Learning Unit Student Guide Outline

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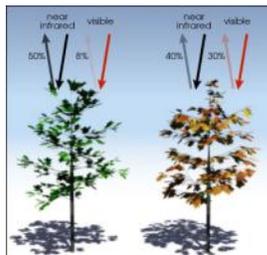**Title:** Gypsy Moth Defoliation Detection – Environmental/Disaster/Invasive Species

Use of Remote Sensing for detection of Gypsy Moth Defoliation

Introduction: Use of Remote Sensing for detection of Gypsy Moth Defoliation

Overview: The purpose of the exercise is to demonstrate the use of satellite remote sensing images to identify the forest defoliation caused by Gypsy Moth Larva. The continued annual defoliation causes the trees to die and results in a significant loss in the value of the forests. The project study area covers the highland mountain areas of Virginia and West Virginia in the eastern and central portions of the two states covered by Landsat 7 - Row 17 and Path 34. The study covers the 2001 growing season as both satellite images and aerial survey/ground based proofing of defoliation is available.
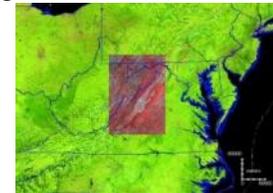
The exercise uses standard methods and existing data to identify the location of possible defoliation and to validate the results by comparing them to actual observations. The Virginia Department of Forestry, (VDOF) and the United States Forest Service provide accessible online historical data for use as validation of the methods. Landsat images are analyzed using ENVI with the application of vegetation indices such as the Normalized Difference Vegetation Index (NDVI)) to determine and classify the lack of leaf coverage. The analyzed image is then compared to shape files of confirmed defoliation to determine how well the method can be used to predict the presence of Gypsy Moths.

Background: The cost of invasive species is estimated to be in excess of 100 billion dollars per year. The invasive species have no natural enemies in their new home, are often able to out-compete native species, and are a primary cause of about 42% of those species listed on the endangered species list. A division of the United States Department of Agriculture supports the control of those species damaging to our economy and ecology. (http://www.invasivespeciesinfo.gov/index.shtml) Recent harmful species in the

news are fire ants, Africanized honeybees, zebra mussels, gypsy moths and the snakehead eel.

However, many invasive species are initially beneficial as they form the basis of much of our agriculture and farm animal populations; only causing problems in their feral or wild state; wild pigs, horses, and burros are examples. Kudzu was brought from Japan as an ornamental plant, then used as forage for animals, and finally for erosion control on highway construction projects. The aggressive plant is now a weed that chokes and kills other plants as it grows up to a foot a day.

The Gypsy Moth was initially imported into the United States for breeding as a possible silk worm at the end of the Civil War. Cotton supplies from the south were limited and silkworms were suffering from a disease. Etienne Leopold Trouvelot, a French born amateur entomologist, imported the moths from Europe to his Medford, MA home and attempted to breed an American silkworm. His belief was based on a mistake in the insect's classification as a member of the silkworm family and the experiment was a failure. Mr. Trouvelot returned to his native France in 1882, about the same time as escaped Gypsy Moths made their presence known on his street. Millions of acres of forest have been defoliated and insect is the major threat to hardwood forests. The battle to eradicate the gypsy moth was started after its introduction and continues until today with a spread rate of about 20 miles per year. The current infestation reaches to North Carolina in the south; Wisconsin and Illinois to the west.

This learning unit will cover the use of remote sensing data to indentify the defoliation caused by Gypsy Moth Larva as they eat and grow to maturity. The gypsy moth hatches in the spring as a larva from eggs laid the previous year, the larva grows and eats tree leaves until mid-June to early-July when it pupates, and a week later emerges as a moth. The females cannot fly and crawl to wait on a male to fly and find them for mating. The females lay eggs in a sticky egg mass that then hatches the next spring. The majority of males and females die within 20 meters of their hatching. Two major vectors or ways that the gypsy moth is spread are attributed to hitchhiking patches of egg masses attached to vehicles and wood to other localities and the wind driven flight of small larva on strings of silk.

