EXELIS

Visual Information Solutions

ENVI Tutorial: Vegetation Analysis

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Vegetation Analysis

This tutorial introduces vegetation analysis using ENVI® Classic. ENVI Classic includes a suite of tools designed to help you determine the overall state of different vegetation types from their reflectance properties.

The application-specific vegetation analysis tools in ENVI Classic classify the scene for vegetation analysis specific to agricultural stress, fire fuel distribution, and overall forest health. This method enables you to perform vegetation analysis using tools that guide index selections for a specific outcome.

In this tutorial, you will calculate vegetation indices using the Vegetation Index Calculator, then perform some manual analysis of a few of the resultant indices.

Files Used in this Tutorial

Download data files from the Exelis website.

File	Description
`JasperRidge98av_flaash_refl.img (and .hdr)`	AVIRIS Reflectance image sample file
`jasper_aviris_urban_mask (and .hdr)`	Mask for major roads and buildings

About Vegetation Analysis in ENVI Classic

Remote sensing offers an efficient way to estimate vegetation properties over large geographic areas. Vegetation indexes (VIs) are constructed from reflectance measurements in two or more wavelengths and can be used to analyze specific characteristics of vegetation, such as total leaf area and water content. Successfully applying VIs with ENVI Classic and analyzing their results requires the following:

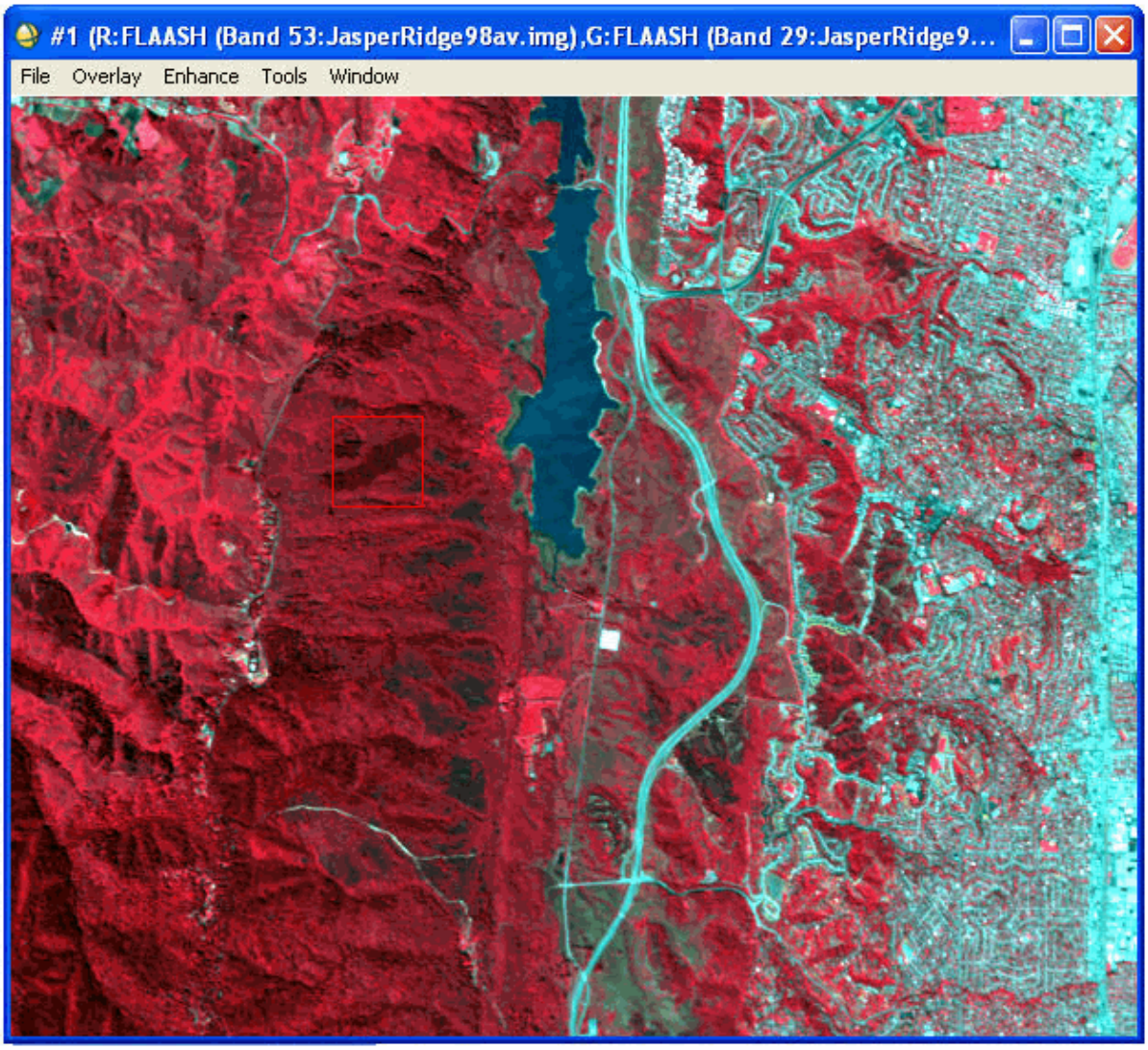
- An understanding of the structure and function of vegetation and its reflectance properties. This enables you to link vegetative structures and their condition to their reflectance behavior in an ecological system of interest.
- An understanding of the vegetation properties that can be estimated by calculating VIs on hyperspectral reflectance data, and knowledge of how these VIs work.
- Using the Vegetation Index Calculator to calculate applicable VIs, then analyzing the output to determine the vegetation conditions in your data.
- Using the Vegetation Analysis Tools to apply classifications to the various ecologies of the indices and analyzing the classifications for specific conditions, such as agricultural stress, fire fuel distribution, and overall forest health.

