GEOGRAPHY 827   NAME _____

DIGITAL IMAGE PROCESSING AND ANALYSIS   FALL 2015

Lab Exercise No. 10   **Due Date:**

Points: 5

<u>**TOPIC: Hyperspectral Imagery & Raster data in R**</u>

<u>**Purpose:**</u> To familiarize yourselves with hyperspectral imagery and differences between narrow and broadband NDVI, as discussed in the lecture, and to introduce working with raster data in R through an exercise in species distribution modeling.

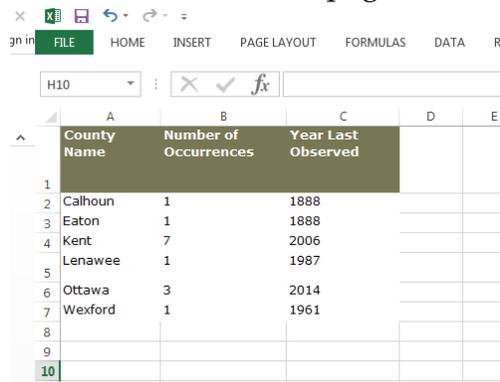<u>**Procedures (Part 1 – Hyperspectral Imagery in ERDAS):**</u>

1. Load "KBS_AVIRIS_2009.img" into ERDAS IMAGINE.
2. Under the big Raster tab go to Multispectral and change the RGB bands to 53, 30, and 20 for a more typical 5-3-2 view.
3. Spend some time looking at the different vegetation types. If you have GoogleEarth on your laptop, take a look at this area in GoogleEarth (note, this is due south of Kellogg Biological Station in Michigan). Note the diagonal stripe feature in the NW corner of the image is a line of train tracks.
4. Use the Spectral Profile > Spectral Profile tool to collect spectra (use the "+" button) from around the image, sampling a wide variety of land cover types, including forest, shaded forest, water, agriculture, soils, etc. Save this set of profiles (ok to just print screen) and in another program like PowerPoint, label the different curves with what they are (forest, water, etc). Describe how this hyperspectral data differs from what you would get from a Landsat image of the same area.
5. NDVI – we're going to compare the results of narrow-band NDVI (using single 10 nm AVIRIS bands) to a 'wide band' NDVI (comparable to NDVI from MODIS). Use your NDVI model and assign band 35 (675 nm) and band 51 (831 nm) as your red and NIR bands, and calculate NDVI. Then develop a new model but average the band values from band 52 to band 56 for NIR (841-880 nm), and band 27 to band 35 for red (618-675 nm), then use those new values to calculate NDVI.
6. Visually compare the two images and describe the differences, then calculate a difference image (narrow band NDVI minus broad band NDVI). Are they very similar? Where are they different?

PART 2 (rare plant distribution modeling in R):

The goal of this part of the lab is to learn how very simple species distribution models are made, using the "Climate Envelope" concept we discussed in class. Each student will choose 2 species of rare plants of Michigan, import data on their whereabouts into Excel then into R, and will use these locations, along with precipitation, temperature, and elevation data to estimate where the species might be found today, and where they might be found in 2100.

Note: You will be making two (or more!) species distribution models. I highly recommend that you go through all the steps once, then start again, rather than trying to batch process all three.

(1)   First, create a folder on your computer to store the data for this project. There should be NO spaces in the entire directory path (e.g. my data is stored in "C:/Users/kdahlin/Dropbox/MSU_GEO401/data_project").

(2)   Go to http://mnfi.anr.msu.edu/data/specialplants.cfm skim thorough the list of rare plants of Michigan and pick a plant that sounds interesting. Click on the "Explorer" link in the far right column to learn more.

(3)   If you read the description and still like the plant, and *it has three or more counties listed in the "Occurrences" table*, proceed. If not, go back to #2 and try again.