The tree of choice for gypsy moth larva in the hardwood forest is the white oak, a valuable hardwood lumber. The detection of gypsy moth dilation with remote sensing is based on the detection of defoliation in the mid-June to mid-July time frame. Trees defoliated by the gypsy moth larva can re-grow their leaves and recover from the attack. Trees suffering less than 50% defoliation normally recover, those experiencing a higher level or two or more years of heavy defoliation usually die.

Two methods of using satellite photos can be used to detect defoliation, one requires three images of the area, one in late May showing the area with leaf growth, one in the mid-July time frame with gypsy moth defoliation present and one in late July to mid-

August with new leaf growth.   The other method involves requires the use of only two images when the area under study is known to be static without logging or other changes that would cause a reduction in foliage. The two images should be of the area in mid June when leaves are present and mid July when defoliation is present. This laboratory will cover the two satellite image method.

Laboratory: Week #1 Analysis of Landsat image using ENVI.

Step 1:   Locate the satellite imagery provided by your instructor for the laboratory exercises. Your instructor may provide the data locally rather than requiring you to download from the Internet. Pan images are only needed if you are required to complete image sharpening.

LandSat:
Go to http://www.wvview.org/index.htm and select data services. Select Path 17 and Row 34. Select and download the multispectral and pan images in matching formats from July 15, 2001. Also download the metadata. Total of 2 files. The data from June 10, 2000 is available for download from the Glovis site.

http://ledaps.nascom.nasa.gov/ledaps/GMAP/productSearchtest.html LEDAPS has forest distribution products.

Gypsy Moth Spread:
Download from the USDA Forest Service site, http://www.fs.fed.us/ne/morgantown/4557/AFPE/data.html , the annual defoliation, Annual Gypsy Moth Defoliation gm_annual_defoliation.zip and its metadata. Two files.

Virginia Land Coverage:
Download the 2000 Virginia Forest Land Use and Tree Coverage shape files from http://www.dof.virginia.gov/gis/datadownload.shtml. Two files.

Step 2:   Open the July image in ENVI and use the **NDVI Transformation** to automatically calculate the index and present the data as an image. Save the new image to the file location your instructor indicates.

Step 3:   **Classify** the NDVI image using the default settings and save the classification.

Step 4:   Automatically calculate other vegetation indices as indicated by your instructor. The **Vegetation Analysis** area under the **Spectral** drop down menu has several built in vegetative indices. Save as instructed. The ratio of Bands 3 and 4 is the most commonly used index.

Step 5:   Classify the images in Step 4 and save as instructed.

Step 6:   Select **Band Math** under **Basic Tools** drop down menu. Calculate the NDVI index by entering the appropriate bands. The index is calculated from the following:

$$NDVI = \frac{Near\ InfraRed\ Band - Red\ Band}{Near\ InfraRed\ Band + Red\ Band} = \frac{B3 - B4}{B3 + B4}$$

The values range from -1 to +1 with a common range from .2 to .8. Image mathematics requires a short description of the methods used to store and complete image operations. Complete the tutorial as directed by your instructor. (pixel bit storage, integer vs. floating calculations.

Step 7:   Duplicate the same process with band mathematics. Use the expression (B4-B3)/(B4+B3) and assign the correct bands to the variables when asked. Load the ENVI created image in one display and your band math image in another window. Are they the same? Why or why not.

Step 8:   Redo the band math and set the variables as (B4-B3)/float(B4+B3). Load the image and link to the ENVI created NDVI. Open a Cursor Location/Value window and read the pixel values for the two images.

Step 9:   Use ENVI to determine the differences between the program automatic calculation of the index (Step 2) and your manually calculated index (Step 6) Your image may show as color while the ENVI image is black and white. The difference is because ENVI reads your image as a classification. Are the pixel values the same the same? Why or Why not.

Step 10:   Redo steps 2-5 as indicated by your instructor for the June Landsat image.

Step 11:   Create a layered image of the two NDVI calculated images to convert the projections, image resolution and image sizes to the same sizes.