For more detailed information, see the ENVI Classic Help. It details what comprises vegetation, how strong vegetation differs from weak vegetation, how vegetation properties and health affect the reflectance spectra of plants and plant canopies, and how to use this information to analyze plant and ecosystem vegetative conditions using ENVI Classic.

Opening the Input Image

1. From the ENVI Classic main menu bar, select **File > Open Image File**.
2. Select `JasperRidge98av_flaash_refl.img` and click **Open**. The Available Bands List appears on your screen.
3. Click the **RGB Color** radio button.
4. Select **FLAASH (Band 53…)**. The band you have chosen is displayed in the field marked **R**.
5. Select **FLAASH (Band 29…)**. The band you have chosen is displayed in the field marked **G**.
6. Select **FLAASH (Band 19…)**. The band you have chosen is displayed in the field marked **B**.
7. Click **Load RGB** to load the image into a new display group.

This data is an AVIRIS scene of Jasper Ridge Ecological Reserve. A color infrared image of this hyperspectral scene is visible. You can see the preserve as a large forested area to the left of the reservoir, with a major highway and the city of Palo Alto, CA to the right. We will attempt to analyze this scene for forest fire risk.



Working with the Vegetation Index Calculator

First, you will use ENVI Classic to calculate all of the available vegetation indices for our input image. The Vegetation Index Calculator can be used to determine the vegetation indices that can be calculated for a given input file and to calculate the indices that are applicable.

