

ISSUES : DATA SET

Investigating the Ecology of West Nile Virus in the United States

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American Crow. Photo by David Liebman PinkGuppy 60. Used with permission.

THE ECOLOGICAL QUESTION:

How do biotic and abiotic environmental factors explain the historic, present, and future prevalence and range of West Nile Virus (WNV) in the US?

ECOLOGICAL CONTENT:

Abiotic and biotic environmental factors, biodiversity, epidemiology.

WHAT STUDENTS DO:

Use maps, online databases, and peer-reviewed literature to: (1) learn background information on WNV (history of emergence in the US; life cycle, hosts, and vectors; different forms of WNV disease and susceptibility of various human age groups) and (2) generate and test hypotheses correlating human, avian, and mosquito WNV infection with avian biodiversity, presence/abundance of different avian hosts, climatology, topography, land use, and presence of specific habitats such as wetlands (Hometown Approach). Use either Supplements (in Resource Files) or Internet databases to analyze data in graphs and interpret maps to answer questions (Structured Approach).

STUDENT-ACTIVE APPROACHES:

[Guided inquiry](#) or [open-ended inquiry](#), [cooperative learning](#), critical thinking

SKILLS:

Ecoinformatics: identification of relevant, reliable online information; downloading data into Excel files; making, downloading, and interpreting online maps; *Science process*: generating and testing hypotheses, manipulating and analyzing data in tables and graphs; communicating with PowerPoint or poster presentations, writing a research report in scientific format; *Collaboration* (Hometown Approach); graphing data, analyzing data, interpreting maps (Structured Approach).

ASSESSABLE OUTCOMES:

Research proposal; tables, graphs, maps; research report; poster or PowerPoint presentation (Hometown Approach). Written assignment with graphs and answered questions (Structured Approach).

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SOURCES:

- National Atlas - <http://nationalatlas.gov/index.html>
- United States Historical Climatology Network (US HCN) - <http://cdiac.ornl.gov/epubs/ndp/ushcn/ushcn.html>
- North American Breeding Bird Survey (BBS) - <https://www.pwrc.usgs.gov/BBS/>
- Centers for Disease Control and Prevention West Nile Virus - <http://www.cdc.gov/ncidod/dvbid/westnile/index.htm>
- US Geological Survey Disease Maps - <http://diseasemaps.usgs.gov/>
- National Climatic Data Center (NCDC) - <http://www.ncdc.noaa.gov/oa/ncdc.html>

OVERVIEW OF THE ECOLOGICAL BACKGROUND

In 1999 a disease new to the Western Hemisphere was discovered in New York City. It spread to the West Coast in four years (Kilpatrick 2011), and had been found in all contiguous US states by 2005 (DeBiasi and Tyler 2006). The infectious agent was West Nile Virus (WNV), a pathogen first identified in Uganda in 1937 (Kilpatrick 2011). WNV is related to viruses causing diseases such as St. Louis encephalitis (SLE), Eastern Equine Encephalitis (EEE), dengue, and yellow fever. Humans are “*dead end*” hosts (from which infections are not transmitted to other hosts); birds are *reservoir hosts* (in which infectious agents multiply and/or develop, and on which they depend for survival in nature); and mosquitoes are *vectors* (organisms that transmit infection). In the US, WNV has been found in at least 48 species of mosquitoes, 18 species of mammals (USDI 2011), and 326 species of birds (CDC 2009). There is no evidence that WNV can be transmitted by direct contact with infected humans, birds, or other animals, living or dead (CDC 2009). However, it can be transmitted through the placenta from mother to unborn child and in blood transfusions, which necessitates testing of blood donors.

Incidence of WNV has not been evenly distributed across the US, either at its onset or later. It is important to identify environmental conditions that correlate to infection. Since mosquito bites are the source of infection, the first directives to the public were to cover up when outdoors; use insect repellent; avoid outdoor activity at dawn and dusk, when mosquitoes are most abundant; and get rid of standing water, such as in clogged rain gutters or old tires, where mosquitoes can breed. *Abiotic* environmental factors linked to WNV include temperature and moisture. Land use such as urbanization, globalization (Kilpatrick 2011), and socioeconomics (Harrigan et al. 2010) also play key roles.