Step 12:   Load a new color display with the June NDVI in the Red band and the July NDVI in the green and red bands. Save as a **Combined Image** for use in ArcMap. The healthy red areas from the June NDVI will show through as pink in the weaker July NDVI areas used to mask the June NDVI image. The dark red values are probably clouds and shadows.

Step 13:   Save all your data and answer the lab questions.

Laboratory: Week #2 Using ArcGIS to validate the vegetation indices analysis.

Step 14:   Open ArcMap and use the SouthernUSA template as a base map.

Step 15:   Change to data view and zoom to the State Boundaries layer.

Step 16:   Add the gm_annual_def_nalambert.lyr from the unzipped Annual Gypsy Moth Defoliation Folder. Notice the spread of the infestation as the layers load into the map.

Step 17:   Clean up your display by turning off the Capitol Cities, Interstate Highways, State Boundaries and Rivers layers. Also turn the labels off in the United States layer.

Step 18:   Use Selection by Attributes to create a layer of the "2001" year defoliation. Create three separate layers of defoliation severity of -1, 1,2, and 3 from the 2001 layer. Total of five layers.

Step 19:   Turn off the gm_annual_def_nalambert layer.

Step 20:   We will use only the layers containing the shape files for defoliation greater than 30% Why? What severity numbers are associated with these two layers?

Step 21:   Add the **Combined Image** from last week's laboratory and set the layer to 50% opacity so that the other layers are visible.

Step 22:   Zoom to a defoliated area and visually compare the image colors within the defoliated areas to see if they show an easily seen pattern. The defoliated areas from the aerial survey should show as a very light pink color in the **Combined Image**. There is not a one-to-one relationship between the sketch maps of defoliation and the satellite determination. What are three reasons that might cause the discrepancy?

Step 23:   Create a documented map of a defoliated area showing the "pink" of defoliation through a transparent sketchmap shape file. Add proper labeling to indicate the defoliation.
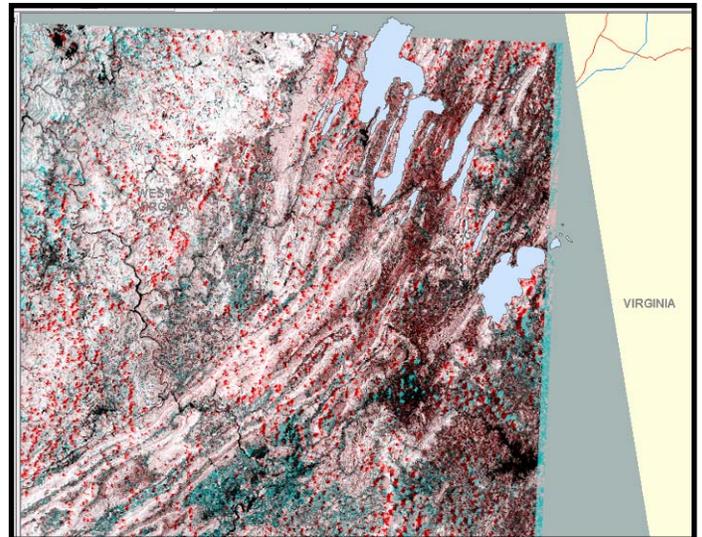
Additional Challenge Activities:
A. Use the classified NDVI shapefiles in ArcMap to analytically determine the values inside the defoliation shapefiles. The Virginia Tree Coverage shapefile can be used to mask non-forested areas. What value indicates defoliation? Apply to other Landsat images and use the values to predict areas with defoliation.

B. Determine another area that has Gypsy Moth or other species invasions and redo the exercise with different satellite images.

C. Redo the satellite image portion of this exercise with MODIS data.

D. Find an area with multiple satellite images available and recreate the exercise using the method utilized for Ohio (Burke).

Key words:
Gypsy Moth, NDVI, invasive species, Virginia, forest defoliation, forest health, Blue Ridge Parkway, and Forestry.