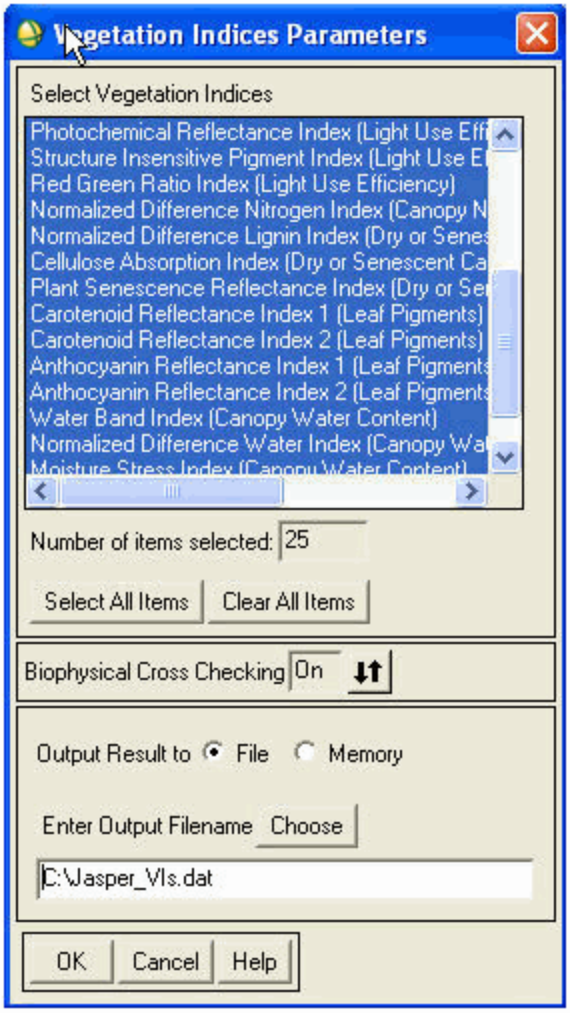
ENVI Classic provides 27 VIs you can use to detect the presence and relative abundance of various vegetation properties. These VIs are combinations of surface reflectance at two or more wavelengths designed to highlight a particular property of vegetation. Each index is grouped into a category by the main function of the index. For more detailed information, see the ENVI Classic Help.

- **Greenness** VIs are designed to measure the overall quantity, amount, and vigor of green vegetation in each pixel.
- **Light use efficiency** VIs are designed to provide a measure of the efficiency with which vegetation is able to use incident light for photosynthesis, which is closely related to carbon uptake and vegetation growth rates.
- The **Canopy nitrogen** VI is designed to provide a measure of nitrogen concentration of remotely sensed foliage.
- **Dry or senescent carbon** VIs are designed to provide an estimate of the amount of carbon in its dry states of lignin and cellulose.
- **Leaf pigment** VIs are designed to provide a measure of stress-related pigments, including carotenoids and anthocyanins, present in vegetation. These pigments are present in higher concentrations in weakened vegetation.
- **Canopy water content** VIs are designed to provide a measure of the amount of water contained in the foliage canopy.

