

exercise 3

vegetation classification and global vegetation patterns

Vegetation classification is important in studying net primary productivity and in monitoring changes in Earth's surface vegetation. In this exercise we will see how phenology can be used to group vegetation into classes that have similar temporal profiles using global monthly composited NDVI data.

We start this exercise by looking at a global classified land cover image and exploring the extent of various cover types. Next, we will investigate how the classified image was generated by selecting several predefined pixels from a stack of 12 monthly NDVI composites for 1987, generating temporal profiles, and matching the temporal profiles for the pixels to a temporal profile legend. For the last step we will select other pixels from the stack of monthly composites and try to determine what type of land cover is represented by each pixel.

BEFORE YOU BEGIN THIS EXERCISE

make sure you have completed the following steps—instructions for them are in the *Tutorial*.

- Start *SEE Image*
- Configure *SEE Image*
- Load the *SEE_macros*

exploring the distribution of different vegetation types from a classified image

To monitor vegetation change on a global scale and develop accurate model concepts such as Earth's radiation budget and net primary productivity, it is important to be able to classify land cover types quickly and over large surface areas. The most efficient way to do this is with satellite data. However, first it is necessary to develop classification techniques that use specific parameters such as NDVI values or changes in NDVI values with time to identify land cover types. This is an area of active research. In fact, this exercise is based on a study conducted by R.S. DeFries and J.R.G. Townshend at the University of Maryland (NDVI-derived land cover classifications at a global scale. *International Journal of Remote Sensing*, 15:3567-358, 1994).

A***opening a classified vegetation map***

1 — Select 'Analyze/Options' and change the Digits Right of Decimal Point (0-8) box to "0."

2 — Select 'File/Open'. Go to Desktop | HD | SEE Image | Data | Veg | vgex3 | VEG_CLSS.TIF and click OK to open the image.

B***generating an equal area projection***

1 — With the vegetation map active, select 'Special/ProjectGoode'. Name the image "Goode Class."

First we will explore a global image that classifies pixels into the world's major land cover types. This type of image can be used for input to climate models.

Do A now.

1. The image you see covers the entire globe with each pixel representing 1.00 degree of latitude and 1.25 degrees of longitude. Does each pixel on the image represent an equal area? How can you tell?

If we want to be sure we are comparing equal areas we need to generate an equal area projection, that is, one in which each pixel represents the same surface area.

Do B now.

2. Move the cursor over the different classes (represented by different colors) in the Goode Class image. As you do this the classification number for a specific area (color) will be found as the Value entry in the Info window. A legend for these values is located below. Note how the different classes are distributed around the globe.

Legend for the Classified Map

0	water
1	broadleaf evergreen forest
2	broadleaf deciduous forest and woodland
3	mixed coniferous and broad-leaf deciduous forest and woodland
4	coniferous forest and woodland
5	high latitude deciduous forest and woodland
6	wooded c4 grassland
7	c4 grassland
9	shrubs and bare ground
10	tundra
11	desert, bare ground
12	cultivation
13	ice
14	c3 wooded grassland
15	c3 grassland

3. Is any general pattern apparent in the distribution of vegetation classes? Explain.

4. Apart from water and ice, are there any classes that seem to predominate? Explain.

To determine the surface area represented by each of the land cover classifications we can use the density slice tool to select and highlight certain values and then use an analysis tool to measure the area. Density slicing allows the user to take a range of values (block of values) and assign a color to them. The default color is red but can be changed. The LUT tool can be used to manipulate the density slice when density slicing is enabled.

First we will define a range by moving the upper and lower boundaries of the density slice. The boundaries can be monitored in the Info window. We will change the color block default color from red to black since red is a color used for one of the classes. Then we will move the density slice block up and down the LUT window, which will change the upper and lower boundaries of the values that we are interested in highlighting in black.

C

making a density slice with the lut tool

1 — From the Tools window double click on the LUT tool (horizontal line with an up and down arrow) to enable density slicing. This will put a solid block of color (default color is red) on the LUT window.

2 — Select the eyedropper from the Tools window and double click it on the color block in the LUT window.

3 — When the color selection window appears, change the “new” color of the block to black and click OK.

4 — Select the LUT tool in the Tools window.

5 — Place the cursor at the top of the black density slice block in the LUT window; click and drag the cursor (and density block) until the upper limit is equal to about 9.0.

6 — Place the cursor at the bottom edge of the black density slice color block in the LUT window; click and drag the cursor (and color block) until the lower limit is about 8.3.

