

Visualization, Web-Access, and Simulation of West Nile Virus Data - From the Regional to the National Level

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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
- DC Analysis
- Spatial Analysis / Modeling
- 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
- 1999: 62 cases (7 deaths), 2000: 21 (2), 2001: 66 (1)

GIS Visualization: Choropleth Maps

A stylized graphic of a mountain range at the bottom of the slide. The mountains are represented by several overlapping, semi-transparent layers in shades of blue and purple, creating a sense of depth and atmospheric perspective. The background of the slide is a light blue gradient.

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



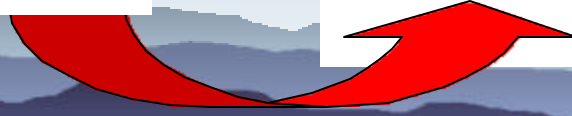
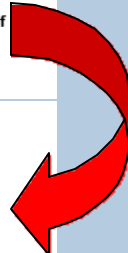
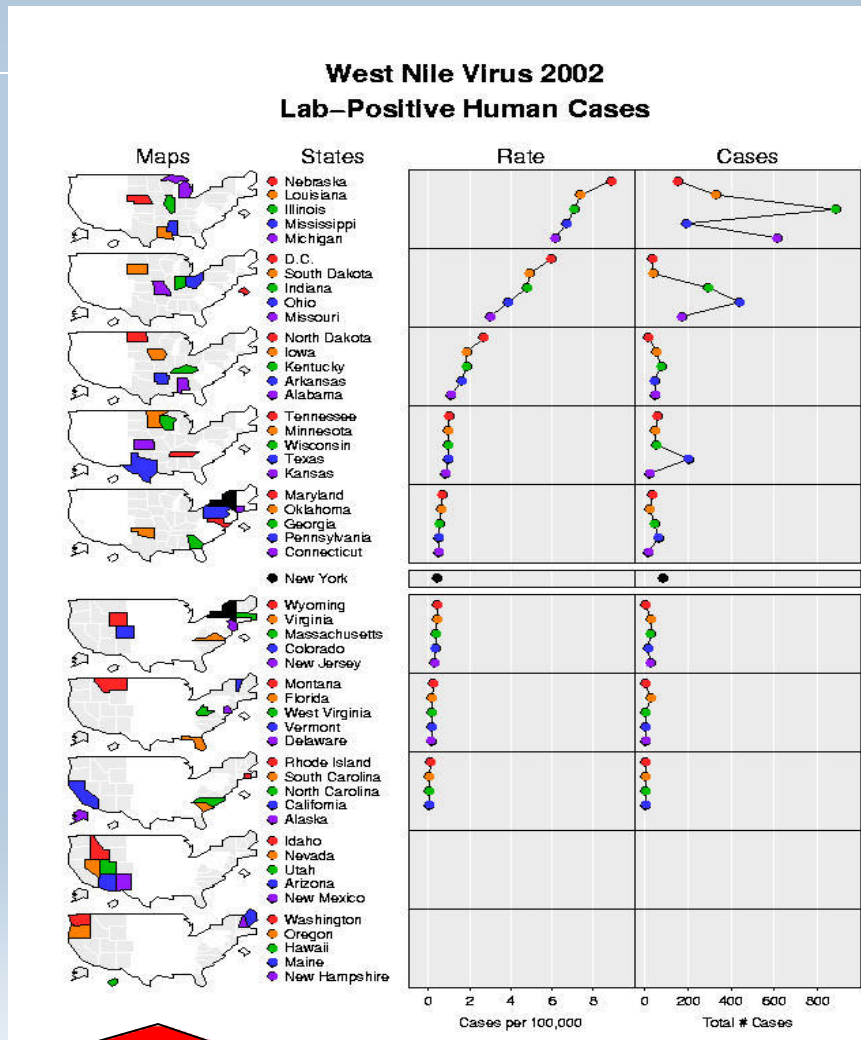
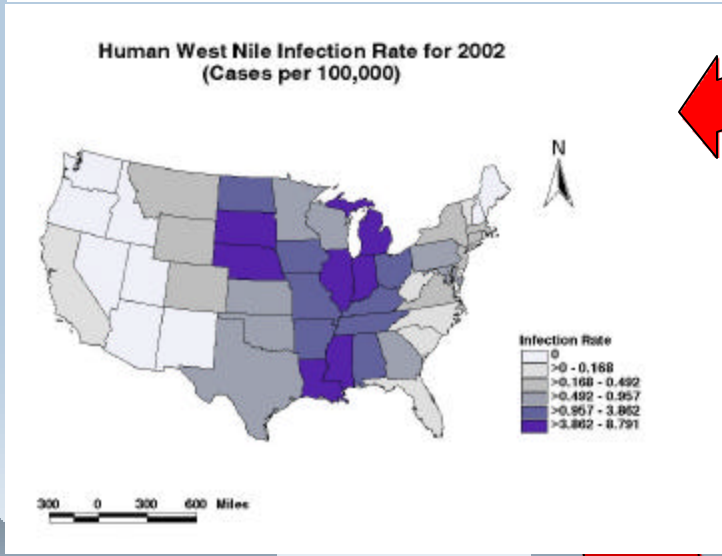
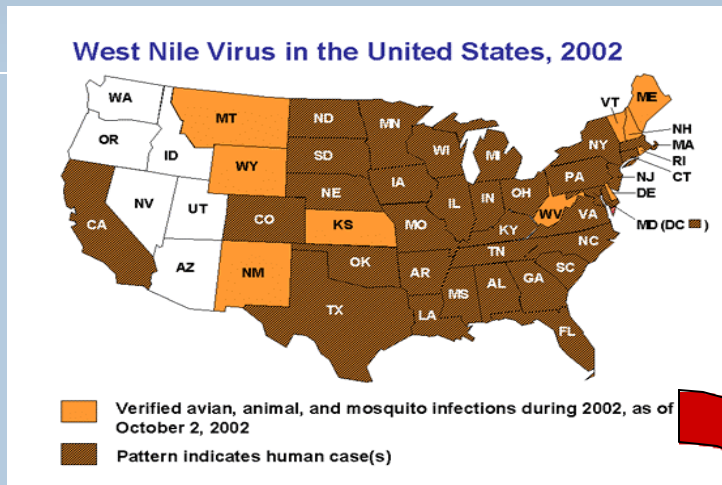
Micromaps

