West Nile Virus: Forests Help Reduce the Risk

In this activity, students learn how the West Nile virus is transmitted, how individuals can protect themselves, ways communities can reduce the risk of outbreaks, and how the loss of tree cover has been linked with higher incidences of West Nile virus.

Subjects
General Science, Environmental Science, Ecology, Biology, Health

Concepts
1.1 Biodiversity results from the interaction of living and nonliving environmental components such as air, water, climate, and geologic features.

1.6 Successful technologies are those that are appropriate to the efficient and sustainable use of resources, and to the preservation and enhancement of environmental quality.

3.5 The application of scientific knowledge and technological systems can have positive or negative effects on the environment.

4.6 Human-built environments, if planned, constructed, and landscaped to be compatible with the environment in which they will be located, can conserve resources, enhance environmental quality, and promote the comfort and well-being of those who will live within them.

5.4 Ecosystems change over time through patterns of growth and succession. They are also affected by other phenomena, such as disease, insects, fire, weather, climate, and human intervention.

Skills
Classifying and Categorizing, Creating, Identifying Attributes and Components, Interpreting, Synthesizing

Materials
Copies of the student pages; one or more computers with Internet access

Time Considerations
Part A – one 90-minute session;
Part B – two 90-minute sessions;
Extension – one or more 90-minute sessions.

Related Activities in Other PLT Guides
Environmental Quality (*GreenSchools! Investigations*), School Site (*GreenSchools! Investigations*), Neighborhood Design (*Places We Live* module), Green Space (*Places We Live* module), A Vision for the Future (*Places We Live* module), Our Changing World (*PreK-8 Environmental Education Activity Guide*)

Objectives
- Students will be able to describe basic facts about West Nile virus transmission, symptoms, and prevention.
- Students will be able to interpret research and a graph indicating how urbanization and the loss of tree cover has been linked with higher incidences of West Nile virus.

Method
- Students learn about West Nile virus by reading a fact sheet and answering questions.
- Students use an interactive map to determine whether the West Nile virus has been found in their state.
- Students analyze research on West Nile virus in Atlanta, Georgia.
- Optional extension activities encourage students to learn more about West Nile virus in their community and to create posters or videos to educate others.

Getting Ready

1. Review the directions and information on the Student Pages "Background Information: West Nile Virus," "Fight the Bite: West Nile Virus," and "Examining the Factors That Promote West Nile Virus."
2. Gather the materials needed for the activity.

Doing the Activity

Part A—What's West Nile Virus?

1. Students may not realize that West Nile virus is found throughout the United States, except in Hawaii and Alaska. They also may not know that this virus is commonly transmitted by mosquitoes and that it can have serious health consequences.

To get students interested in learning about the West Nile virus and to find out what they already know, ask them the questions that follow:

- How many of you have ever been bitten by a mosquito?
- Why do mosquitoes bite? (*Female mosquitoes bite to suck blood because they use it to make eggs. Male and female mosquitoes use plant nectars and fruit juices as their main source of food.*)
- Mosquito bites are annoying and cause you to itch. Why else might it be bad to be bitten by a mosquito? (Mosquitoes can transmit West Nile virus, as well as many other diseases.)
- Besides humans, what animals do mosquitoes bite? (*They bite birds, mammals, reptiles, and frogs.*)

2. Have students find out whether there were recent cases of West Nile virus in their state by using the "Interactive U.S. Map Showing West Nile Virus Incidences in Humans in 2014" at http://diseasemaps.usgs.gov/mapviewer/. They can click on their state to find out how many confirmed West Nile virus cases there were in any given year. Then ask them which parts of the country had the most cases and the fewest cases.

3. Hand out copies of the Student Page "Background Information: West Nile Virus," or have them read it on a tablet or computer. Have students work individually or in small groups, using this background information to answer the questions on the Student Page "Fight the Bite: West Nile Virus."

4. Review the answers with the students. (An answer key is provided.)

5. Ask students: If you were in charge of the Public Health Department of your town, would you be concerned about West Nile virus? Would you try to reduce breeding grounds for mosquitoes? Conclude by explaining that what they've learned about West Nile virus will be useful in the next part of the activity, when they study environmental factors that affect West Nile virus.

