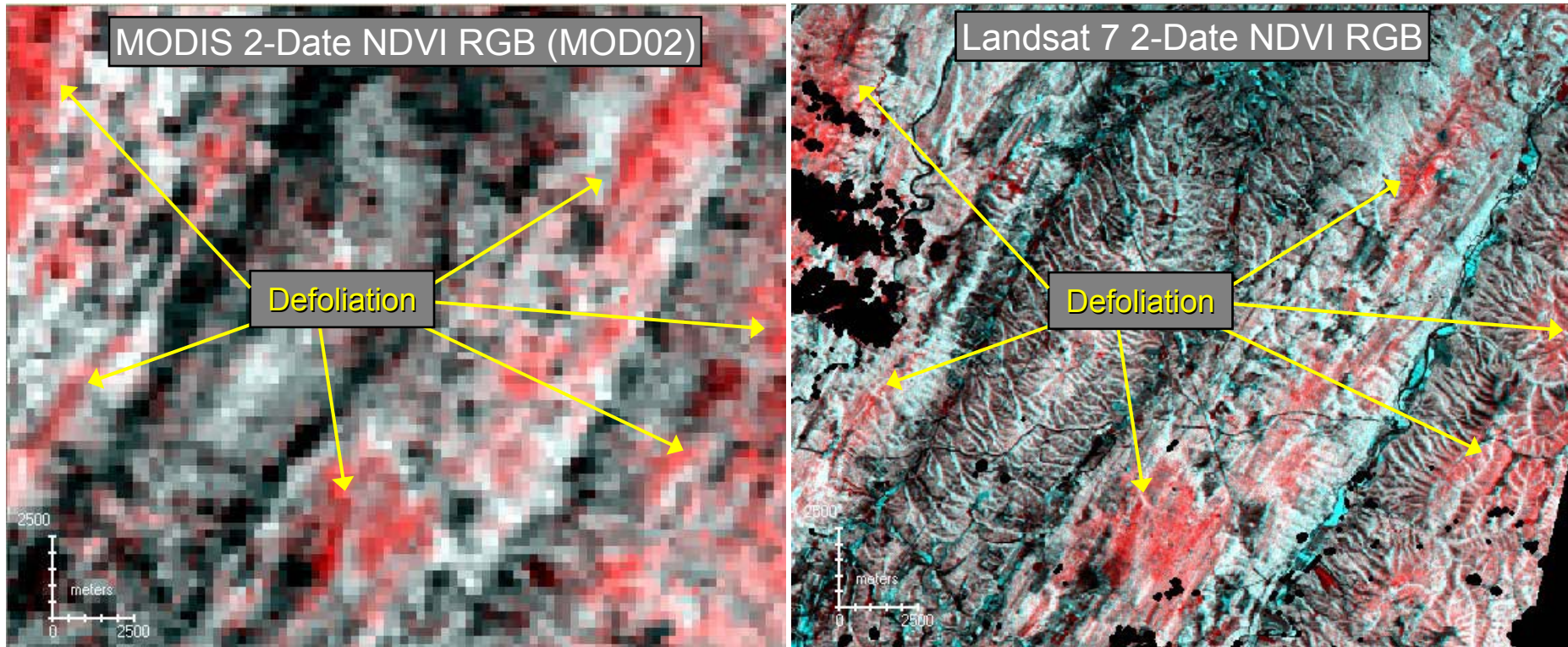
Views of Gypsy Moth Defoliation on MODIS versus Landsat NDVI Data

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MODIS – Maximum NDVI DTF All Years in Red; Same for 2001 in Blue and Green
DTF – Defoliation Time Frame (June 10–July 27)

Landsat – 6/10/2000 NDVI Loaded in Red; 7/15/2001 NDVI Loaded into Blue and Green



- Both RGB images show defoliation from 2001 outbreak in red tones
- MODIS RGB is cloud free due to temporal processing of daily data

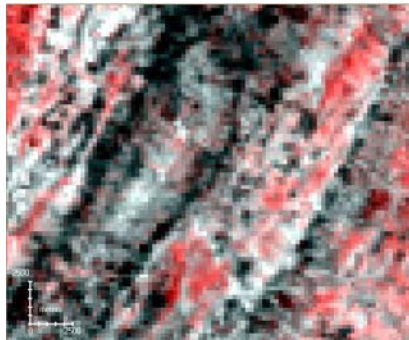
Method for MODIS Image Classification of Gypsy Moth Defoliation



