



Virginia View Curriculum

Lesson Plan

Gypsy Moth Destruction in Virginia

Grade Level

High School: Life Science, Earth Science, Biology

Applicable Virginia SOL

LS 8, 9, 10, 11, 12; ES 3, Bio 9

Summary

This activity examines the issue of spread of the Gypsy Moth and the resulting deforestation in Virginia over time. Students will make observations and connections about how this non-native human introduced species (invasive species) has caused forest damage to the foliage of trees in Virginia. Students will predict areas that are likely to be invaded next and are asked to propose possible prevention methods.

Classroom Materials

This lesson is best completed with computers with ArcGIS and internet access. Options for using computers with internet access only as well as printed maps are available.

Submitted by

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Teacher Guide

Applicable Virginia SOL:

- LS.8 The student will investigate and understand that interactions exist among members of a population.
- LS.9 The student will investigate and understand interactions among populations in a biological community.
- LS.10 The student will investigate and understand how organisms adapt to biotic and abiotic factors in an ecosystem.
- LS.11 The student will investigate and understand that ecosystems, communities, populations, and organisms are dynamic and change over time (daily, seasonal, and long term).
- LS.12 The student will investigate and understand the relationships between ecosystem dynamics and human activity.
- ES.3 The student will investigate and understand how to read and interpret maps, globes, models, charts, and imagery.
- Bio.9 The student will investigate and understand dynamic equilibria within populations, communities, and ecosystems

Teacher Preparation:

- Review the background material on Gypsy Moths with the students (below).
- Follow the Procedure listed in the correct section, depending on the resources available to you:
 - o [Section 1](#): For those using computers with ArcGIS and internet access
 - o [Section 2](#): For those using computers with internet access only.
 - o [Section 3](#): For those without computer access.
- Print the correct Student Worksheet for the section of the exercise that you will be using.
- If using Section 3, print any maps necessary (listed in “Section 3: Procedure”).
- A [key](#) is attached. It uses the section 1 worksheet, but the answers should be relatively the same regardless of what section you use.

Background:

In 1869, Leopold Trouvelot brought the gypsy moth from Europe to Medford, Massachusetts in an attempt to breed them for silk production. Unfortunately, some of the caterpillars escaped and by the early 1900's they began defoliating large areas of New England. (*Gypsy Moth*, Pennsylvania Department of Conservation and Natural Resources, PDCNR, <http://www.dcnr.state.pa.us/forestry/gypsymoth/index.aspx>)

"Gypsy moth was first discovered in Pennsylvania near Pittston, in Luzerne and Lackawanna counties in 1932. During the 30's and 40's it continued to spread to Pike, Lackawanna, Wayne, Monroe, and Carbon counties. By 1969, it had spread west of the Susquehanna River, and by 1980, 38 Pennsylvania counties were infested. The gypsy moth has

now moved beyond our state. It is now found as far west as Minnesota, with populations reaching outbreak levels every 5-10 years.

"(<http://www.dcnr.state.pa.us/forestry/gypsymoth/index.aspx>)

Since its initial introduction to Massachusetts, the Gypsy moth has been spreading southward at an alarming rate and causing much destruction to the hardwood trees of the east coast. The caterpillars have caused lethal defoliation of the trees.

"Although white, chestnut, black and red oak are preferred, gypsy moth caterpillars also eat hundreds of other tree and shrub species including oak, apple, alder, aspen, basswood, birch, poplar, willow, hawthorn, hemlock, tamarack (larch), pine, spruce, and witch hazel. Gypsy moth usually avoids ash, butternut, black walnut, locust, sycamore, and yellow poplar (tulip tree). Although it usually takes more than one year of defoliation before trees die, conifers that are defoliated may be killed after a single season of defoliation."(
<http://www.dcnr.state.pa.us/forestry/gypsymoth/index.aspx>)



" Mature caterpillars pupate from mid June through early July in Pennsylvania. Mice, shrews, and ground beetles eat the pupae, and are an important regulator of gypsy moth in this stage." (<http://www.dcnr.state.pa.us/forestry/gypsymoth/index.aspx>)



Adult gypsy moths emerge about two weeks after pupating. Adults only live about a week, and do not feed. Female gypsy moths use chemicals to attract a mate soon after they emerge. They lay eggs about a day after mating. Adult gypsy moth males have feathery antennae and brown wings and are able to fly, while cream-colored females of European gypsy moths cannot fly and have threadlike antennae. There is also an Asian variety of gypsy moth with flying females that have luckily been eradicated in Western North America on several occasions following accidental introductions"

(<http://www.dcnr.state.pa.us/forestry/gypsymoth/index.aspx>)



(<http://www.dcnr.state.pa.us/forestry/gypsymoth/index.aspx>)

Method to Control Spread

Various strategies have been tried to prevent the spread of these invasive and harmful pests. Traps have been set using the male or female pheromones (hormones) to attract the opposite sex moth. Chemical insecticides have been used, but they have the harmful effect of killing beneficial insects as well, and therefore are not a sustainable solution.