Part B—Examining the Factors That Promote West Nile Virus

1. Ask students the following questions to get them thinking about what influences mosquito populations and the risk of West Nile virus in specific areas of the United States:

   - Have you ever noticed that there are more mosquitoes in some areas than in others? (Mosquitoes rest in tall grass and underbrush near buildings. They favor areas with shallow, still water where they can lay their eggs, including ponds, swamps, and other wetlands. They're also found around human-created habitats such as birdbaths, old tires, and plant pots.)
   - How do you think urbanization might be related to West Nile virus? (Urbanization reduces tree cover and disrupts soil ecology and water flow patterns, increasing mosquito habitat. The increase in urban environments and deforestation are key factors in the rise of West Nile virus.) Explain to students that they will discover the answers to these questions by reading about research on mosquito populations in Atlanta, Georgia.

2. Give your students time to read the Student Page "Examining the Factors That Promote West Nile Virus."

3. Have them discuss the questions at the end of the Student Page in small groups.

4. As a class, review the answers to the questions and discuss the implications of the research. (An answer key is provided.)

5. If you and your students are interested in finding out more about West Nile virus in your community and ways to educate others about it, try the Extensions provided at the end of this activity.

Extensions

#1 West Nile Virus in Your Community

Have students research the status of West Nile virus in their community. Are there any reported cases of West Nile virus for the current year? Is anything being done to control mosquitoes?

#2 Creating a Poster/Video Project on West Nile Virus to Educate Others

Depending on equipment available and time constraints, have students make posters or videos to educate others about West Nile virus. Explain to students that the risk of West Nile virus to humans can be reduced by combining mosquito control measures with health education outreach. Their task is to develop a poster or video to educate people about preventing West Nile virus and to explain how tree cover reduces the risk of West Nile virus.

Hand out copies of the Student Page "Poster/ Video Project on West Nile Virus." Review the task and any other requirements that you have for the project with students. You may wish to assign students to small groups in order to divide up the work and allow them to take advantage of one another's talents. Roles for creating a video could include, for example, researchers, storyboard writers, props and visual designers, and videographers.

Once students have created their posters/videos, have them share their work with others. Consider having them share their posters and videos not only with classmates, but also at school assemblies, PTA meetings, and so forth. In addition, students can upload their videos to a private or public file-sharing site.

Background Information: West Nile Virus

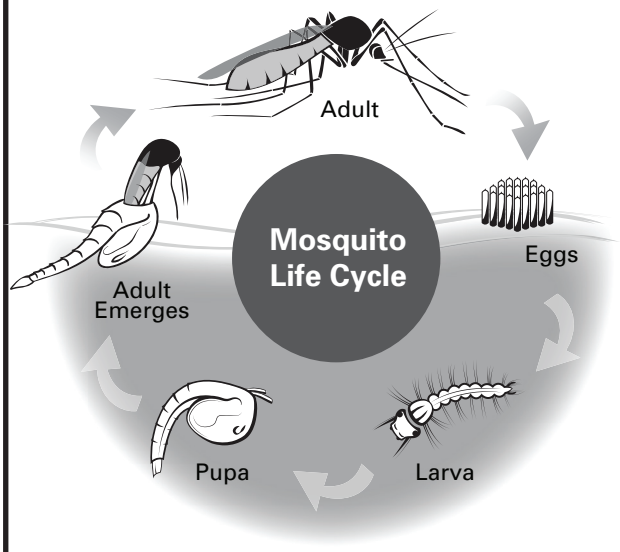
West Nile Virus Basics

What is West Nile virus?

West Nile virus (WNV) was first identified in the west Nile region of Uganda in 1937. Since then, it has spread around the world. The first U.S. case was in New York in 1999; the virus has now been reported in every state except Alaska and Hawaii. In 2012, the worst year for the virus in the United States, WNV was responsible for 286 U.S. deaths.

WNV is most commonly transmitted to humans by mosquitoes belonging to the *Culex* genus. Although the virus generally causes no symptoms or only mild ones, it can cause a serious neurological illness in a small number of cases.

What is the mosquito life cycle?