7 — In the LUT window, place the cursor on the center of the black color block and click and drag the black density slice block to the bottom of the window.

Do C now.

Place the cursor in the middle of the black color block on the LUT window and slowly move the block up the LUT window. You will notice that areas on the globe are highlighted in black. You can determine the classification number for a particular highlighted region by placing the cursor over one of the blackened areas on the image.

Now we will measure the area represented by each of the land cover types on this image.

D

Do D now.

measuring density slice regions

1 — Select 'Analyze/Options'. Be sure that the Area and Mean Density boxes are the only ones checked. Click OK.

2 — Select 'Analyze/Reset'. If you get a message that measurements have not been saved click Continue.

3 — Select 'Analyze/Set Scale'. Select 'Kilometers' from the Units pop-up menu. Enter "1" for Measured Distance in Pixels. Enter "111.2" for Known Distance. Enter "1" for Pixel Aspect Ratio. Click OK.

4 — Select 'Analyze/Show Results'. This will place a Results window on the desktop.

5 — Activate the Goode Class image. Activate the LUT Tool. Move the color block in the LUT window to the bottom of the window. The large area covered by water will be black.

6 — Select 'Analyze/Measure'. The Results window will display the area in square kilometers and the mean which is the classification number.

7 — Slowly move the color block up the LUT window until the black color on the Goode Class image disappears and reappears over a different set of pixels. Select 'Analyze/Measure' and the values for this new vegetation category will appear as the second set of measurements.

8 — Repeat step 7 while moving from bottom to top of the LUT window. When you are finished you should have mean values from 0–15 (with 8 missing) and accompanying areas. You can measure any class (mean) you missed by moving the density slice color block on the LUT window so that mean value desired is within the Upper and Lower range in the Info window and repeating step 7.

9 — Transfer the measurements to the table on the next page. If you have a printer selected for your computer, you can print the results by activating the Results window. Then select 'File/Print Results'.

Class (Mean)	Land Cover Type	Area (km ²)
0	water	
1	broadleaf evergreen forest	
2	broadleaf deciduous forest & woodland	
3	mixed coniferous & broadleaf deciduous forest & woodland	
4	coniferous forest & woodland	
5	high latitude deciduous forest & woodland	
6	wooded c4 grassland	
7	c4 grassland	
9	shrubs & bare ground	
10	tundra	
11	desert, bare ground	
12	cultivation	
13	ice	
14	c3 wooded grassland	
15	c3 grassland	

5. Which land cover types predominate on the basis of area (excluding water and ice) in this 1987 image?

Change “Analyze/Set Scale/Units” from Kilometer to Pixels then close all open images.

classifying land cover using temporal profiles

How do you generate a classification system for land cover types from satellite data? One way is to look at the spectral signature of different types of land cover. Instruments such as the Advanced Very High Resolution Radiometer (AVHRR) are able to measure radiation of multiple wavelengths reflected from Earth’s surface.

Reflectance in the near-infrared and red wavelengths can be used to generate an index of vegetation called the Normalized Difference Vegetation Index (NDVI). The values for this index range from -1 to $+1$. Bare soils have NDVI values that are near zero while green vegetation shows values approaching $+1$. Negative values generally result from snow or water. NDVI values can be used to distinguish between vegetation and bare soils in an image but NDVI values from a single date are often insufficient to determine the type of vegetation.

To refine the classification of vegetation, we can use the change in NDVI values over the period of a year. For example, water will not show a change in NDVI values while a deciduous forest that loses its leaf cover will have NDVI values that vary seasonally. We can use this change-over-time information to identify different types of vegetation by plotting the NDVI values for a particular pixel for each of the twelve months of the year. This plot is called a temporal profile. Different types of vegetation have characteristic temporal profiles.

The different classes on the VEG_CLSS.TIF image have been categorized by temporal profiles. We can use these profiles to assist in identifying the land cover associated with a particular pixel.

We can generate land cover temporal profiles using a stack of NDVI images that cover the same area over a year and are arranged sequentially based on date. If we select a specific pixel on the top image and look along the Z-axis (at the same pixel through the stack) we can see variation in the NDVI value along the Z or time axis. SEE Image allows us to sample an area along the Z axis through a stack and plot the results.

E

importing, stacking and coloring global monthly ndvi composites for 1987

1 — Select 'File/Import DAAC AVHRR'. Make sure the Import DAAC AVHRR NDVI Image radio button is selected. Select all three check boxes: Calibrate images when imported, Use default min and max values for scaling, and Import all images in the folder. Click OK.

