



Mapping historic gypsy moth defoliation with MODIS satellite data: Implications for forest threat early warning system

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Project Background



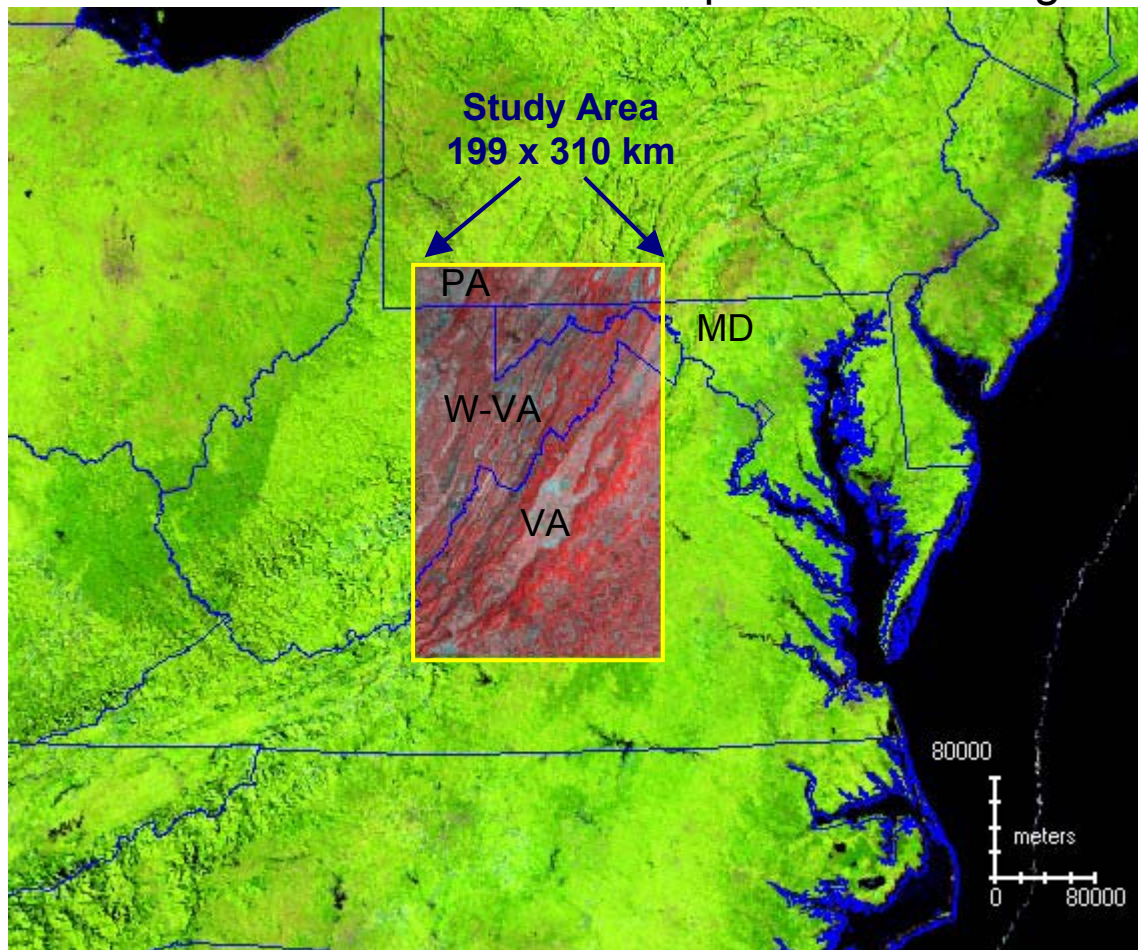
- The project addresses: What is the potential of MODIS data for monitoring historic gypsy moth defoliation?
- This project regards a NASA/USDA Forest Service (USFS) partnership
 - NASA is helping USFS to implement satellite data products into its emerging Forest Threat Early Warning System
 - The latter 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

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

Aerial View of Gypsy Moth Defoliation

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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
 - Focus on 2001 because of known extensive defoliation and available reference data
 - 2001 Landsat and ASTER imagery during defoliation
 - 2001 USFS defoliation sketch maps used for general locations

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 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 Over Peak Defoliation Time Frame