Source: US EPA: http://www2.epa.gov/mosquitocontrol/mosquito-life-cycle

Mosquitoes undergo metamorphosis from an aquatic larva to a winged adult during their life cycle:

- Egg. Eggs hatch within 48 hours of being laid in the water.
- Larva. Mosquito larvae live in the water, but come to the surface to breathe. They feed on bacteria, algae, and bits of organic matter. Larvae molt several times as they grow.
- Pupa. The pupae live in the water and are mobile but do not feed. During this stage, which typically lasts about two days, the mosquito changes into an adult.
- Adult. Adult mosquitoes can fly soon after emerging from the water. They feed on plant juices and nectar, except for females who require a blood meal to obtain the nutrients for reproduction.

The life cycle typically spans two weeks, but depending on conditions, it can range from four days to one month.

What are symptoms of West Nile virus in humans?

About 70%–80% of people who become infected with WNV have no symptoms. Another 20% of people develop West Nile fever, along with other symptoms such as headache, body aches, joint pains, vomiting, fatigue, or rash. These mild symptoms generally resolve after a few days, although fatigue and weakness can persist for a few weeks.

In fewer than 1% of cases, WNV causes encephalitis or meningitis (inflammation of the brain or surrounding tissues). Symptoms may include headache, high fever, neck stiffness, disorientation, coma, tremors, seizures, or paralysis. People who experience this severe version of the disease may not recover for several weeks or months, and they may suffer permanent neurologic damage. Some people who develop neurologic illness due to WNV die.

It is important for people to protect themselves from WNV by wearing protective clothing, using insect repellant, and avoiding exposure to mosquitoes. People who have been exposed to mosquitoes and who experience sudden, severe headache, fever, disorientation, a stiff neck, or weakness should seek medical treatment immediately.

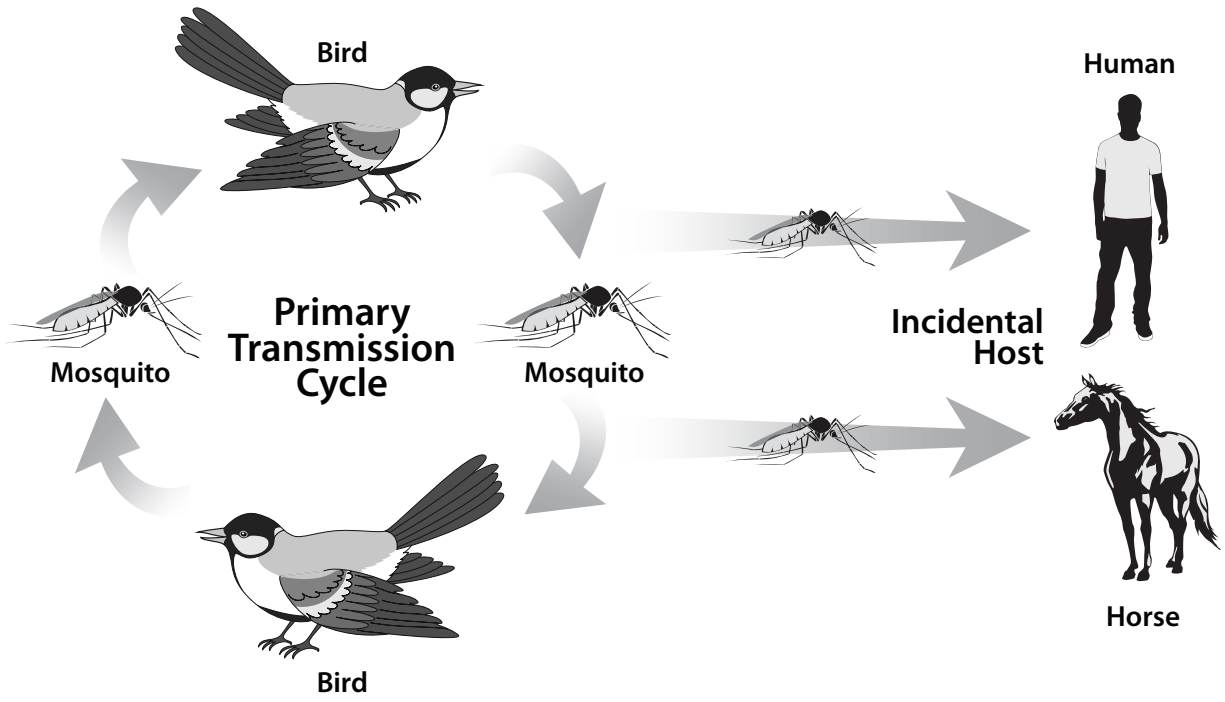
Background Information: West Nile Virus (cont.)