Opening the Vegetation Index Calculator

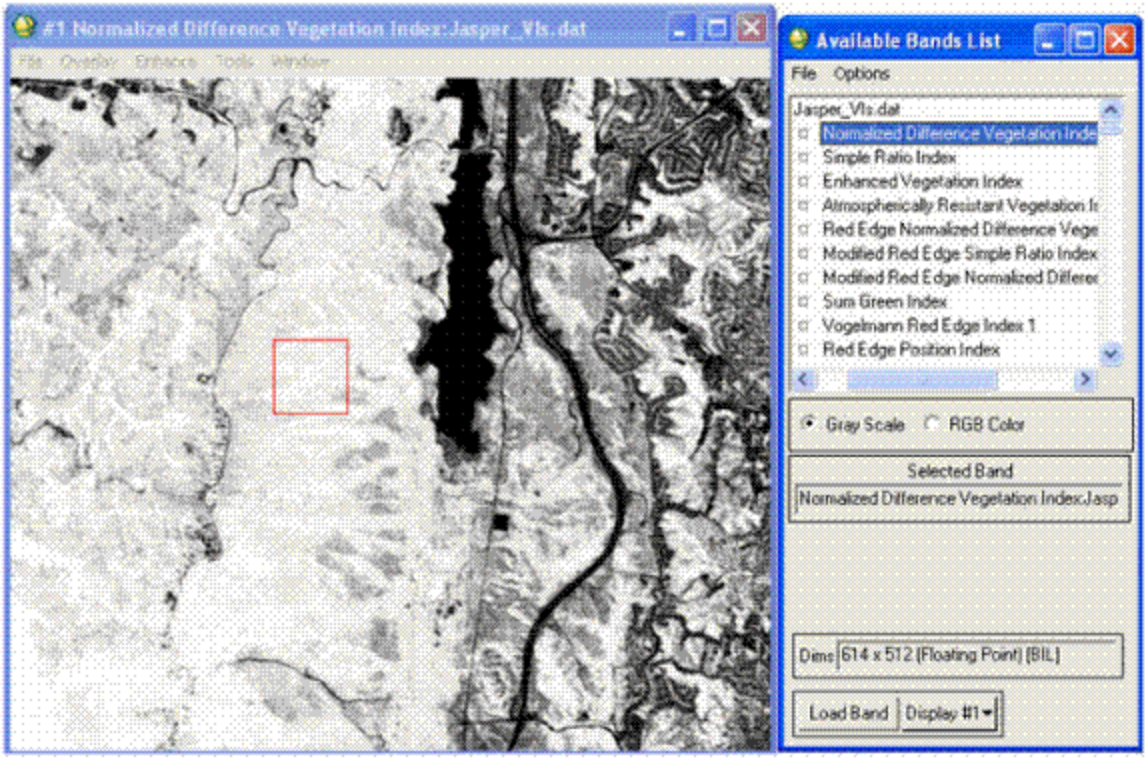
Once you select your input file, the Vegetation Index Calculator automatically determines which of the available 27 indices can be calculated on your input file based on the wavelengths present in your file. If no indices can be calculated because the correct wavelengths are not present, you will be warned at this time.

1. From the ENVI Classic main menu bar, select **Spectral > Vegetation Analysis > Vegetation Index Calculator**. The Vegetation Indices Input File dialog appears.



2. Select the `JasperRidge98av_flaash_refl.img` input file and click `OK`. The Vegetation Indices Parameters dialog appears, showing all of the available indices for the dataset. You can see that for this dataset, 25 of the 27 VIs in ENVI Classic are available and all are selected by default. You could choose to calculate only a subset of these indices by selecting the desired indices from the list. For this exercise, you will calculate all of the available VIs.
3. Ensure that the **Biophysical Cross Checking** toggle is set to **On**. Biophysical cross check is one of the truly unique features of the vegetation analysis component in ENVI Classic. If enabled, it allows the comparison of different indices at each pixel to validate their results. If conflicting values exist between indices, for example, a greenness index shows insufficient vegetation to support the water content measurement from a canopy water index, those data values are ignored.
4. Click the **File** radio button and type or choose an output filename. The output data will be stored in a new file, with one band for each VI calculated, and the band name will contain the name of the VI, ready for use in additional processing in ENVI Classic.

5. Click **OK** to begin processing. The result is passed into the Available Bands List. You can see that each band in the new file is identified by the name of the VI it represents.
6. From the Available Bands List, select the **Normalized Difference Vegetation Index (NDVI)** result (a Greenness VI), then click **Load Band**. Explore this image. You can see that the greenness values appear high in the forested areas, and lower in the urban portions of the scene.



