EPA United States Environmental Protection Agency

2018 ACES A Community on Ecosystem Services
Natural Resources Benefitting People
Celebrating 10 years of ACES!

In partnership with ECOSYSTEM MARKETS Making Them Work
ESP Ecosystem Services Partnership

Ecosystems and spatiotemporal mosquito-borne disease models across a gradient of urbanization

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Office of Research and Development
National Exposure Research Laboratory , Computational Exposure Division

United States Environmental Protection Agency

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West Nile Virus

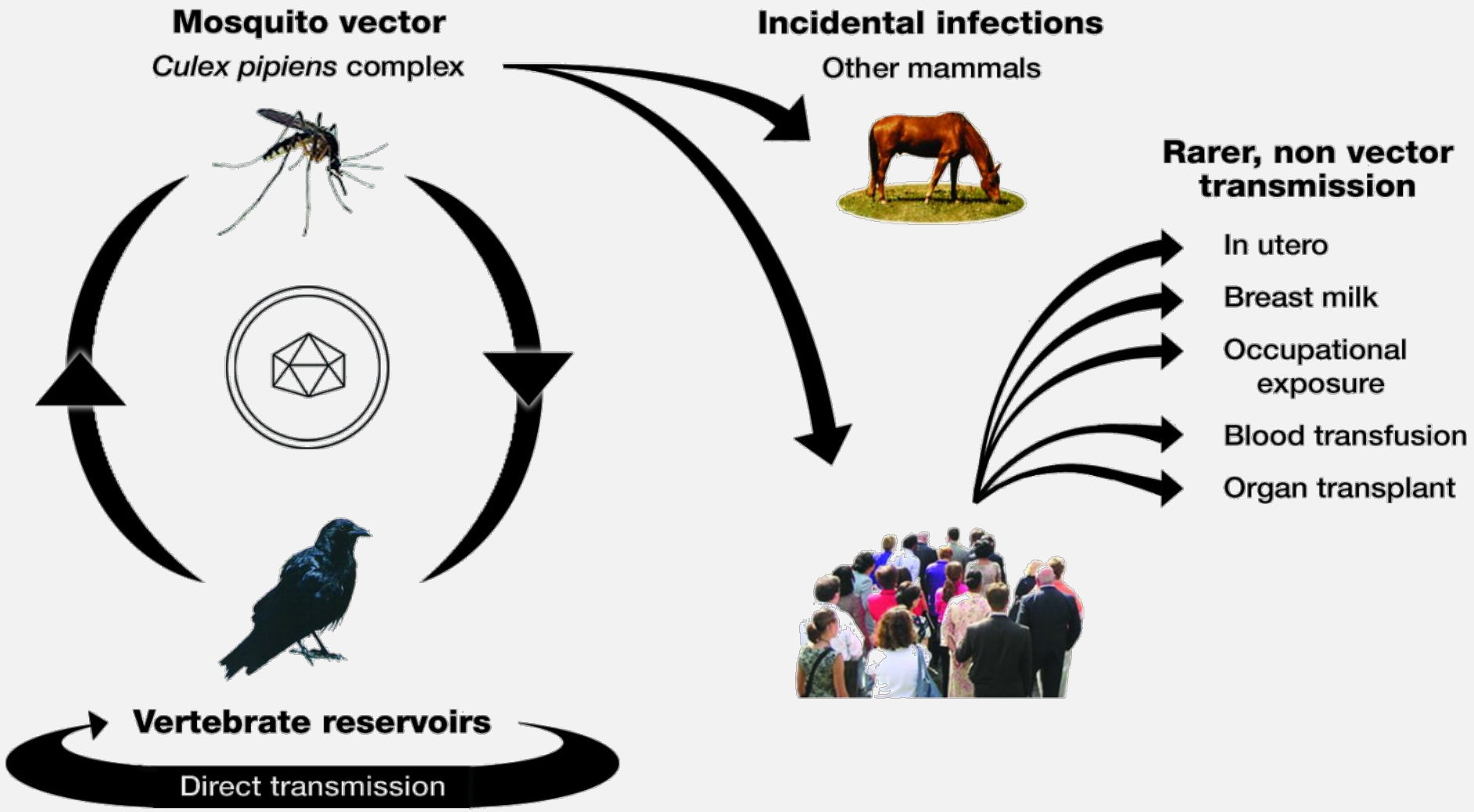

Figure from: Gould L.H., Fikrig E. West Nile Virus: a growing concern? *J Clin Invest.* 2004;113(8):1102-1107. https://doi.org/10.1172/JCI21623

