Multispectral Image Processing in ArcMap
GeoTEd-UAS Institute 2018

Workshop Session Goals:

The objective in this 1.5 hour session is to introduce you to common multispectral processing techniques in ArcMap that would be useful for UAS data. We will cover how to create composite images from greyscale bands to enable to view your data in color, how to calculate relevant vegetation indices from the UAS data [including the simple ratio(SR), the normalized difference vegetation index (NDVI), and the normalized difference red edge index (NDREI)], and image classification.

1. Create composite bands
2. Calculate SR, NDVI, and NDREI
3. Multispectral Image classification (Supervised and Unsupervised)

To help you think about these data, I ask a few questions along the way. Please give them some consideration as you go and make sure you ask questions if you can't determine the answer.

Multispectral UAS Data

The multispectral data for this session comes from the Sequoia Parrot, which is a 4-band VNIR sensor with bands that record in the green, red, red-edge and near-infrared (NIR) wavelengths (Figure 1 and Table 1). These data are stored in the "Vals_sesssion/Multispectral" folder.

Table 1. Sequoia Parrot Band Wavelengths

Description	Wavelengths (nm)
Green	530-570 nm
Red	640-680 nm
Red Edge	730-740 nm
NIR	770-810 nm

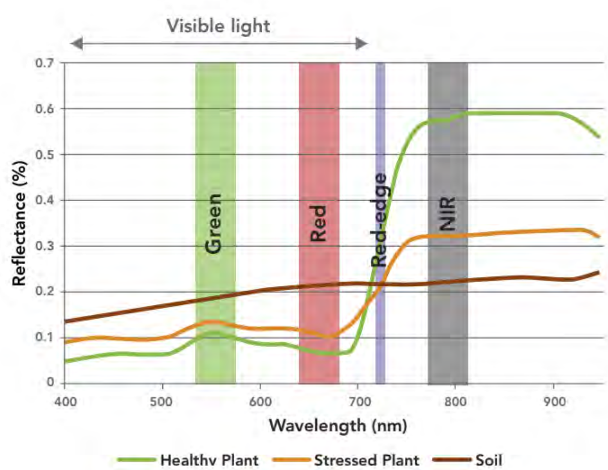


Figure 1. Spectral bands of Sequoia Parrot superimposed over spectral profiles of soils and plants. From: https://static1.squarespace.com/static/579a34a98419c24fcccb6be1/t/57b29110f5e23130c684b3e0/1471320337500/Sequoia_Datasheet_A4_V11.pdf

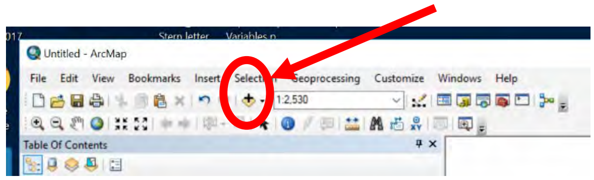
Question 1. *Based on Figure 1, without loading and looking at the imagery, would you expect vegetation to look brighter than, darker than, or about the same as soil in the Green band?* ______________
Red band? __________________
Red edge band?________________
NIR band? _________________

Thermal UAS Data

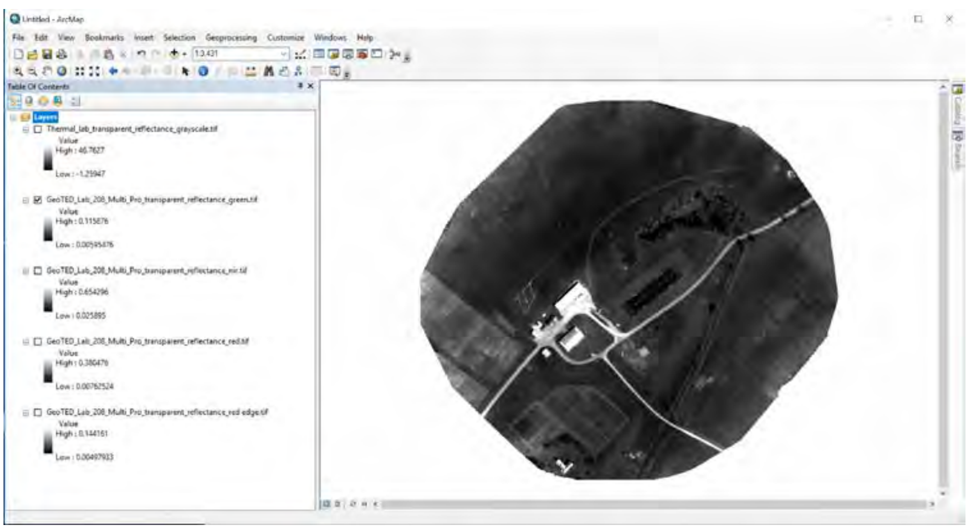
There is a single band of thermal data, collected over a subset of the area covered by the multispectral imagery. These data were collected by the FLIR Vue Pro R, and over the 7.5-13.5 µm portion of the electromagnetic spectrum. The data are stored in the “Vals_session/Thermal” folder.