7. Explore some of the other greenness VI results (displayed in the Available Bands List from **Normalized Difference Vegetation Index** through **Red Edge Position Index**). As you examine some of the greenness indices, you can see that they all look similar overall, but each highlights different areas in different ways. Determining which VI most closely describes the field conditions requires some field measurements to be taken.
8. Explore some of the dry carbon and water content VI results (displayed in the Available Bands List from **Normalized Difference Lignin Index** through **Plant Senescence Reflectance Index**). These can be used for fire fuel measurements. You can see that much of the forested area in these results is masked out. These regions are masked by the biophysical cross check because there is too much green vegetation in the pixels for these VIs to work correctly.
9. Explore some of the canopy water content VI results (displayed in the Available Bands List from **Water Band Index** to **Normalized Difference Infrared Index**). The **Water Band Index** and **Normalized Difference Water Index** (NDWI) are good water content indices, and we can see again that the NDWI has much of its area masked by the biophysical cross check. The VI results are now available for use for further processing in ENVI Classic, if desired.

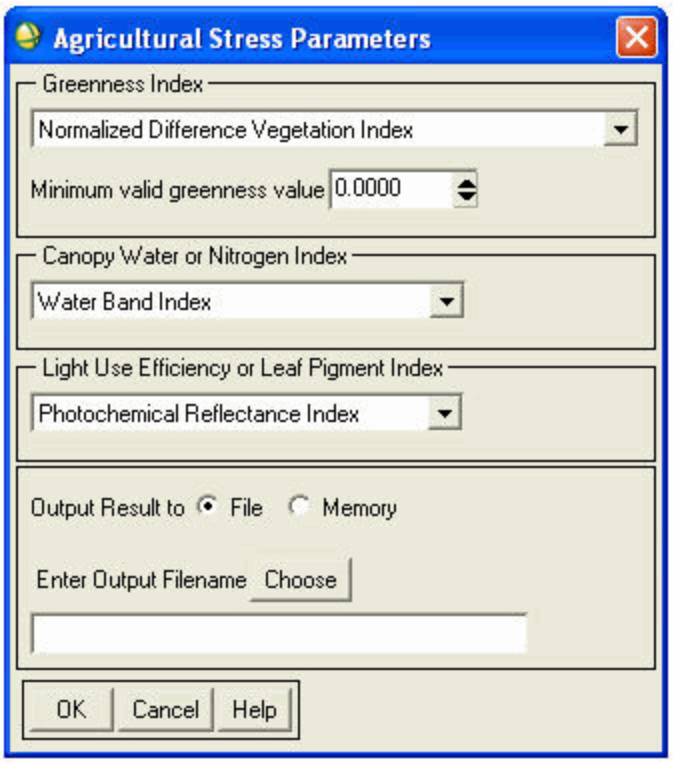
Vegetation Analysis Tools

ENVI Classic provides three application-specific vegetation analysis tools, each specific to one kind of vegetation property: agricultural stress, fire fuels, and forest health. These tools allow you to perform vegetation analysis by guiding you through index selections aimed at a specific outcome. The tools are available from the ENVI Classic main menu bar by selecting **Spectral > Vegetation Analysis**. This tutorial will introduce each tool and explore using the Fire Fuel Tool.

Each of the tools is similar in design and operation as well as in strengths and limitations. The results are relative to the particular input image only and cannot be generalized to other areas or other images. This means that the classes cannot be directly compared between images, as vegetative variability in the image affect the output class distribution. In addition, it is important to field check the results and link the classes in your image to conditions on the ground.

The Agricultural Stress Tool

The Agricultural Stress tool is designed to create a spatial map showing the distribution of crop stress. This tool is intended specifically for use on agricultural land to support precision agriculture analysis.



The conditions that cause agricultural stress are the same as those that cause forest stress; however, agricultural stress analysis concentrates more on growth efficiency. Dry or dying crops do not efficiently use nitrogen and light, indicating agricultural stress, whereas a crop showing healthy, productive vegetation indicates low stress. The Agricultural Stress tool uses the following VI categories:

- **Greenness**, to indicate areas of idle cropland, weak vegetation, and healthy crops
- **Canopy water content**, to show levels of water stress
- **Canopy nitrogen**, to estimate relative nitrogen levels
- **Light use efficiency**, to show vegetation growth rate
- **Leaf pigments**, to highlight vegetation stress

To use this tool, you select one VI from each category, and ENVI Classic combines the information to produce a classification map. The classification map rates the scene from one, representing the least crop stress, to nine, representing the most. The classes are displayed using a color ramp where purple and blue represent low stress, or healthy vegetation, and yellow and reds indicate high stress, or the weakest crops.