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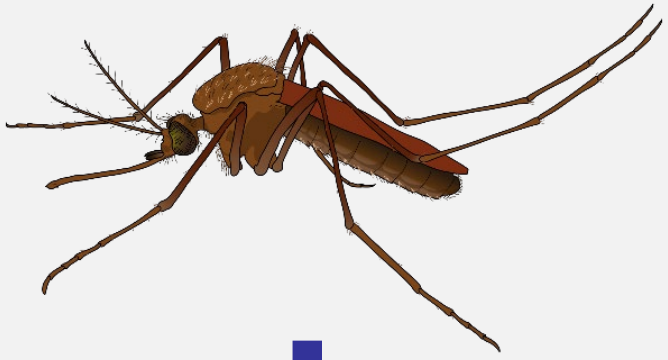
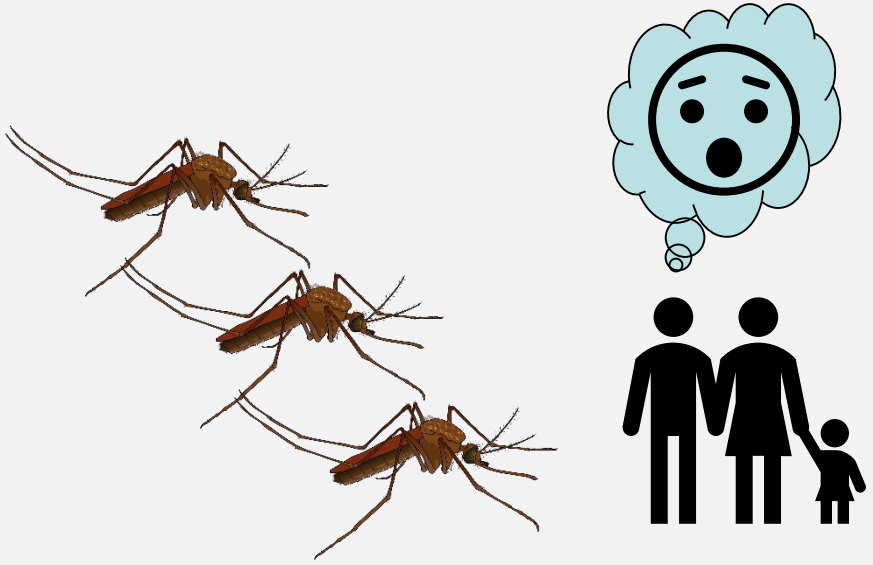
Culex pipiens-restuans



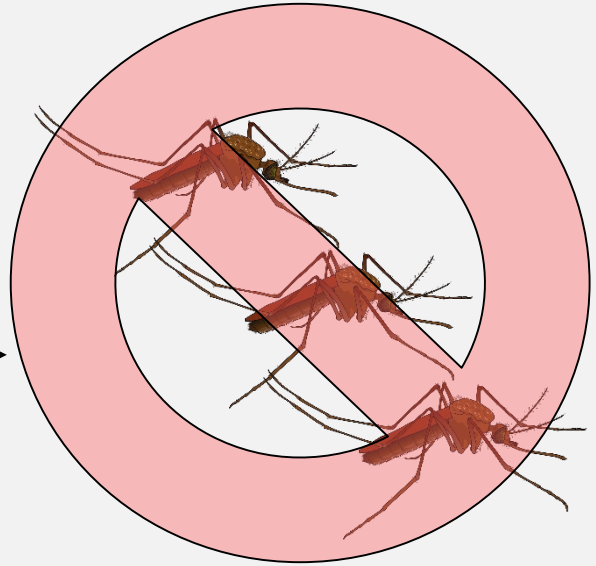
ES and Mosquitoes

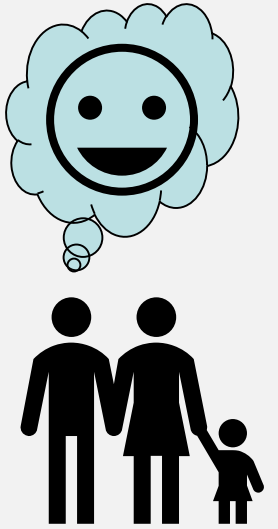
Disservice



ES and Mosquitoes

Service





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Research Questions:

What ecological characteristics predict WNV incidence, controlling for location and time?

What do those predictors tell us about the dynamics of WNV in New York?

Rural vs. suburban vs. urban?

What do the spatial and temporal model components tell us in context of prevention?

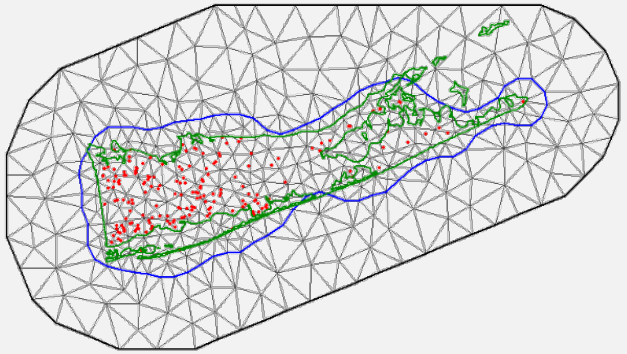
INLA SPDE

Integrated Nested Laplace Approximations with Stochastic Partial Differential Equations