"Various natural environmental factors help control gypsy moth in North America. A disease-causing fungus known as *Entomophaga maimaiga* was first introduced in 1910-1911 to control gypsy moth. This fungus only affects select families of moth caterpillars that encounter infected soil and plants or through contact with other infected caterpillars. The spores of the fungus germinate in the spring and work best if rain is abundant. *E. maimaiga* was responsible for widespread gypsy moth mortality in 1989 and 1990, when wetter than normal conditions were reported in May. Since this time, *E. maimaiga* has become a significant regulator of gypsy moth populations at both low and high densities. Researchers are unsure whether the increased prevalence of the fungus is due to its initial introduction or if it is the result of a more recent reintroduction into the US. Older gypsy moth caterpillars that die as a result of the fungus die in a vertical position with their legs sticking outward.

A nucleopolyhedrosis virus (LdMNPV) kills enough gypsy moth caterpillars when populations are high to eventually end an outbreak. Caterpillars must eat the viral particles in order to become infected. Caterpillars infected with LdMNPV die in an inverted V position, which explains why the common name for LdMNPV is "the wilt". The activity of LdMNPV is specific in that it only kills gypsy moth caterpillars.



(<http://www.dcnr.state.pa.us/forestry/gypsymoth/index.aspx>)

"A large metallic green ground beetle known as *Calosoma sycophanta* was introduced into New England from Europe for gypsy moth control in 1906. It is now established throughout Pennsylvania. *C. sycophanta* larvae and adults eat older gypsy moth caterpillars that rest in the leaf litter during the daytime.

Other factors can influence the impact of oak. The effects of other insects, such as oak leaf roller, oak leaf tier, two lined chestnut borer, and oak sawflies, as well as pathogenic fungi such as oak wilt and *Armillaria* can compound the impact of gypsy moth. In addition, high deer populations in Pennsylvania make oak regeneration a challenge since the arrival of the gypsy moth."

(<http://www.dcnr.state.pa.us/forestry/gypsymoth/index.aspx>)

Virginians need to be aware of these invasive pests and monitor their spread and take measures to curtail the spread of *Lymantria dispar*, the gypsy moth before it destroys our forests!

Artificial Movement of the Gypsy Moth

"Recent studies show that most new isolated infestations of gypsy moths have started from egg masses transported by humans. The human, or artificial, movement of gypsy moth life stages, especially egg masses, spreads the moth faster than would naturally and normally occur. Since the female gypsy moth cannot fly, the only natural movement occurs when the wind blows very young larva as they suspend themselves on silk threads in tree tops. Upon mating, female moths will lay their eggs on anything she can crawl to-anything outdoors-axles to wheelbarrows.

Inspect For Gypsy Moth

You are responsible for making sure that your outdoor items (logs and trees, picnic tables, firewood, and recreational vehicles, etc.) don't carry the gypsy moth life stages to new locations. Inspect any article left outdoors or stored outside. You are the key to preventing the artificial movement of the gypsy moth." (**Virginia Dept of Agriculture and Consumer Services**, <http://www.vdacs.virginia.gov/plant&pest/moth.shtml>)

How To Identify Gypsy Moth Life Stages

The gypsy moth goes through 4 life stages each year-egg, caterpillar (larva), pupa (cocoon) and moth. In late summer the female moth lays a brown, velvet-feeling egg mass that may contain as many as 1000 eggs. The eggs over-winter and hatch in the spring as caterpillars when the leaves begin to appear on trees. Caterpillars eat leaves for 6 to 8 weeks and are the only life stage that damages trees. In late June adult caterpillars form a pupa and after 10-14 days emerge as moths.