Resources:

Gypsy Moth Papers/Data:

Decision Support for Slow-the-Spread (STS) Project, http://da.ento.vt.edu/index.html

Gypsy Moth North America: USDA Forest Service: download maps. http://www.fs.fed.us/ne/morgantown/4557/gmoth/atlas/

Gypsy Moth Slow-the-Spread Foundation, Inc: http://www.gmsts.org/

Ohio State University; The Gypsy Moth Home Page, http://ohioline.osu.edu/~luca/gm/gmhome.htm

Plethora or Gypsy Moth Information and Links http://na.fs.fed.us/fhp/gm/online_info/index.shtm

USDA Gypsy Moth Manual http://www.aphis.usda.gov/import_export/plants/manuals/domestic/downloads/gypsy_moth.pdf

U. S. Department of Agriculture: Invasive species information and maps. http://www.fs.fed.us/ne/morgantown/4557/AFPE/links.html

Virginia Department of Forestry-GIS/Gypsy Moth: http://www.dof.virginia.gov/gis/index.shtml

Virginia Tech, Gypsy Moth in Virginia. http://www.gypsymoth.ento.vt.edu/vagm/

GIS Data:
Virginia:
DEM-
http://www.geocomm.com/

Gypsy Moth-Trapping/GIS/Tabular: Virginia Department of Forestry
http://www.dof.virginia.gov/gis/index.shtml

Orthoimagery, DOQQ: University of Virginia Library http://fisher.lib.virginia.edu/collections/gis/doq/go_to_html.html

Topographic, DRG: Radford University
http://geoserve.asp.radford.edu/

VDOT Road downloads-
http://gis.virginiadot.org/data_download/data_download_draft_roadway_network.asp

Virginia Department of Forestry, Forest Inventory and Analysis, July 15, 2002, VAFOREST. Online Links:
http://www.dof.virginia.gov/gis/datadownload.shtml.

Virginia Department of Forestry, Forest Inventory and Analysis, July 15, 2002, VATREE. Online Links:
http://www.dof.virginia.gov/gis/datadownload.shtml.

National:
Sketch Mapping
http://www.fs.fed.us/foresthealth/aviation/docs/Sketchmapping.pdf

USDA Aerial Survey Guidelines
http://www.fs.fed.us/foresthealth/aviation/

USGS Seamless Data Distribution System, Earth Resources Observation and Science (EROS)-various data layers.
http://seamless.usgs.gov/

Remote sensing data/papers:
Images:
Primer and website flash tutorials in digital image analysis. National Science Foundation under Grants No. DUE-0127280 and DUE-0340969 (PI: Yue-Ling Wong; Co-PI: Jennifer Burg)
http://digitalmedia.wfu.edu/project/digital-media-curriculum-development/

Vegetation indices:
IDENTIFICATION OF LAND USE AND LAND COVER USING BAND RATIOING TECHNIQUE. Rahman,
http://www.murraystate.edu/qacd/cos/geo/gsc641/1997/rahman/

Satellites:
Landsat Images – West Virginia View. P17R34, Dated: 7-15-2001 and 6-10-2000 http://www.wvview.org/Landsat_path17.htm

Landsat- VirginiaView Landsat collection.

http://virginiaview.geog.vt.edu/

Papers/presentations:

Assessing Potential of VIIRS Data for Contribution to a
Forest Threat Early Warning System, Spruce**,** PowerPoint
Presentation, July 11, 2007.
www.gri.msstate.edu/research/**nasa**_rpc/review/SSTI-2220-
0109_n%20spruce.ppt

IDENTIFICATION OF GYPSY MOTH DEFOLIATION IN
OHIO USING LANDSAT DATA. Thesis, Hurley, Wright State
University 2003.

Gypsy Moth Detection with remote sensing: OHIO GYPSY
MOTH DETECTION, CONVENTIONAL AND REMOTE
SENSING , Burke, Ohio Geospatial Technology Conference for
Agriculture and Natural Resources Holiday Inn Worthington,
Columbus, Ohio March 24-26, 2003

Landsat-based analysis of insect outbreaks in southern Siberia,
Can. J. Remote Sensing, Vol. 29, No. 2, pp. 286–297, 2003

The Role of GIS in the National Gypsy Moth Slow the Spread
Project (STS). Roberts, Vol 4, No. 3 The Virginia Geospatial
Newsletter, Summer 2006.