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

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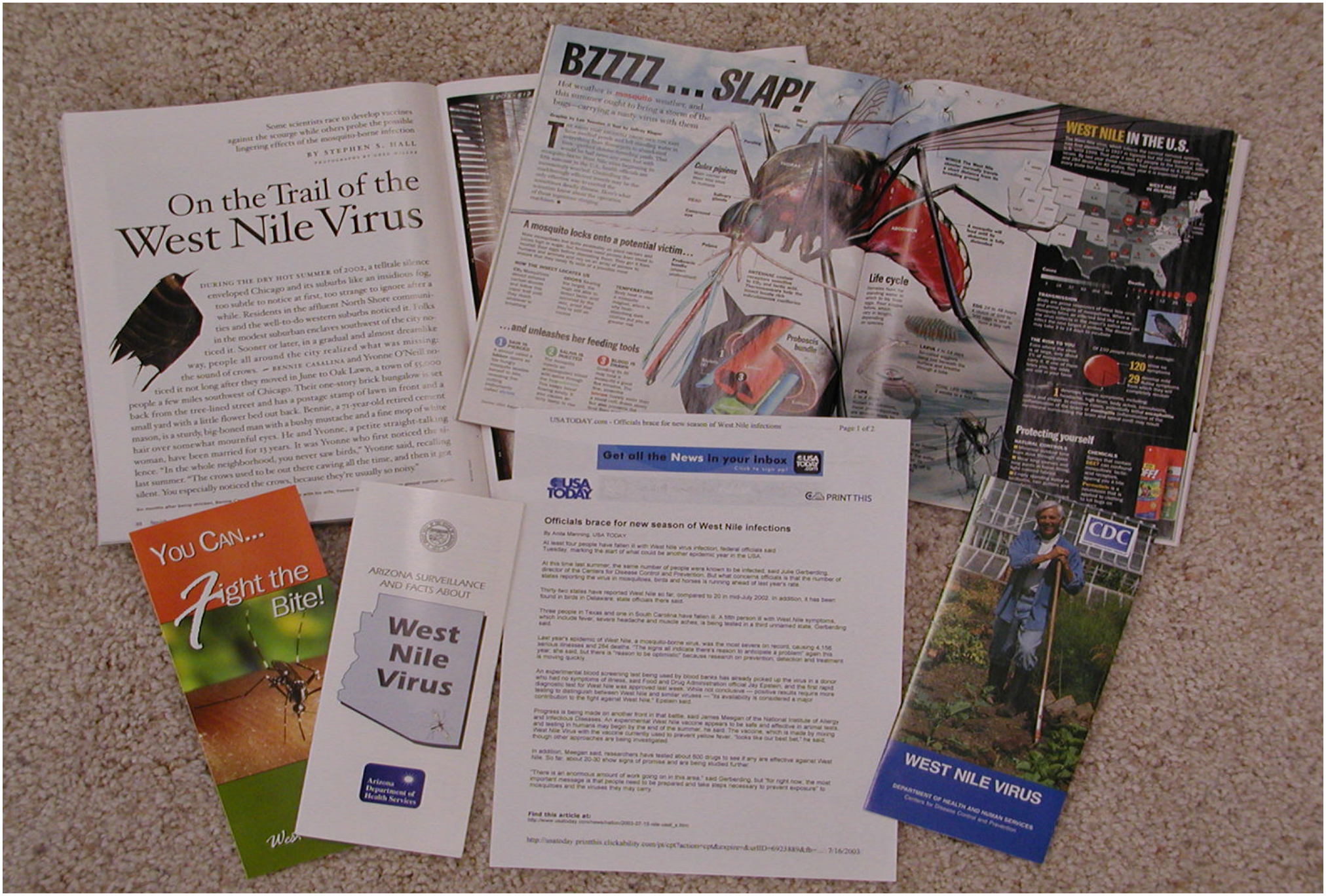
On the Trail of the West Nile Virus
BY STEPHEN S. HALL
BZZZZ... SLAP!
A mosquito locks onto a potential victim...
...and unleashes her feeding tools
Life cycle
WEST NILE IN THE U.S.
Protecting yourself
USA TODAY.com - Officials brace for new season of West Nile infections
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Officials brace for new season of West Nile infections
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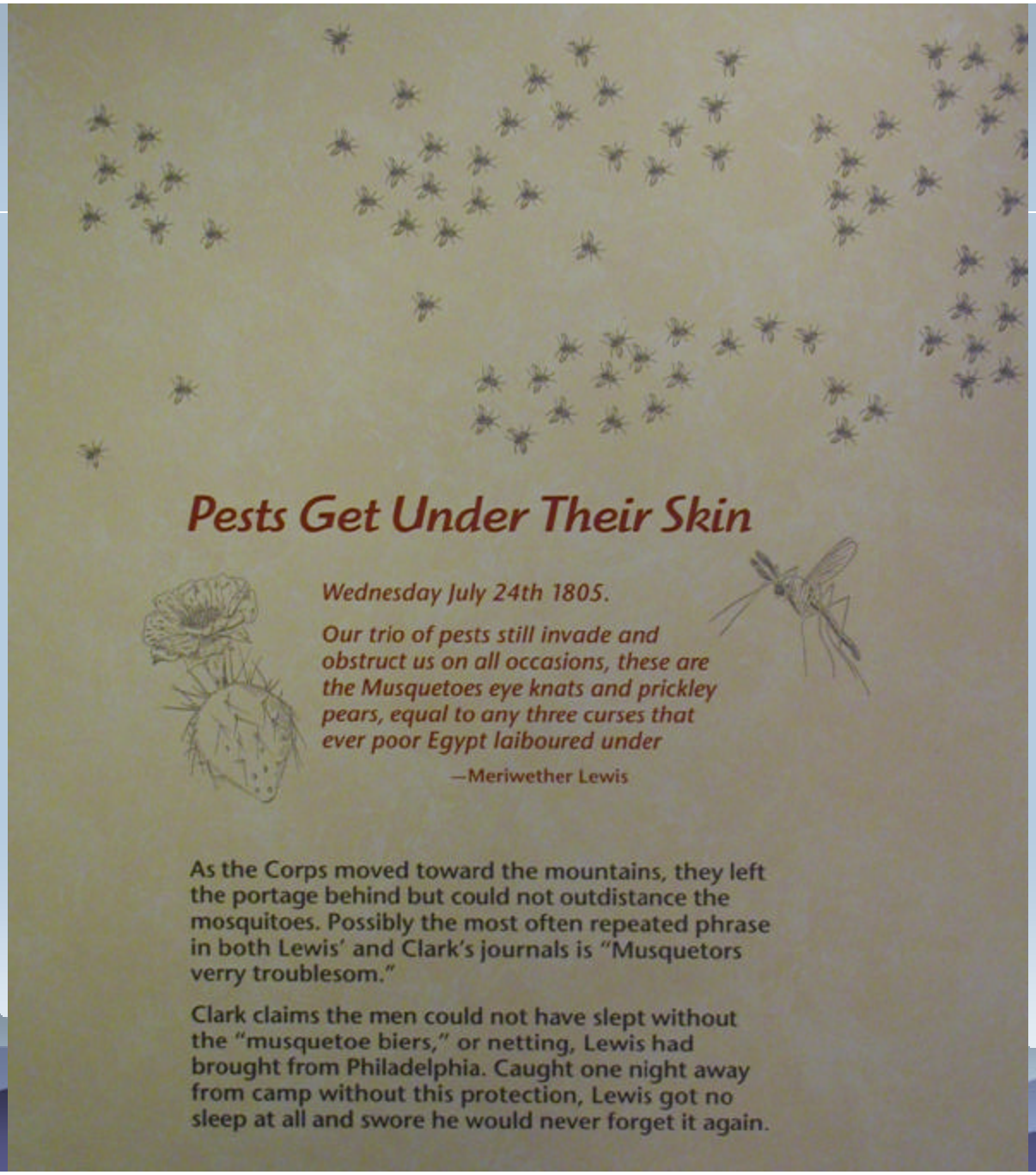
You Can... Fight the Bite!
ARIZONA SURVEILLANCE AND FACTS ABOUT
West Nile Virus
Arizona Department of Health Services
CDC
WEST NILE VIRUS
DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention


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 laiboured 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