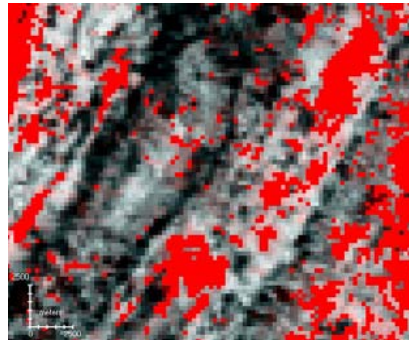
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- Processed 2001 MODIS and VIIRS data into defoliation maps of 2 classes: defoliated versus other
 - Employed unsupervised classification techniques
 - Example results from MOD13 250 m, MOD02 250 m, and simulated VIIRS 400 m data
- Applied post-classification “filtering” technique to reduce commission errors from patches smaller than 1x1 km

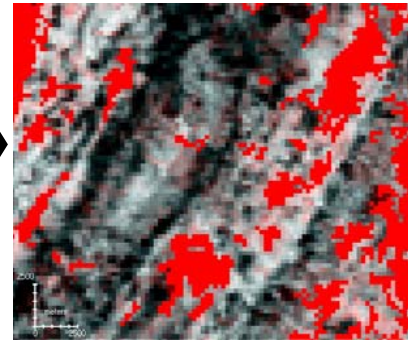
Defoliation RGB - Based on Maximum NDVI DTF for All Years vs. 2001



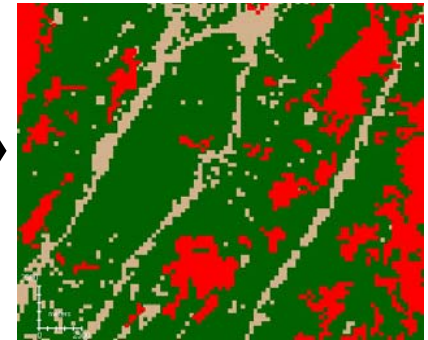
20-Class Unsupervised Classification Defoliated Forest in Red



