The Spread of the West Nile Virus Across the USA - A Visual Analysis

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On the Trail of the West Nile Virus

DURING THE HOT SUMMER of 2012, a wildfire silence enveloped Chicago and its suburbs like an invisible fog, too subtle to notice at first. Too strange to ignore after a while. Residents in the affluent North Shore communities and the well-to-do western suburbs noticed it. Folks in the modest suburban neighborhoods southwest of the city noticed it. Soon or later, it's a gradual what was missing,
Pests Get Under Their Skin

Wednesday July 24th 1805.

Our trio of pests still invade and obstruct us on all occasions, these are the Musquetoes eye knats and prickley pears, equal to any three curses that ever poor Egypt laboured under.

—Meriwether Lewis

As the Corps moved toward the mountains, they left the portage behind but could not outdistance the mosquitoes. Possibly the most often repeated phrase in both Lewis’ and Clark’s journals is “Musquetors verry troublesom.”

Clark claims the men could not have slept without the “musquetoe biers,” or netting. Lewis had brought from Philadelphia. Caught one night away from camp without this protection, Lewis got no sleep at all and swore he would never forget it again.
West Nile Virus

- Virus
  - Initial event - Culex mosquito transmits virus within avian populations
  - Bridging Aedes albopictus transmits virus from birds to animals and humans
Overview

- US Analysis
- GIS Visualization: Choropleth Maps
- Statistical Visualization: Micromaps
- Washington, D.C., Analysis
- Web-based Access to WNV Data
- Conclusion
US Analysis - Summary

- In 2002
  - 4,156 total human cases (284 deaths) in US
  - Ecological damage
    - 140 species of birds, reptiles and mammals infected and killed - 100 US zoos reporting cases

- In 2003:
  - 9,862 total human cases (264 deaths) in US

- >> 14,000 horses killed since 1999

- 2004: 2151 cases (68 deaths) by 10/19/04
GIS Visualization: Choropleth Maps
West Nile Virus Maps in the News

WEST NILE VIRUS IN THE UNITED STATES, 2003
Roll over yellow states for statistics on human cases and deaths.

Click here to see the spread of West Nile Virus in the United States since 1999

NEW!
Navigate to Adjacent States by clicking on those states.

Legend:
- Positive Test Results
- No Data
- Positive Test Results Summarized at State Level Only

Cumulative 2004 Data as of 3 am, Oct 19, 2004
These data are provisional and may be revised or adjusted in the future.
US Analysis

First Appearance of West Nile Virus in Birds, Mosquitoes, and Other Animals by Year

First Appearance of West Nile Virus in Humans by Year
Statistical Visualization: Micromaps
Micromaps

- Link of row-labeled univariate (or multivariate) statistical summaries to corresponding geographical region
- Focus on statistical display and not on maps
Usage of Micromaps

- First presented at 1996 American Statistical Association’s annual meeting (Olsen, Carr, Courbois, Pierson)
- USDA-NASS: Agricultural Census (9/1999)
- NCI: Cancer Data (4/2003)
From 2002 CDC Web Page to Micromaps
From 2003 CDC Web Page to Micromaps

West Nile Virus 2003
Lab-Positive Human Cases

Maps

States

South Dakota
Nebraska
North Dakota
Wyoming
Colorado
Montana
New Mexico
Iowa
Kansas
Texas
Mississippi
Minnesota
Louisiana
Oklahoma
Delaware
Pennsylvania
Maryland
Missouri
Ohio
Arkansas
Alabama
Indiana
Iowa
Iowa
Georgia
Florida

Rate
Cases

Connecticut
Vermont
Tennessee
Illinois
New Jersey
New York
Virginia
Kentucky
Wisconsin
North Carolina
Massachusetts
New Hampshire
Arizona
Michigan
South Carolina
Vermont
New Mexico
Idaho
Utah
California
Washington
Oregon
Alaska
Hawaii
Maine

Infection Rate

0
0.000 - 0.322
0.044 - 0.444
0.844 - 0.944
2.223 - 2.223
>2.223

300 0 300 600 Miles

Human West Nile Infection Rate for 2003
(Cases per 100,000)
Washington, D.C., Analysis
Washington, D.C., Analysis