The female moth cannot fly and attracts males by emitting a scent. Upon mating, the life cycle begins again as the female lays her eggs near where she pupated. It is the egg mass that is most likely to be moved. (<http://www.vdacs.virginia.gov/plant&pest/moth.shtml>)

What To Do If You Find Gypsy Moth Life Stages

The most environmentally safe way to dispose of gypsy moth life stages is to remove them by hand, scraping them into a container of soapy water with a putty knife or stiff brush. Always wear protective clothing and gloves. (<http://www.vdacs.virginia.gov/plant&pest/moth.shtml>)

Quarantines

To help reduce the artificial movement of the moth, Virginia and Federal regulations have established quarantine areas. Areas under quarantine are considered infested with a reproducing population of gypsy moths-the areas are fully infested. Regulated articles, shipped from a quarantined area or state to an area or state not quarantined, must be inspected for the gypsy moth life stages. If life stages are found they must be removed before moving or shipping the regulated article to a non-quarantined area.

What Are Regulated Articles?

The following articles are regulated:

Outdoor Household Articles (OHA'S) include anything kept outside the home such as outdoor furniture, firewood, garden equipment, dog houses, children's toys, barbecue grills and garbage cans.

Log, Pulpwood, Wood Chips, and Bark: basically any forest product with bark on it.

Mobile Homes, Recreation Vehicles, etc., designed to serve, when parked, as a dwelling or place of business, along with associated equipment.

Nursery Products, Including Christmas Trees: all trees with or without roots and shrubs with roots and persistent woody stems, unless greenhouse grown throughout the year.

Any Product, Article, or Conveyance near gypsy moth life stages that, if moved, presents a high risk of artificially spreading the moth.

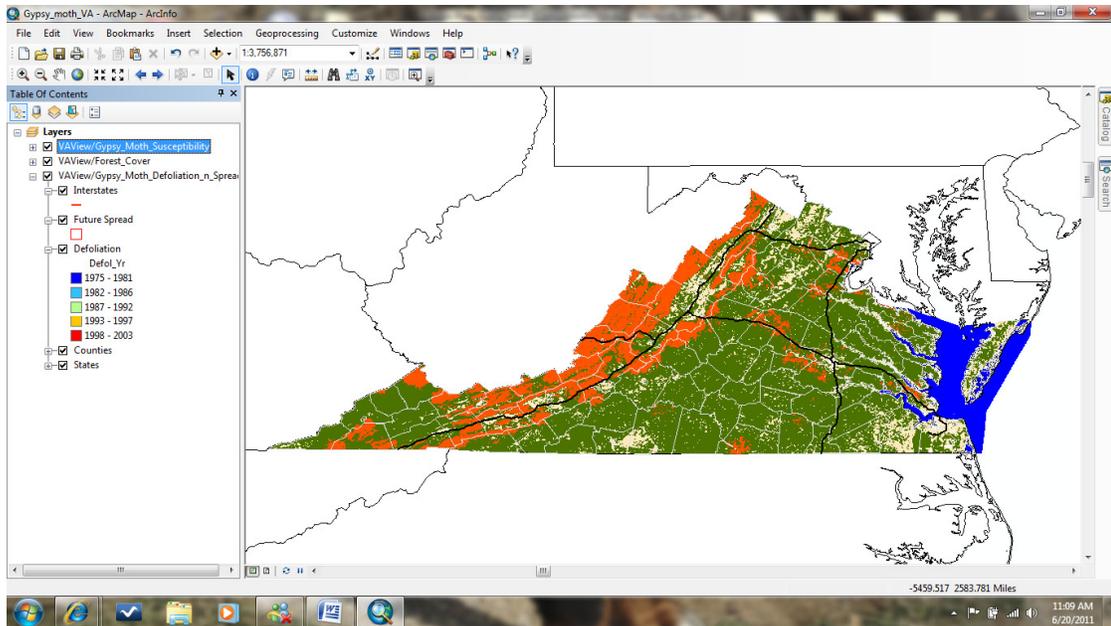
(<http://www.vdacs.virginia.gov/plant&pest/moth.shtml>)

Section 1, For those using ArcGIS - Procedure: (For Teacher and Students)

1. Make sure your CPS are loaded with ArcEditor or ArcMap.
2. Open up ArcMap with an empty map.
3. Click on (+) or go under File; add data
4. In the pop up window "Look in", click on the drop down arrow/menu and choose "GIS Servers" * it may be down at the bottom of the list, so keep looking, then Click Add
***If using ArcGIS 10, in catalog click on drop down menu to "GIS Servers". In window in catalog expand folder GIS Servers, double click Add ArcGIS Server. On the first window, select "Use GIS Services." Follow the directions in the wizard (see steps 7-9 below)**
5. In the next window, select: "Add ArcGIS Server", Click add, a new pop up window "Add ArcGIS Server" appears.
6. Select "use GIS services", click next
7. A new pop up window "General" appears

