# Spatial Analysis of West Nile Virus: Predictive Risk Modeling of a Vector-Borne Infectious Disease in Illinois by means of NASA Earth Observation Systems

DEVELOP

NASA

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## INTRODUCTION

West Nile Virus is a mosquito-borne virus of the family Flaviviridae. It infects birds and various mammals, including humans, and can cause encephalitis that may prove fatal, notably among vulnerable populations. Since its identification in New York City in 1999, WNV has become established in a broad range of ecological settings throughout North America, infecting more than 25,300 people and killing 1,133 as of 2008 (CDC, 2009).

WNV is transmitted by mosquitoes that feed on infected birds. As a result, the degree of human infection depends on local ecology and human exposure. This study hypothesizes that remote sensing and GIS can be used to analyze environmental determinants of WNV transmission, such as climate, elevation, land cover, and vegetation densities, to map areas of WNV risk for surveillance and intervention.

## GOALS

- Increase technical capacity to analyze NASA satellite data, a cost-effective and non-intrusive WNV monitoring method
- Analyze patterns between WNV vectors and selected environmental conditions using satellite remote sensing technologies and geographic information systems (GIS)
- Identify possible high-risk zones for outbreak. Help public health professionals establish targets for intervention and prevention by enhancing disease surveillance and monitoring through *SYRIS*™
- Establish public health contacts in Alabama and Illinois to coordinate future efforts

## ACKNOWLEDGEMENTS

Jeffrey C. Luvall, Ph.D., NASA Marshall Space Flight Center
Sarah Parcak, Ph.D., Director, UAB Laboratory for Global Health Observation (LGHO)
Donna Burnett, Ph.D., Program Manager, UAB LGHO
Ben Jacob, Ph.D., UAB School of Medicine
Robert Novak, Ph.D., UAB School of Medicine

## PARTNERS

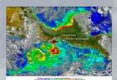
The UAB Laboratory for Global Health Observation

The UAB School of Medicine

The U.S. Geological Survey

## APPLICATIONS OF NATIONAL PRIORITY

Public Health



Ecological Forecasting

## SUMMARY

Satellite imagery can assist public health professionals in locating habitats that are likely sources and transmission sites for vector-borne illnesses such as West Nile Virus (WNV). The UAB-Marshall Space Flight Center NASA DEVELOP student team ascertained correlations between environmental factors and WNV vectors in two Mosquito Abatement Districts (MAD) in Cook County, Illinois, using Advanced Spaceborne Thermal Emission Reflection Radiometer (*ASTER*) satellite data sets. The risk of WNV transmission is associated with land cover type, and land use/land cover classifications and measures of vegetation health were generated to spatially analyze vector distribution and develop a predictive model. Collected data were entered into ARES Corporation's Syndrome Reporting Information System ™ (*SYRIS*) for use by health departments throughout the country to facilitate intervention and disease prevention.

## METHODS

- Two *ASTER* images of September 28, 2007, and two of April 15, 2005, were each combined to cover the area of interest, Desplaines Valley and Northwest MAD in Cook County, Illinois. Satellite imagery was processed with ERMapper 7.1 and ArcGIS 9.3 software to assess elevation, land use/land cover, vegetation, and soil moisture. Environmental data were compared to abundance data for 3745 *Culex pipiens* and *Cx. restuans* mosquitoes collected from gravid traps between May 9–Oct 14, 2004 by Dr. Novak and the lab of Geographic Medicine at UAB, funded by the Illinois waste tire fund.
- Using ArcGIS Geostatistical analyst, three methods of spatial interpolation (inverse distance weighting, universal kriging, and ordinary kriging) were applied to the mosquito geo-database to create a predictive map of abundance at unsampled areas based on environmental factors. Model results were cross-validated.
- Algothrithms for three measures of vegetation health— Normalized Difference Vegetation Index (NDVI), Soil Adjusted Vegetation Index (SAVI), Atmospheric Resistance Vegetation Index (ARVI)— were applied to ASTER imagery to assess potential for vector breeding zones.
- Using USGS 1/3-arc-second National Elevation Datasets (NED), a Digital Elevation Model (DEM) was constructed to map elevation and pinpoint exact locations of possible mosquito habitats. Low-lying areas were of specific interest because of their high moisture content, a common indicator of mosquito habitats.
- Unsupervised classification of the ASTER images was performed using ERMapper's Iterative Self-Organizing Data Analysis Technique (ISODATA) to aggregate the scene's spectral variability into unique clusters or classes of similar values. Supervised classification was performed to delineate land cover features that were potentially misclassified by the ISODATA. Vegetation was divided into evergreens, mixed vegetation, deciduous vegetation, and grass. Land cover was confirmed with Google Earth™.
- Data were formatted for uploading into *SYRIS*™, a platform for two-way disease information sharing and reporting. *SYRIS* provides instantaneous communication between concerned professionals.

**NASA MISSION**
Terra Mission (ASTER data)

## RESULTS

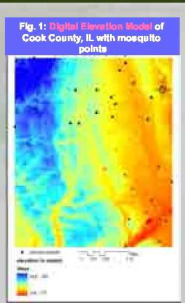



**FIGURE 1:** DEM showing elevation in meters; blue areas represent high elevations.

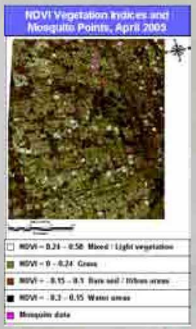
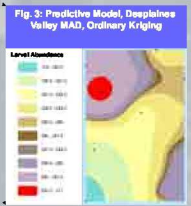



**FIGURE 2:** NDVI with mosquito points of Cook County, IL






**FIGURES 3, 4, 5:** Predictive models showing larval abundance in two Mosquito Abatement Districts (MADs) in Cook County, IL.

## RESULTS CONTD.

Analysis revealed a significant correlation between mosquito abundance and temperature, which mirrored findings of previous DEVELOP projects. Temperature was a significant predictor of mosquito abundance with counts of mosquitoes increasing as low temperature increased.

However, other results for additional environmental variables and the spatial interpolation model contradicted those of previous DEVELOP projects on the same subject of WNV in two ways. First, when both types of interpolation methods were applied to the datasets and compared, neither ordinary kriging nor IDW had the least error overall. Secondly, upon visual inspection of mosquito breeding sites, most mosquito points appeared to lie in moderately vegetated areas and agricultural areas surrounding urban areas.

## CONCLUSIONS & FUTURE RESEARCH

- This study was successful in correlating collected mosquito data with environmental data to create a geospatial model of WNV risk in Illinois. These methods can be applied to other areas to predict mosquito habitation and densities when trapping data are unavailable.
- Uploading data into *SYRIS* could possibly enhance outreach capability. This real-time surveillance platform could be used by local health agencies to describe risk when there are few case reports.
- Future efforts could combine mosquito data with bird infection and population census data to create an outbreak high-risk map for easier diagnosis and surveillance instead of relating vector abundance to landscape type alone.
- Future study will apply methods to Lyme disease vectors.

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## TEAM MEMBERS

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