

# Potential of VIIRS Time Series Data for Aiding the USDA Forest Service Early Warning System for Forest Health Threats: A Gypsy Moth Defoliation Case Study

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**Denuded, Partially Denuded, Chlorotic, and Green Forest Vegetation**

**Introduction and Overview** The Healthy Forest Restoration Act of 2003 mandated that a national forest threat Early Warning System (EWS) be developed. The USFS (USDA Forest Service) is currently building this EWS. NASA is helping the USFS to integrate remotely sensed data into the EWS, including MODIS data for monitoring forest disturbance at broad regional scales.

This RPC experiment assesses the potential of VIIRS (Visible/Infrared Imager/Radiometer Suite) and MODIS (Moderate Resolution Imaging Spectroradiometer) data for contribution to the EWS. In doing so, the RPC project employed multitemporal simulated VIIRS and MODIS data for detecting and monitoring forest defoliation from the non-native Eurasian gypsy moth (*Lymantria dispar*). Gypsy moth is an invasive species threatening eastern U.S. hardwood forests. It is one of eight major forest insect threats listed in the Healthy Forest Restoration Act of 2003. This RPC experiment is relevant to several nationally important mapping applications, including carbon management, ecological forecasting, coastal management, and disaster management.

This RPC experiment was performed during FY 2007 at Stennis Space Center. The mid-Appalachian highlands were selected for the project because extensive gypsy moth defoliation occurred over multiple years during the MODIS operational period.

**Early Warning System DST** To help build the EWS, the USFS has established eastern and western U.S. centers for forest environmental threat assessment. Each threat center has regional responsibility and both have collective national responsibility for developing needed infrastructure and capabilities to establish and maintain an EWS for forest health threats. Initial activities are underway to develop, refine, and implement remote-sensing-based forest health anomaly detection capabilities. In developing the needed applied technologies and infrastructure, the USFS forest threat centers will be integrating remotely sensed data products into the EWS. Once completed, the EWS will be a multi-scale GIS-based observatory of forest conditions within the United States.

**NASA Input** In this experiment, MODIS data and VIIRS data simulated from MODIS were assessed for their ability to contribute broad, regional geospatial information on gypsy moth defoliation, whereas Landsat and ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) data were used to assess the quality of gypsy moth defoliation mapping products derived from MODIS data and from simulated VIIRS data. The project focused on use of data from MODIS Terra as opposed to MODIS Aqua mainly because only MODIS Terra data was collected during 2000 and 2001: years with

comparatively high amounts of gypsy moth defoliation within the study area.

**USFS Early Warning System RPC Experiment** Gypsy moth defoliation mapping products from simulated VIIRS and MOD02 time series were produced using image classification and change detection via image differencing methods. The latter enabled an automated defoliation detection product computed using percent change in maximum NDVI (Normalized Difference Vegetation Index) for a peak defoliation period during 2001 compared to maximum NDVI across the entire 2000–2006 time frame. Final gypsy moth defoliation mapping products were assessed for accuracy using randomly sampled locations found on Landsat and ASTER data displays along with reference data from the USFS.

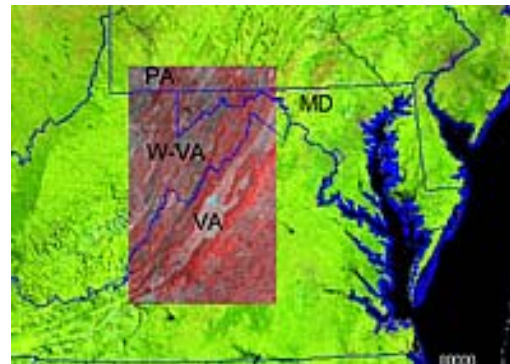
Extensive gypsy moth defoliation patches were evident on screen displays of multitemporal color composites derived from MODIS data and from simulated VIIRS vegetation index data. Such defoliation was particularly evident for 2001, although large areas were also seen for 2000 and 2003. These visualizations were validated using reference data, such as screen displays of Landsat and ASTER data, USFS sketch maps of gypsy moth defoliation, and publications discussing use of Landsat and/or SPOT data for mapping gypsy moth defoliation. Defoliation patches were visible on displays of MODIS-based NDVI and NDMI (Normalized Difference Moisture Index) data. The viewing of apparent defoliation patches on all of these products necessitated specialized processing in time frame and analysis method (e.g., maximum NDVI during the peak defoliation time frame). The frequency of cloud cover necessitated this approach.

The project assessed the quality of VIIRS data simulation. Hyperion data was employed to assess the quality of MODIS-based VIIRS simulation datasets using image correlation analysis techniques. The ART (Application Research Toolbox) software was used for data simulation.

Correlation analysis between MODIS- and Hyperion-simulated VIIRS data for red, NIR (near-infrared), and NDVI image data products collectively indicate that useful, effective VIIRS simulations can be produced using Hyperion and MODIS data sources.

The RPC experiment also generated MODIS-based time series data products using the Time Series Product Tool (TSPT) software. Time series of simulated VIIRS NDVI products were produced at approximately 400-meter resolution (i.e., Ground Sampling Distance or GSD) at nadir for comparison to MODIS NDVI products at either 250- or 500-meter GSD. The project also computed MODIS (MOD02) NDMI products at 500-meter GSD for comparison to NDVI-based products. For each year during 2000–2006, MODIS and VIIRS (simulated from MOD02) time series were computed during the peak gypsy moth defoliation time frame in the study area (~June 10 through July 27).

Multitemporal simulated VIIRS and MODIS Terra data both produced effective general classifications of defoliated forest versus other land cover. Automated defoliation detection products from circa 2001 simulated VIIRS and MOD02 data also yielded similar, relatively high overall classification accuracy. In contrast, the USFS aerial sketch map of gypsy moth defoliation showed a lower overall classification accuracy.



**~15.5 Million Acre Study Area Highlighted Received Heavy GM Damage in 2001**