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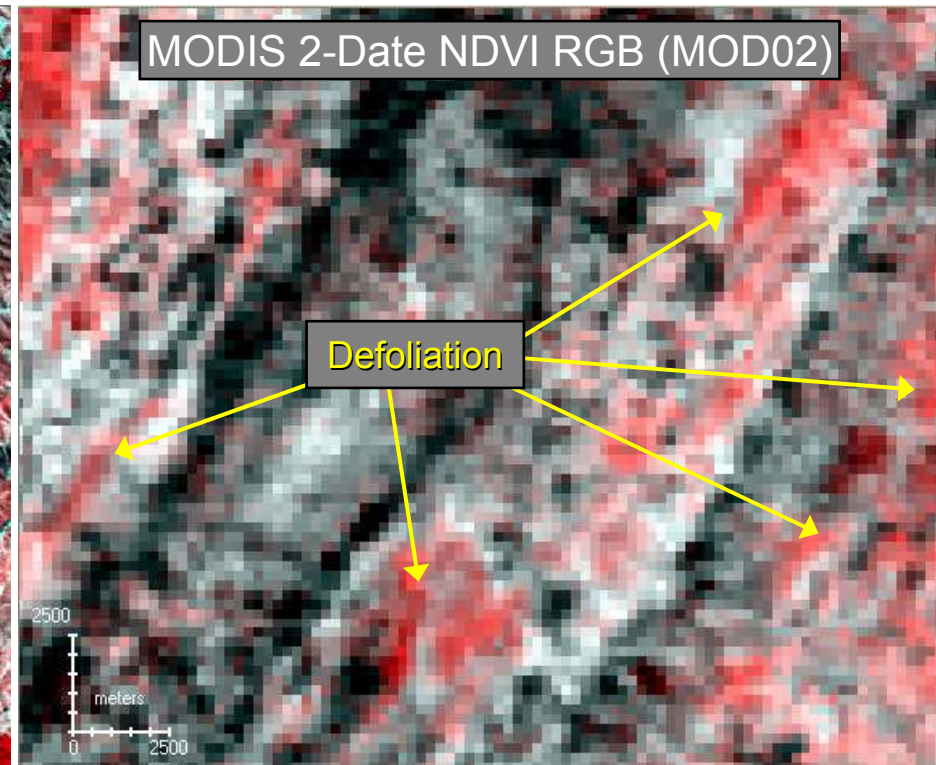
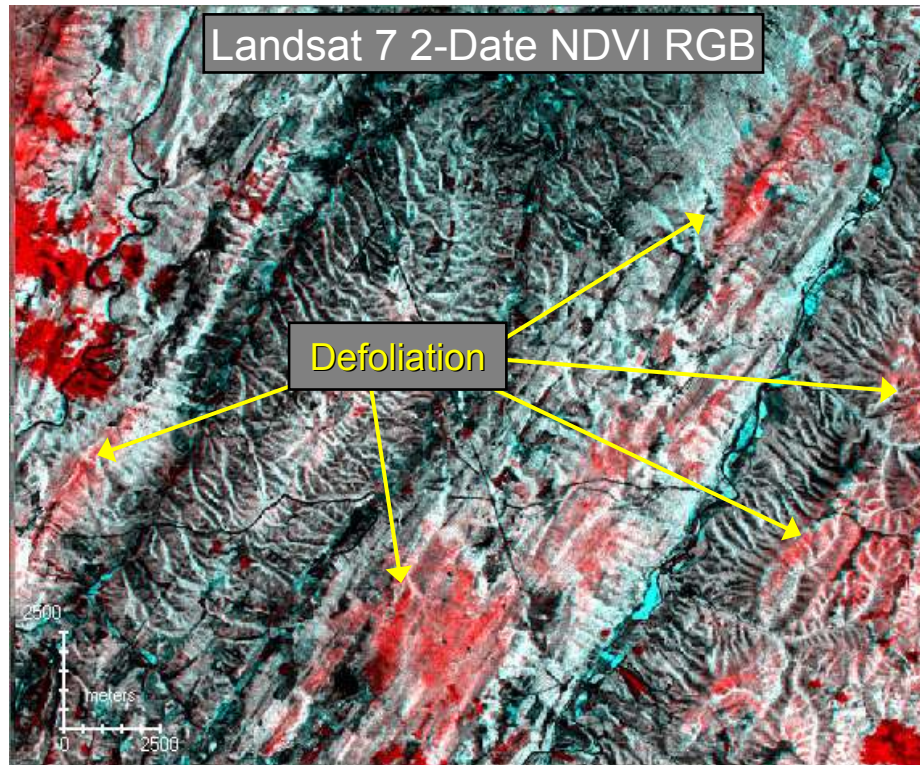
- We computed a maximum NDVI composite for the gypsy moth defoliation period of each year (June 10–July 27)
 - Time series includes defoliated and non-defoliated years
- Stacked 2001 maximum NDVI peak defoliation image, along with maximum NDVI peak defoliation image over the whole 2000–2006 time series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