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

Usage of Micromaps

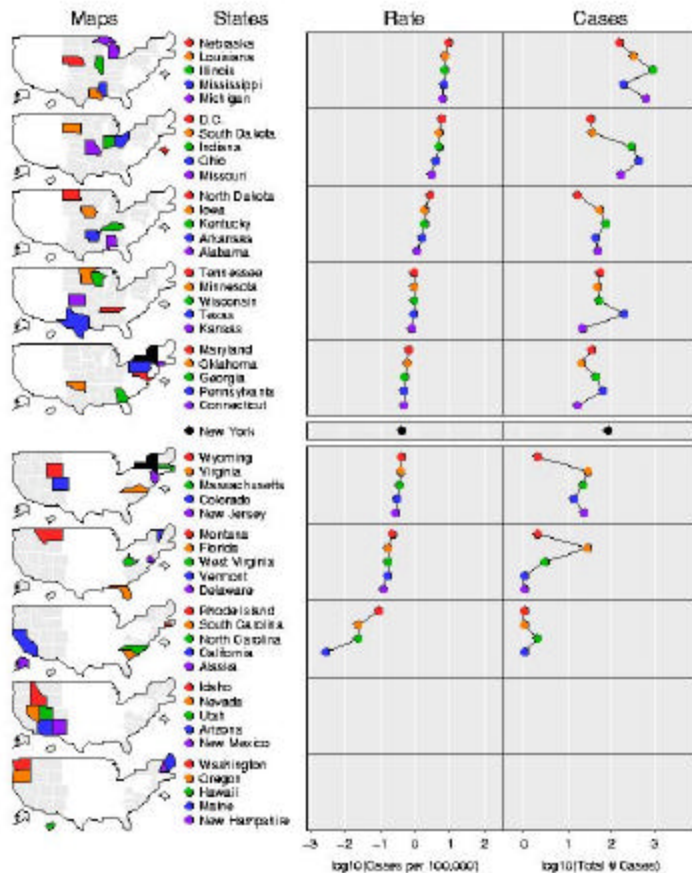
- First presented at 1996 American Statistical Association's annual meeting (Olsen, Carr, Courbois, Pierson)
- EPA: Cumulative Exposure Project (1998 - intended)
- USDA-NASS: Agricultural Census (2000)
- NCI: Cancer Data (2003)

From 2002 CDC Web Page to Micromaps

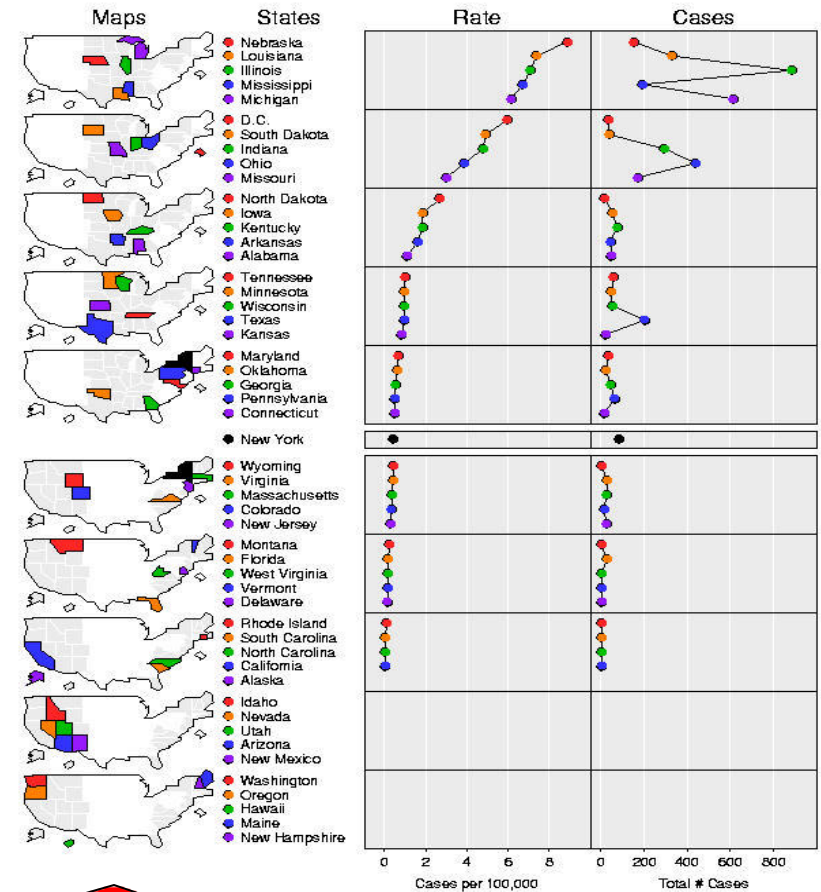


From 2002 CDC Web Page to Micromaps

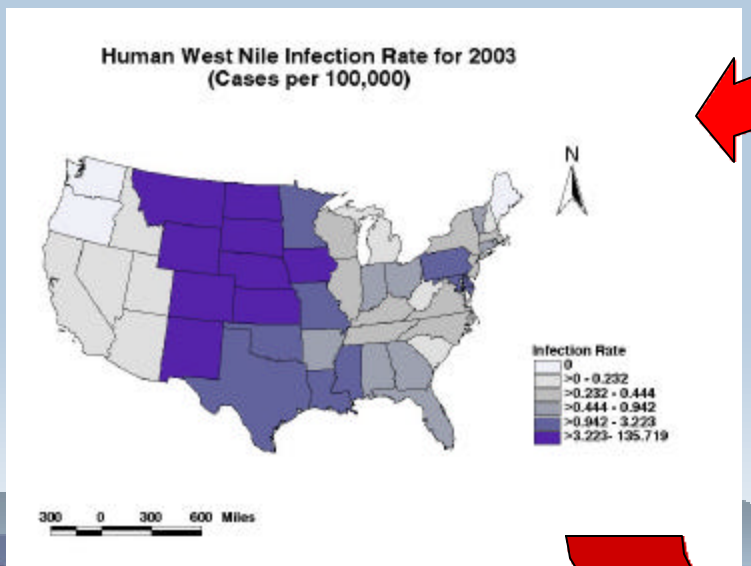
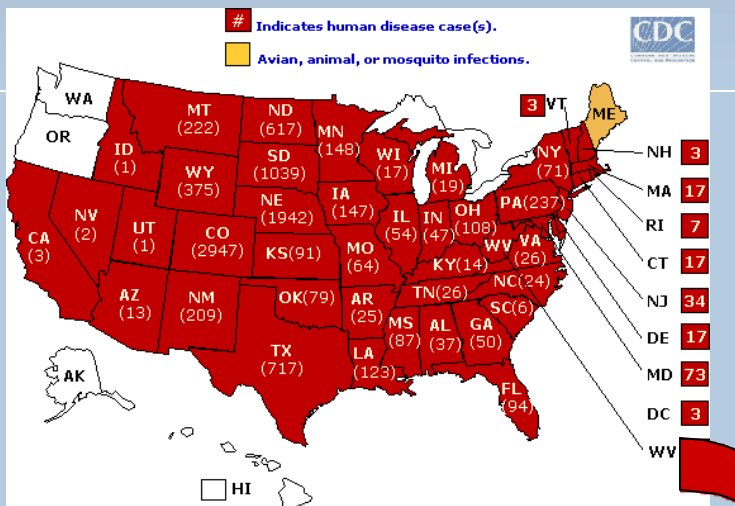
**West Nile Virus 2002
Lab-Positive Human Cases**