2 — When the file selection window appears, go to Desktop | HD | SEE Image | Data | Veg | vgx3 | NDVI1987. Make sure the NDVI1987 folder is open and an image is selected (it doesn't matter which image is selected) then click on Open. All 12 images will open, overlaying each other automatically.

3 — Select 'Stacks/Windows to Stack'. The images will compress into a stack.

4 — Select 'Options/Color Tables/DAAC NDVI' to color all images in the stack.

Close all images.

Do E now.

F

generating a temporal profile

1 — Select 'Options/Preferences' and then click on the Display Stack Title and Slice Titles radio button if it has not already been selected. Click OK.

2 — Activate the stack ND8701–ND8701. Click the line selection tool (the dashed diagonal line) in the Tools window.

3 — Move the cursor over the second pixel listed in the table below and click on that pixel. Select 'Special/Plot Temporal Profile'. Enter "1" for the maximum value and click OK. Enter "–0.4" for the minimum value then click OK.

creating temporal profiles for different land cover types

Now that we have a stack of images we can generate temporal profiles.

Do F now.

The resulting temporal profile (Z-Axis Profile Plot) shows the months on the x axis (1=January, since we stacked the images in order from January to December). The NDVI values are displayed on the y axis.

6. Sketch the profile, labeling the axes. If you have a printer you may print the profile by selecting 'File/Print Image'.

Compare the profile you created with the plots in the profile legend shown at the end of this exercise. As you make the comparison keep in mind the profile shape, the starting value for the plot, the lengths of level and inclined segments, and the maximum values on the curves.

Pixel Location		Land Cover Type
X	Y	
115	95	broadleaf evergreen forest
98	53	broadleaf deciduous forest & woodland
98	40	coniferous evergreen forest & woodland
209	110	wooded grassland, southern hemisphere
104	30	tundra
311	38	northern latitude deciduous forest & woodland
88	51	cultivated northern hemisphere
200	90	cultivated southern hemisphere
180	65	desert bare ground

7. Repeat the plot routine for each pixel in the table, comparing each profile to the legend. You may notice that some curves have precipitous rises or declines at the beginning or end of the plots. This may be a result of no-data values on the first and last images. Consider the rest of the curve for comparison purposes. How well do your profiles match the profiles for the specific land cover type?

identifying land cover types using temporal profiles

Now that you have had some experience looking at temporal profiles for different land cover let's use that information to classify some additional areas on your images.

8. Select six pixels from around the globe that appear to represent varying land cover types. Avoid water and high latitudes where there may be snow or ice cover. Using the instructions in procedure F for generating a profile, produce one for each pixel and identify the cover type from the temporal profile legend. Record each pixel location and your classification in the table below. Locate the same pixel in the VEG_CLSS.TIF image to see how that pixel was classified.