The Fire Fuel Tool

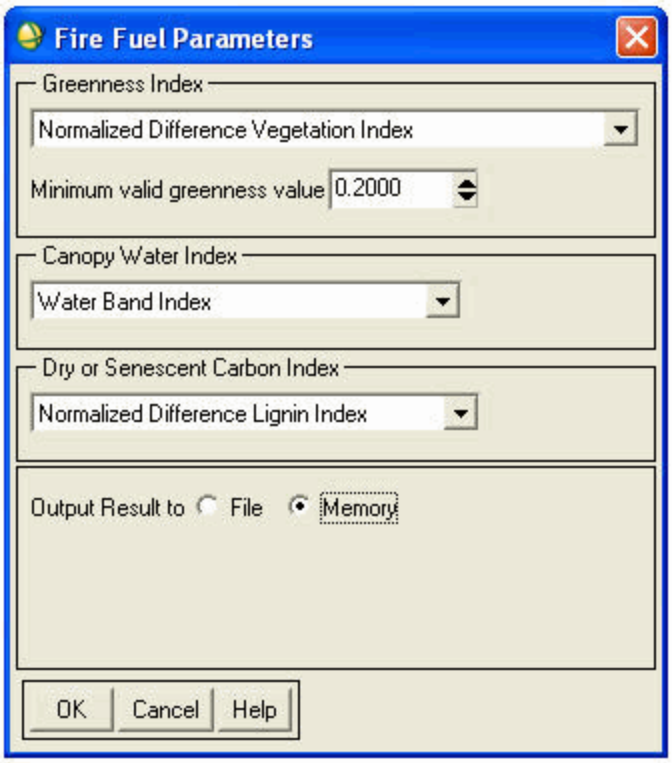
The Fire Fuel tool creates a spatial map showing the distribution of fire fuels and burn hazard for a region. Fire fuel mapping can be useful for forest planners, as well as local governments attempting to mitigate fire risks within the rapidly growing forest/urban interface. High fire fuel distributions contain dry or dying plant material, which contains less water, whereas low fire fuel distributions typically comprise lush, green plants. Fire fuel analysis uses the following VI categories:

- **Greenness**, to show the bulk amount of green vegetation.
- **Canopy water content**, to show the water content of the vegetation.
- **Dry or senescent carbon**, to highlight non-photosynthetic vegetation (NPV).

Running a Fire Fuel Vegetation Analysis

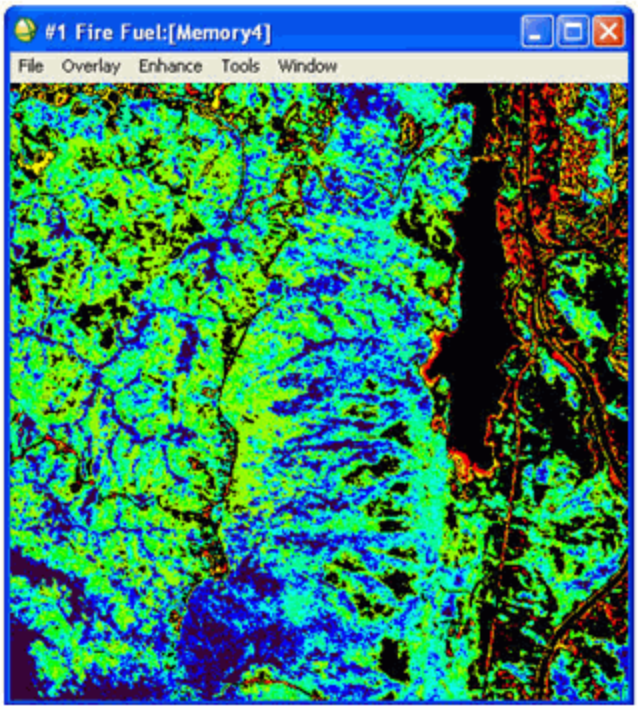
You will now use the Fire Fuels Tool to analyze your data.