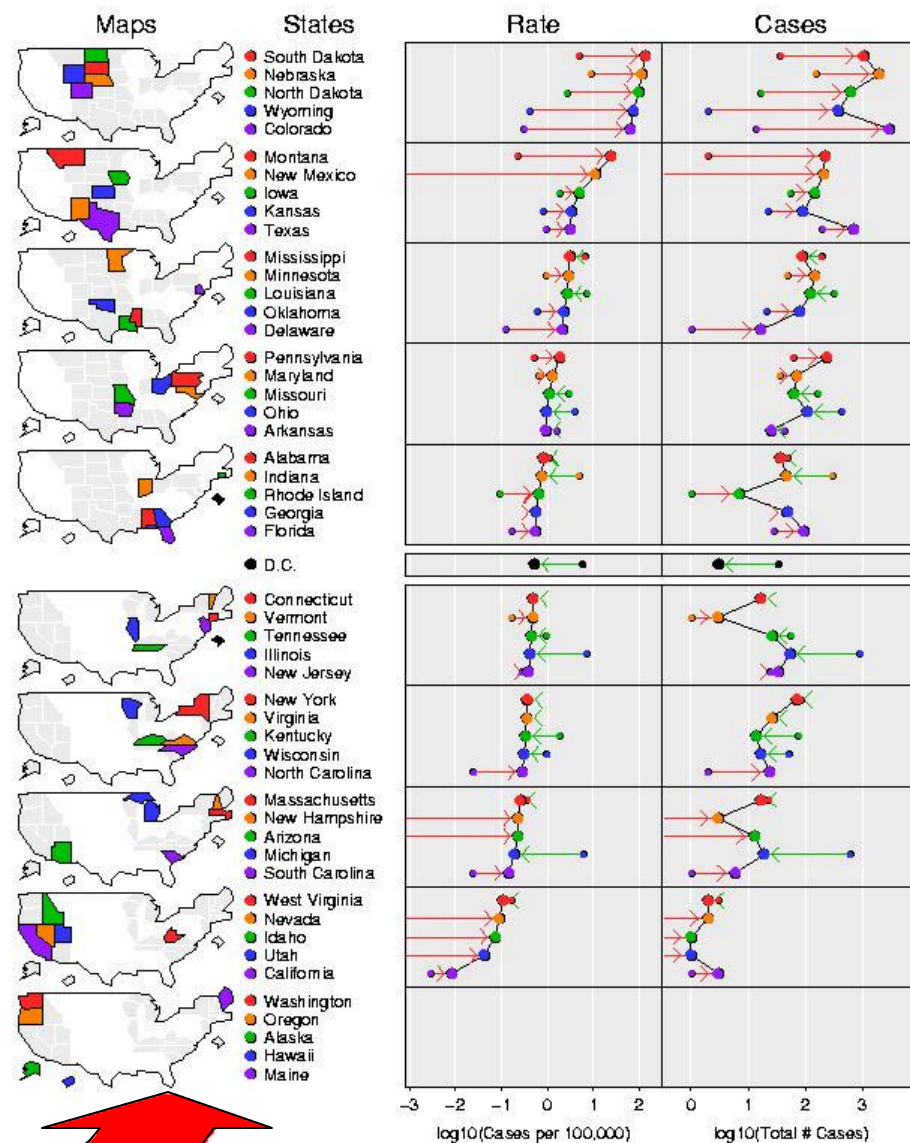
**West Nile Virus 2002
Lab-Positive Human Cases**



From 2003 CDC



West Nile Virus 2003 Lab-Positive Human Cases

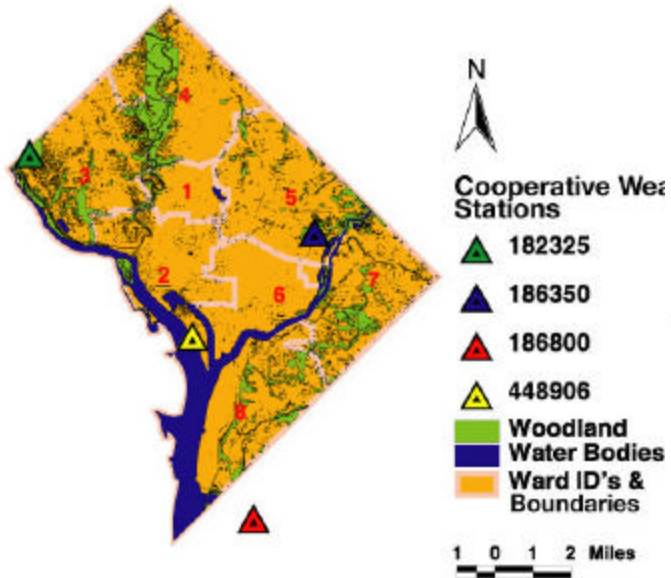


DC Analysis

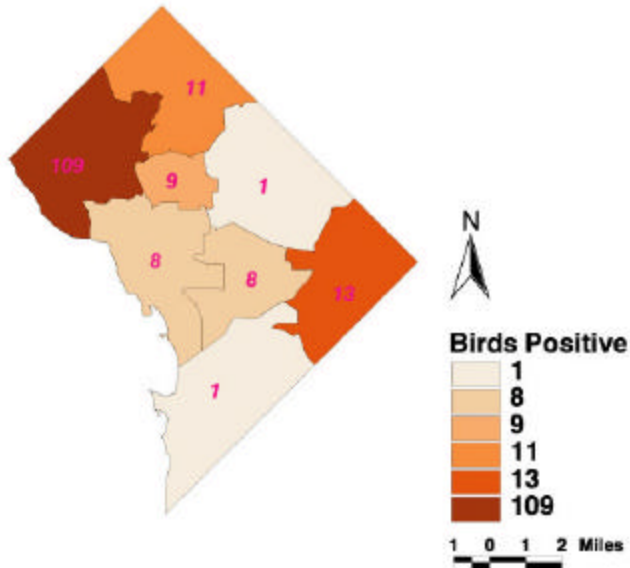
The background of the slide features a light blue gradient that transitions from a slightly darker shade at the top to a lighter shade at the bottom. At the very bottom, there is a silhouette of a mountain range with several peaks, rendered in a dark blue color.