Workshop Session Tasks

1. Open ArcMap
2. Use the “Add Data” tool to add the 4 multispectral images and the 1 thermal image to your ArcMap document.



3. Explore each band of the data to ensure your answers to Question 1 are correct. Note that you can turn layers on and off by clicking the “checkmark” beside the file name in the Table of Contents. The below example shows the green layer, with all other layers turned off.

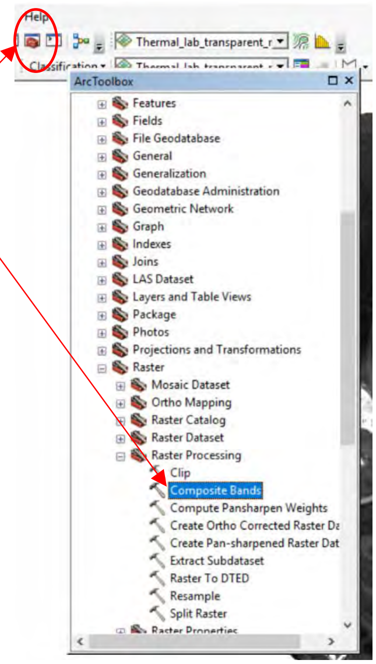


4. Ensure that the necessary extensions are loaded. From the menu along the top, select Customize/Extensions and ensure that “Spatial Analyst” is checked.
5. Ensure that the desired toolbars are loaded. From the menu along the top, select Customize/Toolbars and ensure that “Spatial Analyt” and “Image Classification” are checked. A new pop-up window might appear. If so, you can leave as is, or drag and drop to the toolbar along the top.

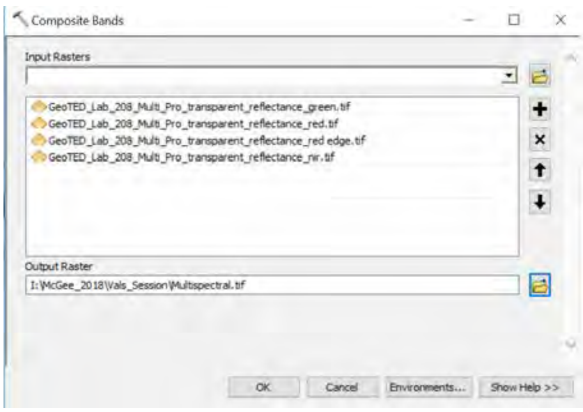
Objective 1. Create a composite image from the multispectral imagery

ArcMap has a “composite bands” tool to enable you to display imagery in RGB color, as opposed to only greyscale.

6. In ArcToolbox, select Data Management/Raster/Raster Processing/Composite Bands.

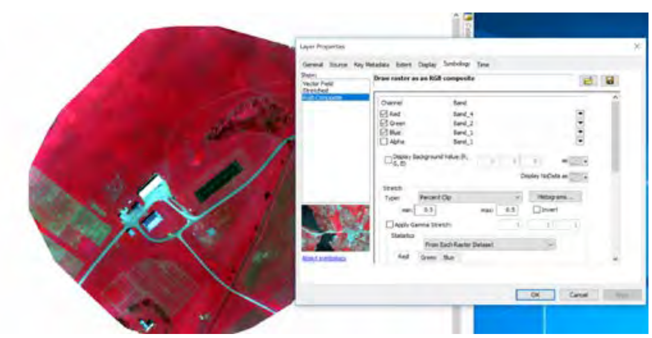


7. Add the 4 multispectral bands, and order them from low to high wavelengths. Give the output raster a logical name, and make sure you save into your own folder.