Many species of birds are especially susceptible to WNV infection; their populations declined drastically as WNV swept through an area (LaDeau et al. 2007). Other species are good (*competent*) hosts, because they do not die from the infection and therefore can transmit WNV when bitten by mosquitoes, which only bite living animals. Previously applied to Lyme disease by Schmidt and Ostfeld (2001), the *dilution hypothesis* has been used to show that the greater

the species diversity of birds in an area, the lesser the risk of human infection with WNV. This directly links the importance of biodiversity to human health (Swaddle and Calos 2008).

An important concept in the *epidemiology* of infectious disease is that the more *susceptible hosts* in a population, the higher the *prevalence* of a disease. Since WNV in the US is an *emerging disease*, the *incidence* of infection was high in areas to which the virus spread. Most infections are asymptomatic (about 80%); of those people showing symptoms, most have a mild, flu-like illness. However, WNV, like other viruses of the Flaviviridae, can infect the central nervous system, causing meningitis or encephalitis, which can be fatal, especially in the elderly (CDC 2010). Although not as *virulent* as some other flaviviruses, WNV has caused a number of fatalities in susceptible persons. The case-fatality rate for WNV infection in the US from 2002-2005 was 2-7%. Neuroinvasive disease, which causes most of the fatalities, occurs in about 1 in 150 WNV infections, or less than 1% (DeBiasi and Tyler 2006).

REFERENCES

- CDC (US Centers for Disease Control and Prevention). 2010. Surveillance for human West Nile Virus disease -- United States, 1999 – 2008, Morbidity and Mortality Weekly Report (MMWR) 59:SS-2: 1-20.
- CDC (US Centers for Disease Control and Prevention). 2009. Vertebrate ecology (bird species). <http://cdc.gov/ncidod/dvibid/westnie/birdspecies.html>
- Debiasi, RL, and KL Tyler. 2006. West Nile Virus meningoencephalitis. *Nature Clinical Practice Neurology* 2:264-274.
- Harrigan, RJ, HA Thomassen, W Buermann, RF Cummings, ME Kahn, and TB Smith. 2010. Economic conditions predict prevalence of West Nile Virus. *PLoS ONE* 5:e15437.
- Kilpatrick, AM. 2011. Globalization, land use, and the invasion of West Nile Virus. *Science* 334: 323-327.
- LaDeau, SL, AM Kilpatrick, and PP Marra. 2007. West Nile Virus emergence and large-scale declines of North American bird populations. *Nature* 447:710-714.
- Schmidt, KA, and RS Ostfield. 2001. Biodiversity and the dilution effect in disease ecology. *Ecology* 82:609-619.

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Swaddle JP and SE Calos. 2008. Increased avian diversity is associated with lower incidence of human West Nile infection: Observation of the dilution effect. PLoS ONE 3:e2488.

USDI (US Dept. of the Interior). 2011. National Atlas of the United States. Article: West Nile Virus. http://www.nationalatlas.gov/articles/biology/a_wnv.html

KEY RESOURCES

- National Atlas - <http://nationalatlas.gov/index.html>
- United States Historical Climatology Network (US HCN) <http://cdiac.ornl.gov/epubs/ndp/ushcn/ushcn.html>
- North American Breeding Bird Survey (BBS) - <https://www.pwrc.usgs.gov/BBS/>
- Centers for Disease Control and Prevention West Nile Virus - <http://www.cdc.gov/ncidod/dvbid/westnile/index.htm>
- US Geological Survey Disease Maps - <http://diseasemaps.usgs.gov/>
- National Climatic Data Center (NCDC) - <http://www.ncdc.noaa.gov/oa/ncdc.html>

DATA SETS

1. Other Resource Files for the Hometown Approach (students get their own data from online sites). The first five files contain instructions for using the Web sites and sample data sets and/or maps from each site. These are not meant to be used in analysis, but may be given to students at the discretion of the instructor. *Remember to check whether the Web sites have been updated before giving these files to students.*