Pixel Location		Land Cover Classification
X	Y	

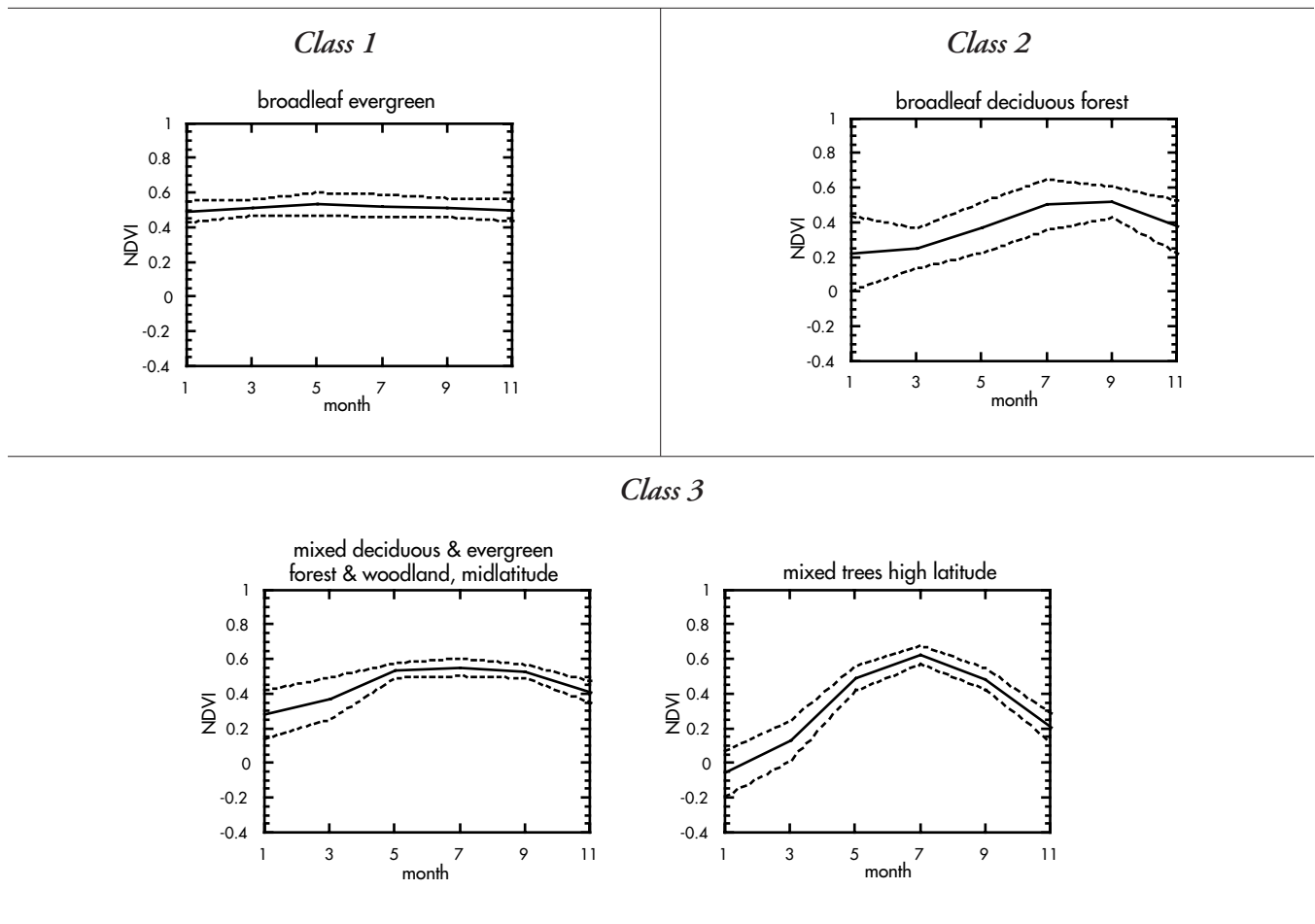
9. How accurate were your classifications?

10. What might be the possible causes for wrongly classifying a particular pixel?

As you try to identify different cover type classes you will see that in some cases the profile of the pixel does not seem to fit any of those in the legend or it seems to be in between two or more profiles. This illustrates that it can be very difficult to make a decision as to how to classify a particular pixel. The task of image classification is to make the best choice possible given the restraints of

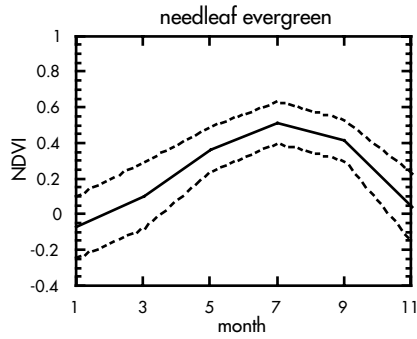
the algorithm (formula for the classification). In some cases a pixel may be incorrectly classified. Even if a pixel is “correctly” classified based on the rules of the classification process, it may actually be composed of more than one class.

The classified vegetation map used in this exercise was generated using an automated classification process. This process involved selecting representative pixels, known as training sets, for each vegetation class. This was done using vegetation maps. Statistics from these training sets were then used to assign a particular land cover type to each pixel using a computer algorithm. In essence, for each pixel the algorithm compares the reference profile from each training set (these are the profiles that we used as a reference in this exercise) with the profile of the twelve NDVI images. Once the best match is found that particular pixel is assigned a value that identifies it with a particular cover type. This is similar to what we did in this exercise.

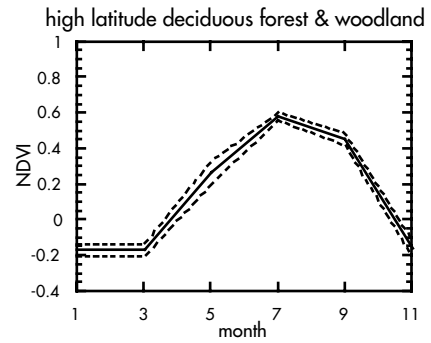


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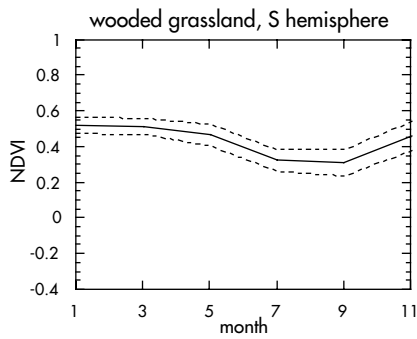
Class 4