DC Analysis

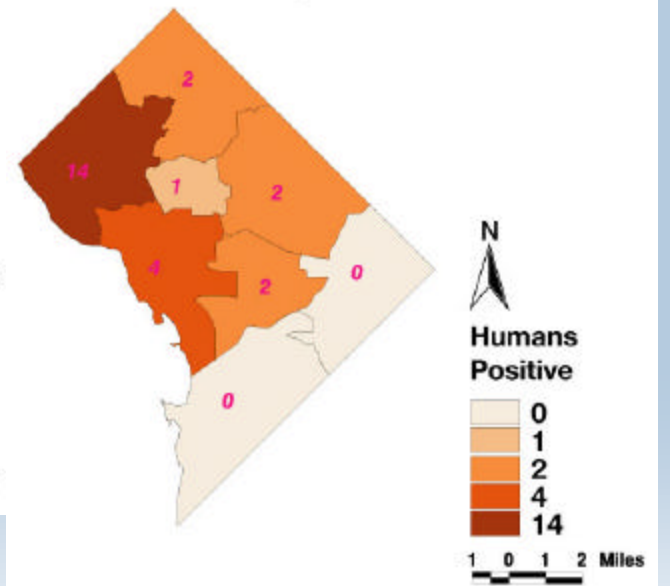
Washington, DC by Ward



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

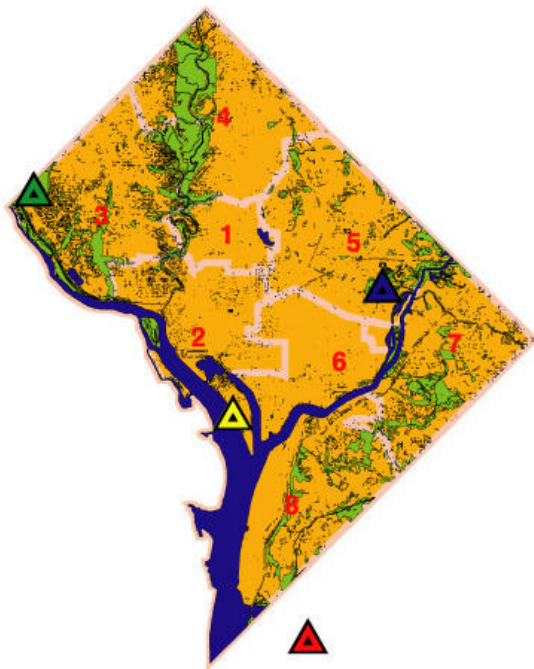


Total Number of West Nile Cases in Humans by Ward in DC for 2002



West Nile – DC Geographic Time Series

Washington, DC by Ward

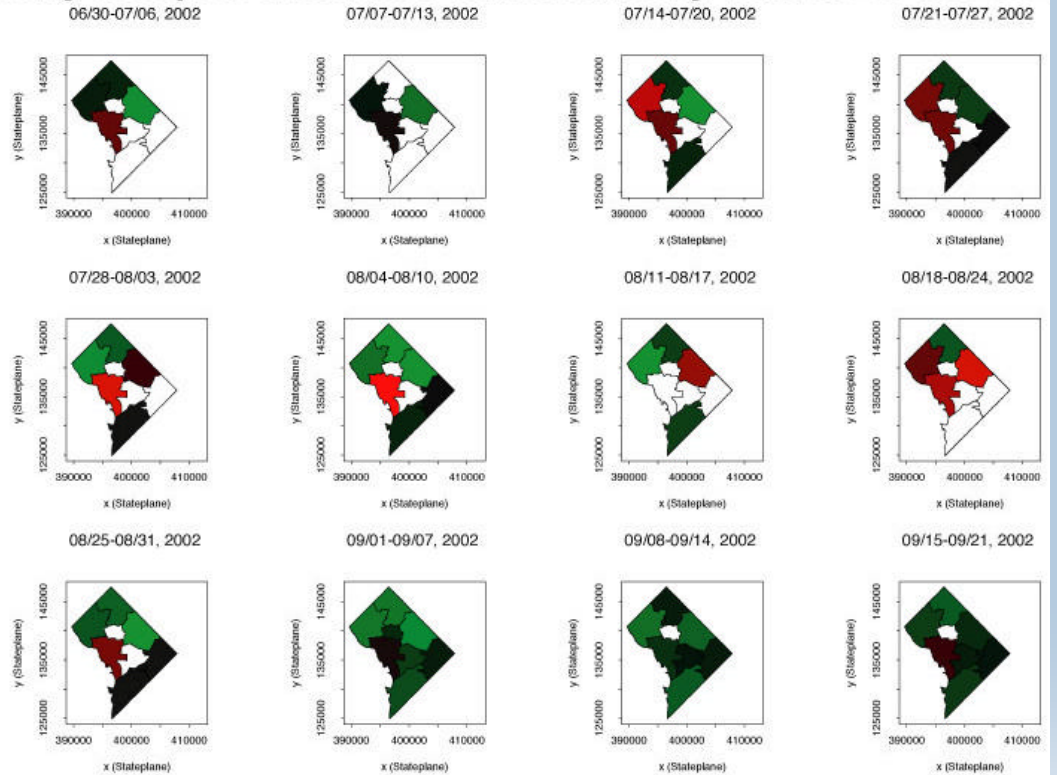


Cooperative Weather Stations

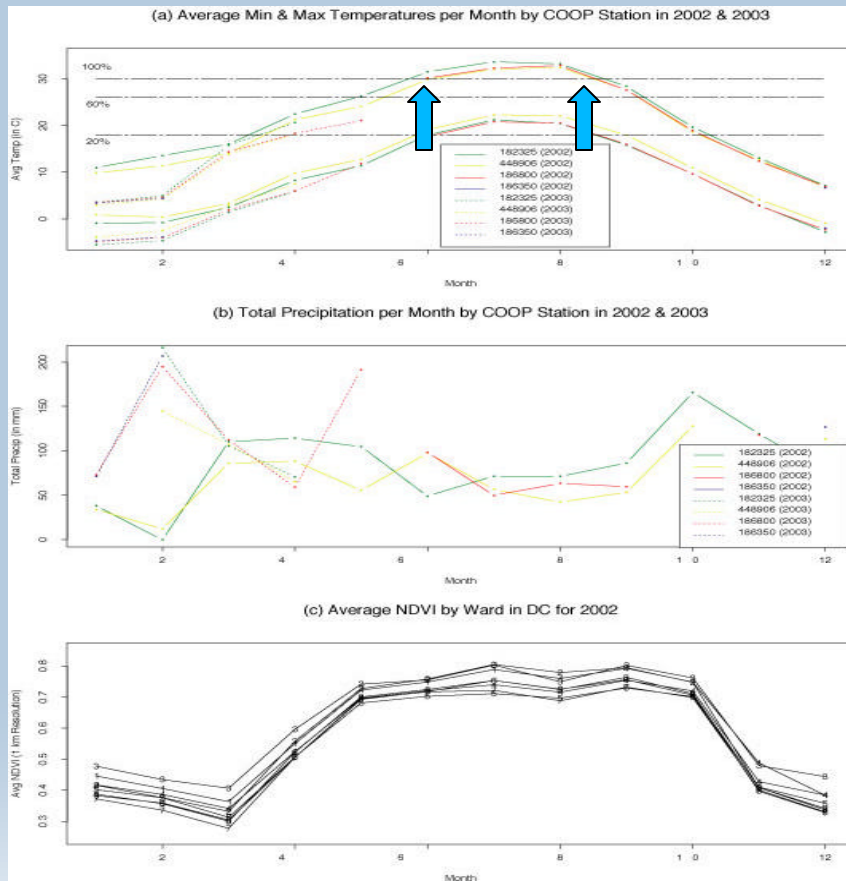
-  182325
-  186350
-  186800
-  448906
-  Woodland
-  Water Bodies
-  Ward ID's & Boundaries

1 0 1 2 Miles

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

Spatial Modeling / Analysis

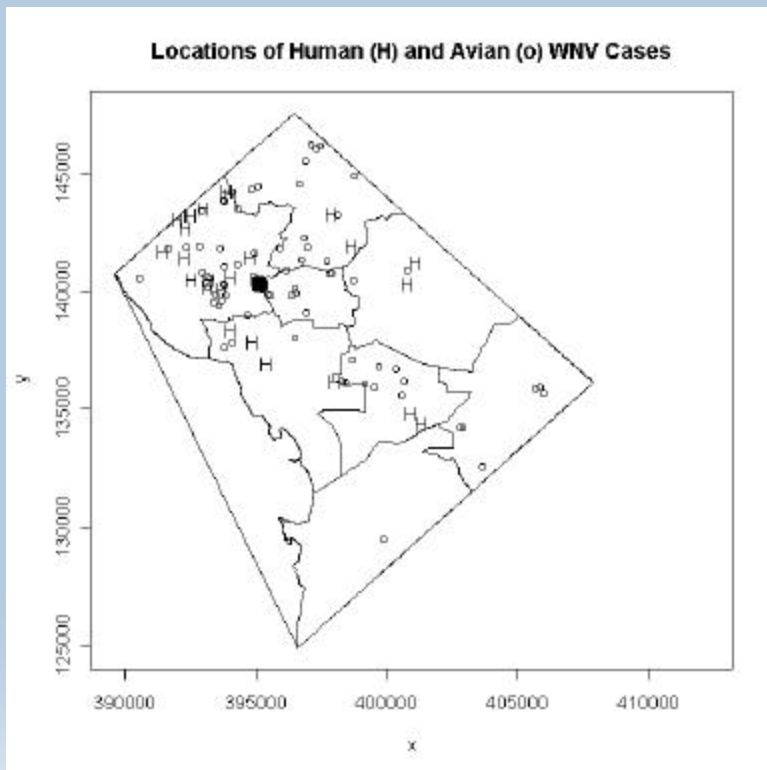


Spatial Statistical Analysis for the DC Area

- SPLANC: Spatial Point Pattern Analysis Code in S-PLUS
- Analysis is preliminary
 - Fairly rudimentary convex hull