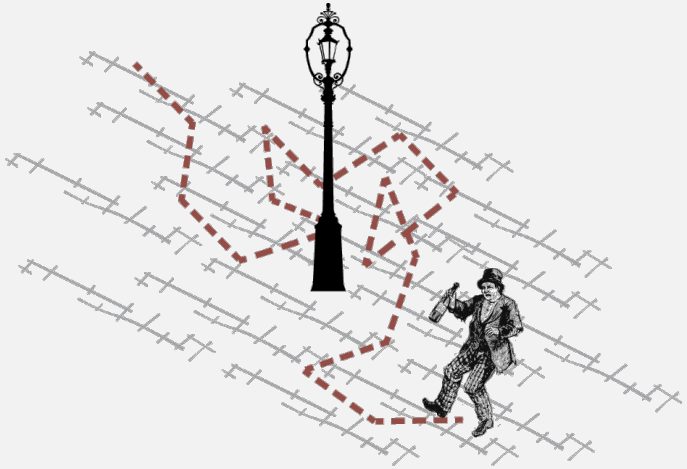
It's Bayesian…

$$\underbrace{P(A|B)}_{\text{Posterior}} = \frac{\overbrace{P(B|A)}^{\text{Prior}} \times P(A)}{\underbrace{P(B)}_{\text{Evidence (data)}}}$$

and spatial…

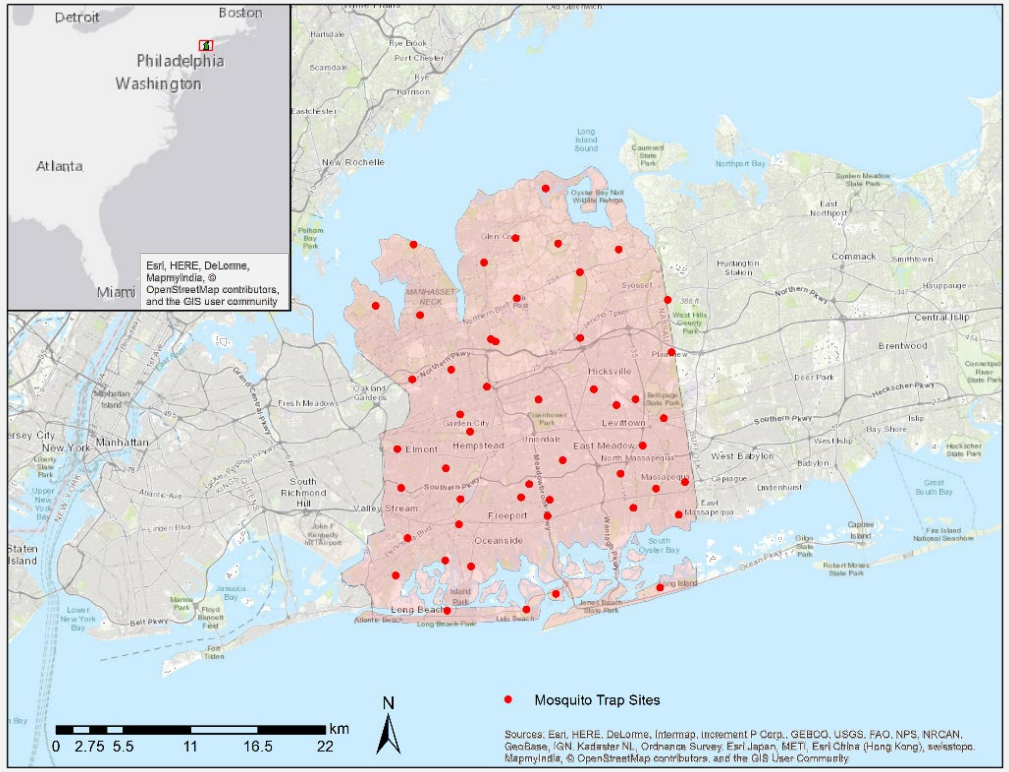


and temporal.