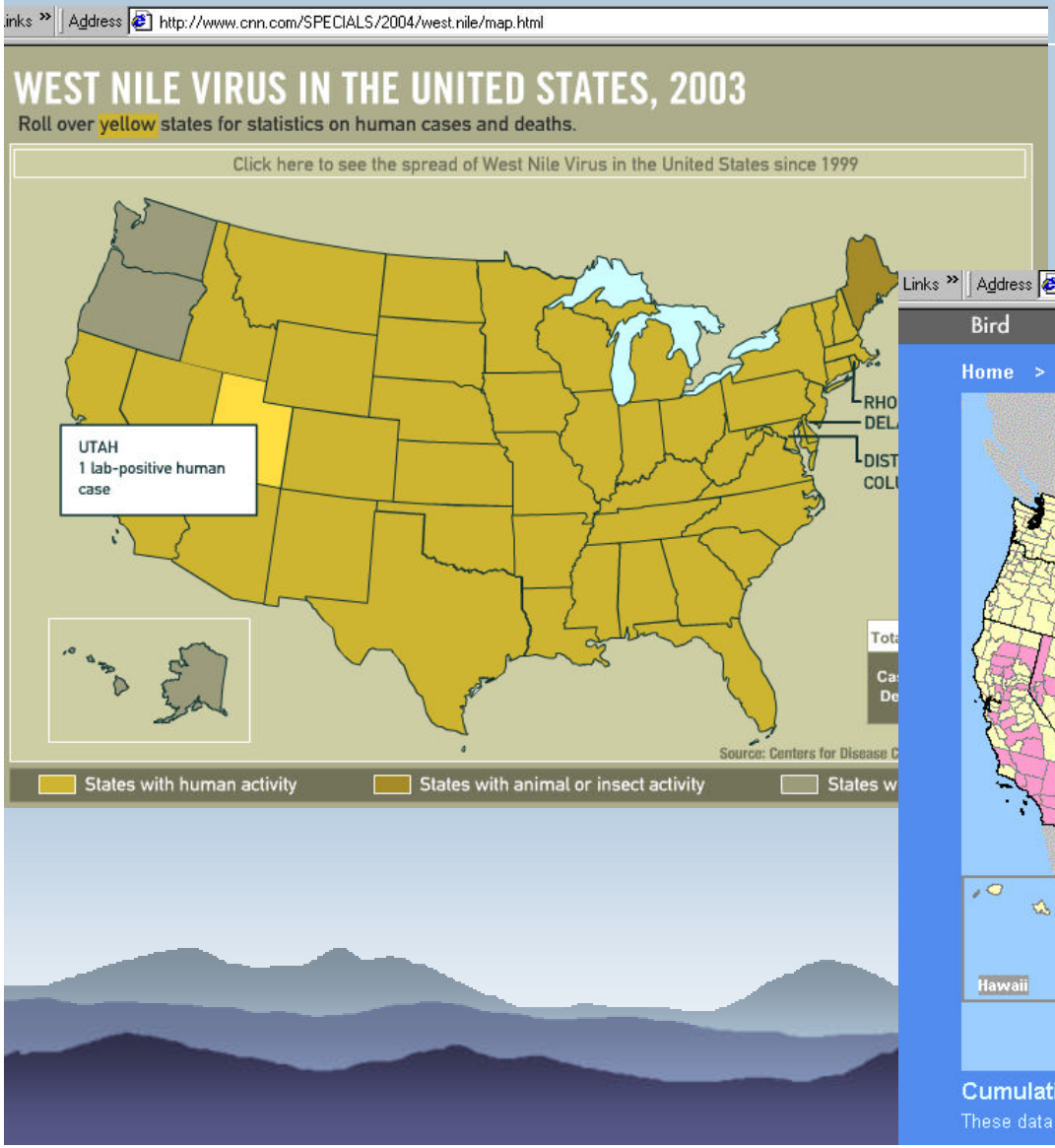
- US Analysis
- GIS Visualization: Choropleth Maps
- Statistical Visualization: Micromaps
- Washington, D.C., Analysis
- Web-based Access to WNV Data
- Conclusion

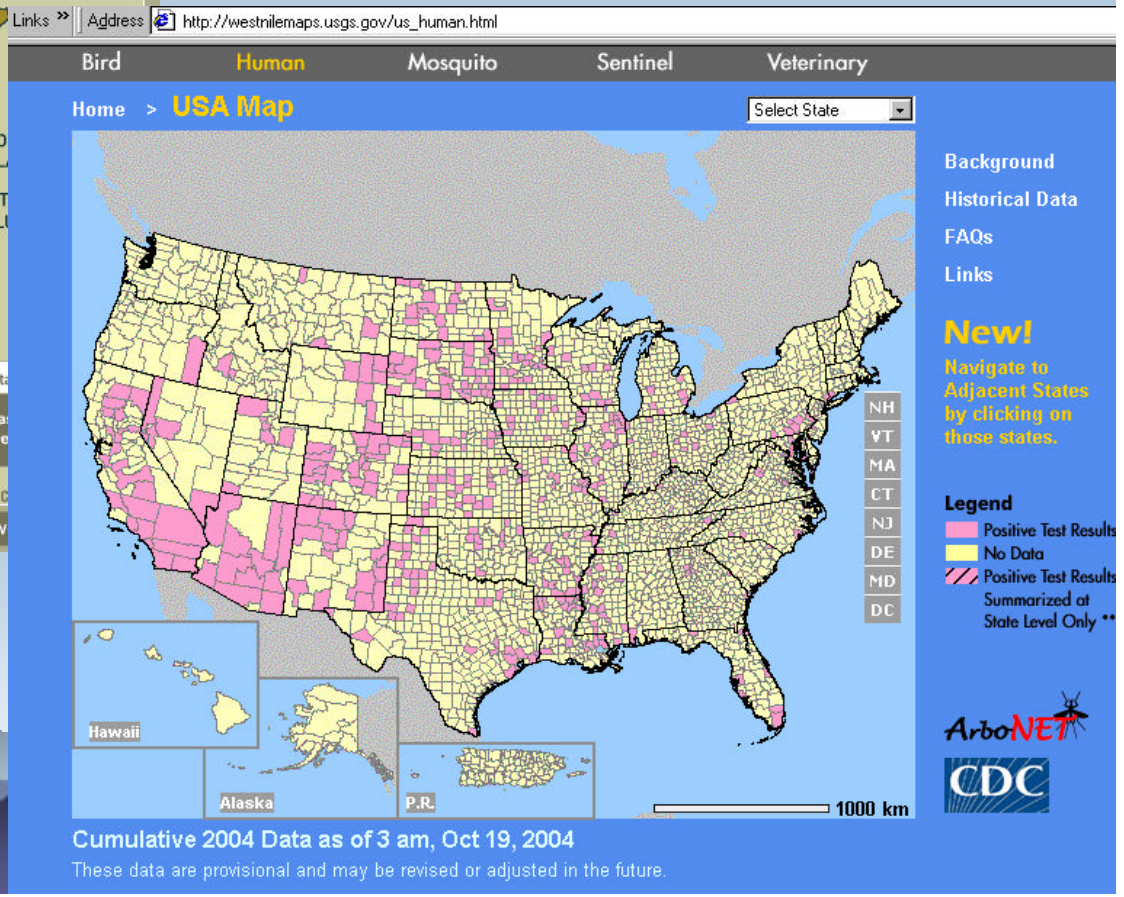
US Analysis - Summary

- 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
- 1999: 62 cases (7 deaths), 2000: 21 (2), 2001: 66 (1)
- 2004: 2151 cases (68 deaths) by 10/19/04