- National Atlas [[docx](#)]
- United States Historical Climatology Network (US HCN) [[docx](#)]
- North American Breeding Bird Survey (BBS) [[docx](#)]
- Centers for Disease Control and Prevention West Nile Virus [[docx](#)]
- US Geological Survey Disease Maps [[docx](#)]
- Additional Resources – may be supplied to students if the instructor chooses:
 - Format for a Research Proposal [[docx](#)]
 - Format for a Scientific Research Report [[docx](#)]
 - Glossary of terms related to West Nile Virus [[docx](#)]

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- Species Diversity Calculations [[docx](#)]
- Additional Peer-reviewed Sources on WNV [[docx](#)]
- Additional Web Sites for In-depth or International Study [[docx](#)]

2. Other Resource Files for the Structured Approach (or Structured Exercises):

- Student Handout for Structured Exercises - to be provided to students for completing the Structured Exercises. [[doc](#)]
- Faculty Cheat Sheet for Structured Exercises - possible answers to the Structured Exercises. [[doc](#)]
- Supplement 1 for Structured Exercises: West Nile Virus Human Neuroinvasive Disease Incidence in the United States for 1999-2009 - data for Part 1 of the Structured Exercises if the Internet is not used. [[pdf](#)]
- Supplement 2 for Structured Exercises: Tables of Human Cases Reported to CDC 1999 to 2010 - data for Part 1 of the Structured Exercises if the Internet is not used. [[pdf](#)]
- Supplement 3 for Structured Exercises: USGS WNV Maps 2003-2010 for CA - data for Part 2 of the Structured Exercises if the Internet is not used. [[pdf](#)]
- Supplement 4 for Structured Exercises: June, July, Aug 1999-2010 Temps - data for Part 3 of the Structured Exercises if the Internet is not used. [[pdf](#)]
- Supplement 5 for Structured Exercises: Climate at a Glance Summer Temps 2000-2010 - data for Part 3 of the Structured Exercises if the Internet is not used. [[pdf](#)]

STUDENT INSTRUCTIONS

West Nile Virus (WNV) was first found in the US in 1999 and spread across the country, causing epidemic human disease and reduction in population sizes of multiple species of birds in 2002-2003. This module explores online epidemiological, medical, and ecological data on West Nile Virus (WNV) in the US. It is important to understand the environmental factors that contribute to spread and maintenance of WNV, as well as its medical importance.

Web sites:

1. National Atlas- <http://nationalatlas.gov/index.html>
2. United States Historical Climatology Network (US HCN) - <http://cdiac.ornl.gov/epubs/ndp/ushcn/ushcn.html>

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3. North American Breeding Bird Survey (BBS) - <https://www.pwrc.usgs.gov/BBS/>
4. Centers for Disease Control and Prevention West Nile Virus - <http://www.cdc.gov/ncidod/dvbid/westnile/index.htm>
5. US Geological Survey Disease Maps - <http://diseasemaps.usgs.gov/>
6. National Climatic Data Center (NCDC) - <http://www.ncdc.noaa.gov/oa/ncdc.html>

The instructor will assign one of the approaches below:

Hometown Approach:

1. First read the Background Information and [Glossary](#) included in this module. Additional information is on the Web sites and in the References.
2. Next think about WNV in your hometown or county. Has it occurred there? When? How many cases? How many fatalities? Has it been measured in mosquitoes? In birds? In other animals? (To answer these questions you will have to use several of the Web sites.)
3. Try to think of some environmental factors that you believe contribute to differences in WNV in different areas. Talk to other students from different areas about their answers to No. 2 and compare WNV in their areas to that in yours. Is the incidence or prevalence different? Are the environmental factors different? Which ones? Select one or more environmental factors that you think explain the incidence of WNV in your home area (by comparing with other students' data). You might want to focus on the effects of WNV on either people or birds.
4. View the sample maps and/or data sets for each Web site (Resource Files), then go to the Web sites and map or download data on the environmental factors you have selected and the incidence or prevalence of WNV for the same area and time period.
5. Write a short *research proposal* explaining what you will do in this project. See the Resource File entitled "[Format for a Research Proposal](#)" for what to include. The good news is that much of your proposal will go right into your final report!
6. Interpret the maps, tables, and graphs that you create online.
7. Try to explain your results in discussion with other students. Some environmental factors should be graphed against WNV and/or statistically analyzed to examine *correlation* or *causation*.
8. Use the Web sites to explain your data. Compare and revise explanations if necessary, in group discussion.
9. Write your final Research Report. See the Resource File labeled "[Format of a Scientific Research Report](#)".
10. Present the results of your research to your classmates in PowerPoint or poster format.

