HUMAN AND ENVIRONMENTAL INFLUENCES ON ECOSYSTEM SERVICES AND WEST NILE VIRUS VECTOR INFECTION IN SUFFOLK COUNTY, NEW YORK (USA)

Mark H. Myer\textsuperscript{1}, Scott R. Campbell\textsuperscript{2}, and John M. Johnston\textsuperscript{1}

\textsuperscript{1}Computational Exposure Division, Watershed Exposure Branch, USEPA/ORD, Athens, Georgia, USA

\textsuperscript{2}Arthropod-Borne Disease Laboratory, Suffolk County Department of Health Services, Yaphank, NY, USA
• West Nile Virus is a mosquito-borne disease endemic in Suffolk County, NY.

• Surveillance programs sample mosquito populations across the county and test for the presence of West Nile.
Factors Influencing WNV Ecology

- **Land cover and use**
  - WNV mosquitoes are associated with developed land.

- **Weather**
  - Warm weather and low precipitation favor WNV transmission.
  - Cases occur in the summer.

- **Anthropogenic influences**
  - WNV mosquitoes breed in containers and ponds.
  - Water contaminated with nutrient and organic runoff favors WNV mosquitoes.

http://www.cdc.gov/ncidod/dvbid/westnile/surv&control.htm

http://www.esrl.noaa.gov/psd/data/usclimdivs/
• Previous models of West Nile in mosquitoes struggled to incorporate spatial and temporal variability.

• The Integrated Nested Laplace Approximation – Stochastic Partial Differential Equation (INLA SPDE) allows a complex spatiotemporal model in common R statistical software.
Variables Evaluated

- 21 SSURGO soil types
- Septic systems
- NDVI
- 6 DAYMET weather variables
- 15 NLCD land cover types
Septic Systems on Long Island

- Population grew by 471% between 1940-1970, leading to a construction boom.

- 74% of residences are unsewered.

- Unusually high prevalence of old, unserviced cesspool systems.

- “Much of the nitrogen pollution in Suffolk County waters has been linked to unsewered, dense suburban sprawl” - Suffolk County Comprehensive Water Resources Management Plan 2015.


Source: riverheadlocal.com
Septic Systems as Mosquito Habitat

Source: Marin Sonoma Mosquito & Vector Control

Source: affordableseptics.com
Variable Selection

<table>
<thead>
<tr>
<th>Variable 1</th>
<th>Variable 2</th>
<th>Variable 3</th>
<th>Variable 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value 1</td>
<td>Value 2</td>
<td>Value 3</td>
<td>Value 4</td>
</tr>
<tr>
<td>Value 5</td>
<td>Value 6</td>
<td>Value 7</td>
<td>Value 8</td>
</tr>
<tr>
<td>Value 9</td>
<td>Value 10</td>
<td>Value 11</td>
<td>Value 12</td>
</tr>
</tbody>
</table>

Further details and analysis can be found in the report.
Variable Selection
# Regression Results

<table>
<thead>
<tr>
<th>Variable name</th>
<th>Coefficient (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Water</td>
<td>-0.92 (-1.29:-0.57)</td>
</tr>
<tr>
<td>Average Temperature</td>
<td>0.29 (0.15:0.42)</td>
</tr>
<tr>
<td>Septic Count</td>
<td>0.23 (0.09:0.40)</td>
</tr>
<tr>
<td>Woody Wetlands</td>
<td>-0.14 (-0.29:-0.01)</td>
</tr>
<tr>
<td>Precipitation</td>
<td>-0.11 (-0.20:-0.02)</td>
</tr>
<tr>
<td>NDVI</td>
<td>-0.14 (-0.34:0.07)</td>
</tr>
<tr>
<td>Developed, Low Intensity</td>
<td>-0.08 (-0.29:0.11)</td>
</tr>
<tr>
<td>Emergent Herbaceous Wetlands</td>
<td>-0.02 (-0.19:0.16)</td>
</tr>
<tr>
<td>$\sigma_s^2$ (spatial variance)</td>
<td>1.29 (0.40:3.36)</td>
</tr>
<tr>
<td>$r$ (spatial range)</td>
<td>82 (32:191)</td>
</tr>
<tr>
<td>$\varphi$ (AR1 coefficient)</td>
<td>0.98 (0.94:0.99)</td>
</tr>
</tbody>
</table>
Spatial Regression Results

Units are log-odds of a mosquito pool testing positive for WNV
Septic Systems as Nitrogen Polluters

Long Island has a high water table, and groundwater is the only freshwater source.
Healthy Wetlands Reduce Vector-Borne Disease

Year-round wetland availability discourages clustering of birds and bridge vectors.

Avian biodiversity “dilutes” community composition away from WNV reservoirs.

Source: myweb.rollins.edu
Conclusions

- Septic systems are correlated with an increase in WNV incidence.

- Woody wetlands are correlated with a reduction in WNV incidence.

- Nitrogen pollution from septic systems is known to degrade wetlands.
  - A modest negative correlation was found between septic count and woody wetland cover, $r = -.306$
  - Dynamics of the relationship as it relates to WNV are unknown.
• Prevention of disease is valuable, especially for life-threatening diseases spread by mosquitoes.
  • Existing treatment and prevention efforts are expensive and time-consuming.

• The relationship between healthy wetland function and vector-borne disease prevention merits further research to determine whether prevention represents an overlooked wetland service.