 - Analysis pertains to Avian and Human data only
 - Limited simulations to 100 for each dataset



Locations of Cases Within the Convex Hull

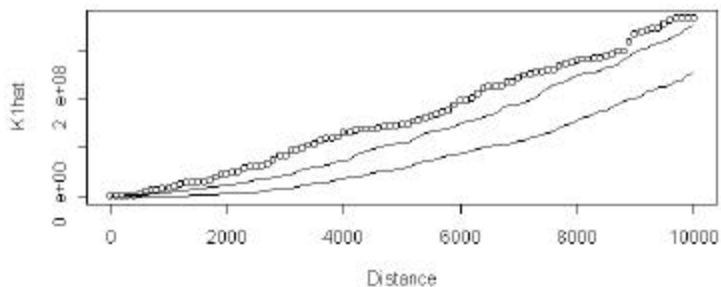


- Just shows locations:
 - H: Human cases
 - o: Avian cases
- Many observations of mosquito cases appear at one specific point

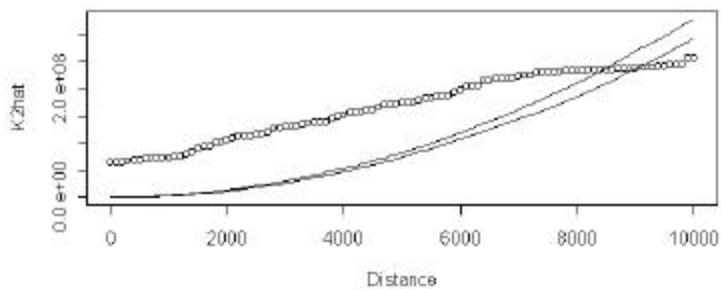
Estimation of K-function

- K-function: expected number of further points within a distance s of an arbitrary point, divided by the overall density of the points
- Based upon Complete Spatial Randomness (CSR)
- Evaluate K-function up to about one-third of linear extent of polygon (~ 8000)
- Plot: estimated (observed) bivariate K-function vs. Simulation Envelopes
- Criteria:
 - Obs above: Clustering
 - Obs within: CSR
 - Obs below: Regularity