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Questions for Discussion:

1. *Is WNV a species? Why or why not? What are some differences in environmental factors affecting an obligate pathogen vs. those affecting a free-living organism?*
2. *What do you think will happen to WNV prevalence with global climate change? Why? Will the same thing happen in different areas? Why or why not? (Explore the [NASA Global Climate Change Website](#) for answers. This could be an additional topic if the instructor and students are interested.)*

Structured Approach:

You will need the Student Handout for Structured Exercises, which contains additional information and instructions. This approach has three parts.

Part I. Examining Maps of West Nile Virus Incidence and Reported Cases from the CDC

You will be examining maps of WNV Human Neuroinvasive Disease Incidence and Tables of Human Cases Reported to the Centers for Disease Control. You will either be instructed to use the links provided in the [Student Handout for Structured Exercises](#) or [Supplement 1](#) and [Supplement 2](#) provided by your instructor.

1. WNV Human Neuroinvasive Disease Incidence Maps

- a. What do the maps show?
- b. How many years did it take for any WNV activity to reach the West Coast?
- c. How many years did it take for any state on the West Coast to report an incidence per million greater than 100 or more cases?
- d. Are there regions of the US with more or less WNV?

2. Tables of Human Cases Reported to the Centers for Disease Control

- a. What is the difference between West Nile encephalitis and West Nile meningitis?
- b. What is West Nile fever?
- c. What is reported in Total Human Cases Reported to the CDC?
- d. What is ArboNET?
- e. Why does West Nile Virus disease reflect a bias in surveillance reporting?
- f. Among all people infected with West Nile Virus what percentage will develop severe neuroinvasive disease?

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3. For your state of interest:

- a. In which year were WNV cases first reported?
- b. Describe any trends in the number of Total Cases in WNV for the state since it was first reported.

Part II. Examining Biotic Predictors of West Nile Virus Infection Risk in Humans

You will be examining US Geological Survey West Nile Virus Maps for Bird, Human, Mosquito, Sentinel, and Veterinary WNV cases. You will either be instructed to use the links provided in the [Student Handout for Structured Exercises](#) or [Supplement 3](#) provided by your instructor.

Predicting areas of increased human risk of WNV has used animal surveillance data (this includes infections of mosquitoes, birds and other non-human vertebrates). You will extract data from USGS WNV Maps for Bird, Human, Mosquito, Sentinel and Veterinary infections. Sentinel data (from USGS WNV Maps) may include chickens and/or horses.

1. Which type of WNV infection (Bird, Mosquito, Sentinel or Veterinary) has the strongest relationship with the number of Human Disease Cases?
2. Which of these disease cases best predict the number of human cases?

Part III. Examining a Climatic Factor of West Nile Virus

You will be examining temperature data from the National Climatic Data Center (NCDC) and US Climate at a Glance depicting departures from normal summer temperatures. You will be instructed to use either the links provided in the [Student Handout for Structured Exercises](#) or [Supplement 4](#) and [Supplement 5](#).

1. Is WNV incidence related to average summer temperatures for your state of interest?
2. Using maps of summer temperature variation and WNV incidence, how do regions of higher incidence [greater than 100 per million (red dots)] of WNV cases compare to summer temperature variations?

NOTES TO FACULTY

This teaching module includes two different approaches. The goal of both approaches is to introduce WNV biology and ecology. The Hometown Approach

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uses online data and maps to generate and test hypotheses about interactions between an emerging disease organism and its environment. The Structured Approach/ Structured Exercises present data on reported cases and biological and environmental predictors of WNV to interpret and analyze. The instructor can decide which approach to use depending on available time, type of class (freshmen vs. upperclassmen; majors vs. non-majors; lecture vs. lab), availability of computers, and Internet access.