Select "internet" and type or paste URL in window: <http://arc.gis.vt.edu/arcgis/services>

8. Leave Authentication (optional) info blank, click "finish"
9. You will see the name **arcgis on arc.gis.vt.edu** as a listing/choice in the "Add Data" pop up window
10. Close the "General" window
11. In the "Add Data window, click on **arcgis on arc.gis.vt.edu** and make sure in the name field it says "arcgis on arc.gis.vt.edu", and the Show of type says "Datasets and layers (.lyr), Click ADD
12. In the new "Add Data window", click/select the folder "VA View", then ADD
13. Select : "**Gypsy_moth_defoliation_n_spread**", "**Gypsy_Moth_Susceptibility**", and "**Forest_Cover**" (use the Ctrl key to select more than one layer to add at a time), then click ADD.
14. IF you get a warning box when adding the forest layer , just check "close".
15. Adjust the layers so that the Gypsy Moth Susceptibility layer is first, then Forest Cover, then Defoliation and Spread. You can do this by highlighting and dragging the layer name in the Table of Contents. Then, expand (click the + sign) next to each sub-layer on the **Gypsy_Moth_Defoliation_n_Spread** layer.
16. Your map should look like this.



17. Be sure to name (no spaces between names, use _, if you need to space out words) and save your map frequently on your C drive in a designated folder. Under File-Click on **Map Document Properties- Under the General Tab**, make sure that the box near "Pathnames" is checked to "**Store Relative pathnames to data sources**" is selected.
18. Zoom into the state of Virginia so it fills your map page! (hint: use the (+) magnifier and click and drag a box around the state of Virginia! You might need to do this more than once. Remember if the globe/world is spinning the program is redrawing the map. PLEASE be patient and let it redraw before you zoom in again!

Section 1: Student Worksheet

Gypsy Moths in Virginia

Name _____ Partner's Name _____

1. Turn Off the "**Forest Cover**" and "**Gypsy_Moth_Susceptability**" layers (uncheck the box next to the names)

What areas of Virginia have the gypsy moths invaded in Virginia? (Ex: Western Virginia, Coastal Region, Northern VA, etc)

2. Make sure you have expanded the menu in "Gypsy_Moth_Defoliation_n_Spread" so you can see the various colors and years of defoliation. (Ex: 1979-1981 = dark blue, 1982-1986 = royal blue, etc) What do you notice about the trend/spread of the gypsy moths in Virginia since 1980's to 2003? (hint: What direction are they spreading?)

3. Use the zoom (+ magnifier) button to zoom into the blue area where the moth's first invaded Virginia.

4. Select the Identify tool (i). Click on an area. In the dialog box, Use the drop-down menu next to "Identify From:" and choose the Gypsy_Moth_Defoliation_N_Spread", "Counties" sub-layer. Now you can click on a county and identify it using this tool. What counties in Virginia did the moths invade first ? _____

5. Zoom back out to see the whole state of Virginia. Turn on the "**Gypsy_Moth_Susceptability**" layer and expand all the menus (hint: click all the + signs until they are - signs). Notice that the Forest Susceptability is divided into four categories/ area in Virginia. What are the colors and categories?

1) _____ 2) _____

3) _____ 4) _____

6. Where do you notice that the most at risk forests in Virginia are located?

_____ How do you think deforestation would affect the behavior/patterns of the wildlife in these National Forests?

The Appalachian Forest has the highest diversity of hardwoods in the United States, and some say the world. Should the people of Virginia be protecting this valuable and unique natural resource? _____ Why or why not?

7. Turn off the "**Gypsy_Moth_Susceptability**" layer (uncheck the box).

8. Make sure the **VAView/Gypsy_Moth_Defoliation_n_Spread** layer is still on. Zoom out until you can see all of the regions of Virginia where the gypsy moths have spread and defoliated on your map. What is the most southern county in Virginia that the moths have invaded in 1987-1992? (hint: use the identify tool just as you did in question 4)_____

9. What was the most southern county in Virginia that the moths invaded in 1993 -1997?

10. How has the area the moths have invaded/spread changed from 1987-1992 to 1993-1997 (hint: increased, decreased, stayed the same)?_____ How could you test your hypothesis using the map?

11. Zoom into the part of the state where you can see the 1987-1992 area and the 1993-1997 area. Click on the measuring tool (the ruler). Select the area icon in the "Measure" pop up window. Click on the drop down arrow and change the distance units to **Miles**. Click on and drag the tool to measure the area in miles of the 1987-1992 invasion. (hint: just get a rough estimate) What is the area in square miles for 1987-1992? (hint: You might have to measure more than one area, calculate the miles and add them to another area you measured to get the sum total for the 1987-1992 invasion) _____.