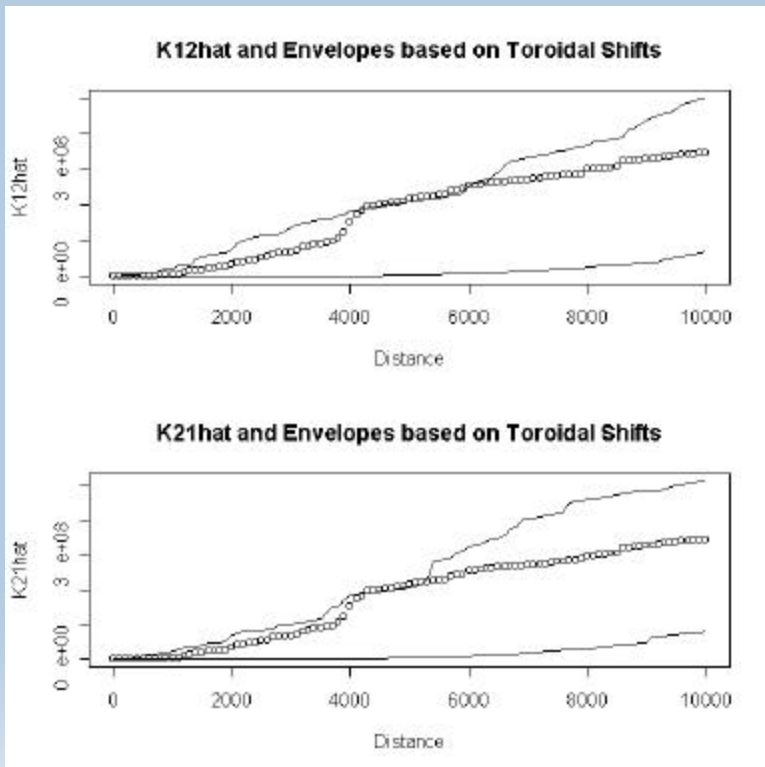
K1hat and Envelopes based on CSR



K2hat and Envelopes based on CSR



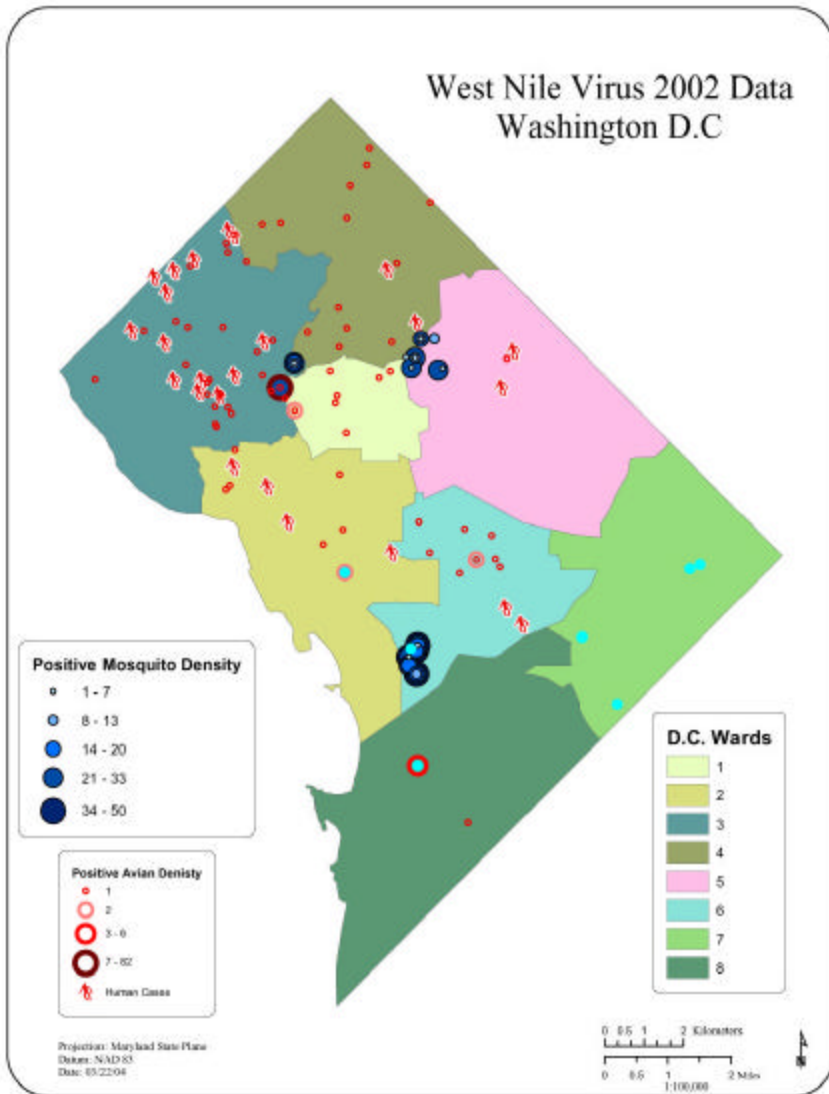
Estimate of Bivariate K-function ($K_{12\hat{}}$) and Computation of Envelope of $K_{12\hat{}}$ from Random Toroidal Shifts of Two Point Patterns



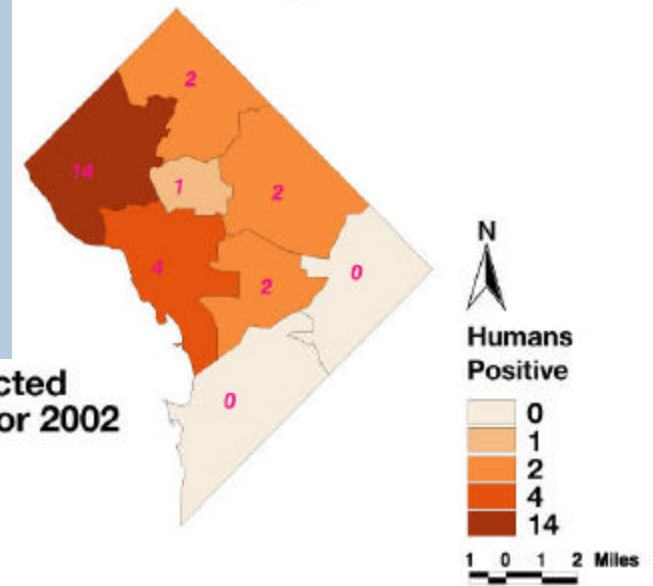
- bivariate K-function: expected number of points of pattern 1 within a distance s of an arbitrary point of pattern 2, divided by the overall density of the points in pattern 1
- Plot: estimated (observed) bivariate K-function vs. Simulation Envelopes
- Criteria:
 - Obs Above: Attraction
 - Obs Within: Independence
 - Obs Below: Repulsion