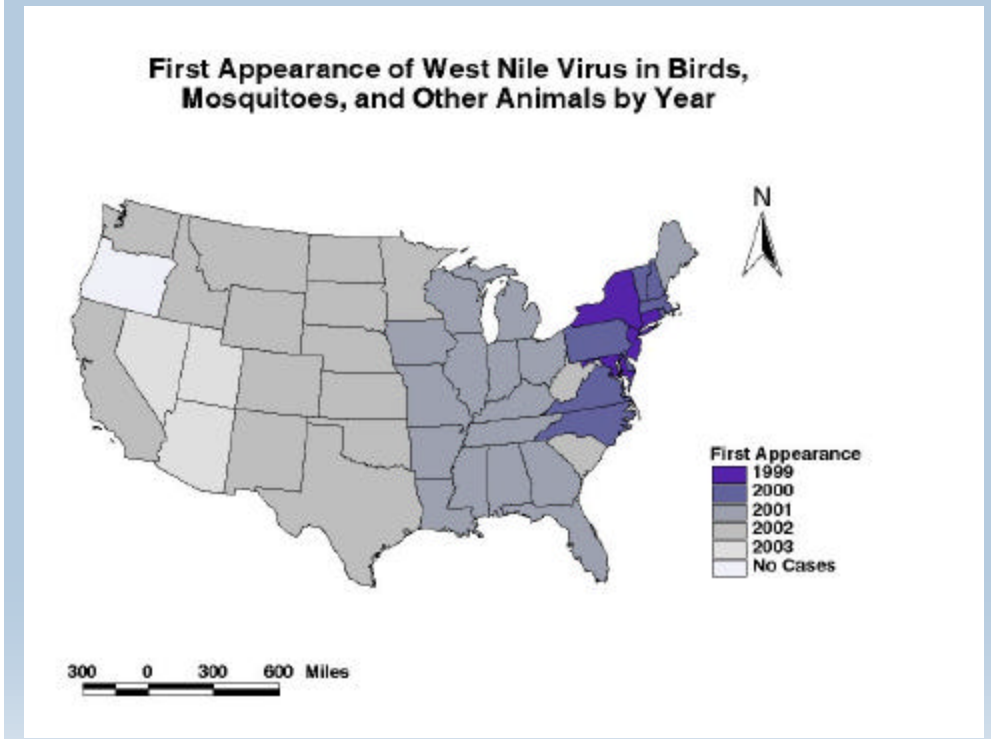
GIS Visualization: Choropleth Maps

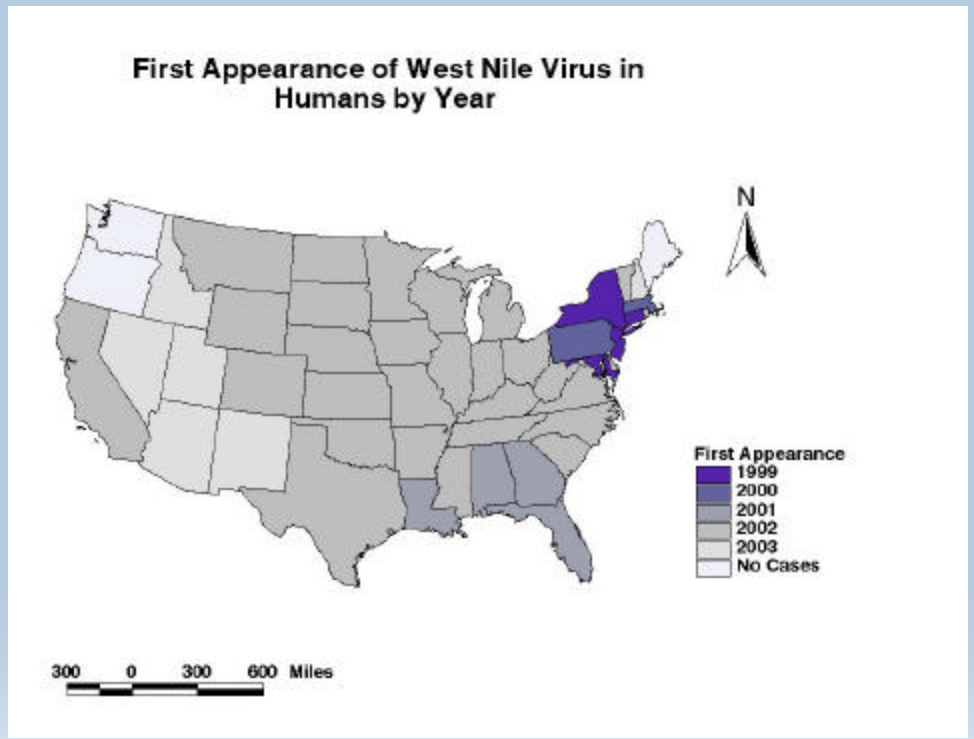
West Nile Virus Maps in the News





US Analysis


First Appearance of West Nile Virus in Birds, Mosquitoes, and Other Animals by Year
N
First Appearance
1999
2000
2001
2002
2003
No Cases
300 0 300 600 Miles


First Appearance of West Nile Virus in Humans by Year
N
First Appearance
1999
2000
2001
2002
2003
No Cases
300 0 300 600 Miles