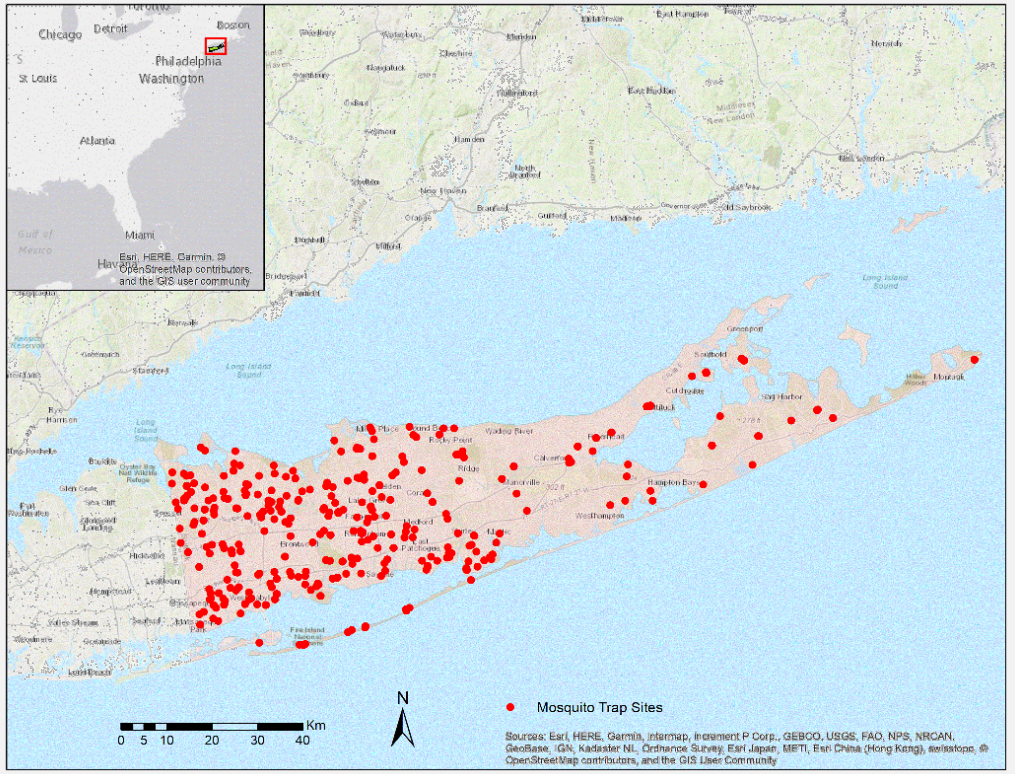
And it runs in

Datasets



Nassau County, NY

2001 – 2015
49 trap sites
5,474 observations

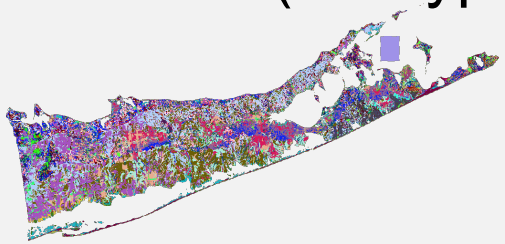


Suffolk County, NY

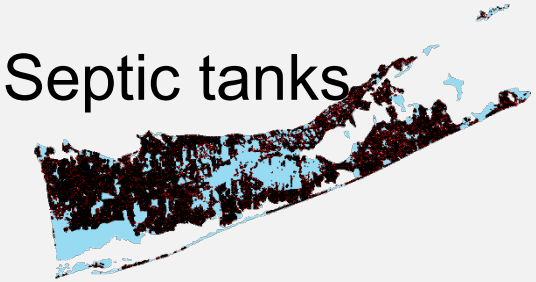
2008 – 2015
193 trap sites
10,596 observations

Input Variables

SSURGO (soil type)

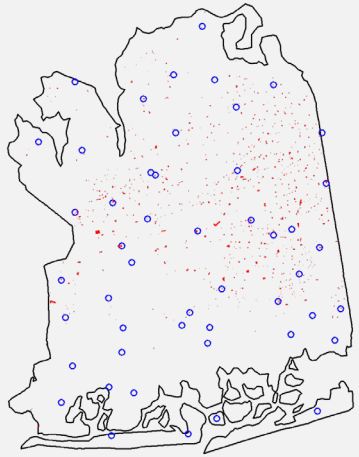


Septic tanks

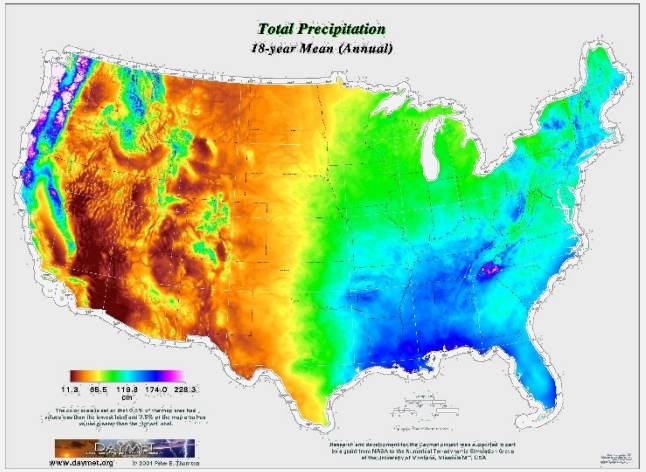


NDVI

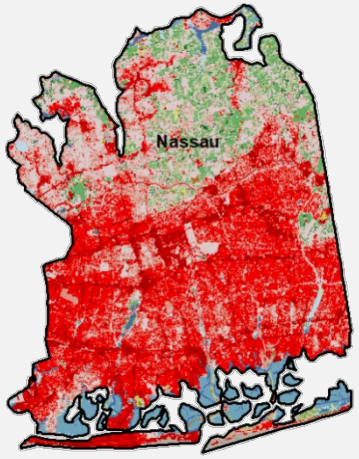
Stormwater basins

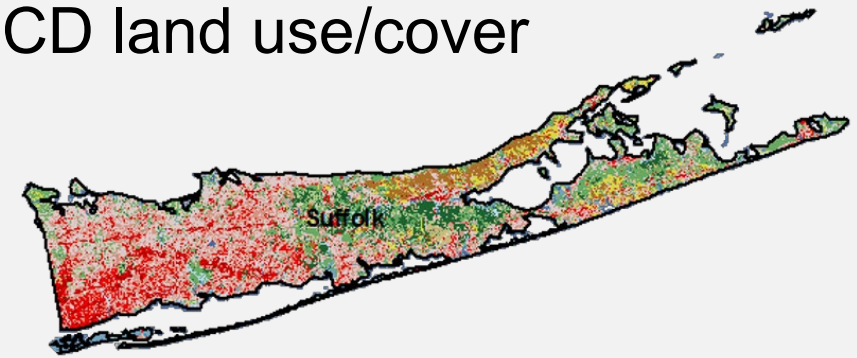


DAYMET (daily climate)