Warning: DC Results Based on Preliminary Spatial Locations

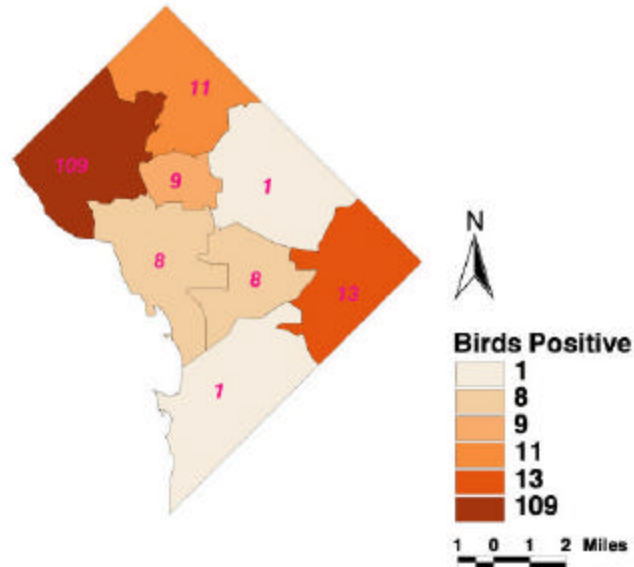
West Nile Virus 2002 Data
Washington D.C



Total Number of West Nile Cases
in Humans by Ward in DC for 2002



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



Web-based Access to WNV Data

Left Column Data

Area: US - state level

Data Group: West Nile Virus

Host Group: Human Cases

Statistic: Infection Rate

Year: 2002

Sex: Both Sexes

Right Column Data (optional)

Data Group: West Nile Virus

Host Group: Human Cases

Statistic: Infection Count

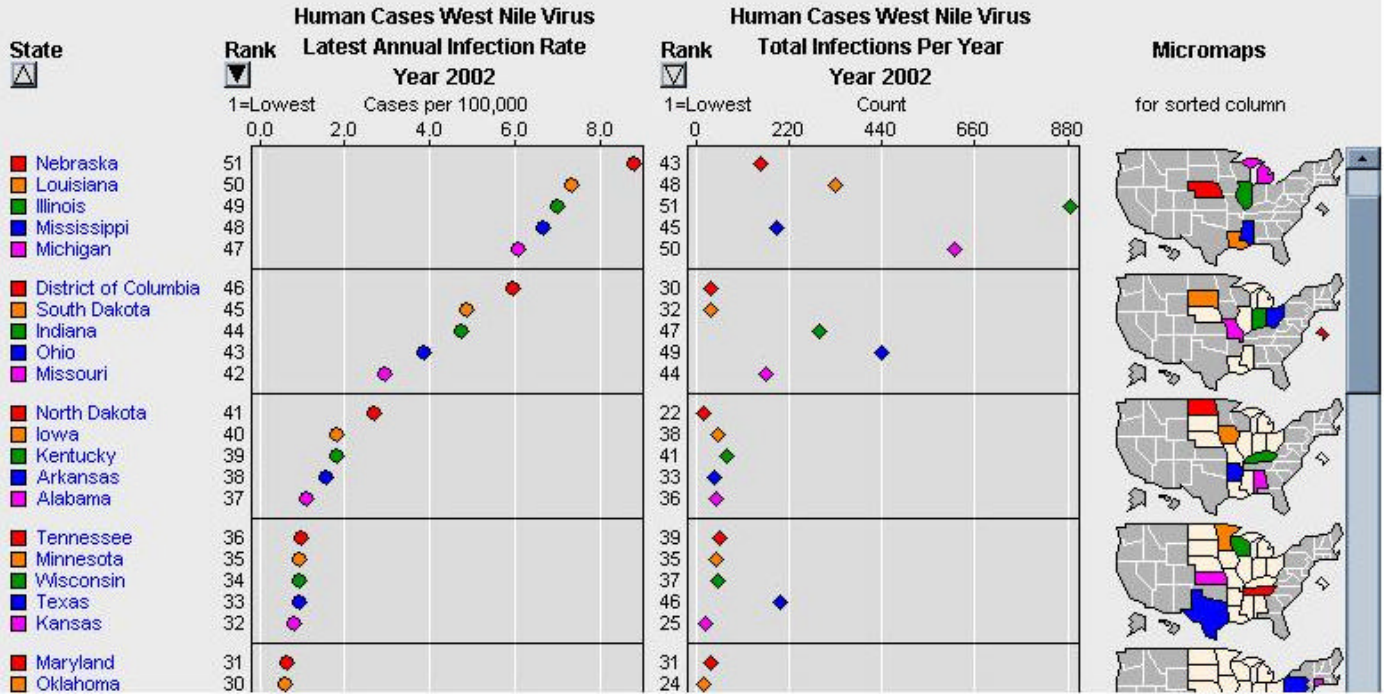
Year: 2002

Sex: Both Sexes

Draw Clear

Overview

Options ? [Print] [Refresh]



Left Column Data

Area: US - state level

Data Group: West Nile Virus

Host Group: Human Cases

Statistic: Infection Rate

Year: 2003

Sex: Both Sexes

Right Column Data (optional)