Application of 1x1 km Clump Aggregation Filter



Final Result Overlain onto NLCD Forest Mask



2001 Defoliation Classifications from MOD13, MOD02, and Simulated VIIRS NDVI Products

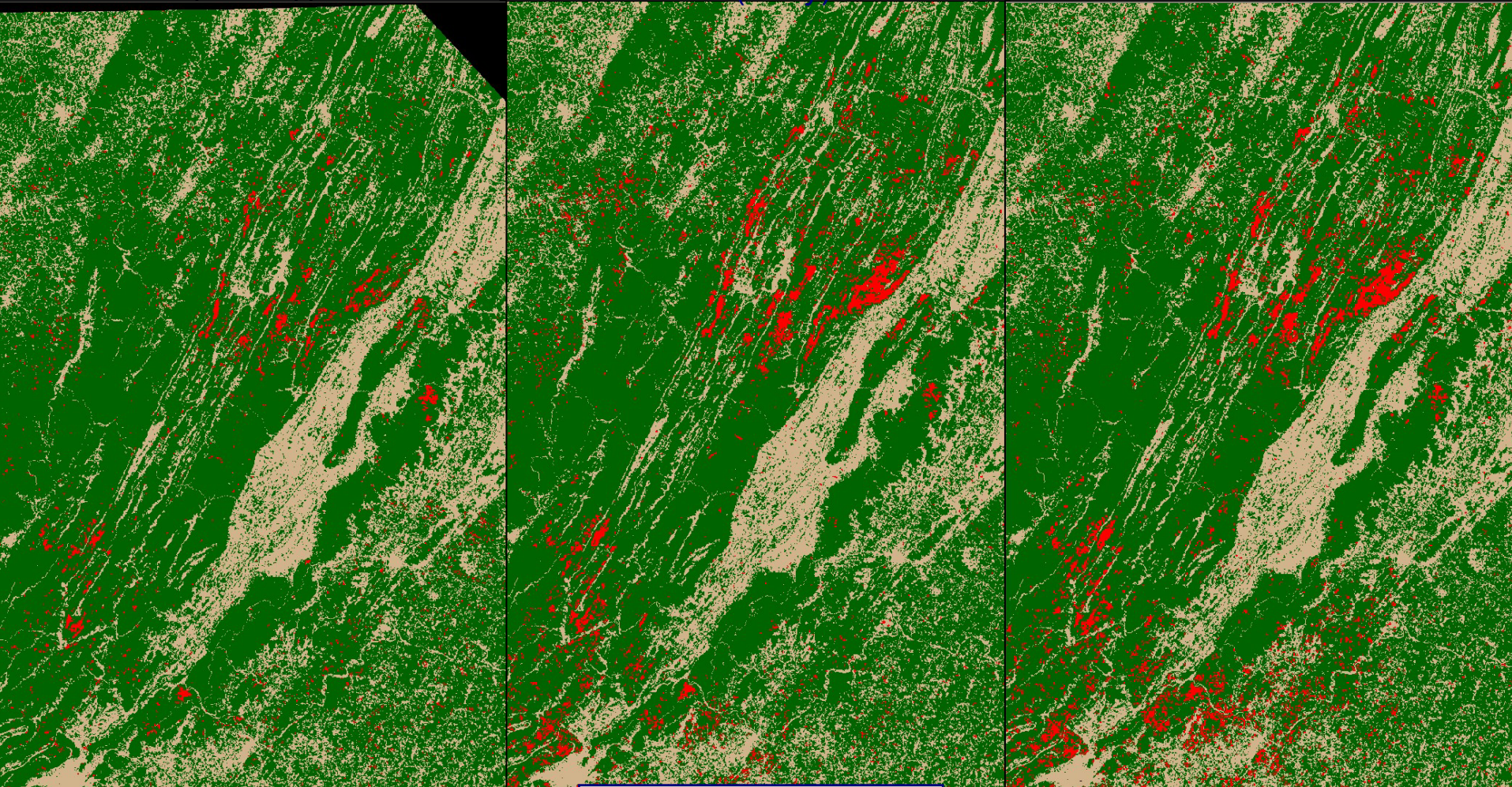
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MOD13 (16-day) 250 m

MOD02 (Daily) 250 m

Simulated VIIRS (Daily) 400 m



NON-FOREST – TAN
HEALTHY FOREST – GREEN
DEFOLIATED FOREST – RED
FOREST MASK – NLCD 2001

Method for Accuracy Assessment of Defoliation Detection Products

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- Drew stratified random sample locations from best apparent classification (MOD02 250-meter result)
 - Drew samples for defoliated forest versus other classes
- An image analyst interpreted each sample location Landsat or ASTER as being defoliated or other
- Interpretation results were then compared to each test classification
 - Examples - MOD02, simulated VIIRS, and MOD13 products
- Final results were summarized for defoliated forest versus “other” class

Relative Accuracy of Example 2001 Defoliation Classification Products

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2001 Classification Product	Defoliated Forest			Other			Overall	
	PA	UA	Kappa	PA	UA	Kappa	OA	OK
MOD02 NDVI 250 m	91% (52/57)	78% (52/67)	0.67	87% (101/116)	95% (101/106)	0.86	88% (153/173)	0.75
VIIRS NDVI 400 m (Simulated from MOD02)	86% (49/57)	78% (49/63)	0.67	88% (102/116)	93% (102/110)	0.78	87% (151/173)	0.72
MOD13 NDVI 250 m	44% (25/57)	86% (25/29)	0.79	97% (112/116)	78% (112/144)	0.33	79% (137/173)	0.46

Note: PA = % Producer's Agreement (# correct/total), UA = % User's Agreement (# correct/total), Kappa = Kappa Statistic, OA = % Overall Agreement (# correct/total), and OK = Overall Kappa.

Conclusions for Example 2001 Defoliation Mapping Products

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- MODIS and simulated VIIRS time series data produced effective regional defoliation maps for 2001
 - Temporal processing techniques and pest phenology knowledge aided the application
- MOD02 daily products yielded the best results
 - MOD02 250 m and simulated 400 m VIIRS NDVI products yielded similar measures of accuracy
 - MOD13 NDVI defoliation maps showed the lower overall accuracy, in part from omission of defoliation areas