How is West Nile virus transmitted?
Birds are the natural hosts for WNV, particularly members of the Corvidae (crow) family. A mosquito becomes a carrier when it drinks the blood of an infected bird that has high levels of the virus in its bloodstream. After an incubation period of about a week, the virus enters the mosquito's salivary glands and the mosquito can pass the virus on to any humans that it bites. Mosquitoes with WNV also bite and infect people, horses, and other animals, all of whom are "dead end" hosts because they don't develop high levels of virus in their bloodstream and therefore can't pass the virus on to other biting mosquitoes. The virus cannot be transmitted from human to human through casual contact or saliva. It takes 3–14 days for symptoms to appear in an infected person.

How is West Nile virus diagnosed?
West Nile may be diagnosed by testing the blood for the antibodies that the human immune system makes against the virus. Usually, clinical signs and symptoms suggest that the virus is present and indicate the need for a blood test. In more severe cases, brain inflammation may be diagnosed by a spinal tap, electroencephalogram, or MRI.

How is West Nile virus treated?
There are no medications intended specifically to treat WNV. People with milder symptoms can use over-the-counter pain relievers to treat fever and muscle aches. More severe cases generally require hospitalization with intravenous fluids, respiratory support, and treatment to prevent secondary infections.

Is there a vaccine for West Nile virus?
There is no WNV vaccine for people, although efforts to develop one are underway. A vaccine has been approved for use in horses, as the virus can cause severe disease and death in these animals.



Background Information: West Nile Virus (cont.)

Prevention of West Nile Virus

How can you protect yourself?

The best way to avoid WNV disease is to avoid being bitten by mosquitoes. Avoid places and times of day when mosquitoes are active; use mosquito nets; wear light-colored clothing that covers your arms and legs; and use insect repellant containing DEET, picaridin, IR3535, or oil of lemon, eucalyptus, and para-menthane-diol products. Be particularly vigilant from June through September, the months when most people are infected. You should also report dead birds to the local health authorities.

How can you mosquito-proof your home?

To keep mosquitoes out of your home, make sure there are intact screens on windows and doors. Also, be sure to empty standing water from containers near your home, such as flowerpots, gutters, buckets, water dishes for pets, and discarded tires. Change the water in birdbaths frequently to get rid of developing mosquito larvae.

Community Control of Mosquitoes

Local authorities, including county and city governments, typically handle mosquito control. Information about these activities is often posted on the websites for local government and the State Department of Public Health.

Mosquito control activities include eliminating larval habitats (standing water), using insecticides to kill larvae, or spraying insecticides from trucks or aircraft to kill adult mosquitoes.

The Centers for Disease Control and Prevention (CDC) recommends the following approach to mosquito management:

1. Surveillance. By monitoring levels of mosquito activity and locations where virus transmission is occurring, health authorities can better focus their mosquito control efforts.
2. Reduction of mosquito breeding sites.
3. Control of larvae and adults. Typically, both pesticides and biological control methods (integrated pest management) are used to target mosquito populations that have been identified as a threat.
4. Community outreach and public education. Informed members of the public can protect themselves and others and will be able to recognize symptoms of serious disease, should they develop.

As control measures can be costly and the use of pesticides can have environmental consequences, the CDC recommends basing control measures on surveillance data and the risk of human disease. One of the best ways to reduce the mosquito population, and one that is environmentally friendly, is to eliminate standing water that provides larval habitat.

Factors That Influence West Nile Virus Outbreaks

Many factors influence the locations and timing of WNV outbreaks: climate, weather, land use/cover, water quality, the number of local birds that are infected, and the amount and quality of mosquito habitat.[1] For example, mosquito populations may be especially high during a summer that was preceded by a mild winter and warm spring, and in areas where trees have been removed. In recent years, the incidence of WNV has been highest in the Midwest and South.

