An environmentally informed statistical model and forecast system for West Nile virus infection rates among mosquitoes in the Coachella Valley, CA

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Why Forecast Infectious Diseases?

– Infectious disease patterns continually shift
– Within infectious disease outbreak response is reactive
  • Based on ongoing surveillance
– Accurate, reliable forecasts with sufficient lead times would provide greater opportunity to plan adaptive mitigation and control efforts
– Influenza, Ebola, Dengue, West Nile virus
Impact of WNV in the US
West Nile Virus Transmission Cycle

Amplifier Host

Vector

Zoonotic Transmission Cycle

Incidental Transmission “Spillover”

“Dead End” Host
Environmental Components Influence the Transmission Cycle

Humidity  Temperature  Hydrology/Precipitation
Temporal variability of Mosquito infection rates

Background
Spatial variability of mosquito infection rates

Background
Prevention

- No human vaccine or specific treatment
- Personal protection
  - Mosquito repellent
  - Long sleeve shirts and pants
- Community based mosquito control programs
Aim

- Identifying the key environmental conditions that facilitate and accelerate West Nile transmission
- Identify this at an appropriate spatial scale to effectively inform vector control.
Environmental parameters that drive infections rates

• ECOSTRESS
  – Land surface temperature
  – Evapotranspiration
• Multimodel inference system
  – Ensemble of statistical models
  – All parameters statistically significant
  – Model weights were generated relative to best fit model
Environmental predictions at 13 km²

- Climatic conditions associated with the enzootic cycle between mosquito vectors and bird hosts.
  - Dry to wet winter
  - Followed by a warm spring
  - Cool summer
Results

Retrospective Forecasts
2019, 2020 and 2021

3-Predictor NLDAS-scale forecast

Threshold absolute difference: 1 infected mosquito per 1000 tested
Environmental predictions at 13 km²

Results

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  - Dry to wet winter
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Results

ECOSTRESS 2020

[Map showing geographic data with symbols for negative and positive results, with a scale indicating ET mean z-score and a compassrose.]
Results

WNV Disease Emergence

Changes in the hydrological conditions associated with the onset of detecting WNV in a localized area.

- Dry to wet
Results

ECOSTRESS Predicting Onset

Specificity = 0.83
Sensitivity = 0.64
Potential to help guide public health interventions

- WNV transmission is driven by an enzootic cycle between mosquito vectors and bird hosts
- Identifying key environmental conditions that facilitate and accelerate this cycle may be used to inform effective vector control
- Statistical models using ECOSTRESS', 70 m resolution, showed that drier than normal conditions followed by an increase in moisture was associated with an increase in detecting WNV infected mosquitoes for the region
- ECOSTRESS has the potential to identify changes in hydrologically rich areas where mosquitoes and birds interact during warm spring months at the start of seasonal WNV transmission

Changes in the hydrological conditions associated with the onset of detecting WNV in a localized area.

Mean evapotranspiration (ET) (W/m²) as measured by ECOSTRESS in the Coachella Valley, CA during the early season (Panel A: March - May) and late season (Panel B: June - Aug) with trap locations (red X) for 2019.

Forecasted infection rates 2021, Coachella Valley, CA.
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Questions?