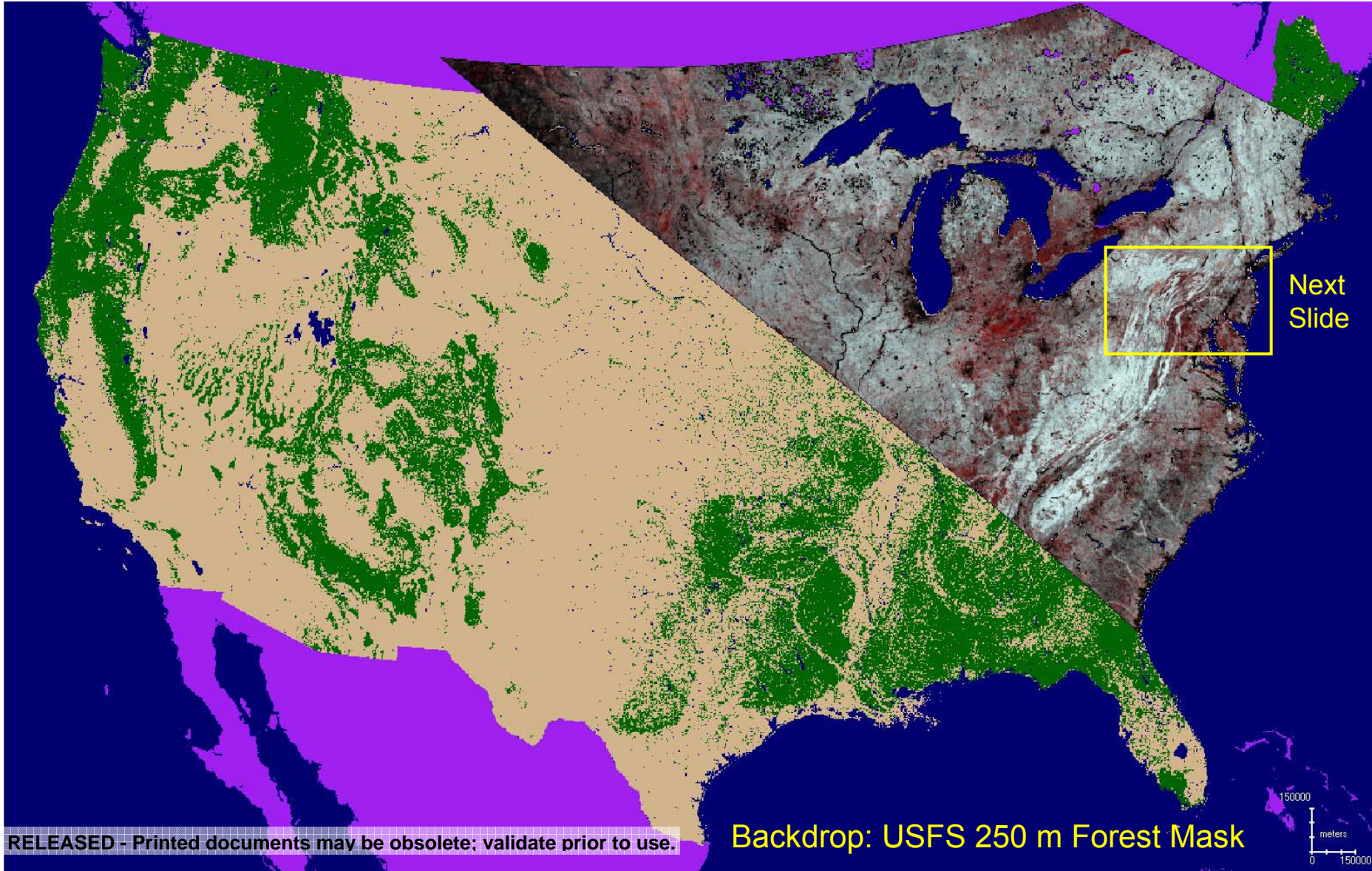
Gypsy Moth Defoliation of 2007

Preliminary Results Using Available MOD13 NDVI Data

View of Entire MOD13 Mosaic Used in 2007 Case Study

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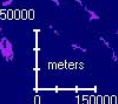
Maximum NDVI 2007 DTF in Red; Maximum NDVI DTF All Years in Blue and Green