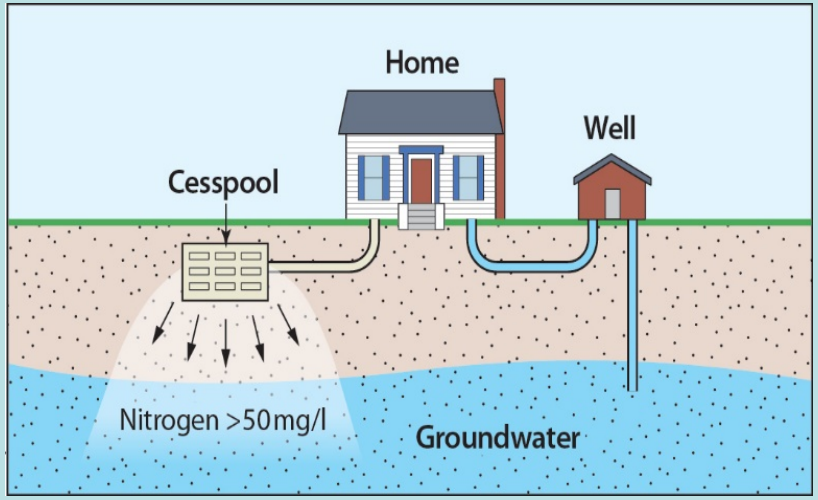


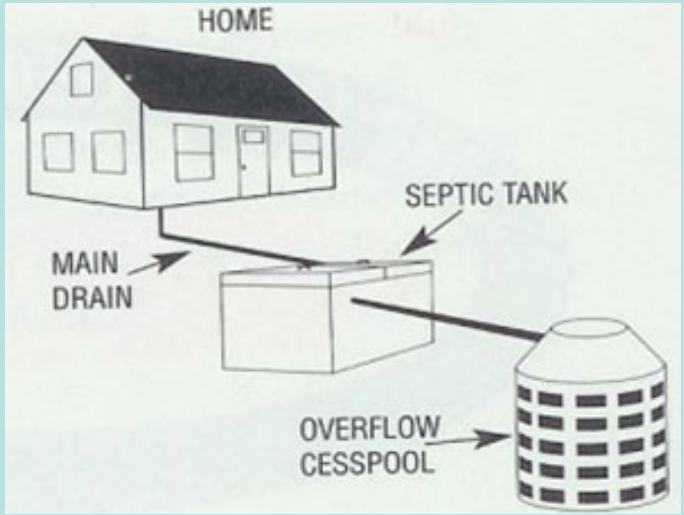
NLCD land use/cover





Septic Systems?





Results

Positive

Negative

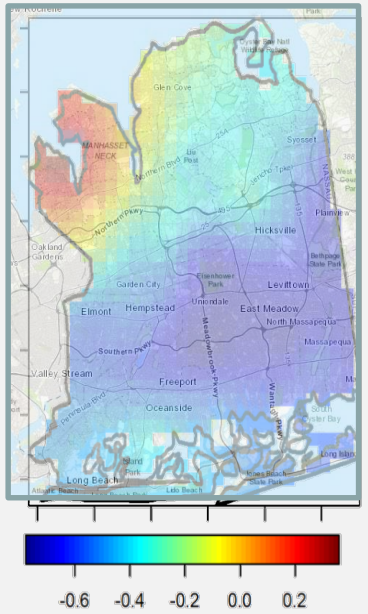
Bold: statistically "important"