Views of Gypsy Moth Defoliation on Landsat 7 and MODIS NDVI Data

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Landsat – 6/10/2000 NDVI Loaded in Red; 7/15/2001 NDVI Loaded into Blue and Green
MODIS – Maximum NDVI Peak Defoliation All Years in Red; Same for 2001 in Blue in Green



- Red tones – defoliation in 2001, except some deep red is clouds on the Landsat data
- Both Landsat and MODIS show defoliation, though the MODIS composite is cloud free

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 classification errors from patches smaller than 1x1 km

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

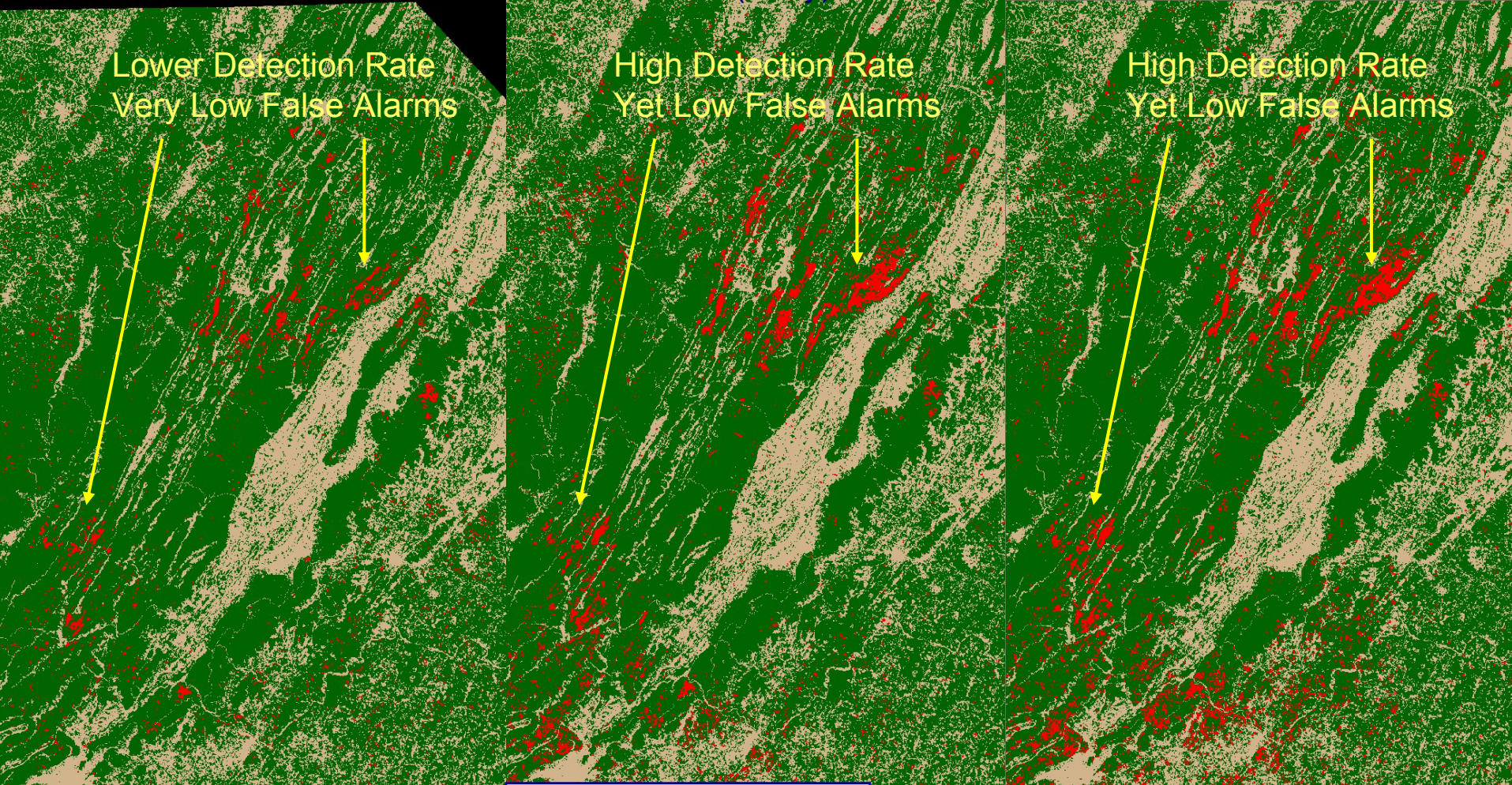
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MOD13 (16-day) 250 m