Hometown Approach: The Hometown Approach gives students a set of Web sites containing archived and current data on WNV and environmental factors, and asks them to use these Web sites to find information for their hometowns or counties in the US. Students form hypotheses about which environmental factors influence WNV incidence/prevalence in their local areas. An added value of the Hometown Approach is giving students experience using reliable Web sites. However, instructors should always check the Web sites before each use, as Web sites are updated frequently. Different Web sites can be used for different aspects of the topic, e.g., the National Atlas for *mapping* biotic and abiotic environmental variables affecting WNV; the United States Historical Climatology Network for *making tables and graphs* of climate through time in an area; the Breeding Bird Survey for *downloading data for calculations* addressing the *dilution effect hypothesis* or the effect of WNV on specific bird species; and the CDC and USGS WNV sites for the relative medical importance, history, and incidence/prevalence of WNV in mosquitoes, people, and birds.

Structured Approach: The Structured Approach/Exercises are designed to provide a broad overview of WNV incidence and prevalence. First, students will examine maps of WNV Human Neuroinvasive Disease Incidence and Tables of Human Cases Reported to the Centers for Disease Control. The Structured Exercises also introduce biotic and climatic predictors of WNV. Biotic predictors of increased human risk of WNV include infections of vector mosquitoes, birds and non-human vertebrates (Liu et al. 2009). Students will then explore US Geological Survey WNV Maps for Bird, Human, Mosquito, Sentinel and Veterinary infections. Lastly, students will evaluate average summer temperature data from the National Climatic Data Center against numbers of WNV cases, as warmer temperatures along with elevated humidity and heavy precipitation has increased the rate of human WNV infection in the United States (Soverow et al. 2009). This Structured Approach uses either the Supplements (available as Resource Files) or Internet databases (links available in the [Student Handout for Structured Exercises](#)). The Supplements were designed to be a backup to online databases and offer a subset of data, allowing the Structured Exercises to be performed without the Internet or if the relevant information was taken offline.

Literature Cited

Liu, A, V. Lee, D. Galusha, M.D. Slade, M. Diuk-Wasser, T. Andreadis, M. Scotch, and P.M. Rabinowitz. 2009. Risk factors for human infection with West Nile Virus in Connecticut: a multi-year analysis. *International Journal of Health Geographics* 8: 67.

Soverow, J.E., G.A. Wellenius, D.N. Fisman, and M.A. Mittleman. 2009. Infectious disease in a warming world: How weather influenced West Nile Virus in the United States (2001–2005). *Environmental Health Perspectives* 117: 1049–1052.

COMMENTS ON INTRODUCING THE ACTIVITY TO YOUR STUDENTS

Extensive discussion may be necessary for freshmen, who have not previously studied ecology in college. Although inquiry based learning techniques emphasize not giving out answers before asking questions, naïve students will not be able to connect environmental factors to WNV incidence without a general discussion of how environmental factors influence distribution and abundance of organisms.

- **Hometown Approach:** Because the focus of this module is a human pathogen, students are interested. The Hometown Approach further enhances student interest by focusing on the student's home area. An important aspect of the Hometown Approach is to have students share the information they have found. The more different their hometowns are, the better comparisons students will be able to make regarding why one area has more WNV than another. One thing students will not expect is the very low incidence of WNV in most areas. The instructor should also be sure that students have a clear understanding of the symptoms/effects of different kinds of WNV infection. They will almost certainly overestimate both the incidence and the mortality of this infection. It may be instructive to compare WNV with other mosquito-borne infections. These data also can be found on the CDC site.
- **Structured Approach:** The Structured Approach complements the Hometown Approach and was designed to be done with the instructor choosing the state of interest (if possible the home state of the student). The Structured Exercises give a broad overview of WNV incidence/prevalence, introduce WNV biotic and climatic predictors, and expose students to the corresponding Internet resources. Instructions and links are provided for Internet databases, but the Internet is a dynamic resource and links can change, which voids the instructions. To address this, Supplements are provided. These are subsets of data available that allow students to perform exercises, without Internet

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access, only for California as the state of interest. It is at the discretion of the instructor to do the Structured Exercises using Internet databases (for a particular state of interest) or to just use the Supplements.