On an individual level, people who work outside and frequent mosquito-infested areas, such as wetlands, are at higher risk. Those who are over age 50 and have compromised immune systems are more likely to develop the severe form of the disease.[2]

Fight the Bite: West Nile Virus

Name(s): _____ Date:_____

1. What is West Nile virus?

2. What insect most commonly transmits West Nile virus to humans?

3. Were there any cases of West Nile virus in your state last year?

4. Does everyone who is infected with West Nile virus get sick?

5. What are the symptoms of West Nile virus?

6. How is West Nile virus diagnosed?

7. What is the treatment for West Nile virus, and is there a vaccine for humans?

8. How can you protect yourself from mosquito bites?

9. What can communities do to control mosquitoes and West Nile virus?

10. What factors influence mosquito populations and the transmission risk of the virus?

Examining the Factors That Promote West Nile Virus

As of mid-2015, more than 41,000 cases of West Nile virus (WNV) disease have been reported to the Centers for Disease Control and Prevention. The worst year on record was 2003, during which there were more than 9,800 cases, followed by 2012, with over 5,600 cases. Some of the states that have been hardest hit include Colorado, with over 5,000 cases total, and Texas, with over 4,600 cases total. Because many people who are infected show no symptoms or develop health problems only later, the total number of human cases may be much higher, as high as 3 million by one estimate.

Georgia has reported a total of 368 cases of WNV. In 2012, the worst year for Georgia, the state reported 99 cases of WNV in humans and six deaths from WNV.

Researchers at Auburn University in Alabama teamed up with scientists at other institutions to study the factors that affect mosquito populations in Atlanta, Georgia. Numerous cases of WNV-infected mosquitoes have been documented in this area, which has a range of environmental conditions, making it a good study location. The goal of the study was to determine the factors that affect mosquito populations, in order to reduce these populations and the associated risk of WNV.[3]

The researchers looked at a variety of factors to determine what caused some neighborhoods in Atlanta to have high numbers of mosquitoes. They were particularly interested in finding out whether there was a link between the urbanization of an area and occurrences of WNV. Poor water quality is known to be associated with higher mosquito populations. However, in previous studies, models provided conflicting information about the role of factors such as precipitation and land use in mosquito populations.

The study revealed some important facts:

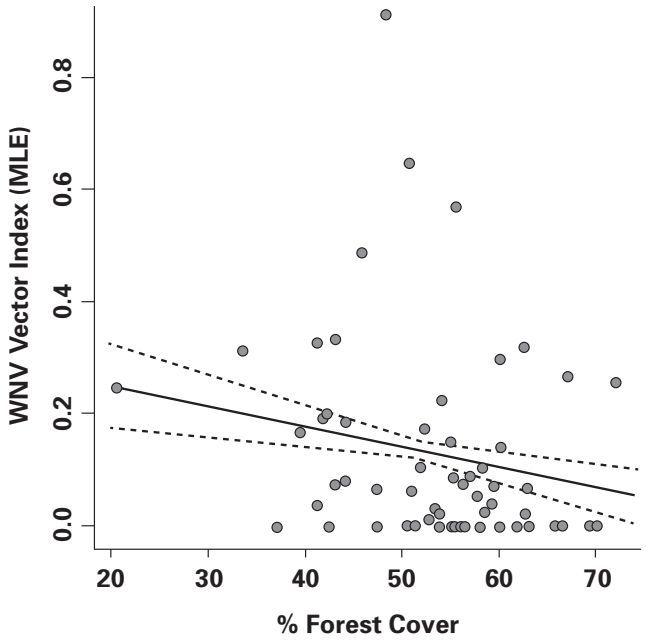
- Urbanization is the primary cause of tree cover loss in the southeastern United States.
- The loss of tree cover has been linked with higher incidence of some insect-borne diseases, such as WNV.
- Forested watersheds are characterized by stable hydrology and clean water.
- As tree cover declines due to development, factors such as stream velocity, discharge, and concentrations of non–point source pollutants climb dramatically.
- The loss of tree cover has been associated with major impacts on stream hydrology and reductions in water quality.
- These changes increase the likelihood of sewer overflows and the formation of stagnant pools of polluted water, conditions that provide mosquito habitat.