1. From the ENVI Classic main menu bar, select **Spectral > Vegetation Analysis > Fire Fuel**. The Vegetation Products Calculation Input File dialog appears.



2. Because this image displays mixed terrain with both forest and urban types, you will use a mask to exclude much of the urban area from classification. Click the **Open** drop-down button and select **New File**.
3. Select `Jasper_aviris_urban_mask` and click **Open**.
4. From the **Select Input File** area, click to select the file you created in the Vegetation Index Calculator exercise.
5. Click the **Select Mask Band** button, select the `Jasper_aviris_urban_mask` **Mask Band** file and click **OK**.
6. Click **OK** on the Vegetation Products Calculation Input File dialog. The Fire Fuel Parameters dialog appears.
7. Increase the **Minimum** valid greenness value to **0.2000**, which will mask regions with NDVI less than 0.2 (major roads and buildings). Accept the other default field values.
8. Click the **Memory** radio button to output to memory.
9. Click **OK** to begin processing. ENVI Classic begins calculating the three selected VIs, then combines them to create the classification map. The result is passed into the Available Bands List.
10. From the Available Bands List, select the **Fire Fuel** result then click **Load Band**. Examine your classification result. The classification appears to have selected most of the urban areas,

including roads as highest risk, and the forest as lowest risk. This highlights the difficulty of using the tools in mixed terrain types, in this case mixed forest and urban.



The areas of highest risk (red) around the roads largely consist of dry grasslands. These orange areas, which can be seen in the VI results as areas where timber is not present, favoring drier underbrush, are clearly identified as areas of interest. There are still some medium high risk (yellow) areas that are probably miss-classified due to urban clutter, but these areas do not detract from the remainder of the result. We can see that much of this forest is too green to burn efficiently, but that there are still areas within it that are worthy of closer examination.

The Forest Health Tool

The Forest Health tool can be used to create a spatial map showing the overall health and vigor of a forested region. Forest health mapping can be useful for detecting pest and blight conditions in a forest, and is useful in assessing areas of timber harvest. A forest exhibiting low stress conditions is usually made up of healthy vegetation, whereas a forest under high stress conditions shows signs of dry or dying plant material, very dense or sparse canopy, and inefficient light use. The Forest Health analysis uses the following VI categories:

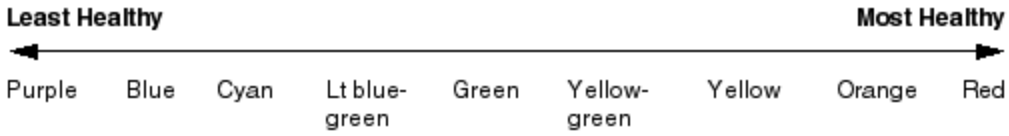
Greenness, to show the distribution of green vegetation

Leaf pigments, to show the concentration of carotenoids and anthocyanin pigments for stress levels

Canopy water content, to show the concentration of water

Light use efficiency, to show the forest growth rate

To use this tool, you select one VI from each category, and ENVI Classic combines the information to produce a classification map. The classification map rates the scene from one, representing the least healthy forest (weakest) to the healthiest forest (strongest)—which help to assess relative forest health conditions within the scene. The classes are displayed using a color ramp where purple and blue represent least healthy and yellow and reds indicate the most healthy.



When you are finished experimenting with the Agricultural Stress Tool, Fire Fuel Tool, and Forest Health Tool, exit ENVI Classic by selecting **File > Exit** from the ENVI Classic main menu bar.