How to Use These Data Sets in a Class: Depending on which approach is used, this module is suitable for one class period or a semester-long project. The numerous Web sites and references contain all the information the instructor should need to fully understand the topic, introduce it to students, and discuss additional hypotheses not covered in the module (for example, the effect of global climate change on mosquito-vectored disease). The choice of this topic was guided by the desire to show pre-health students the importance of the environment in human health, and also to show them the relative importance of WNV compared to other arthropod-borne infections.

If only one or two lab periods are available for this module, the Structured Approach Exercises can provide a discrete learning experience connecting ecology and human health. For a short Hometown Approach, the National Atlas combined with CDC and/or USGS Disease Maps data could be used to give non-majors' or freshman biology courses an historical overview and to ask such questions as, "Why did WNV sweep across the country so fast?" and "How do specific environmental variables such as presence of wetlands influence the incidence of WNV?" In an Ecology or Ornithology course, using Breeding Bird Survey data along with the human incidence data and calculating species diversity to address the *dilution effect hypothesis* could be a one lab period exercise. For a longer research experience, the Hometown Approach could include exploration of a number of biotic and abiotic environmental influences by using all of the Web sites and perhaps adding some in the Additional Resources.

How to Use the Structured Approach Supplements in a Class:

Supplements 1-5 (Resource Files) were designed to be a backup to online databases, allowing the Structured Exercises to be performed if the Internet was not available in the lab or if the relevant information was no longer available online. Supplements are subsets of the data available online and are sufficient to answer questions for California. Internet, however, will be required if students are to do the Structured Exercises for other states. If possible, we hope that students will be able to access the Web sites to do the Structured Exercises. The module was designed to expose students to the various online resources directly to explore West Nile Virus in their home states. The instructions provided in the Student Handout for Structured Exercises about navigating each of the Web sites was current at the time of publication, but if a Web site has changed, you may need to navigate it differently in order to produce maps and data sets of interest to you.

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Structured Exercises:

Students will need the Student Handout for Structured Exercises, which is available as a Resource File. The required Supplements are also available as Resource Files.

The Structured Exercises are meant to complement the Hometown Approach. The exercises are straightforward and should take a ninety-minute lab period. Anything not completed within the lab period can be completed as homework. We suggest that small groups of students can work together, especially in extracting data from dozens of maps and outputs from online resources (or Supplements).

The [Student Handout for Structured Exercises](#) is divided into three parts and can either be completed with students accessing data from Web sites or using the provided Resource Files (Supplements 1-5). If students are instructed to directly access the listed Web sites for the exercises, it is recommended they do the exercises using data from their respective home states (as an extension of the Hometown Approach).

Part I: Examining Trends in West Nile Virus Prevalence

Students will either be instructed to use the links provided in the [Student Handout for Structured Exercises](#) or [Supplement 1](#) and [Supplement 2](#). Supplement 1 consists of maps of WNV Human Neuroinvasive Disease Incidence from 1999-2009 compiled as a single PDF. Supplement 2 consists of Tables of Human Cases Reported to CDC 1999 to 2010. If students are instructed to use links provided, we recommend checking the links before the assignment is given. Additional incidence maps and tables of human cases for more recent years might also be available.

Students might be confused about the difference between “incidence” and “prevalence.” The CDC maps are of incidence for a particular year, but asking if there are regions of the US more or less prone to WNV is a question of prevalence. We found the following CDC link useful pointing out the difference between incidence and prevalence:

<http://www.cdc.gov/hiv/topics/surveillance/basic.htm>.

“HIV Incidence: The number of new HIV infections in a specific population during a specific period of time.”

“HIV Prevalence: The number of people living with HIV infection in a given year.”