12. Use the area tool to determine the miles of the spread/invasion in 1993-1997. What is the rough area in miles in 1993-1997? _____

13. Calculate the percent increase in area of invasion/spread of the gypsy moths from 1987-1992 to 1993-1997. **Show all work!**

14. Compare the spread/invasion in 1993-1997 to 1998-2003.

What trend do you notice? _____ How could you prove your hypothesis using the map?

16. Zoom back out to the view the whole state of Virginia. What county do you live in? _____ Does your county have a problem currently with gypsy moth destruction? Explain.

17. Turn back on the "VA View/Gypsy_Moth_Susceptability" layer. Is your county AT RISK for gypsy moth damage in the future? _____. If you county is not in immediate risk, name a nearby county that is at risk, according to the map.

Conclusion:

1. Why do you think the spread of the gypsy moth decreased in Virginia from 1993-1997 to 1998-2003?

2. Describe some solutions to remedy the gypsy moth increases in your county or nearby counties at risk.

Section 2: Internet Access only

Procedure: Students and Teacher

1. Open your web browser
2. On separate tabs, open each of the following links:
 - a. Go to www.virginiaview.net and click on the Digital Atlas link. Scroll down to “Digital Atlas Layers” and click on “**Areas that have been Defoliated by Gypsy Moth and the Predicted Extent of Future Spreads**” (they are listed alphabetically). Under “Access Options” click on the link for the Interactive Web mapper.
 - b. Repeat the above steps for the “**Susceptibility of Virginia's Forests to Gypsy Moth**” map on the Interactive Web Mapper from Virginia View.
3. Use the interactive web mapper links you just opened to complete the following exercise.

Section 2: Student Worksheet

Gypsy Moths in Virginia

Name _____ Partner's Name _____

1. Go to the Defoliation and Spread map. What areas of Virginia have the gypsy moths invaded in Virginia? (Ex: Western Virginia, Coastal Region, Northern VA, etc)

2. Make sure you have expanded the menus in "Gypsy_Moth_Defoliation_n_Spread" so you can see the various colors and years of defoliation (use the + symbol next to each layer name). (Ex: 1979-1981 = dark blue, 1982-1986 = royal blue, etc) What do you notice about the trend/spread of the gypsy moths in Virginia since 1980's to 2003? (hint: What direction are they spreading?)

3. Use the zoom (+ magnifier) button to zoom into the blue area where the moth's first invaded Virginia.

4. Select the Identify tool (i). To identify a County, first zoom to the county you want to identify. Turn off (uncheck) all other layers other than "County." Now you can click on a county and identify it using this tool. What counties in Virginia did the moths invade first ? (you may need to turn the other layers on and off again to find the answer).

5. Switch to the **Susceptibility** map. Expand all the layers (the + sign). Notice that the Forest Susceptibility is divided into four categories/ area in Virginia. What are the colors and categories?

1) _____ 2) _____

3) _____ 4) _____

6. Where do you notice that the most at risk forests in Virginia are located?

_____ How do you think deforestation would affect the behavior/patterns of the wildlife in these National Forests?

The Appalachian Forest has the highest diversity of hardwoods in the United States, and some say the world. Should the people of Virginia be protecting this valuable and unique natural resource? _____ Why or why not?

7. Go back to the **Defoliation and Spread** map.

8. Zoom out until you can see all of the regions of Virginia where the gypsy moths have spread and defoliated on your map. What is the most southern county in Virginia that the moths have invaded in 1987-1992? (hint: use the identify tool just as you did in question

4) _____

9. What was the most southern county in Virginia that the moths invaded in 1993 -1997?

10. How has the area the moths have invaded/spread changed from 1987-1992 to 1993-1997 (hint: increased, decreased, stayed the same)? _____ How could you test your hypothesis using the map?

11. Zoom into the part of the state where you can see the 1987-1992 area and the 1993-1997 area. Click on the measuring tool (the ruler). Select the area icon in the "Measure" pop up window. Click on the drop down arrow and change the distance units to **Miles**. Click on each corner of an area to measure the area in square miles of the 1987-1992 invasion. (hint: just get a rough estimate) What is the area in square miles for 1987-1992? (hint: You might have to measure more than one area, calculate the miles and add them to another area you measured to get the sum total for the 1987-1992 invasion) _____.

