Combating West Nile Virus with Remote Sensing

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In the late 1990's, NASA conducted research utilizing remote sensing and satellite imaging to track the spread of public health threats. Leveraging these capabilities, the Monterey County, California Health Department took pro-active steps to help address the threat of the West Nile virus in their community. Countywide maps were created with satellite images and matched with data to identify high-risk mosquito sources and habitats. The final outcome of the research helped identify at-risk communities, enhance virus and prevention planning, and inform land developers of what areas are at risk.

Imagine enjoying a nice day outside and getting bitten by mosquitoes - nothing unusual about that. However, what if, as a result of mosquito bites, you experienced symptoms such as nausea or fever, or worse, paralysis or even death? That is why, when the West Nile Virus (WNV) found its way to North America in 1999 via mosquitoes, the public became concerned about the suddenly harmful consequences a mosquito bite may carry.

In the years since its arrival, nearly every state has reported the presence of the virus. Leveraging NASA's capabilities to track the spread of public health threats assisted by satellite imaging, the Monterey County, California Health Department utilized remote sensing to take pro-active steps to address the threat of West Nile to its community.

About West Nile Virus

WNV is a mosquito-borne virus that affects the central nervous system in humans, horses and birds. WNV has been described in Africa, Europe, the Middle East, west and central Asia, Oceania, and most recently, North America. WNV was first isolated in the West Nile District of Uganda in 1937, and the virus became recognized as a cause of severe human meningitis or encephalitis in elderly patients during an outbreak in Israel in 1957. WNV was first detected in the United States in the fall of 1999 in New York City. Since then, more than 4000 cases of infection with WNV have been detected in nearly every state, including California.

Most often, WNV is spread by the bite of an infected mosquito. Mosquitoes are WNV carriers that become infected when they feed on infected birds. Infected mosquitoes can then spread WNV to humans and other animals. In 2002, four additional routes of transmission to humans were documented: blood transfusion, organ transplantation, transplacental transfer and breastfeeding.

The incubation period in humans is usually three to 14 days, and most WNV infections are nearly unnoticeable. Approximately 80 percent of people infected with WNV will not show any symptoms at all, but about 20 percent of infected people will develop a milder form of disease known as West Nile Fever. Symptoms include fever, head and body aches, and occasionally a skin rash or swollen lymph glands; and these symptoms often last for just a few days, though even healthy people have been sick for several weeks. About one in 150 people infected with WNV will develop severe illness, with severe symptoms that can

include high fever, headache, neck stiffness, stupor, disorientation, coma, tremors, convulsions, muscle weakness, vision loss, numbness and paralysis. These symptoms may last several weeks, and neurological effects may be permanent.

The most significant risk factor for developing severe neurological disease is advanced age. People over 55 years of age are considered to be at highest risk of contracting the virus, as their immune systems are weaker. Because Monterey County is one of California's largest retirement communities with a high percentage of senior residents, the County needed to be especially attentive to this virus.

NASA West Nile Virus Research

NASA, through its Public Health Applications Program, is conducting research that allows public health officials to better track and predict the spread of WNV. NASA has provided innovative technologies, data and satellite imagery to empower efforts to combat the disease. The program is designed to supply public health agencies with access to NASA information so they can better understand how and where WNV spreads, focus resources and battle the disease more efficiently.

Working in conjunction with federal, state and local public health agency initiatives, three NASA programs are playing key roles in WNV research. The Healthy Planet program is working to publicly disseminate information from NASA satellites and databases, scientific research and communications networks. The International Research Partnership for Infectious Diseases (INTREPID) is developing databases derived from satellite data to show nation-wide temperatures, distributions of vegetation, bird migration routes and areas of reported cases. Additionally, the NASA Center for Health Applications of Aerospace Related Technologies is evaluating how remote sensing and GIS can be used to locate habitats in California's Sacramento valley with favorable conditions for both birds and mosquitoes. The project specifically tracks encephalitis, which is caused by a virus similar to WNV that also primarily infects birds through mosquitoes.

Together, these programs help scientists predict disease outbreaks by showing when and where habitats are suitable for mosquitoes to thrive and where the WNV appears to be spreading.