Washington, DC by Ward

Total Number of WN Infected Dead Birds by Ward in DC for 2002

Total Number of West Nile Cases in Humans by Ward in DC for 2002
West Nile – D.C. Geographic Time Series

Washington, DC by Ward

Weekly Mosquito West Nile Positive Rates by Ward in DC for 2002
Enviro-Climatic Coupling

- Prior precipitation regime conducive to hydration and hatching of mosquito eggs
- Transmission competency (26° to 30°C) - indicative of higher efficiency of mosquito to transmit the virus
- Positive mosquito and human cases seen previously to occur within this time frame
Temporal Development

Weekly Counts (throughout DC) and Temperatures in 2002

Weekly Avian West Nile Positive Counts in DC for 2002

Weekly Mosquito West Nile Positive Pool Counts in DC for 2002

Weekly Human West Nile Positive Counts in DC for 2002

Temperatures, #Avians, #Mosquito Pools, and #Humans in 2002
Web-based Access to WNV Data
### Left Column Data

<table>
<thead>
<tr>
<th>Area</th>
<th>US - state level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Group</td>
<td>West Nile Virus</td>
</tr>
<tr>
<td>Host Group</td>
<td>Human Cases</td>
</tr>
<tr>
<td>Statistic</td>
<td>Infection Rate</td>
</tr>
<tr>
<td>Year</td>
<td>2003</td>
</tr>
<tr>
<td>Sex</td>
<td>Both Sexes</td>
</tr>
</tbody>
</table>

### Human Cases West Nile Virus

<table>
<thead>
<tr>
<th>State</th>
<th>Rank 1=Lowest</th>
<th>Latest Annual Infection Rate 1=Lowest</th>
<th>Year 2003 Cases per 100,000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colorado</td>
<td>51</td>
<td>47</td>
<td>3,200</td>
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<tr>
<td>Nebraska</td>
<td>50</td>
<td>51</td>
<td>7,200</td>
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<tr>
<td>South Dakota</td>
<td>51</td>
<td>42</td>
<td>1,400</td>
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<tr>
<td>Texas</td>
<td>48</td>
<td>49</td>
<td>1,900</td>
</tr>
<tr>
<td>North Dakota</td>
<td>49</td>
<td>48</td>
<td>2,200</td>
</tr>
</tbody>
</table>

- **Year 2003 Total Infections Per Year**
  - **Colorado**: 2,047
WNV in 2004
West Nile Virus 2004 (as of 10/19/04)
Lab-Positive Human Cases

Maps

States
- Arizona
- South Dakota
- Colorado
- New Mexico
- North Dakota
- Nebraska
- California
- Wyoming
- Kansas
- Louisiana
- Nevada
- Mississippi
- Arkansas
- Minnesota
- Iowa
- Missouri
- Montana
- Illinois
- Texas
- Oklahoma
- Utah
- Alabama
- Maryland
- Florida
- Georgia
- Wisconsin
- D.C.
- Kansas
- Idaho
- Kentucky
- Indiana
- Michigan
- Pennsylvania
- Ohio
- Virginia
- North Carolina
- Connecticut
- Oregon
- New York
- South Carolina
- New Jersey
- Alaska
- Delaware
- Hawaii
- Maine
- Massachusetts
- New Hampshire
- Rhode Island
- Vermont
- Washington
- West Virginia

Rate

Cases

log_{10}(Cases per 100,000)
log_{10}(Total # Cases)
Concluding Remarks

- WNV, as an example of a vector-borne pathogen, is a spatially and temporally complex phenomenon, but can be
  - Described well &
  - Summarized, using visualization techniques
Ongoing Work

- Linking of West Nile Micromap Server with USU Climate Data Base
- Assessment of spatially adjusted WNV-positive human, avian, and mosquito locations in DC
- Spatial statistical analysis tools can be used to provide an analytical representation of the WNV DC data
Acknowledgements

- Thanks to everyone who provided data!
- USU West Nile Micromap Server based on source code from NCI’s micromap cancer Web site (http://www.statecancerprofiles.cancer.gov)
- S-Plus micromaps adapted from S-Plus sample code from Dan Carr
- Color suggestions obtained from Cindy Brewer’s Web site (http://colorbrewer.com)
Questions ???