The process of urbanization disturbs the land surface, removes ground cover, and causes ditches and ruts to form that collect rainwater and serve as breeding grounds for mosquitoes. Furthermore, when trees and plants that were holding the soil are removed, more sediment washes into puddles, ditches, and shallow bodies of water. This sediment carries nutrients that allow bacteria to grow. Because mosquito larvae feed on bacteria, as well as on floating bits of organic matter and algae, the nutrient-rich water is an ideal environment where mosquitoes can breed. Even a small volume of water, such as a flooded wheel rut only 6 inches deep, can easily produce 1,000 mosquitoes in a short period of time.[4] A mosquito can develop from an egg to an adult in about a week.

The researchers concluded that environmental disturbances, such as urbanization and deforestation, play a key role in the emergence of WNV. They hope that the results of their study will help to prevent outbreaks of WNV. They also hope that their research will bring into focus the importance of forestland to human health.

Examining the Factors That Promote West Nile Virus (cont.)

Forest Cover and West Nile Virus in Atlanta Study[5, 6]



Maximum Likelihood Estimate (MLE), a statistical method, was used to calculate the WNV infection rates of female mosquitoes in the area.

Discussion Questions:

1. Why are researchers studying WNV in Atlanta, Georgia?

2. How does urbanization affect mosquito populations?

3. According to the graph, what is the relationship between forest cover and WNV?

4. How might the results of this research help prevent future outbreaks of WNV?

5. What benefits do you think urban forests and green space have for human health?

Answer Key for "Fight the Bite: West Nile Virus"

1. What is West Nile virus?
West Nile virus is carried primarily by mosquitoes and can infect humans, causing serious neurological illness in a small percentage of cases.

2. What insect most commonly transmits West Nile virus to humans?
Mosquitoes, often those of the Culex genus, transmit WNV to humans after biting infected birds.

3. Were there any cases of West Nile Virus in your state last year?
Students can find this out by using the interactive U.S. map showing West Nile virus incidences in humans at http://diseasemaps.usgs.gov/mapviewer and choosing the state and year of interest from the drop-down menu.

4. Does everyone who is infected with West Nile virus get sick?
No, most people (70%–80%) who become infected with West Nile virus do not develop any symptoms.

5. What are the symptoms of West Nile virus?
About 20% of people develop a fever, along with headache, body aches, joint pains, vomiting, or rash. Fewer than 1% of people develop a serious neurologic illness, with symptoms such as headache, high fever, stiff neck, disorientation, coma, tremors, seizures, or paralysis.

6. How is West Nile virus diagnosed?
Diagnosis is based on a combination of clinical signs and symptoms and blood tests for antibodies. Other tests, such as spinal tap and MRI, can determine neurological involvement.

7. What is the treatment for West Nile virus, and is there a vaccine for humans?
Pain relievers reduce fever and relieve some symptoms. In severe cases, patients may need to be hospitalized to receive intravenous fluids and pain medication. There is no vaccine for humans yet, although one is under development.

8. How can you protect yourself from mosquito bites?
Use an effective insect repellent and wear light-colored protective clothing; use screens on windows and doors to keep mosquitoes out of your home; and reduce the number of mosquitoes around your home by emptying standing water from items that collect water.

9. What can communities do to control mosquitoes and West Nile virus?
Communities can monitor levels of mosquito activity and determine where virus transmission is occurring, reduce mosquito breeding sites using pesticides and biological methods, and educate community members.

10. What factors influence mosquito populations and the transmission risk of the virus?
Climate, weather, land use/cover, water quality, and mosquito habitat.

Answer Key for "Examining the Factors That Promote West Nile Virus"

1. Why are researchers studying WNV in Atlanta, Georgia?
Although Georgia is not among the top states for number of WNV cases, numerous cases of WNV-infected mosquitoes have been documented in the metro Atlanta area. The area also provides a range of environmental conditions in which to study mosquito populations.

2. How does urbanization affect mosquito populations?
When an area is urbanized, the land is disturbed, and ditches and ruts are formed that collect rain water and serve as breeding grounds for mosquitoes. Furthermore, when trees and plants are removed, more sediment washes into puddles, ditches, and shallow bodies of water. This sediment carries nutrients that allow bacteria to grow. Because mosquito larvae feed on bacteria, this creates an ideal environment where mosquitoes can breed.