Statistical Visualization: Micromaps

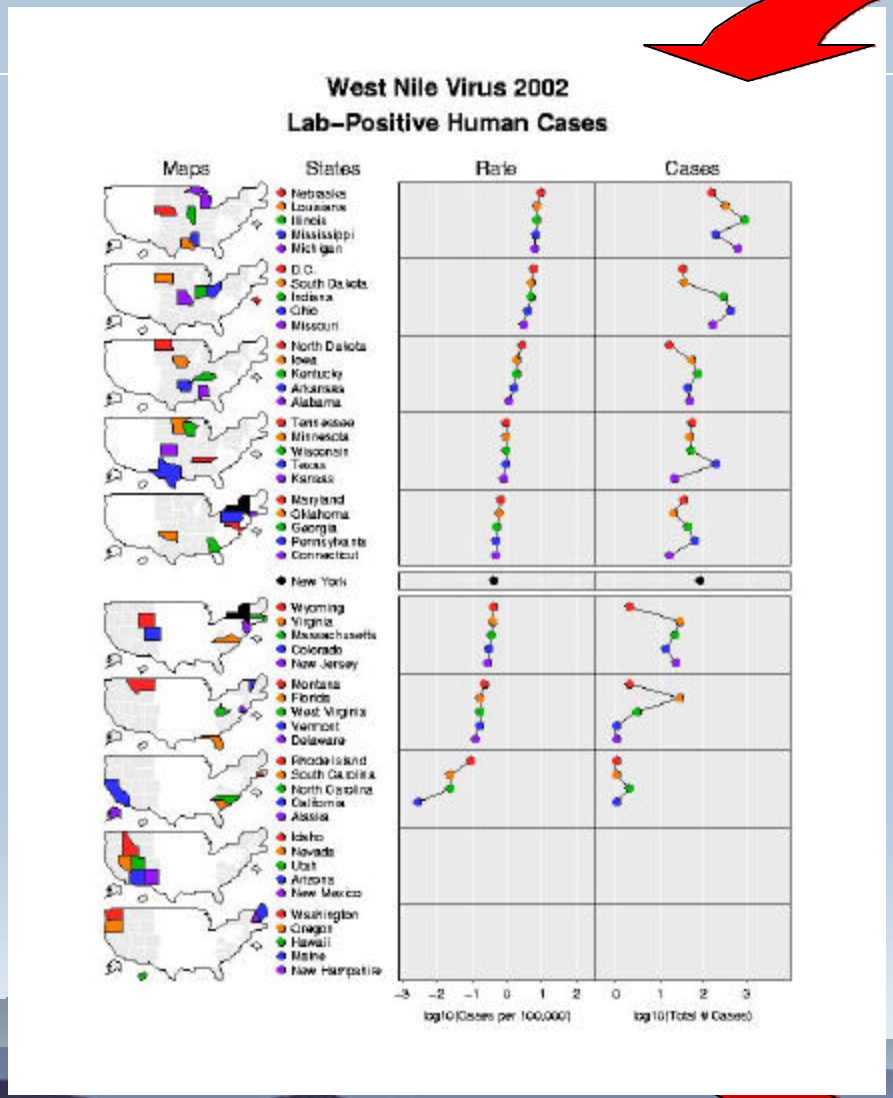
Micromaps

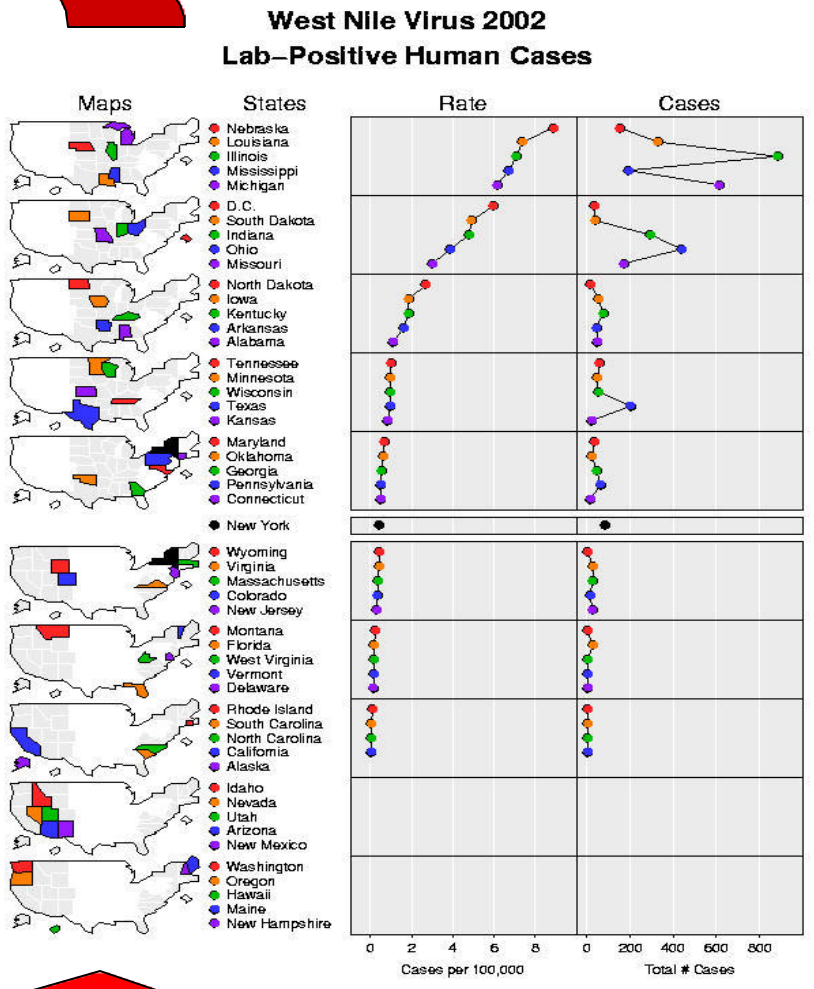
- Link of row-labeled univariate (or multivariate) statistical summaries to corresponding geographical region
- Focus on statistical display and not on maps

Usage of Micromaps

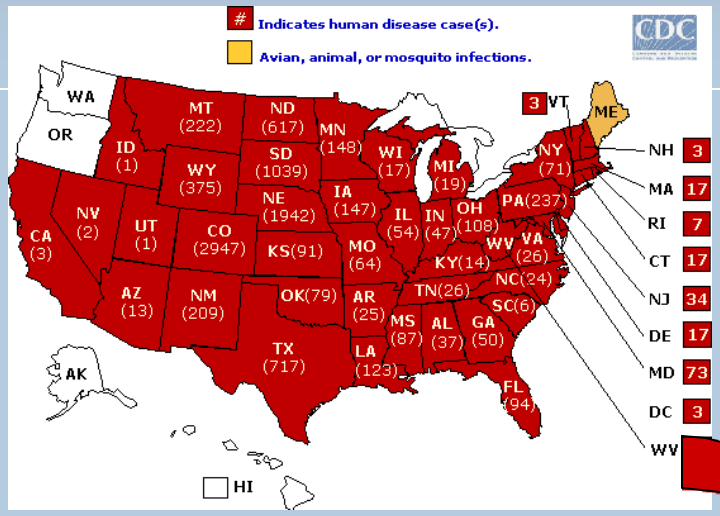
- First presented at 1996 American Statistical Association's annual meeting (Olsen, Carr, Courbois, Pierson)
- EPA: Cumulative Exposure Project (1998/1999 - intended)
- USDA-NASS: Agricultural Census (9/1999)
- NCI: Cancer Data (4/2003)