(4)   Highlight everything in the Occurrences table (but nothing else on the webpage), and copy this data (right click and select copy, or hit Ctrl+C or Cmd+C)

(5)   Open a blank Microsoft Excel or other spreadsheet and paste this data into the table, so it looks just like the one on the webpage. It should look like this:

(6)   Reformat so it's just a simple table (remove fill, make all the text black), and rename the columns so there are no spaces but the column names are still understandable. Now it should look something like this:

(7) Sort by the "Year_Obs" column by highlighting everything in the table (easiest way to do that is just to click the upper left corner of the table), then go to Data > Sort and select "Year_Obs" from the "Sort by" dropdown menu. We're only interested in semi-recent observations, which, for this class, we'll define as observations from 1900 or later, so delete any rows with years before 1900 (highlight the entire row, right click and select delete).

(8) Save this file, first as an Excel file, then as a .csv in the folder you created in #1. When you save as a csv Excel might give you an error message, but just say 'yes' and it should be ok. Now the data are ready to be read in to R!

(9) Before we do that, go to the Dropbox folder for this lab and download the .R file. Then go to the 'Climate Data' folder and download the nine .tif files.

ALL OF THESE FILES SHOULD BE SAVED IN YOUR DESIGNATED FOLDER!

About these data: All of these files are outputs from a climate model – specifically the US National Center for Atmospheric Research's Community Earth System Model (CESM), run with biogeochemistry (carbon and nitrogen cycles) turned on (hence, CESM-BGC). Even the 1980-2000 data are from the model – running a model over a historic time period allows researchers to compare what the model says to our actual historical data. For our class, though, we're just treating the 1980-2000 data as 'truth'. This is just one of >30 earth system models that was used in the Coupled Model Intercomparison Project round 5 (CMIP5) and then 'downscaled' (as discussed in class) for the continental U.S., using two different Representative Concentration Pathways (RCPs). Monthly data were downloaded from here: https://cds.nccs.nasa.gov/nex/ and then processed to be maximum and minimum temperatures and average annual precipitation. The research papers in the 'readings' folder in the Lab 10 folder give more info about these data, which might be of interest. If you are feeling super adventurous, I'm happy to share details of how I got and processed these data, so you could do the same project again using a different climate model.

ON TO THE ANALYSIS!

(10) Assuming you've already installed R and RStudio and have confirmed that they function properly, open RStudio then open the .R file you downloaded.

(11) Proceed with the lab in R following the instructions in the code.

(12) Turn in the figures you generate along with descriptions of the differences between the figures (like the 'Results' section of a manuscript).

PART 3 (bonus if you have time – AVIRIS data in R):

(1) Still have more time? Try exporting the AVIRIS data from ERDAS to a .tif file by going to Manage Data > Export Data and saving as a GeoTIFF. Transfer this file to your laptop using a thumb drive (or get the data from Kyla).

(2) Now read in the data as you did in the above exercise in R and try different things with it. A few tips – to read in a .tif with multiple layers use the 'brick' command instead of 'raster'.

(3) Then to select an individual layer for analysis use double brackets – so to calculate NDVI, if I called the raster brick 'kbs.aviris' I would type

(kbs.aviris[[a]] – kbs.aviris[[b]]) / (kbs.aviris[[a]] + kbs.aviris[[b]])

Where a and b are the layer numbers. Note these won't correspond to the band numbers used above, since I cleaned this dataset for you, removing bad bands, so you'll have to do a bit of thinking.

(4) For basic functions you can treat the raster brick just like you would any other data vector – typing 'mean(kbs.aviris)' will give you the average value at each pixel for the stack of layers. Same goes for min, max, and basic math.

(5) To perform more complex analyses where you treat each pixel location as a vector of data, you need to first write a function to do the analysis (too complex for this lab if this is new to you), then use the 'calc' function in the Raster package.

(6) The Raster Package is a super powerful set of tools – for more info go to
https://cran.r-project.org/web/packages/raster/raster.pdf