Next
Slide

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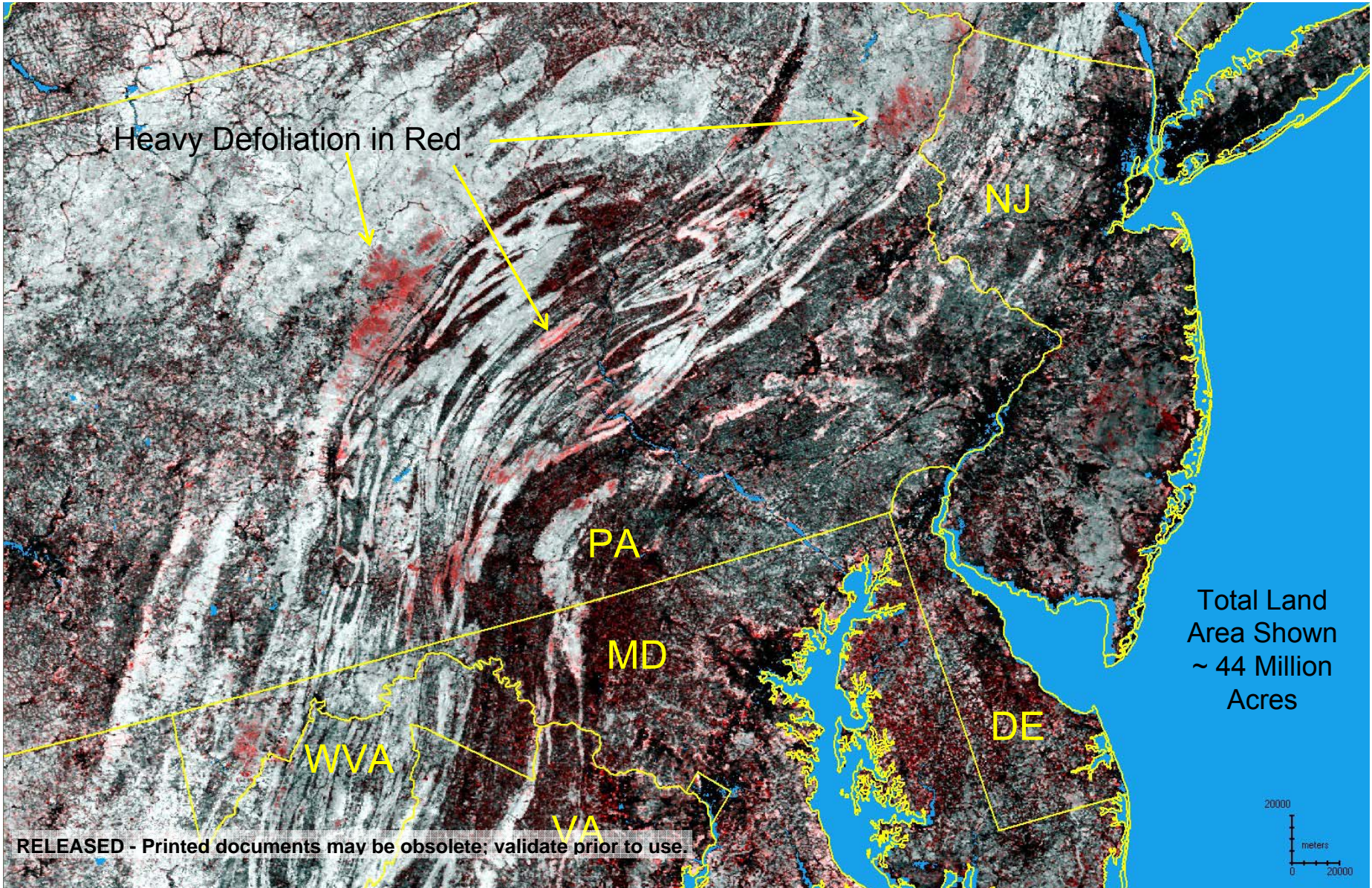
Backdrop: USFS 250 m Forest Mask



View of 2007 Gypsy Moth Defoliation From MOD13 Data

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Maximum NDVI 2007 DTF in Red; Maximum NDVI DTF All Years in Blue and Green