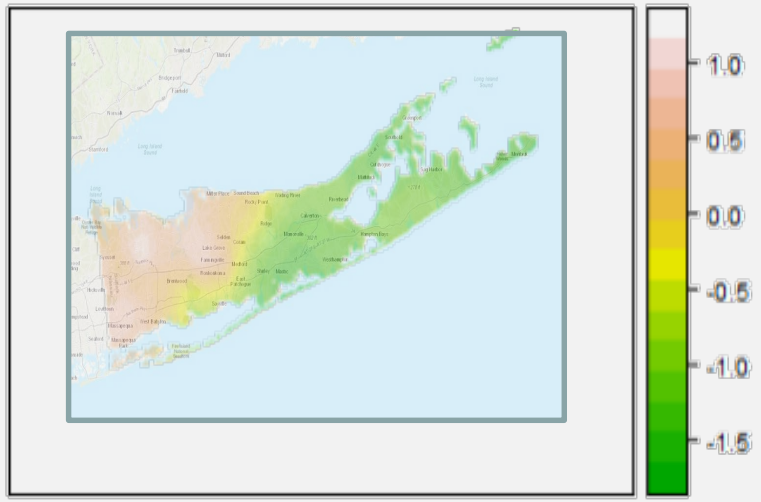
Magnitude of coefficient

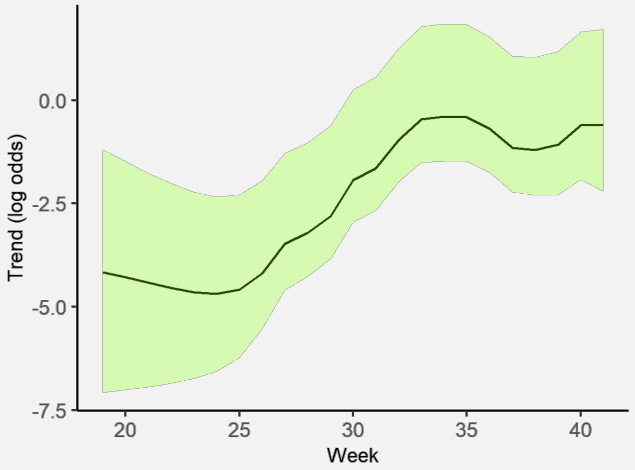
Nassau County	Suffolk County
NDVI (Vegetation index)	**Open Water**
# Mosquitoes Trapped	**Temperature**
Temperature	**Septic Count**
High Intensity Development	**Woody Wetlands**
Open Water	**Precipitation**
Emergent Herbaceous Wetlands	NDVI
Precipitation	Low Intensity Development
Catch Basin Area	Emergent Herbaceous Wetlands