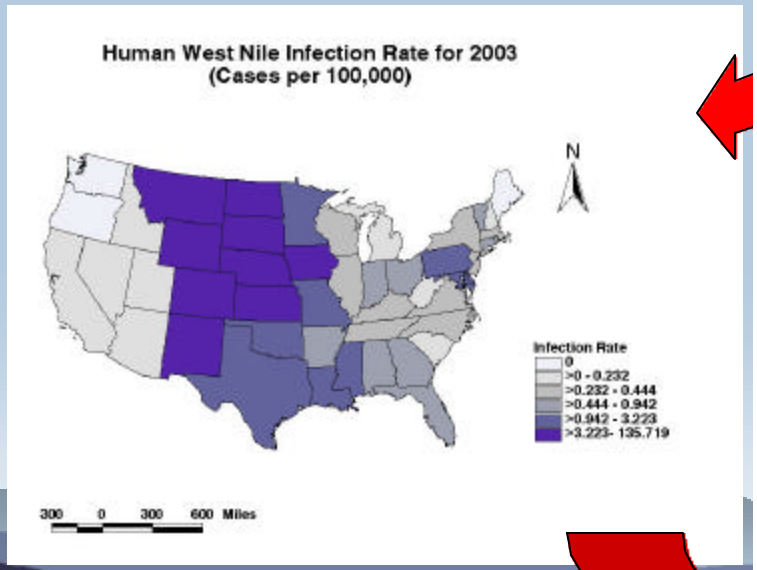
From 2002 CDC Web Page to Micromaps

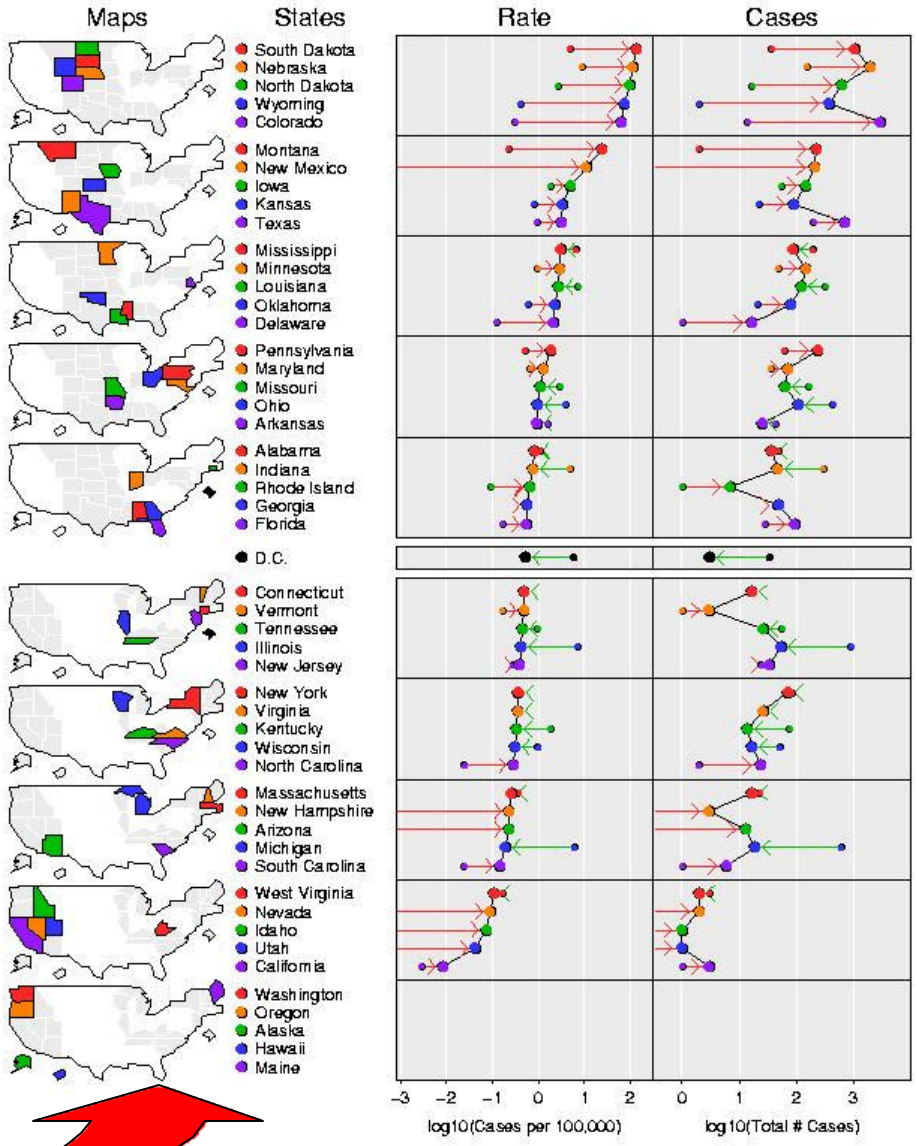




From 2003 CDC

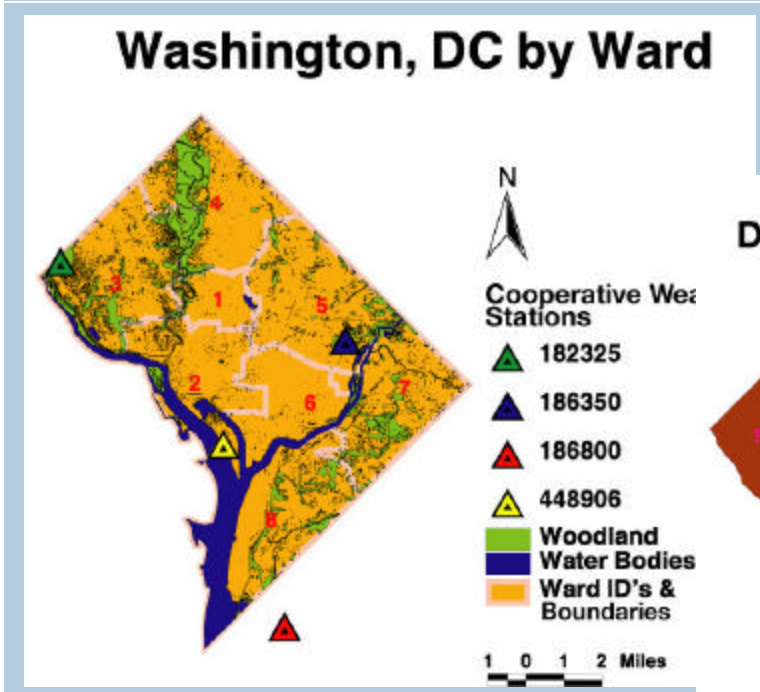


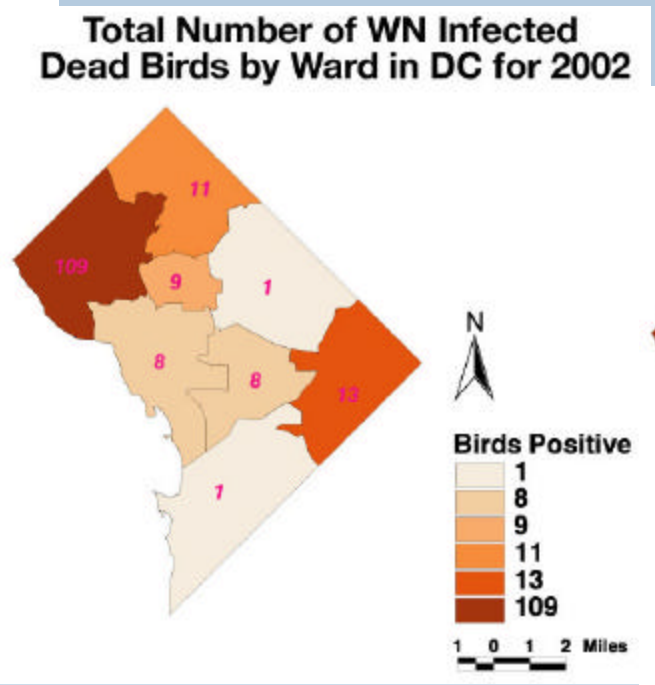


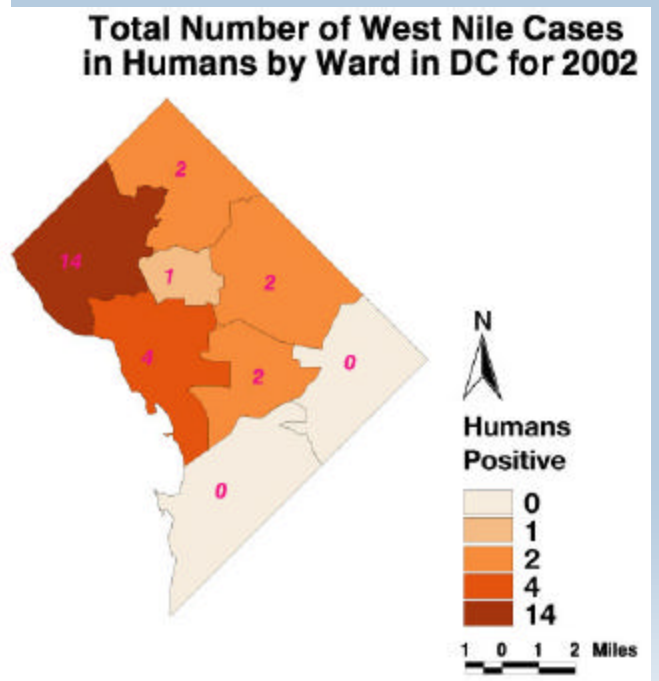


Washington, D.C., Analysis