12. Use the area tool to determine the miles of the spread/invasion in 1993-1997. What is the rough area in miles in 1993-1997? _____

13. Calculate the percent increase in area of invasion/spread of the gypsy moths from 1987-1992 to 1993-1997. **Show all work!**

14. Compare the spread/invasion in 1993-1997 to 1998-2003.

What trend do you notice? _____ How could you prove your hypothesis using the map?

16. Zoom back out to the view the whole state of Virginia. What county do you live in? _____ Does your county have a problem currently with gypsy moth destruction? Explain.

17. Go back to the **Susceptibility** map. Is your county AT RISK for gypsy moth damage in the future? _____. If your county is not in immediate risk, name a nearby county that is at risk, according to the map. _____

Conclusion:

1. Why do you think the spread of the gypsy moth decreased in Virginia from 1993-1997 to 1998-2003?

2. Describe some solutions to remedy the gypsy moth increases in your county or nearby counties at risk.

Section 3: No computer access

Procedure for teacher's preparation:

1. Print out the maps at:
 - a. http://gep.frec.vt.edu/Digital_Atlas_PDFs/VA_Gypsy_Moth_Susceptibility.pdf
 - b. http://gep.frec.vt.edu/Digital_Atlas_PDFs/VA_Gypsy_Moth_Defoliation_n_Spread.pdf

2. You will need a dot grid, planimeter, or other area measurement tool for the students.

Section 3: Student Worksheet

Gypsy Moths in Virginia

Name _____

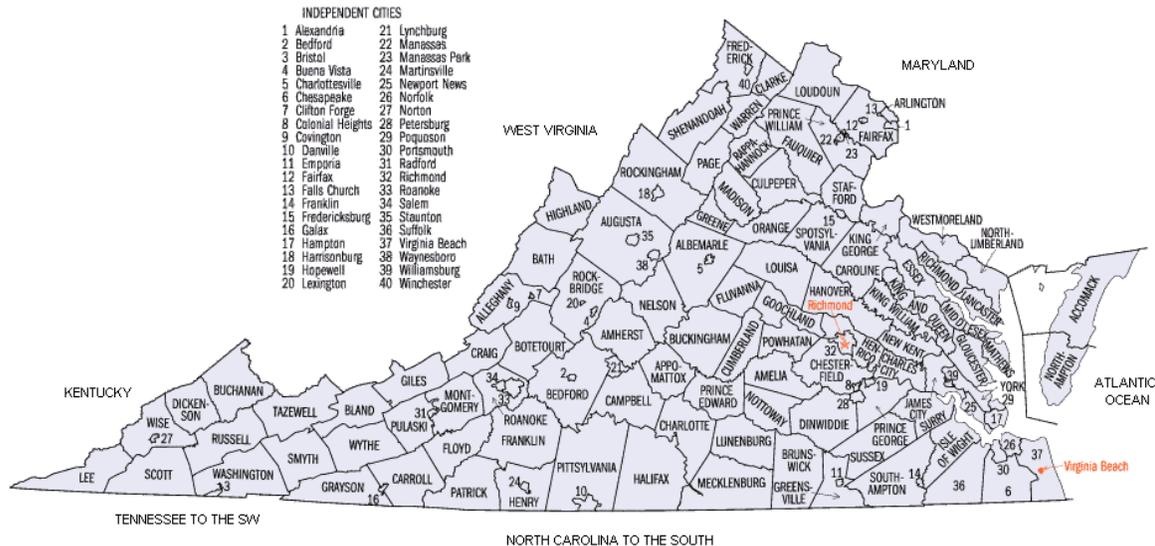
Partner's Name _____

1. Look at the “Areas that have been Defoliated by Gypsy Moth...” (Defoliation) map.

What areas of Virginia have the gypsy moths invaded in Virginia? (Ex: Western Virginia, Coastal Region, Northern VA, etc)

2. What do you notice about the trend/spread of the gypsy moths in Virginia since 1980's to 2003? (hint: What direction are they spreading?)

4. Use the county key below while looking at the Defoliation map. What counties in Virginia did the moths invade first? _____



Source: U.S. Census Bureau

5. Look at the map, “**Susceptibility of Virginia’s Forests to Gypsy Moth.**” Notice that the Forest Susceptibility is divided into four categories/ area in Virginia. What are the colors and categories?

1) _____ 2) _____

3) _____ 4) _____

6. Where do you notice that the most at risk forests in Virginia are located?

_____ How do you think deforestation would affect the behavior/patterns of the wildlife in these National Forests?

The Appalachian Forest has the highest diversity of hardwoods in the United States, and some say the world. Should the people of Virginia be protecting this valuable and unique natural resource? _____ Why or why not?