Monterey County, California

Realizing NASA was doing similar work, the Monterey County Health Department contacted NASA's research center and in 2003 received a grant from NASA to conduct its own project. The project's main goals were to identify mosquito habitats that; correlate the habitats with the County's vulnerable population; and create a risk map to help decision-makers effectively combat WNV.

The Health Department worked with four students from NASA's DEVELOP Program, based at the Ames Research Center in Moffett Field, California, who conducted research and analysis for the project. This included the development of risk maps, satellite images of the area with overlays depicting mosquito concentrations in the County.

The students made ground surveys of mosquito habitat then matched their data with satellite pictures and data to make a countywide map that officials are using to help deploy mosquito abatement teams and equipment. The project was divided into two phases: in Phase I, the vector maps were created and in Phase II, a dynamic GIS was implemented for virus incident and response tracking. Initially, the areas at highest risk of being infiltrated by the virus had to be identified. This was done by mapping the disease carriers' breeding source and adult habitat areas in correlation with county population. Landsat 7 ETM+ images of the County were acquired.

With ERDAS IMAGINE® software, supervised and unsupervised classification of vegetation and urban areas were run to identify potential mosquito habitats. Additionally, the students used IMAGINE Spectral Analysis tools for model building and radiometric correction of the studied areas.

The vegetation classification was put into a vector coverage to integrate with other data layers within the ESRI ArcGIS environment. Overlay analysis was conducted to produce three specific layers that targeted the problem. These layers mapped:

- Mosquito breeding source areas,
- Adult mosquito habitat areas, and
- High-risk mosquito source and habitat areas.

The three mosquito species most likely to carry the virus were identified. The students queried the specific traits and habitats of these species and received distinct outputs, such as specific fly-zones, for each mosquito species. From this information, two maps were created: the Mosquito Vector Risk Map for Monterey County and the West Nile Virus Surveillance Risk Map for Monterey County.

The Risk Map depicts high-risk areas in red. These are mosquito breeding areas that are located close to densely-populated areas, including hospitals, retirement centers and horse facilities. It appears that such areas required a more aggressive stance in reducing mosquitoes, especially if WNV becomes active in the region. The Surveillance Risk Map shows potential entry points of the virus, near wetlands and mixed forest lands. It also identifies the most high risk mosquito sources and habitats, as well as existing and proposed sentinel flock and mosquito traps.

Within IMAGINE VirtualGIS®, a fly-through of the County which was created. The fly-through model serves as an excellent public education and information tool. It has been very effective in driving home the message to the public that the County is doing everything possible to prepare for possible outbreak of this disease and that citizens must do their part by taking responsibility for their own property.

"The final outputs of this project have helped identify at-risk communities, enhance virus planning and prevention planning and inform land developers seeking building permits become aware of what areas are more at risk," said Darryl Tyler, GIS Analyst, Monterey County IT Department. "These maps are also helping influence virus policy and management decision-makers."

The map outputs of Phase I provided a baseline assessment of the County's vulnerability to WNV. This allowed the County to take educated surveillance measures to determine where limited resources would have the greatest effect. The data is being used by the Northern Salinas Valley Mosquito Abatement District (NMCMAD) and the County of Monterey.

These maps also provided the data necessary for Phase II, the creation of a dynamic GIS used for incident and response tracking. This is being done by the County health department's Environmental Health Division. The division is responsible for investigating and mitigating mosquito activity complaints in Monterey County not covered by the NMCMAD.

Remote sensing and GIS technology were valuable to Monterey County in taking pro-active steps to protect its citizens from the invasion of the WNV. The mosquito surveillance project is enabling Monterey County officials to more effectively direct their mosquito abatement program to areas where the WNV would most likely affect its residents, particularly at-risk people who are 55 and older. Now, the County will be forewarned of the presence of the virus before it hits populated areas.

Furthermore, since the methodology of this project is adaptable to the study of any arbor virus carrier such as a mosquito, tick or flea, it can be repeated as needed. Other government organizations are taking notice of the effectiveness of this project and are considering using the methodology for their own purposes.

"This project was key in helping decision-makers understand that remote sensing technology is capable of much more than providing nice photos," said Tyler. "They realized that remote sensing proved to be a highly-effective tool for assessing current and future diseases."

Images and maps are available on www.co.monterey.ca.us/health. For current information on West Nile Virus in Monterey County, log onto westnile.ca.gov/maps.htm.