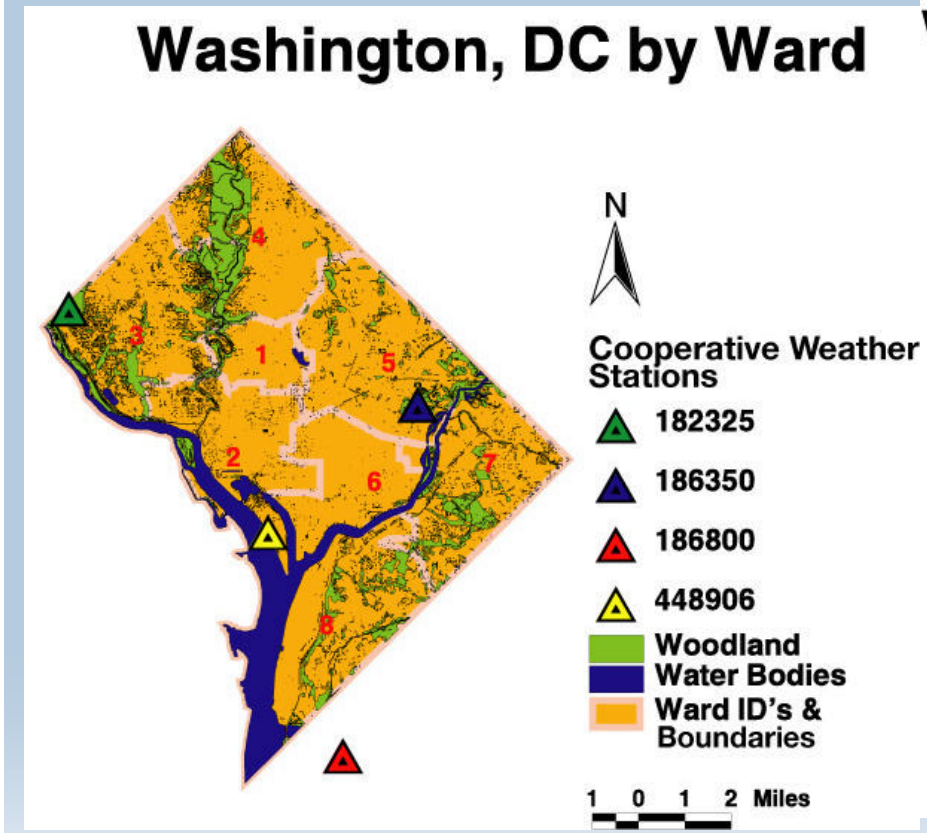
Washington, D.C., Analysis

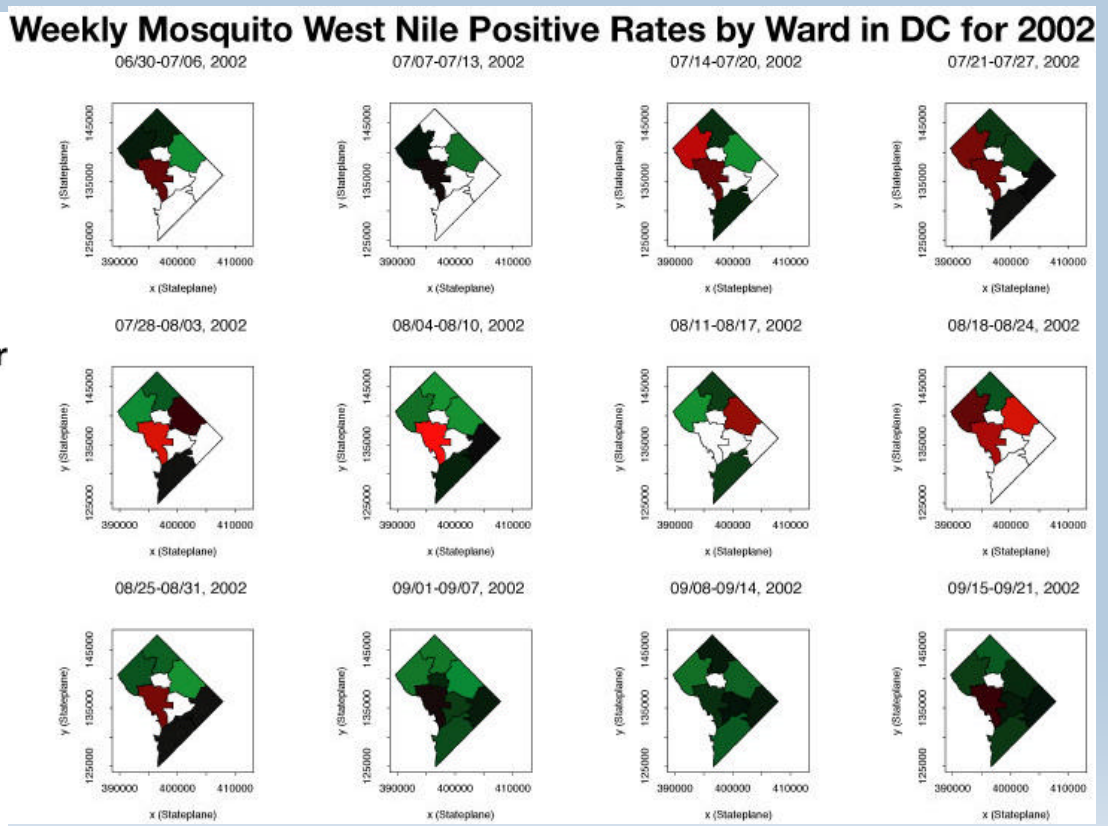




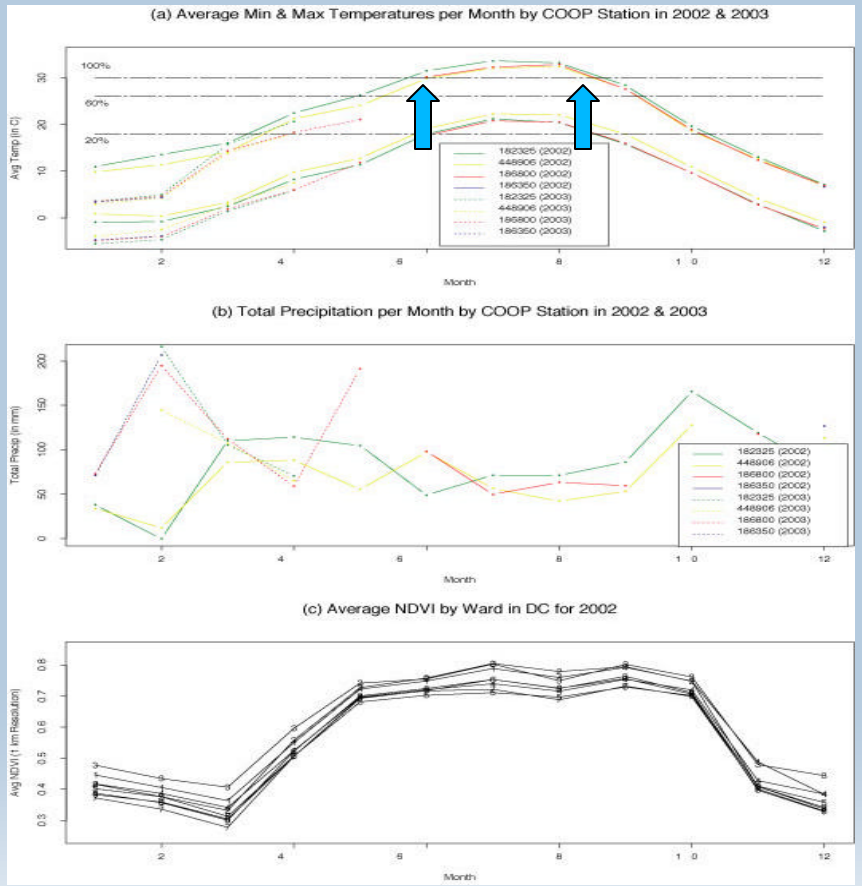


West Nile – D.C. Geographic Time Series



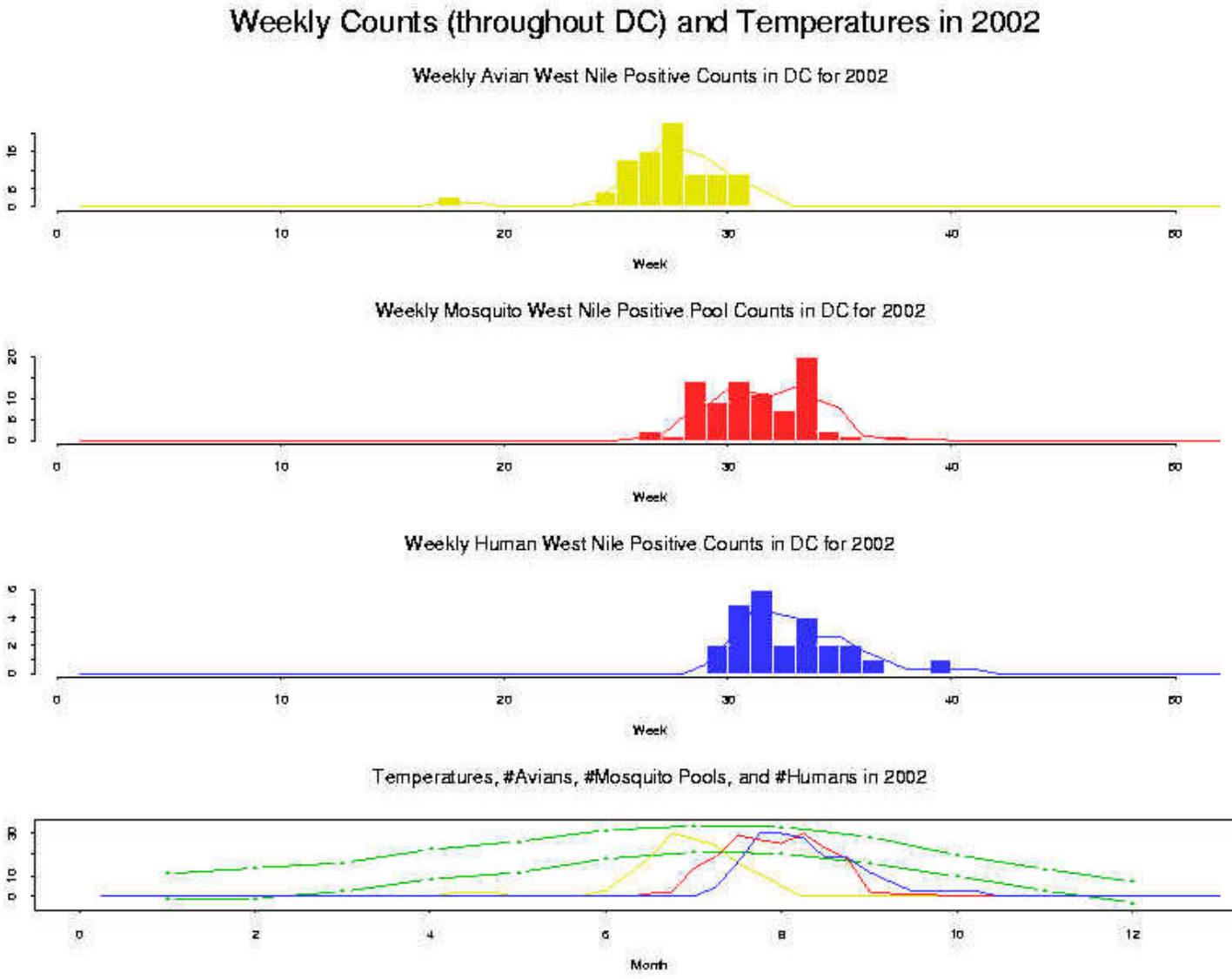


Enviro-Climatic Coupling

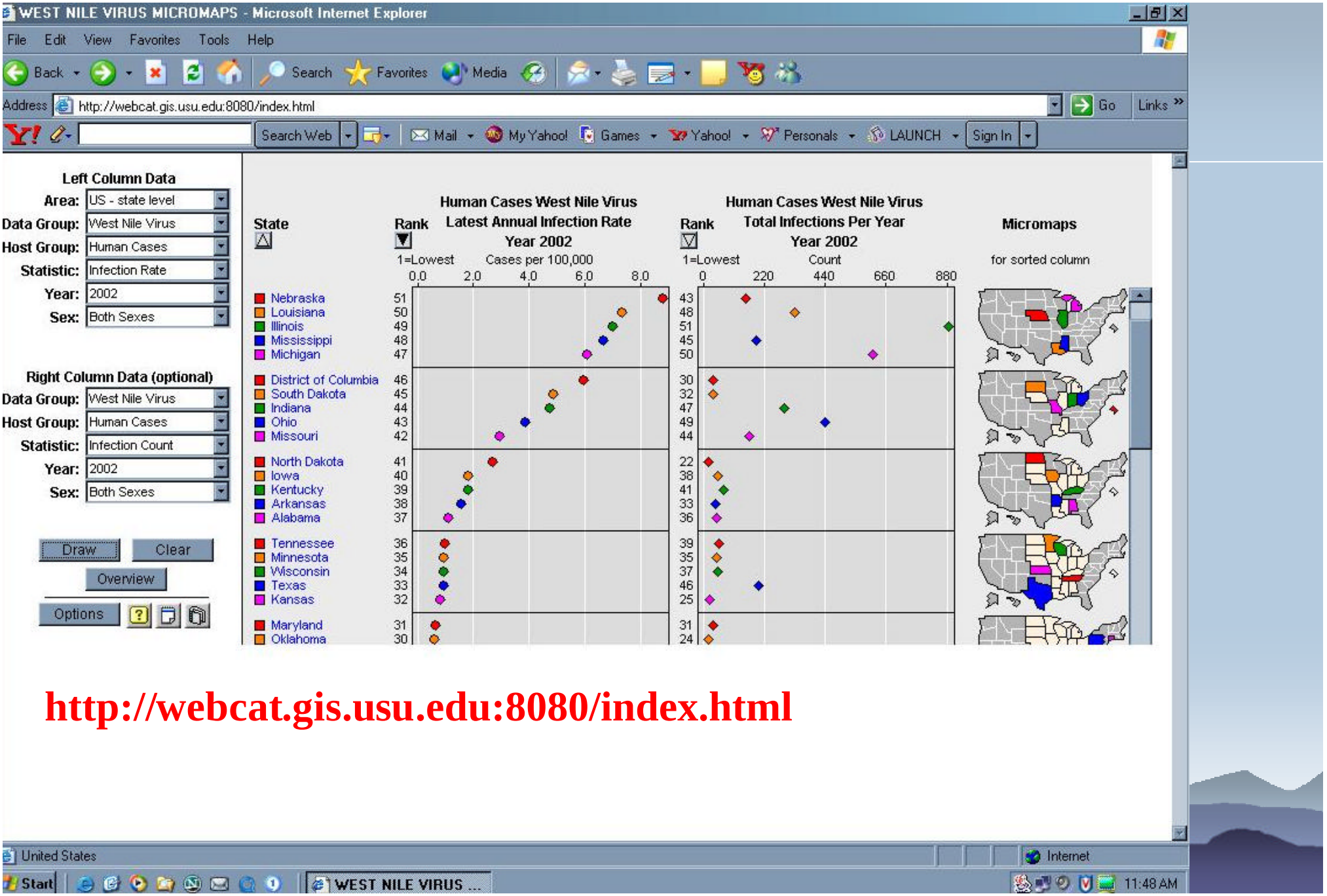


- Prior precipitation regime conducive to hydration and hatching of mosquito eggs
- Transmission competency (26° to 30° C) - indicative of higher efficiency of mosquito to transmit the virus
- Positive mosquito and human cases seen previously to occur within this time frame