8. Look at the **Defoliation** map again. What is the most southern county in Virginia that the moths have invaded in 1987-1992? _____

9. What was the most southern county in Virginia that the moths invaded in 1993 -1997?

10. How has the area the moths have invaded/spread changed from 1987-1992 to 1993-1997 (hint: increased, decreased, stayed the same)? _____ How could you test your hypothesis using the map?

11. Using a dot grid or other area measurement tool given by your teacher, find the area of defoliation in square miles for 1987-1992? (hint: You might have to measure more than one area,

calculate the miles and add them to another area you measured to get the sum total for the 1987-1992 invasion) _____.

12. Determine the miles of the spread/invasion in 1993-1997. What is the rough area in miles in 1993-1997? _____

13. Calculate the percent increase in area of invasion/spread of the gypsy moths from 1987-1992 to 1993-1997. **Show all work!**

14. Compare the spread/invasion in 1993-1997 to 1998-2003.

What trend do you notice? _____ How could you prove your hypothesis using the map?

16. What county do you live in? _____ Does your county have a problem currently with gypsy moth destruction? Explain.

17. Look again at the **Susceptibility** map. Is your county AT RISK for gypsy moth damage in the future? _____. If your county is not in immediate risk, name a nearby county that is at risk, according to the map.

Conclusion:

1. Why do you think the spread of the gypsy moth decreased in Virginia from 1993-1997 to 1998-2003?

2. Describe some solutions to remedy the gypsy moth increases in your county or nearby counties at risk.

Student Worksheet (Key)

Gypsy Moths in Virginia

Name _____ Partner's Name _____

1. Turn Off the "**Forest Cover and Gypsy_Moth_Susceptability**" layers (uncheck the box next to the names)

What areas of Virginia have Gypsy Moths invaded in Virginia? (Ex: Western Virginia, Coastal Region, Northern VA, etc)

Gypsy Moths have invaded primarily the western part of the state from Front Royal all the way to the Shenandoah Valley. There are also pockets around Richmond and South Hill areas.

2. Make sure you have expanded the menu in "Gypsy_Moth_Defoliation_n_Spread" so you can see the various colors and years of defoliation. (Ex: 1979-1981 = dark blue, 1982-1986 = royal blue, etc) What do you notice about the trend/spread of the Gypsy moths in Virginia since 1980's to 2003? (hint: What direction are they spreading?) **The gypsy moths invasion started in the north western part of the state and are spreading primarily southward, however there are some pockets of invasion near Richmond, VA and South Hill, VA.**

3. Use the zoom (+ magnifyer) button to zoom into the blue area where the moth's first invaded Virginia.

4. In ArcMap go under File; "**Add Data from ArcGis online**". Add **Topo Maps** to your map. Click and drag Topo Maps to the top of all the other layers in the list. Right click "US topo Maps" and click on **properties**. Click on the display tab and set the transparency to 20%. **In ArcGIS 10, Go to File, Add Data, Add Basemap, add Topo Maps.** What counties in Virginia did the moths invade first ? **The gypsy moths invaded Warren County, Loudoun County and Clarke County first.**

5. Zoom back out to see the whole state of Virginia. Turn on the "**Gypsy_Moth_Susceptability**" layer and expand all the menus (hint: click all the + signs until they are - signs). Notice that the

Forest Susceptibility is divided into four categories/ area in Virginia. What are the colors and categories?

1) Low = white 2) Low-Medium = peach

3) Medium = green, 4) High = Orange

6. Where do you notice that the most at risk forests in Virginia are located? George Washington National Forest, Shenandoah National Park, Jefferson National Forest, How do you think deforestation would affect the behavior/patterns of the wildlife in these National Forests? The trees are the primary producers in these ecosystems. If they die the whole ecosystem will collapse. If the gypsy moths kill the dominant hardwoods, then conifers or less dominant hardwoods would become the dominant species. The animals that depend on the hardwoods for food and shelter would leave the area or become extinct there. This would be a major change to the Appalachian forest ecosystem!

The Appalachian Forest has the highest diversity of hardwoods in the United States, and some say the world. Should the people of Virginia be protecting this valuable and unique natural resource? yes Why or why not? This is a unique and special ecosystem. If it is lost it cannot be replaced, we need to protect our natural resources.