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Basic Statistics | Statistics and Surveillance | Topics | CDC HIV/AIDS. 2011. Centers for Disease Control and Prevention. 1 Jan. 2012
<<http://www.cdc.gov/hiv/topics/surveillance/basic.htm>>

Students will be asked to plot the number of Total Human Cases (Neuroinvasive Disease Cases + Nonneuroinvasive Disease Cases) Reported to CDC from 1999 to present (or 2010). Students should be able to do this in Excel. A table is provided to assist students in recording data, but additional years should be added if needed.

Part II. Examining Biotic Predictors of West Nile Virus Infection Risk in Humans

Students might need to review R^2 and how to plot and create trend lines in Excel (or other program of choice). Also, if students are instructed to use links provided, we recommend checking the links before the assignment is given. Data for more recent years might also be available. Use the table to record incidences of Human, Bird, Mosquito, Sentinel and Veterinary cases for years in which data are available. Students are encouraged to explore the Web site and extract the data needed for the exercise. States are chosen using the Select State drop down menu. A link for "Historical Data" provides archived maps and data for previous years. [Supplement 3](#) of the Resource Files (USGS WNV Maps 2003-2010 for CA) can be used in Part II.

Students particularly interested in Part II are encouraged to read:

Liu, A, V. Lee, D. Galusha, M.D. Slade, M. Diuk-Wasser, T. Andreadis, M. Scotch, and P.M. Rabinowitz. 2009. Risk factors for human infection with West Nile Virus in Connecticut: a multi-year analysis. *International Journal of Health Geographics* 8: 67.

We found this link useful to provide a brief background on WNV:
http://diseasemaps.usgs.gov/wnv_background.html

We found this USGS link useful in explaining Sentinel and Veterinary species:
<http://diseasemaps.usgs.gov/faqs.html?wnv>

Part III: Examining a Climatic Predictor of West Nile Virus

Students will either use the links provided to access data online or do the Structured Exercises for California using [Supplement 4](#) of the Resource Files. If the Internet is used, instructors should familiarize themselves with the links to anticipate problems and to be able to assist students in navigating the Web site.

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<http://www.ncdc.noaa.gov/temp-and-precip/time-series/>

Choosing month and state should recover temperatures. The temperature for the month and year can be displayed as comma-delimited data or be copied by hand from the output. This process needs to be repeated for June, July and August. The three months are then averaged to get an average summer temperature. Our hope is that students will be able to appreciate that such data exist and keep it in mind as a potential resource in the future.

Comparing maps of temperature deviations and the number of WNV cases is meant as a straightforward exercise in which students make side by side comparisons of maps and report what they observe.

Students who are interested in more quantitative analysis are directed to:

Soverow, J.E., G.A. Wellenius, D.N. Fisman, and M.A. Mittleman. 2009. Infectious disease in a warming world: How weather influenced West Nile Virus in the United States (2001–2005). *Environmental Health Perspectives* 117: 1049–1052.

COMMENTS ON CHALLENGES TO ANTICIPATE AND SOLVE

- **Wide range of student abilities on the computer.** *The best ways to alleviate this potential problem are for the instructor or TA to circulate around the room and help anyone who needs it – but also to pair or group students to help each other.*
- **Administrative stops on downloading software.** *As written, the module can be used without downloading any specialized software. Excel is needed for downloading data into tables and constructing graphs from downloaded data. The structured exercises provide data, so downloading is not necessary; however, Excel is still useful for graphing.*
- **Distraction factor of so many cool Web sites (amount of available material can also be overwhelming).** *Keep students focused while in class, at least, by periodically stopping them and asking what they have found so far. Group sharing also can help keep students on track. Not a problem with the structured exercises.*
- **Lack of enthusiasm for working in groups.** *Assure students that grades will be based on their individual reports. Students work readily in groups to gather information in class, but many serious students are more content to be graded on their own report. Collaborative group reports can be a disaster if one or more members do not do their part, so a solution is collaborative data gathering but individual report writing. If a group report is desired by the instructor (e.g., for reasons of grading time), it should always be graded with a rubric that includes a “collaboration score” that is assessed by peers. That way, if the*

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group agrees that a member did not do his/her part, that student alone is graded down. BJA usually allows 10% of the report grade for collaboration.