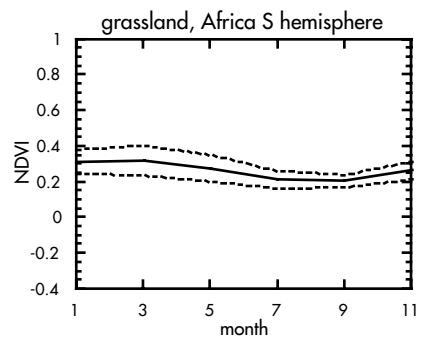
Class 5



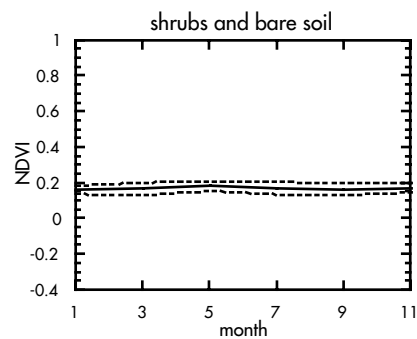
Class 6



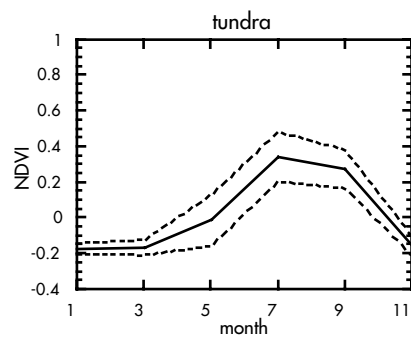
Class 7



Class 9

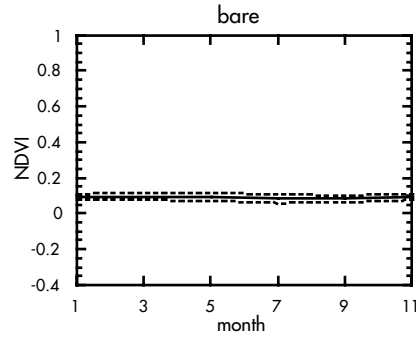


Class 10

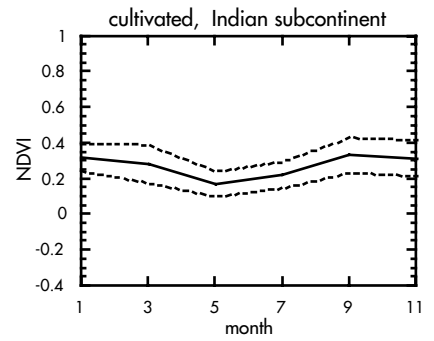
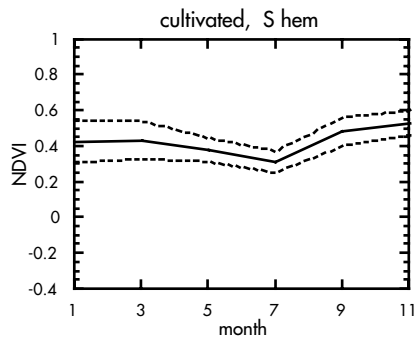
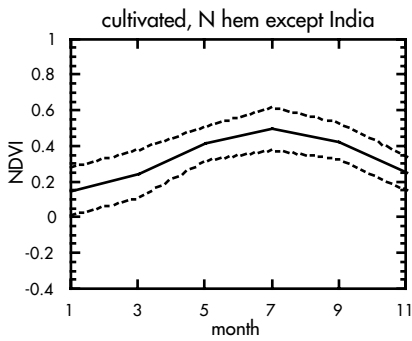


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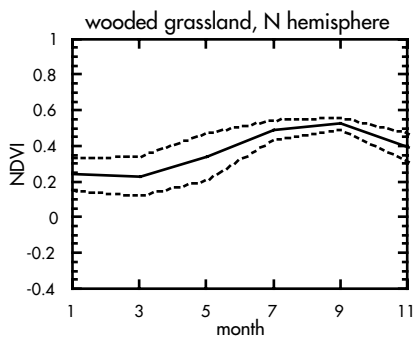
Class 11



Class 12



Class 14



Class 15