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 defoliation versus other classes
- An image analyst interpreted each sample location Landsat or ASTER as to 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”

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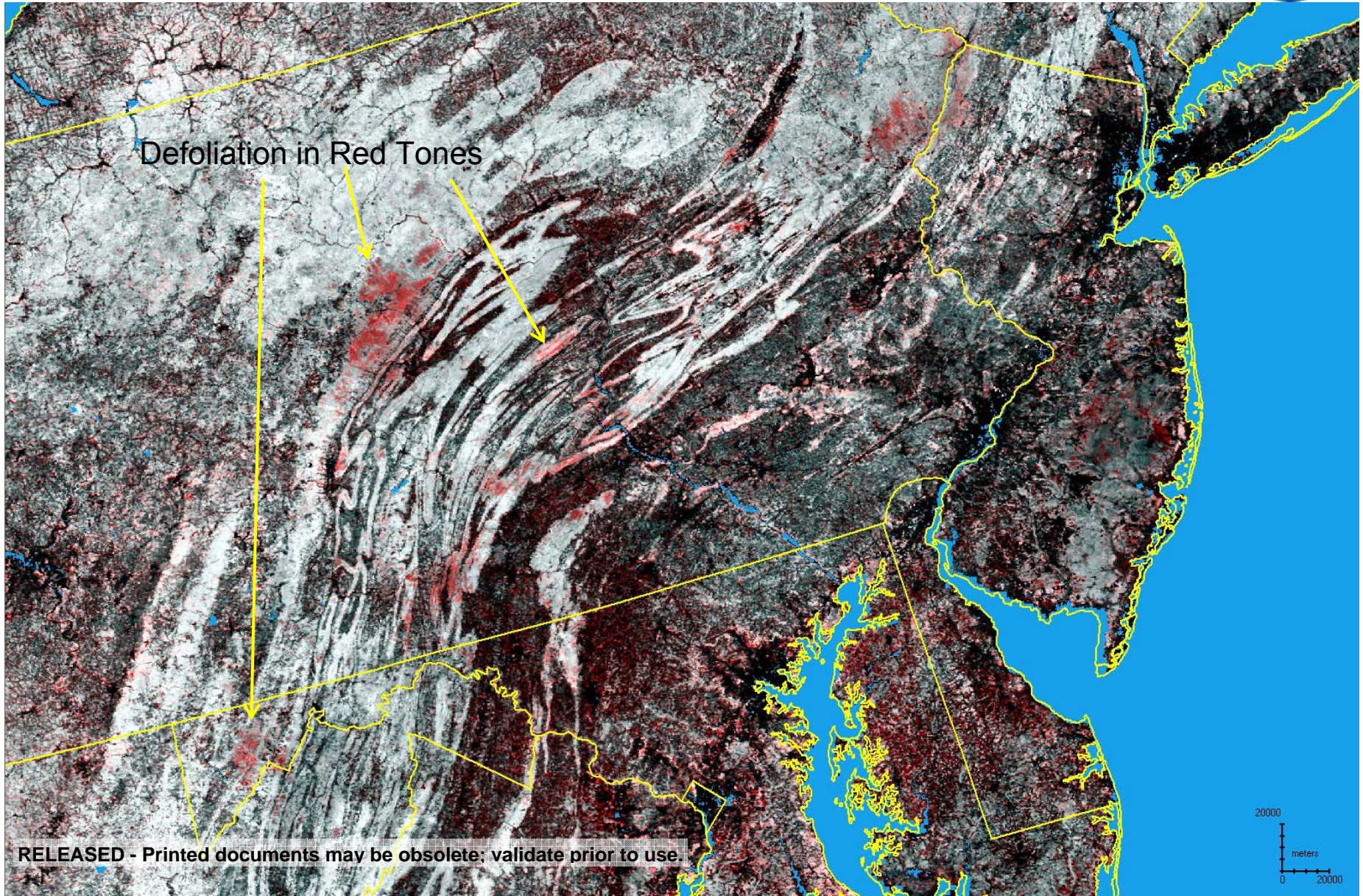
- MODIS and simulated VIIRS time series data produced effective regional defoliation maps for 2001
 - Temporal processing techniques and pest phenology knowledge aided the application
- MOD02 daily products yielded the best results
 - MOD02 250 m and simulated 400 m VIIRS NDVI products produced similar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