3. According to the graph, what is the relationship between forest cover and WNV?
The graph shows an inverse relationship between the percentage of forest cover and WNV risk. In other words, as tree coverage decreases, the risk of WNV increases; and as tree cover increases, risk declines. In Atlanta, areas with a greater percentage of forest cover have a lower incidence of WNV.

4. How might the results of this research help prevent future outbreaks of WNV?
Knowing that there may be a greater risk of WNV transmission when urbanization occurs and forest cover is lost may help predict where outbreaks of WNV may occur.

5. What benefits do you think forests and green space have for human health?
Urban forests and trees play an important role in reducing the WNV infection risk to humans.

Poster/Video Project on West Nile Virus

Task: To create a poster or video to educate others about West Nile virus.

Your message should include information on the following topic:

- The importance of tree cover and forests for minimizing mosquito outbreaks.

It can also include information on

- How West Nile virus is transmitted,
- How to protect yourself from mosquito bites,
- How to reduce mosquitoes around your house and in your yard or neighborhood, and
- How communities can reduce mosquitoes.

Here are the poster requirements:

- Written information and pictures/images
- No objectionable material
- Credits (anyone working on the poster or providing photographs, drawings, and so forth)

Here are the video requirements:

- Approximately two minutes in length
- At least one visual effect
- Narration by one or more students
- No objectionable material
- Credits (group members, names of anybody else appearing in your video, name of any music used)

Use the chart below to organize your group project:

Name	Task	Timeline	Date Completed

Appendix. References Cited and Web Resources

References Cited

[1] Noori, Navideh. 2015. "Role of Climate, Land Use/Cover and Water Quality on West Nile Virus Incidence: A Modeling Approach." Dissertation draft. Auburn, AL.

[2] Mayo Clinic. 2015. "West Nile virus." Available at http://www.mayoclinic.org/diseases-conditions/west-nile-virus/basics/definition/con-20023076. Accessed on 7/11/2015.

[3] Noori, Navideh, Latif Kalin, and Graeme Lockaby. 2015. "Linkage between Land Use/Cover and Water Quality and its Impact on West Nile Virus Incidence." School of Forestry and Wildlife Sciences, Auburn University, Auburn, AL.

[4] Virginia Department of Health. 2015. "Mosquito Breeding Habitats." Available at http://www.vdh.virginia.gov/lhd/CentralShenandoah/EH/WNV/mosquito_breeding_habitats.htm. Accessed on 6/17/2015.

[5] Noori, Navideh, Krisztian Magori, Latif Kalin, and Graeme Lockaby. "Impacts of Climate Variability on West Nile Virus Infections in Central North Georgia, USA." Presented at the American Meteorology Society meeting on February 2–6, 2014, in Atlanta, GA.

[6] Magori, Krisztian, Graeme Lockaby, Latif Kalin, Wayde Morse, Wayne C. Zippere, Navideh Noori, Rajesh Sawant, and Rosmarie Kelly. "Combined Landscape and Social Conditions Create High WNV Infection Risk in Atlanta, GA."

Web Resources

Centers for Disease Control and Prevention. "West Nile virus."
http://www.cdc.gov/westnile/index.html
In-depth information about West Nile virus, how it is transmitted, and how individuals and communities can take action to prevent infection.

Illinois Department of Public Health. "West Nile Virus."
http://www.idph.state.il.us/envhealth/wnvgenpublic.htm
Information on mosquitoes and West Nile virus in English and Spanish, as well as links to radio and televisions campaigns, an educational poster, and an online quiz about West Nile virus.

American Mosquito Control Association. "Welcome to the American Mosquito Control Association."
http://www.mosquito.org/
Information and education from a nonprofit organization about how the suppression of mosquitoes can enhance public health. A fact sheet, "Mosquito Prevention and Protection," is available at
http://www.mosquito.org/assets/12987%20amca%20fact%20sheet%20v3%20web.pdf.

Information Sources

Dr. Wayne Zipperer (US Forest Service – Gainesville, FL) and Dr. Graeme Lockaby (Auburn University). The financial support provided by the USDA Forest Service is gratefully acknowledged.