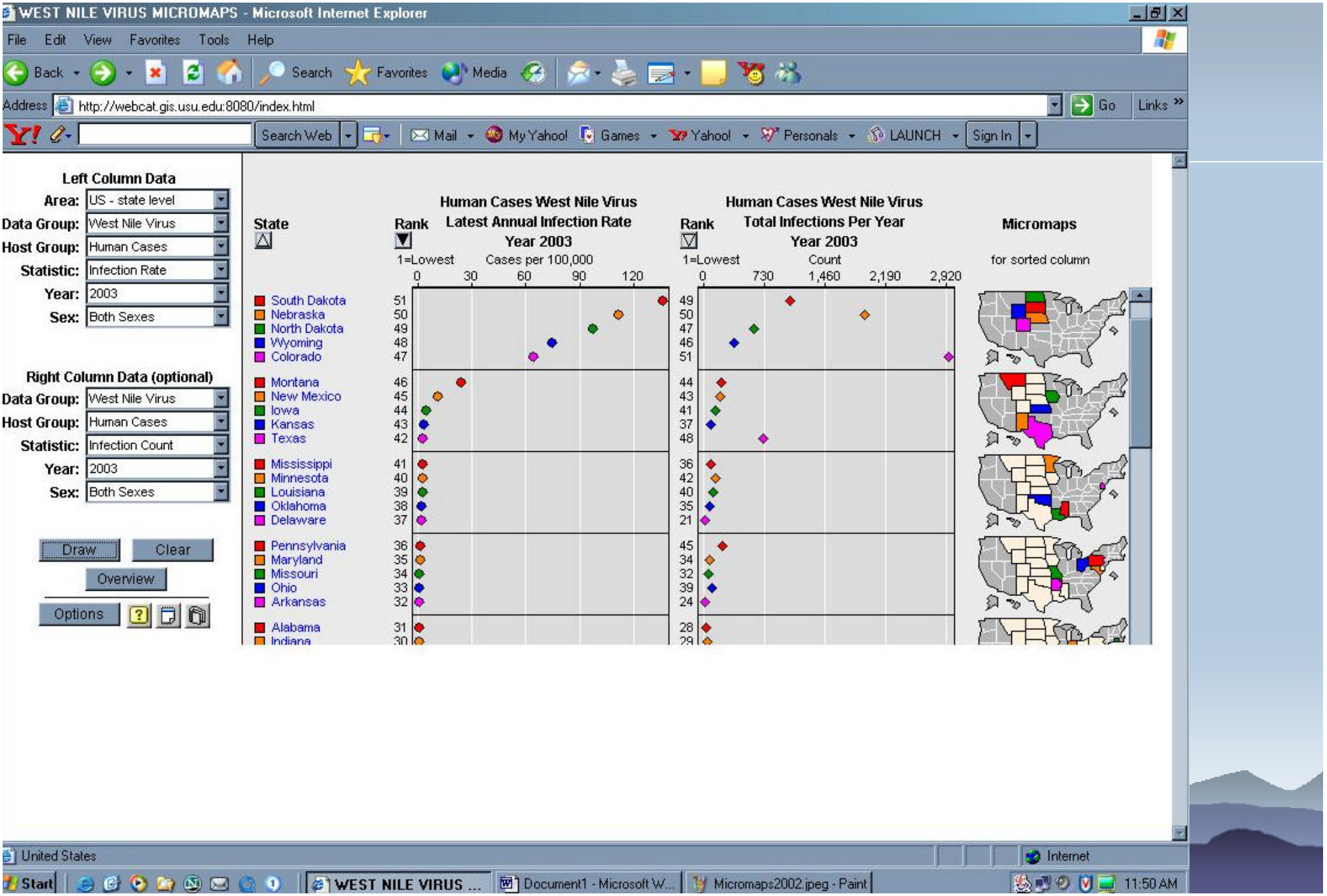
Temporal Development



Web-based Access to WNV Data



http://webcat.gis.usu.edu:8080/index.html


WEST NILE VIRUS MICROMAPS - Microsoft Internet Explorer
File Edit View Favorites Tools Help
Back Search Favorites Media
Address http://webcat.gis.usu.edu:8080/index.html
Go Links
Search Web Mail My Yahoo! Games Yahoo! Personals LAUNCH Sign In
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
Overview
Options
State
Human Cases West Nile Virus
Latest Annual Infection Rate
Year 2003
Rank
1=Lowest
Cases per 100,000
0 30 60 90 120
South Dakota 51
Nebraska 50
North Dakota 49
Wyoming 48
Colorado 47
Montana 46
New Mexico 45
Iowa 44
Kansas 43
Texas 42
Mississippi 41
Minnesota 40
Louisiana 39
Oklahoma 38
Delaware 37
Pennsylvania 36
Maryland 35
Missouri 34
Ohio 33
Arkansas 32
Alabama 31
Indiana 30
Human Cases West Nile Virus
Total Infections Per Year
Year 2003
Rank
1=Lowest
Count
0 730 1,460 2,190 2,920
49
50
47
46
51
44
43
41
37
48
36
42
40
35
21
45
34
32
39
24
28
29
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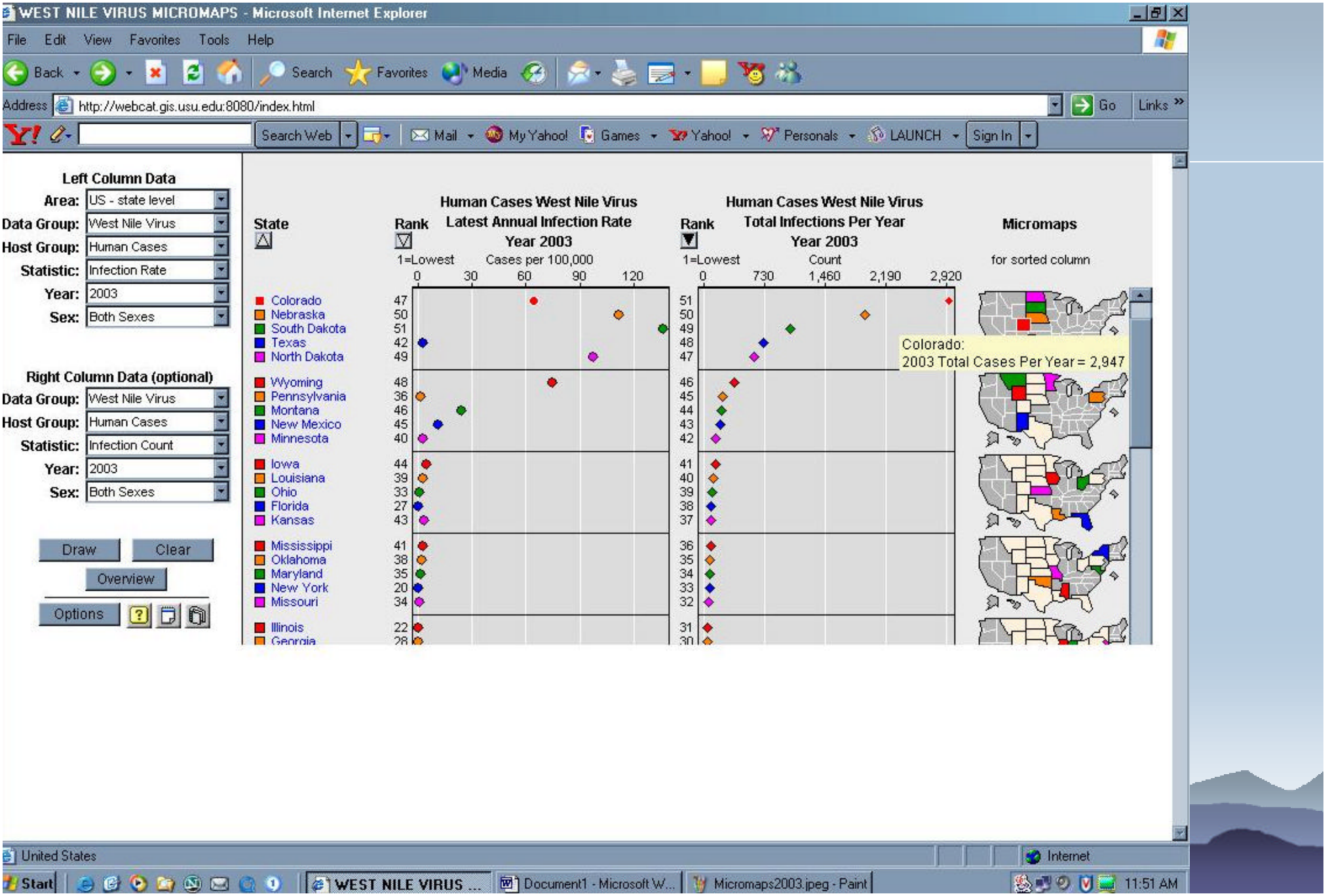
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File Edit View Favorites Tools Help
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Draw
Clear
Overview
Options
State
Human Cases West Nile Virus
Latest Annual Infection Rate
Year 2003
Rank
1=Lowest
Cases per 100,000
0 30 60 90 120
Human Cases West Nile Virus
Total Infections Per Year
Year 2003
Rank
1=Lowest
Count
0 730 1,460 2,190 2,920
Micromaps
for sorted column
Colorado 47
Nebraska 50
South Dakota 51
Texas 42
North Dakota 49
Wyoming 48
Pennsylvania 36
Montana 46
New Mexico 45
Minnesota 40
Iowa 44
Louisiana 39
Ohio 33
Florida 27
Kansas 43
Mississippi 41
Oklahoma 38
Maryland 35
New York 20
Missouri 34
Illinois 22
Georgia 28
51 50 49 48 47
46 45 44 43 42
41 40 39 38 37
36 35 34 33 32
31 30
Colorado:
2003 Total Cases Per Year = 2,947
United States
Internet
Start
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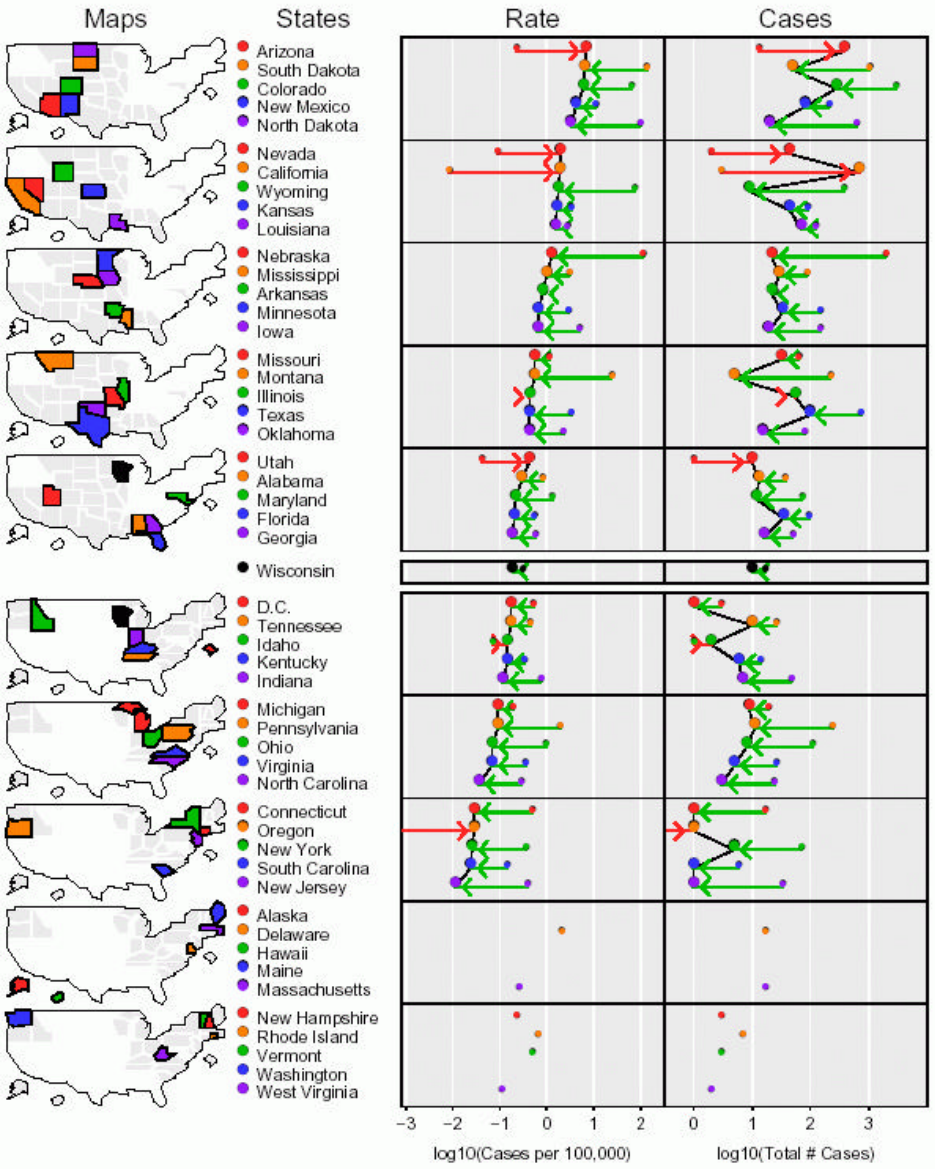
WNV in 2004


West Nile Virus 2004 (as of 10/19/04)
Lab−Positive Human Cases
Maps
States
Rate
Cases
Arizona
South Dakota
Colorado
New Mexico
North Dakota
Nevada
California
Wyoming
Kansas
Louisiana
Nebraska
Mississippi
Arkansas
Minnesota
Iowa
Missouri
Montana
Illinois
Texas
Oklahoma
Utah
Alabama
Maryland
Florida
Georgia
Wisconsin
D.C.
Tennessee
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
−3 −2 −1 0 1 2
log10(Cases per 100,000)
0 1 2 3
log10(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 ???