View of 2007 Gypsy Moth Defoliation From MOD13 Data

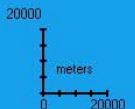
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Defoliation in Red Tones



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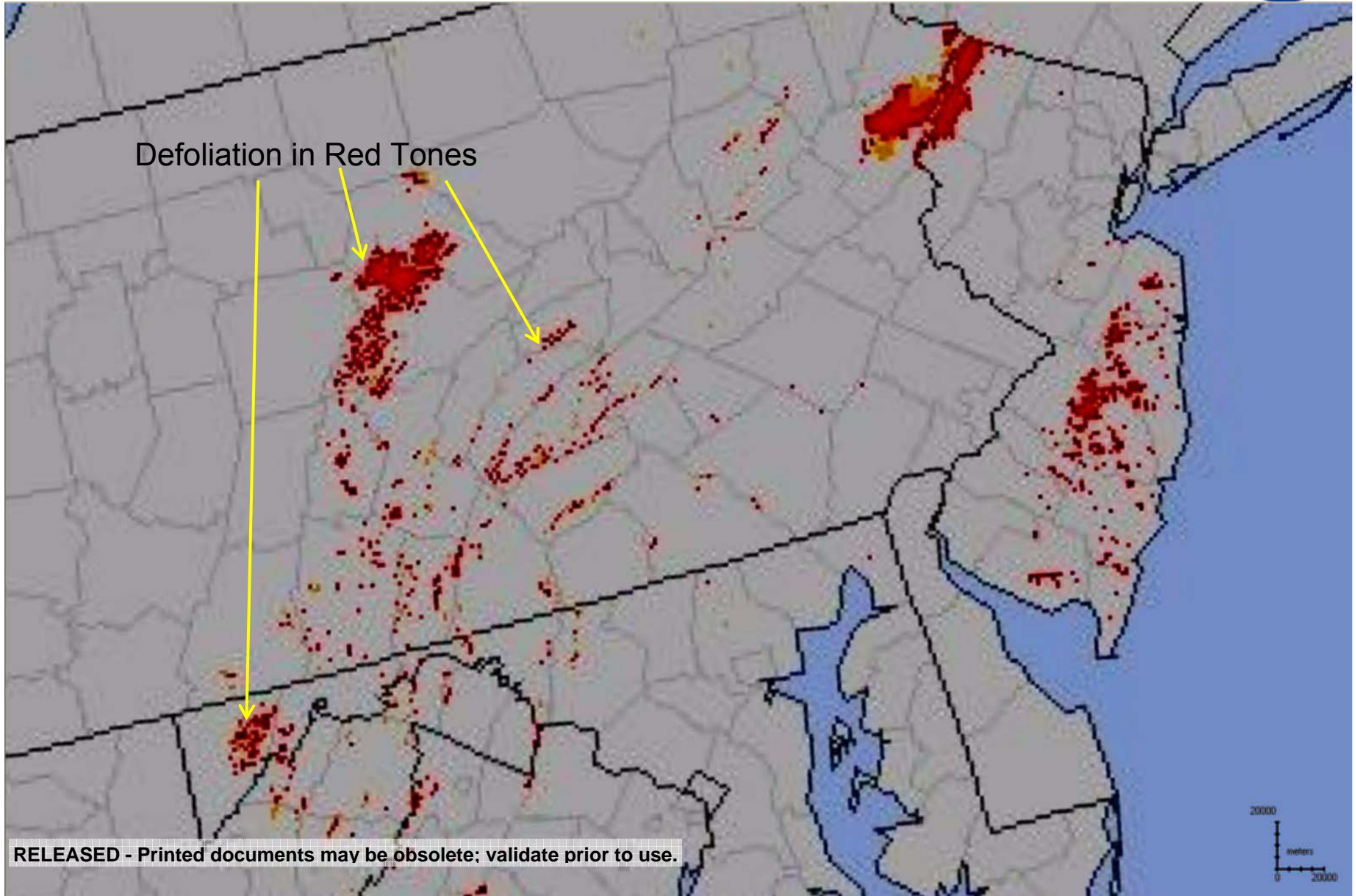


View of 2007 Gypsy Moth Defoliation From USFS Sketch Map

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Defoliation in Red Tones



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Relevance of Project



- The project showed potential of MODIS and VIIRS time series data for contributing gypsy moth defoliation 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)
- More work also needs to be done to assess potential of technology for nowcasts
- MODIS-based defoliation maps offer promise for complementing aerial sketch maps either in planning surveys and/or adjusting acreage estimates of annual defoliation