7. Turn off the "Gypsy_Moth_Susceptability" layer (uncheck the box).

8. Make sure the **VAView/Gypsy_Moth_Defoliation_n_Spread** layer is still on, as well as the **Topo Map** layer. Zoom out until you can see all of the regions of Virginia where the gypsy moths have spread and defoliated on your map. What is the most southern county in Virginia that the moths have invaded in 1987-1992? Northern Amherst County and Nelson County

9. What was the most southern county in Virginia that the moths invaded in 1993 -1997? Southern Amherst County and Northern Roanoke County

10. How has the area the moths have invaded/spread changed from 1987-1992 to 1993-1997 (hint: increased, decreased, stayed the same)? area increased How could you test your

hypothesis using the map? **Measure the area on invasion in 1987-1992 and compare the area of invasion in 1993-1997.**

11. Zoom into the part of the state where you can see the 1987-1992 area and the 1993-1997 area. Click on the measuring tool (the ruler). Select the area icon in the "Measure" pop up window. Click on the drop down arrow and change the area units to **Miles**. Click on and drag the tool to measure the area in miles of the 1987-1992 invasion. (hint: Turn off topo map to see better! Also, just get a rough estimate) What is the area in miles for 1987-1992? (hint: You might have to measure more than one area, calculate the miles and add them to another area you measured to get the sum total for the 1987-1992 invasion) **56 + 339 = 395 miles (depends upon how much you zoom in or out and how precise you followed boundaries)**

12. Use the area tool to determine the miles of the spread/invasion in 1993-1997. What is the rough area in miles in 1993-1997? **129 + 236 + 182 + 69 + 123 = 739 miles (depends upon how much you zoom in or out and how precise you followed boundaries). The point is 1993-1997 area should be larger than the 1987-1992 area!**

13. Calculate the percent increase in area of invasion/spread of the gypsy moths from 1987-1992 to 1993-1997. **Show all work!**

$739-395/395 \times 100 \% = 46\%$, Again this value will depend on your initial areas calculated in steps 11 & 12. The point is that the area has increased greatly!

14. Compare the spread/invasion in 1993-1997 to 1998-2003.

What trend do you notice? **Students should notice that there seemed to be a decrease in spreading from 1993-1997 to 1998-2003 time period.** How could you prove your hypothesis using the map? **You could use the measuring tool and calculate the area of invasion during 1998-2003 and calculate the percentage decrease from 1993-1997.**

16. Zoom back out to the view the whole state of Virginia. **Turn back on the topo map layer.** What county do you live in? **Answers will vary** Does your county have a problem currently with gypsy moth destruction, Explain? **Answers will vary, depending upon which county the students live in.**

17. Turn back on the "VA View/Gypsy_Moth_Susceptability" layer. Is your county AT RISK for gypsy moth damage in the future? Answers will vary If your county is not in immediate risk, name a nearby county that is at risk, according to the map. Answers will vary, but everyone should be able to name at least one county that is nearby (a relative term) and that is at risk!

Conclusion:

1. Why do you think the spread of the gypsy moth decreased in Virginia from 1993-1997 to 1998-2003?

Answers will vary. Possible causes are: 1) Increased awareness of the problem of gypsy moth spread led to changes of behavior in humans (i.e. checking for gypsy moths on items quarantined), 2) Introduction of toxic fungus to gypsy moth, 3) Chemical insecticides, 4) Introduction of virus that attacks the caterpillars, 5) Introduction of green beetle that eats caterpillars, 5) predators of caterpillars increased preying on them, 6) non-favorable weather conditions, etc

2.. Describe some solutions to remedy the gypsy moth increases in your county or nearby counties at risk? in Virginia? in the US?

1)Raise awareness, 2) Don't transport eggs from infested areas to other areas of state (check gear), 3) eradicate eggs if found by scraping them off of trees into soapy water, 4) set traps to capture moths, 5) use specific biological pathogens (i.e. fungus or virus), 5) green beetles (caution that they do not turn into a new pest), etc

Resources

Digital Atlas of Virginia: http://virginiaview.cnre.vt.edu/digital_atlas.html

A map-based resource designed for Virginia teachers. The Digital Atlas contains many different maps pertinent to Virginia in several accessible formats.

National Atlas: <http://www.nationalatlas.gov/>

A Federal source of national-scale maps and geographic data of many different themes, including base maps.

Gypsy Moth information: <http://www.dcnr.state.pa.us/forestry/gypsymoth/index.aspx>

Source used for much of the background information.

Virginia Gypsy moth information: <http://www.vdacs.virginia.gov/plant&pest/moth.shtml>

Information on Virginia Gypsy moth infestation.