- **Math anxiety.** *This is a tough one. If a student fears his ability to complete a math-related task, it can influence his attitude toward the whole project. Again, the instructor or TA should be in the lab during the exercise. If it is given as homework, the instructor should allow office hours or class time to go over problem calculations. Offer individual help outside of class for those who don't want to show their math anxiety to their peers. Grouping students together to help one another (informal peer instruction) is an effective technique for overcoming math anxiety*
- **Tendency to believe and/or express unfounded claims.** *Examples: WNV is a major, deadly epidemic; global climate change is not happening...you get the idea. Class discussion either before or after students use the appropriate Web sites/data sets is essential. Students will NOT change preconceptions unless the issues are discussed. Discussion allows unfounded or false claims to be aired and discounted (gently).*

COMMENTS ON THE DATA COLLECTION AND ANALYSIS METHODS USED

We endeavored to complete the basic module without a requirement for downloading any software (assuming students have Excel and Word). Some data sets in Additional Resources that might be useful in advanced classes require special software to open. Where this is the case, appropriate software is noted.

Hometown Approach: The National Atlas maps are very easy (and fun) to use; freshmen and non-majors should start there. The mapping parts of the module can be used in middle or high schools. Other material such as the Breeding Bird Survey data download and diversity calculations might work better in Ecology or other upper division classes, unless the instructor has lots of time to go over the calculations.

Web sites with international information have been added to Additional Resources, but if a student is not native to the US, some parts of the module will not be applicable unless the student chooses his/her institution's location as "home." Instructors could add to the module for their home institution. Feel free to email [the lead author](#) to discuss adding an international component to the module.

COMMENTS ON HOW USING LARGE DATA SETS CAN BE MORE EFFECTIVE IN TEACHING SELECTED CONCEPTS

The Hometown Approach is particularly effective in revealing the sheer breadth of information available online. Most undergraduates will not have found these reliable governmental sites, even if they are experienced Web surfers. These

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Web sites offer much practical information on the environment or human health, thus tying together these two fields of study – something that may help pre-meds to see the importance of the environment. The topic of the module was chosen specifically with this goal in mind. The instructor may have to spend more time making this connection explicit (if desired) with the Structured Approach, because the students may not be using the actual Web sites.

Assessment Methods: The research proposal, research report, and presentation are unnecessary for the Structured Approach. Answering the questions and making the graphs and tables are the assessable outcomes. If these exercises are completed in class, handwritten lab notebooks or filling in handouts can take the place of a formal report, although if the Internet is available, students can still use Excel and Word to submit a paper online. This method of submission will obviously take longer, and might be assigned as homework after the exercises were completed.

For the Hometown Approach, some instructors may want to guide student projects more than others. If students choose their own questions, a research proposal, research report (including tables, graphs, and maps), and a PowerPoint or poster presentation are assessable outcomes. If the instructor chooses the question for the class (or individual students or groups), the proposal is not necessary. If the whole class researches the same question, presentation is not necessary. This approach can be used for one lab period up to a semester-long project, depending on the depth and number of questions asked.

COMMENTS ON THE ASSESSMENT OF STUDENT LEARNING OUTCOMES

A beta version of this module (Hometown Approach only) has been used with several Honors classes of 9-17 freshman biology and pre-pharmacy majors. Freshman Honors students tended to forget to cite the Web sites they used in their Methods, unless they were specifically reminded. They did very well at creating simple maps on the National Atlas site, but did not use overlays without specific instructions, or used several that obscured each other. The most difficult parts of the reports for freshmen were the Introduction and Discussion, because they were novices at using peer-reviewed literature to give background or to compare to their results. Lack of mathematical skills was unfortunately apparent in the difficulty many students found in calculating species diversities.

Grading the Structured Exercises should be straightforward; the [Faculty Cheat Sheet for Structured Exercises](#) (Resource Files) is designed to aid in grading. The assignment can be typed with plots and graphs pasted in from Excel (or another program).

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