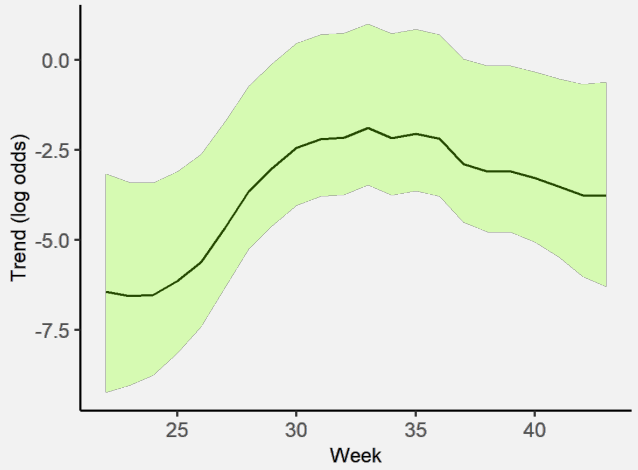
More urban → Less urban

Results





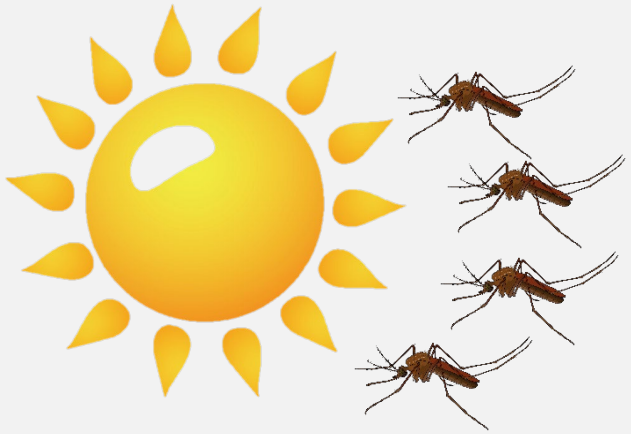




Units: log-odds

Meteorological Variables

Temperature



Development time

Blood meals

Precipitation

Flushes eggs & larvae

Wetlands and WNV

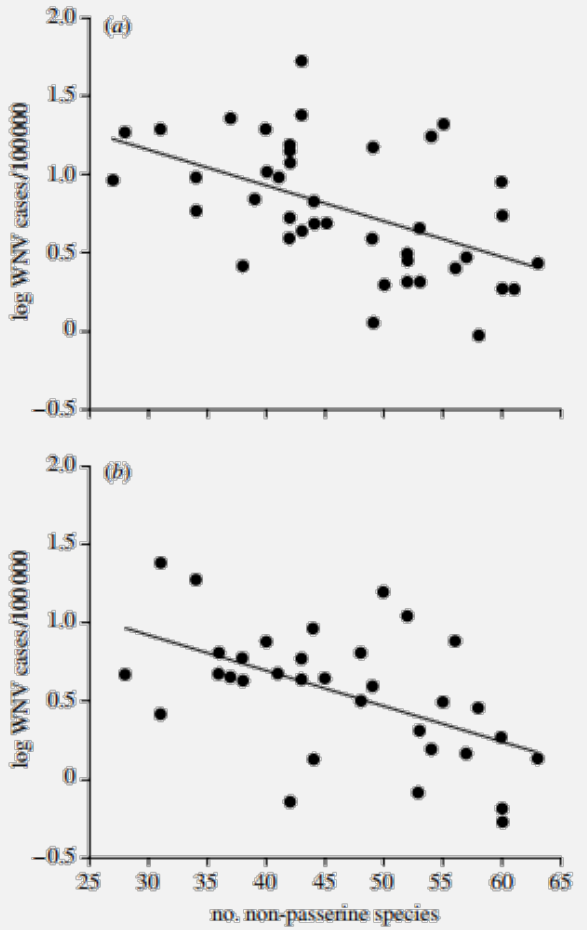
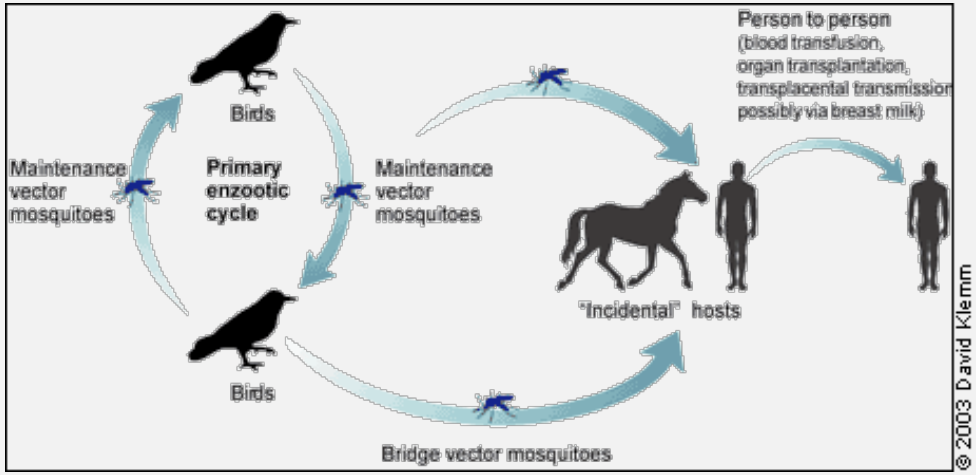


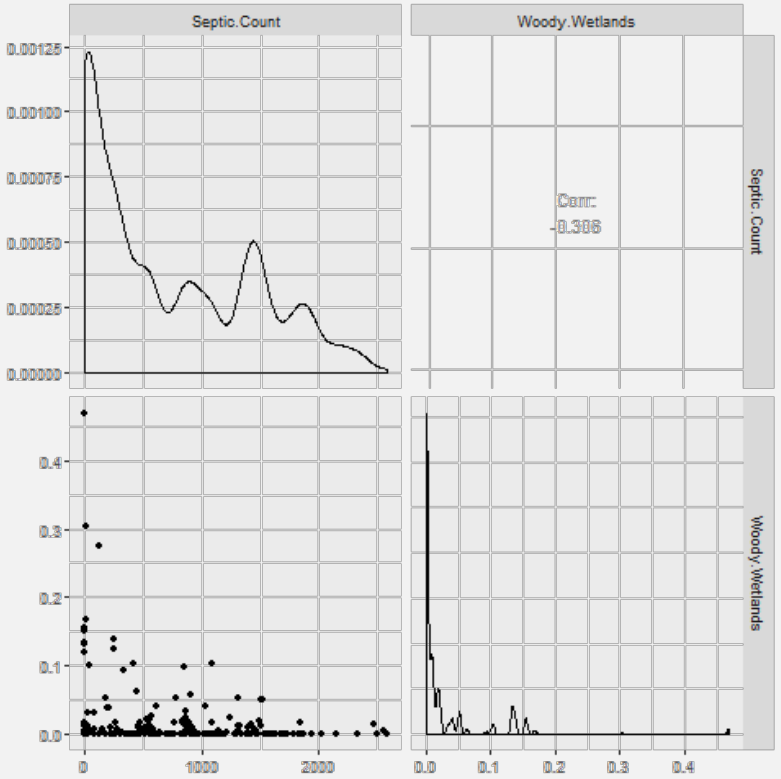
Figure 3. Relationship between human WNV disease incidence by county and non-passerine species richness in (*a*) 2002 and (*b*) 2003. In minimum adequate multiple regression models, non-passerine species richness was the sole predictor of disease incidence in 2002 ($r=-0.52$, $t=-3.79$, $p<0.001$), and one of two predictors of disease incidence in 2003 ($r=-0.34$, $t=-2.49$, $p<0.05$).