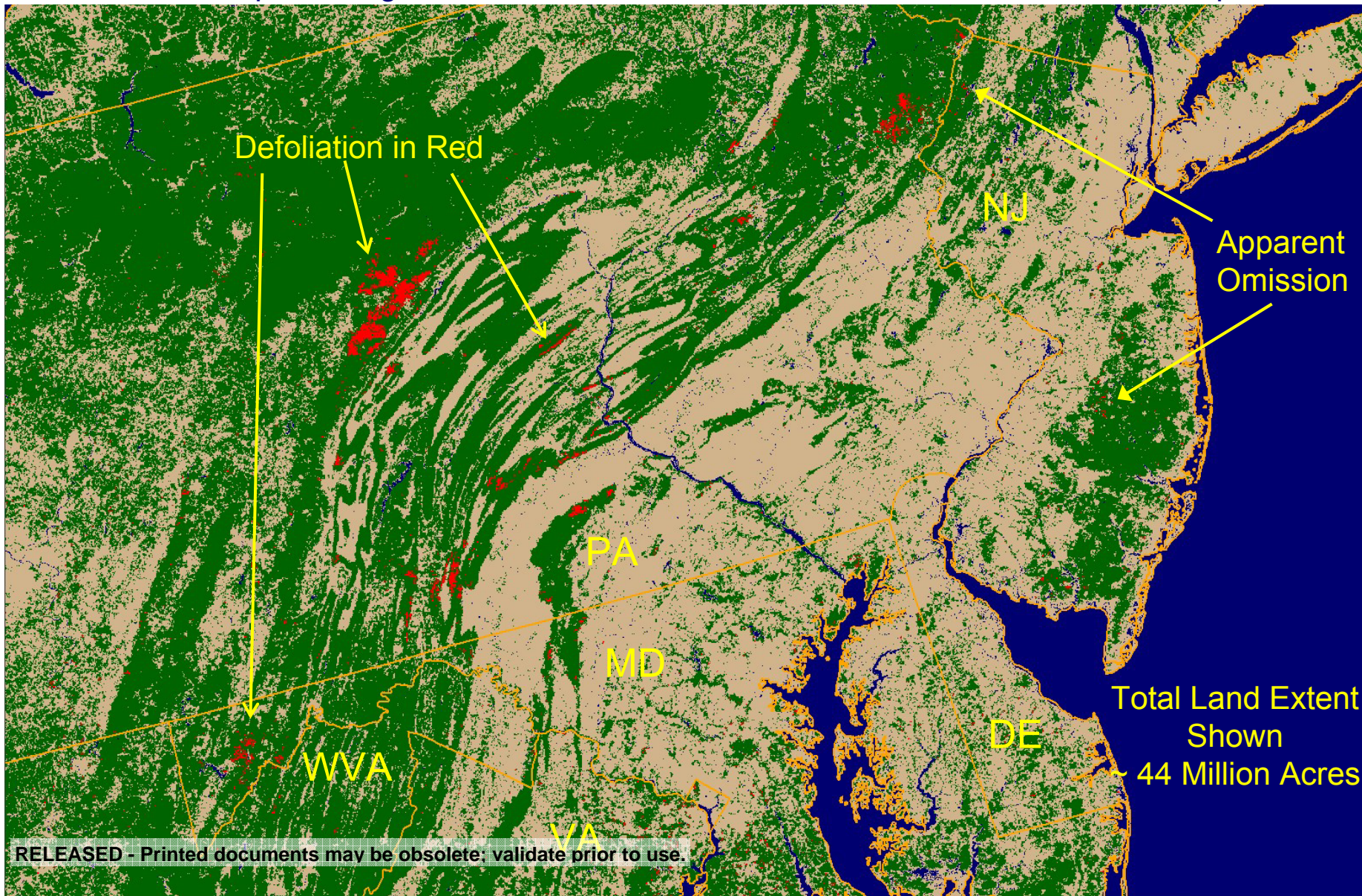
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View of 2007 Gypsy Moth Defoliation Map from MOD13 Data

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Defoliation Map in Foreground is Overlain onto USFS 250 m Forest/Non-Forest Map