Data Group: West Nile Virus

Host Group: Human Cases

Statistic: Infection Count

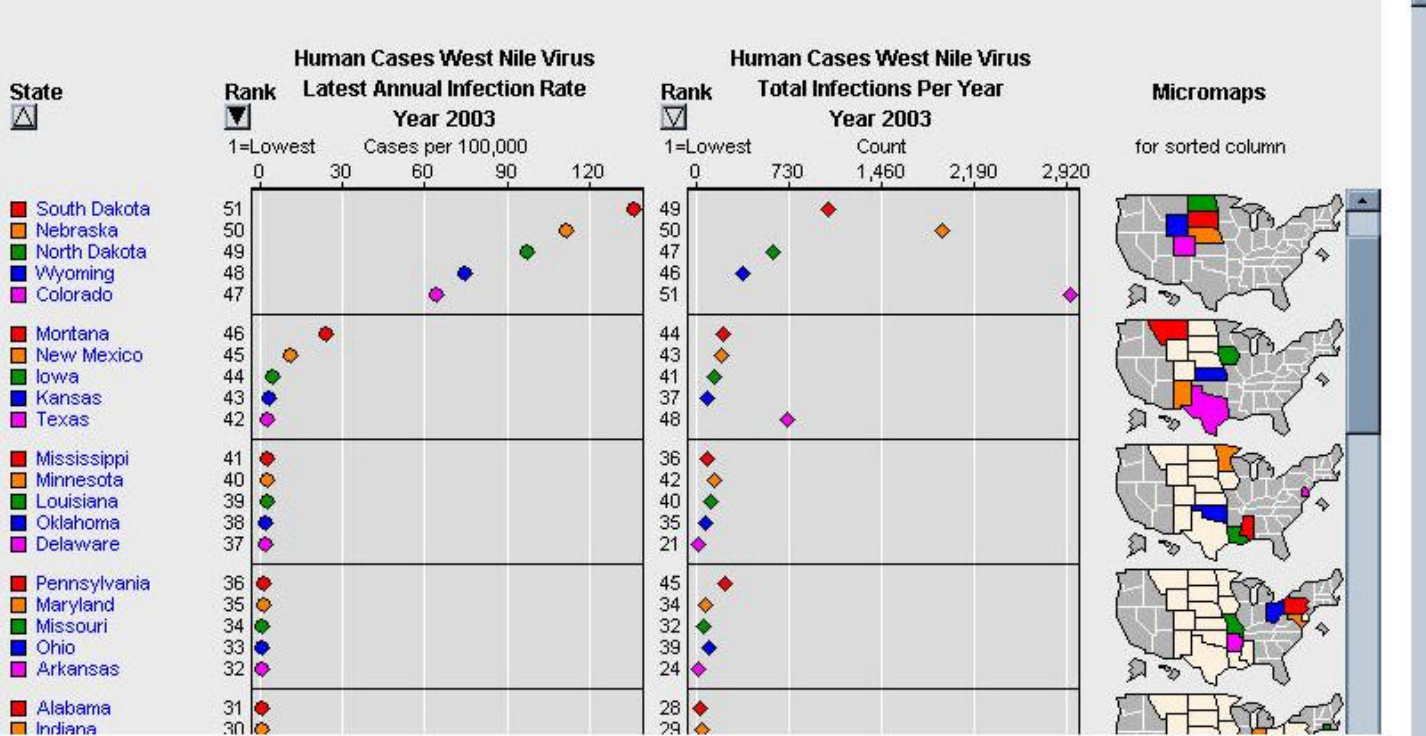
Year: 2003

Sex: Both Sexes

Draw Clear

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Left Column Data

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Right Column Data (optional)

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Host Group: Human Cases

Statistic: Infection Count

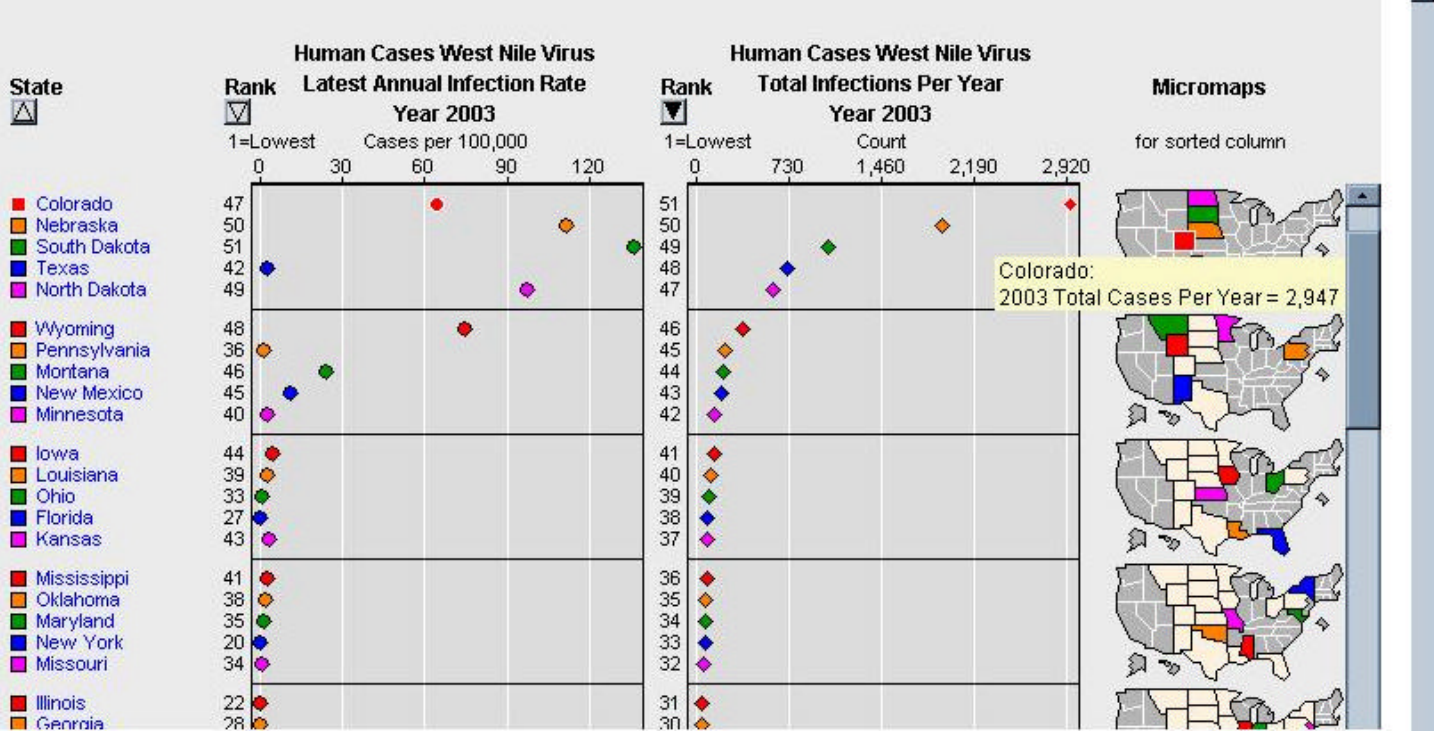
Year: 2003

Sex: Both Sexes

Draw Clear

Overview

Options ?



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
- Spatial statistical analysis tools can be used to provide an analytical representation of the WNV DC data

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

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>)