Avian biodiversity ↑

WNV incidence ↓



Septics, Wetlands, and WNV

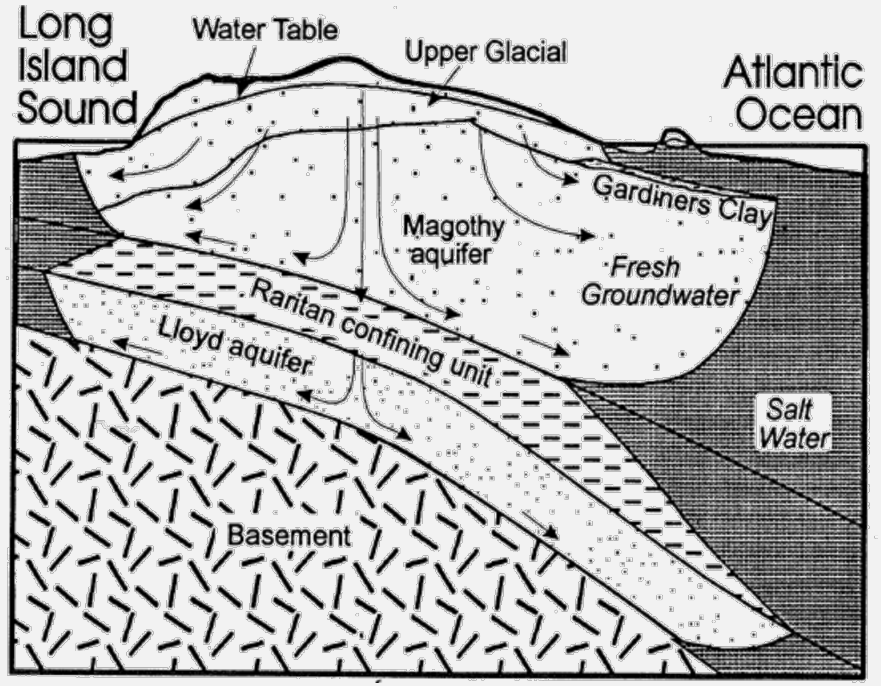


Culex restuans (Diptera: Culicidae) Oviposition Behavior Determined by Larval Habitat Quality and Quantity in Southeastern Michigan

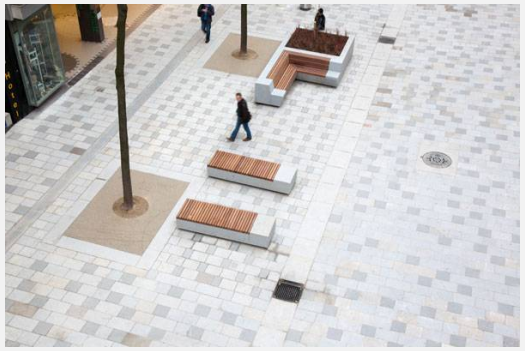
Michael H. Reiskind, Mark L. Wilson

Linking environmental nutrient enrichment and disease emergence in humans and wildlife

Pieter T. J. Johnson,[1,*] Alan R. Townsend,[1,2] Cory C. Cleveland,[3] Patricia M. Glibert,[4] Robert W. Howarth,[5] Valerie J. McKenzie,[1] Eliska Rejmankova,[6] and Mary H. Ward[7]



Greenness and Urbanization



WNV Incidence

Interspecies competition, not enough WNV reservoirs

Not enough habitat or WNV reservoirs

Urbanization →

Study Area Comparison

Nassau County

Urban/Suburban

Suburbs at higher risk

Catch basin treatment is working

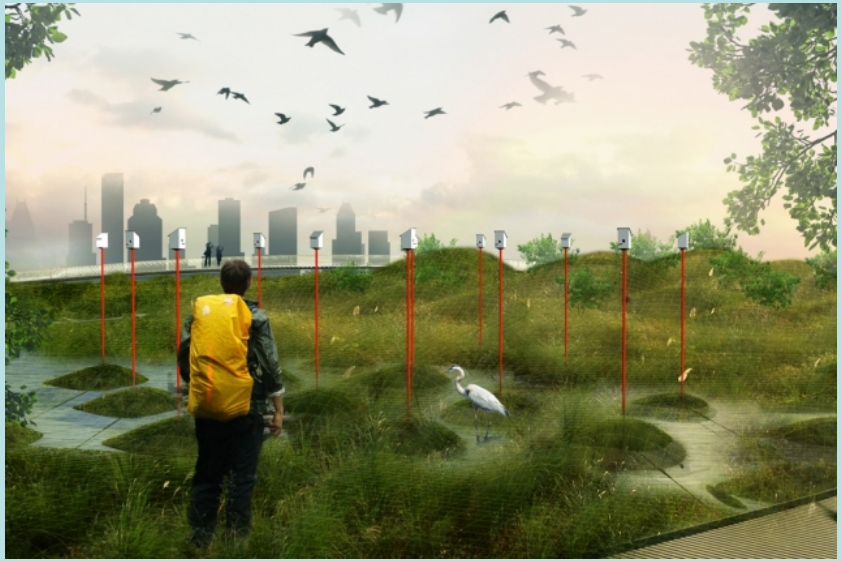
Suffolk County

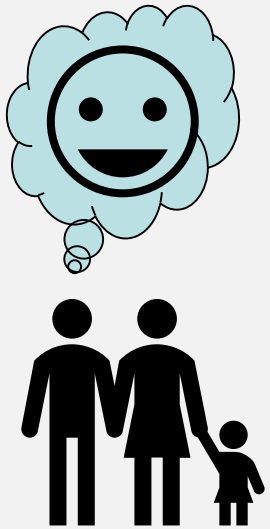
Rural/Exurban

Woody wetlands protective

Septic systems present additional risk

Urban Ecosystem Services to Reduce WNV





Continuing Work in Texas