Fight the Bite - Applying Remote Sensing Technologies to Detect Mosquito Breeding Habitats

CWI Workshop
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Mosquito-Borne Diseases

**Aedes spp.**
- Chikungunya
- Dengue fever
- Lymphatic filariasis
- Rift Valley fever
- Yellow fever
- Zika

**Anopheles**
- Malaria
- Lymphatic filariasis

**Culex**
- Japanese encephalitis
- Lymphatic filariasis
- West Nile fever

[Link to Gates Notes: Health/Most-Lethal-Animal-Mosquito-Week](https://www.gatesnotes.com/Health/Most-Lethal-Animal-Mosquito-Week)
Major Limitations of Mosquito Borne Disease Prevention

1. Majority of these diseases originate in infrastructure-poor, resource-limited countries
   I. Hard to predict spread of new Mosquito-Borne Diseases
      a. Arboviral mutations
         i. Unpredictable jump to new mosquito species-animal hosts
      b. Lack of surveillance
         i. Can’t identify new epidemics
         ii. Can’t track spread
         iii. Unaware of highest-risk populations

2. Globalization contributes to spread of disease

3. Paucity of available diagnostics, vaccines, and therapeutics
Zika Epidemic in the Americas

2007–2009
State of Yap, Micronesia
New Caledonia
Cook Islands
2012–2014
French Polynesia
Easter Island, Chile
Philippines
Cambodia
Indonesia
Thailand
2015
January–October
Malaysia
Vanuatu
Fiji
Colombia
2015
November
Brazil
Cape Verde
Samoa
Solomon Islands
El Salvador
Guatemala
Mexico
2015
December
Paraguay
Suriname
Venezuela
French Guiana
Honduras
Martinique
Panama
Puerto Rico
2016
January
Bolivia
U.S. Virgin Islands
Dominican Republic
Costa Rica
Guadeloupe
St. Martin
Nicaragua
Barbados
2016
February
Ecuador
Guayaquil
Jamaica
Curaçao
Maldives
2016
March
Haiti
American Samoa
Tonga
Bonaire
St. Maarten
Cuba
Dominica
Laos
New Caledonia
St. Maarten
Cuba
Dominica

Use of Remote Sensing and Geographic Information Systems to Predict Locations of Anopheles darlingi-Positive Breeding Sites Within the Sibun River in Belize, Central America

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Examination of the confusion matrix indicated a 75.9% accuracy rate by which all land cover categories were classified. Bare ground, forest, and pasture/low grass land cover categories had the highest accuracy rates with 98.8, 97.0, and 94.9% of the pixels being correctly classified, respectively. The orchard and sandbar land cover classes suffered from the worse classification confusion, with 58.8 and 58.6% of the pixels, respect-
ExxonMobil Upstream Activities

• Application of Remote Sensing Technologies
  – Assess environmental impact
    • Baseline survey of vegetation cover & health (*chlorophyll count*)
    • Post-Oil exploration and drilling survey of vegetation
  – Assess environmental recovery post-spill clean-up
  – Search for geographic features that indicate oil reserves
    • Surface oil slicks, phytoplankton

*NASA’s MODIS Aqua sensor; https://www.boem.gov/BOEM-2016-082/*; Ian McDonald
Collaborative Project Goals

1) Develop a image analysis workflow that can identify mosquito breeding habitats

2) Evaluate efficacy of our model with real-world validation

3) Determine public health impact with arboviral surveillance
**Project Overview**

**Spring** – 370 sq.km.: High WNV + mosquito & High WNV+ human incidence 2014

**West Harris** – 263 sq.km.: “control” area, Low WNV+ mosquitos & human cases

**Downtown/Ship Channel** – 357 sq.km.: Mixed use areas (industrial & residential) which should provide a widest range of habitats
### Satellite Imaging Provider Selection