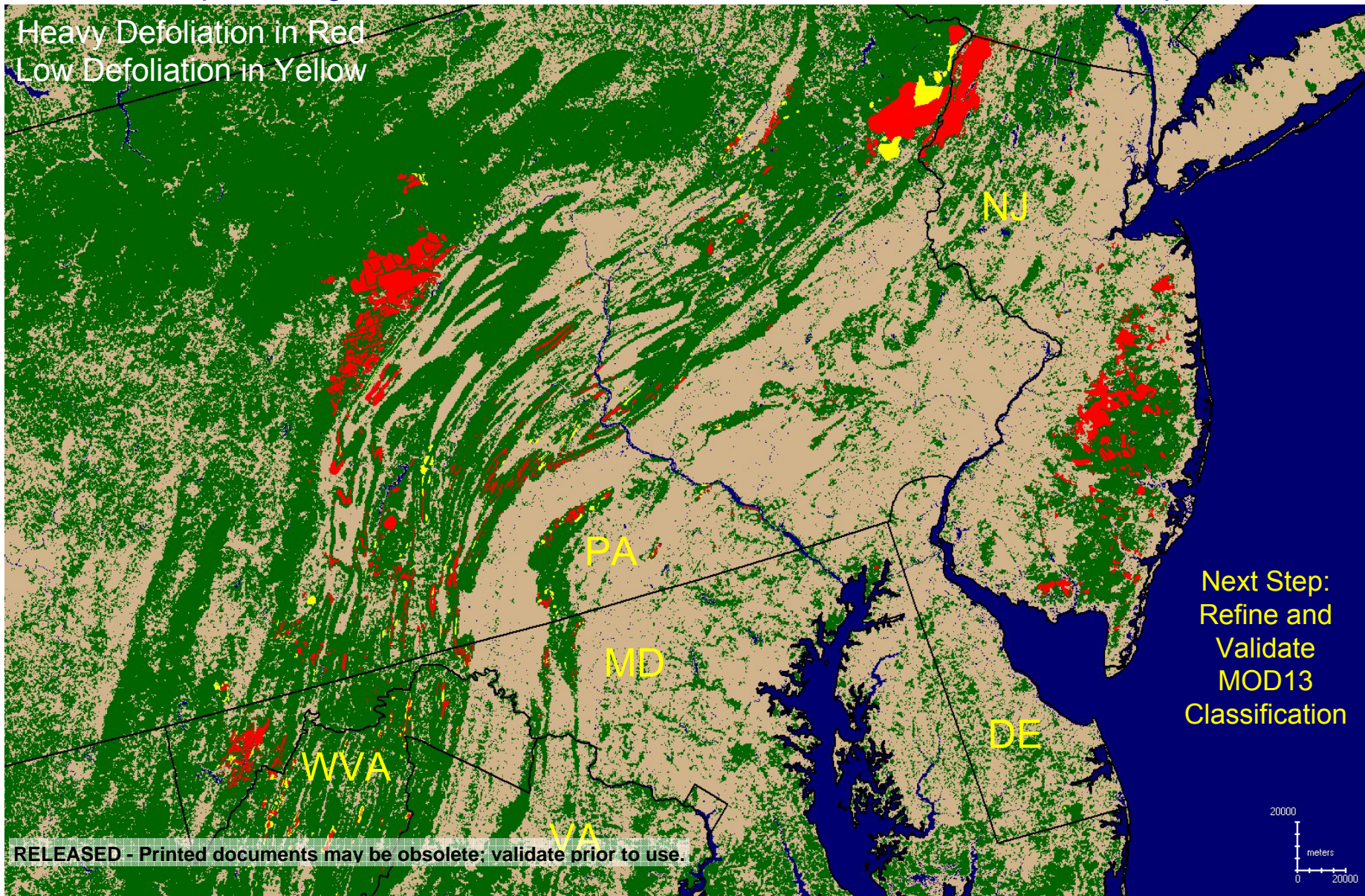
View of 2007 Gypsy Moth Defoliation From USFS Sketch Map



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Sketch Map in Foreground is Overlain onto USFS 250 m Forest/Non-Forest Map

Heavy Defoliation in Red
Low Defoliation in Yellow



Next Step:
Refine and
Validate
MOD13
Classification

Relevance of Project



- The project showed potential of MODIS and VIIRS time series data for contributing defoliation detection products to the USFS forest threat early warning system
- This study yielded the first satellite-based wall-to-wall 2001 gypsy moth defoliation map for the study area
- Initial results led to follow-on work to map 2007 gypsy moth defoliation over the eastern United States (in progress)
- MODIS-based defoliation maps offer promise for aiding aerial sketch maps either in planning surveys and/or adjusting acreage estimates of annual defoliation
- More work still needs to be done to assess potential of technology for “now casts” of defoliation





Extra Slides

MODIS-Related Terminology



- MODIS – Moderate Resolution Imaging Spectroradiometer
 - 2 MODIS instruments in space (Aqua and Terra satellites)
 - Each sensor collects 1 image per location each day
 - 250-meter resolution for NIR (near infrared) and red bands

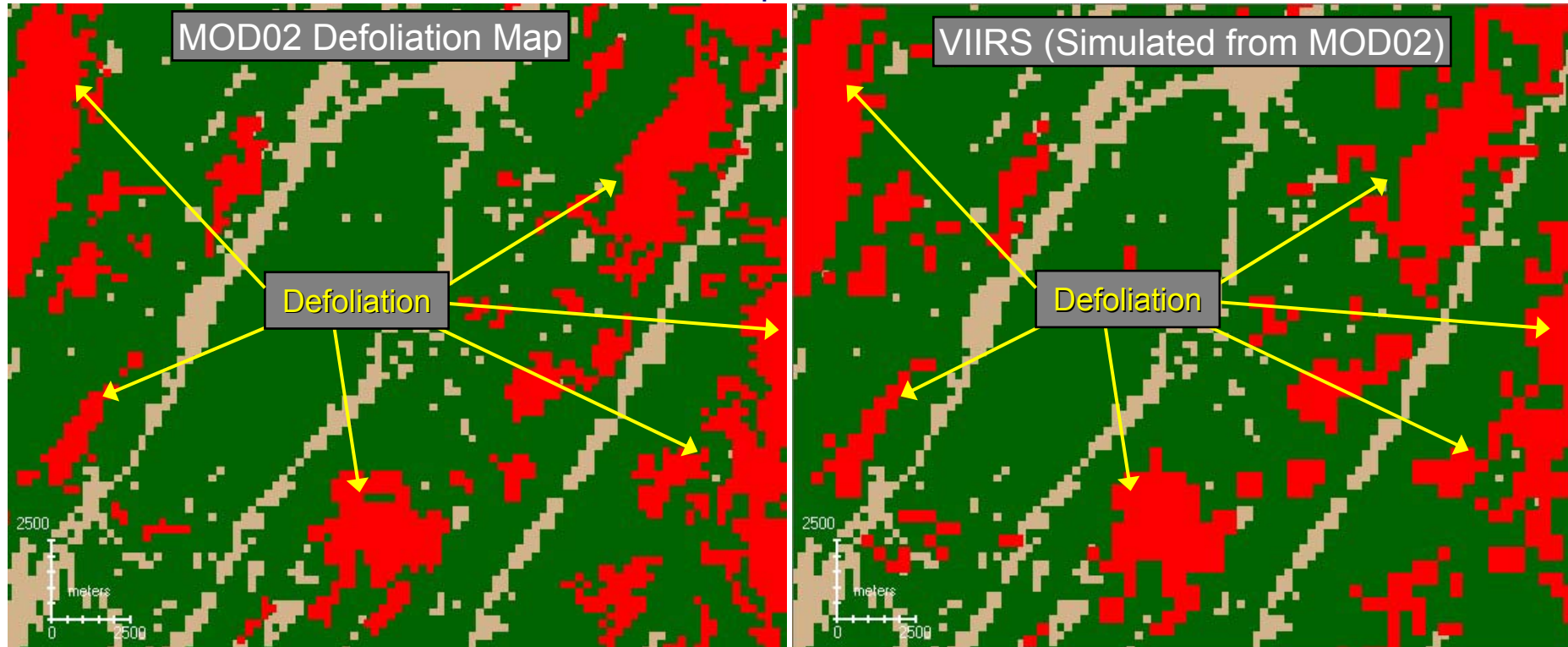
- NDVI – Normalized Difference Vegetation Index
 - $NDVI = (NIR - red) / (NIR + red)$
 - Can be computed from multiple MODIS products
 - MOD02 – Daily MODIS Radiance Data
 - MOD13 – MODIS 16 Day Composite Vegetation Indices

- VIIRS – Visible/Infrared Imager/Radiometer Suite
 - future follow-on to MODIS

Gypsy Moth Defoliation Maps from MODIS and Simulated VIIRS Data



MODIS (MOD02) and VIIRS Products Produced Similar Results
Both Tended to Map Same Outbreak Areas



Red – Defoliation
Green – Forest from NLCD
Tan – Non Forest from NLCD

Aerial View of Gypsy Moth Defoliation

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