<table>
<thead>
<tr>
<th>Satellite</th>
<th>Pixel Size (m)</th>
<th># pixels that fit into a single Landsat-8 pixel</th>
<th>Number of Bands</th>
</tr>
</thead>
<tbody>
<tr>
<td>WorldView-3</td>
<td>0.31</td>
<td>2341.3</td>
<td>16</td>
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<tr>
<td>WorldView-2</td>
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<td>1063.3</td>
<td>8</td>
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<tr>
<td>QuickBird</td>
<td>0.65</td>
<td>532.5</td>
<td>4</td>
</tr>
<tr>
<td>SPOT-6</td>
<td>1.50</td>
<td>100.0</td>
<td>4</td>
</tr>
<tr>
<td>Sentinel-2</td>
<td>10.00</td>
<td>2.3</td>
<td>13</td>
</tr>
<tr>
<td>Landsat-8</td>
<td>15.00</td>
<td>1.0</td>
<td>11</td>
</tr>
</tbody>
</table>

The two free public domain sources, Sentinel-2 and Landsat-8, might be useful for mapping in large areas such as parks, vacant lots and fields. These images will be explored at a later time.

*WorldView-2 Image, Post Harvey. Courtesy DigitalGlobe*
Image Analysis Workflows

• Visual Inspection:
  – **Abandoned tires**: Look for ‘dark pixels” using automated classification refined by visual inspection of images and spectral readings
  – **OSSF**: look for clustering of permitted systems

• Color Band Ratios:
  – Normalized difference vegetation index (NDVI) to find areas with a high density of healthy vegetation
  – Normalized difference water index (NDWI) to find areas with standing water

• Image Classification “object oriented”:
  – If we know where good habitats for mosquito growth exist, we can use pixels from specific components of those habitats to predict where similar pixels exist

• LIDAR
  – Find roadside ditches and classify by depth
Mosquito Life Cycle

Department of Medical Entomology, University of Sydney and Westmead Hospital, Australia
Mosquito Breeding Habitats & Model Identification Plan

*Culex quinquefasciatus*

1. Drainage ditches
2. Septic leaks
3. Manhole covers
4. Vegetated stagnant water
Mosquito Breeding Habitats & Model Identification Plan

*Aedes aegypti* & *A. albopictus*

1. Tire grouping- ASDI HandHeld2 spectroradiometer
2. Trash/container index (junk)
3. Construction sites- *master plan communities*
4. Industrial yards
5. Cemeteries
Public Health Relevance
Trap Locations
Trap Locations
3 areas of interest

- Downtown
  - 4 trapping quadrants (q1-4)
    - 10 houses (gravid and BG traps)
    - 10 Storm Sewer (SS)
- Spring
  - 4 trapping quadrants (q1-4)
    - 10 houses (gravid and BG)
    - 10 SS
- West Harris
  - 4 trapping quadrants (q1-4)
    - 10 houses (gravid and BG)
    - 10 SS
Trap Locations

- 120 traps set per month
  - Repeated for 4 months (June-September)

- Mosquito data:
  - Quantify number of adult A. *albopictus*, A. *aegypti*, and *Culex* mosquitoes are collected in each trap
  - Test for arbovirus:
    - *Aedes* sp.- Zika, Denge, and Chickingunya
    - *Culex* - West Nile Virus

- Validate the model
  - Ground truthing survey
Future Directions

• **Refinement of Mosquito Breeding Habitat Model**
  • *Integration of Dog Detection as a Validation Measure*
  • *Artificial Intelligence (Neural network analysis), LiDAR data, Texture filters*

• **Habitat Prediction Models and Potential Applications**
  • Afghanistan/Iraq Sandfly (Leishmaniasis)
  • Africa *Anopheles* sp. Mosquito (Malaria)
  • Integrated Vector Management for *Aedes, Culex, and Ixodes* sp.
    (Zika, Dengue, Chikungunya, West Nile, and St. Louis Encephalitis viruses, and Lyme disease)
Acknowledgements

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