Note: Give this command a few minutes to run. When it is finished, the image will automatically load into your ArcMap document.

8. You can now load whatever band combination you want to view the image in color. To change the RGB band combination, right click the layer and select “Properties” from the dropdown menu. You can adjust the band combination as desired. If the band order is low-wavelengths-to-high (as above), then the combination of 4,2,1 will give the standard false color composite.



Question 2. *What band/wavelength combination would make vegetation appear green?* __________

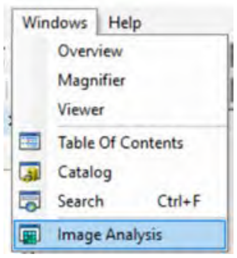
Question 3. *Does the answer for question 2 give a “true color composite”?* _______________

Objective 2. Calculating SR, NDVI, and NDREI

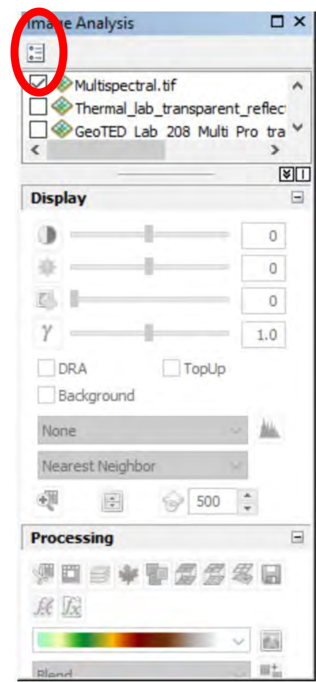
$$SR = \frac{NIR}{RED} \qquad NDVI = \frac{NIR - RED}{NIR + RED} \qquad NDREI = \frac{NIR - RE}{NIR + RE}$$

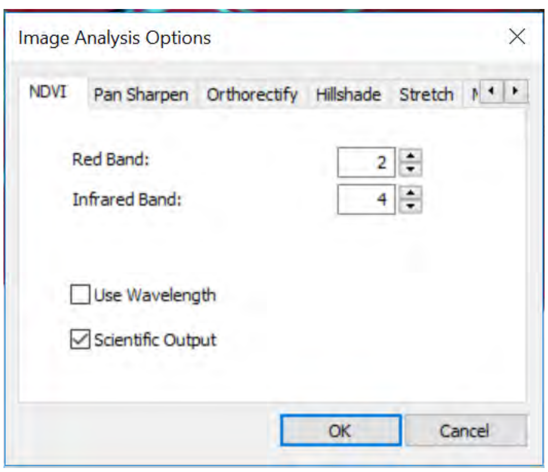
There are a number of ways these indices can be calculated in ArcMap. ArcMap has an NDVI calculator for multispectral imagery in the "Image Analysis" menu. Alternatively, you can calculate it manually in the raster calculator.

9. Open the image analysis menu by clicking Window/Image Analysis.



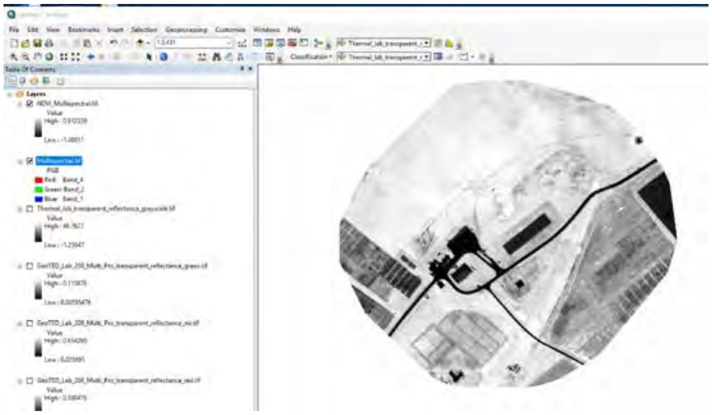
10. Access the various Image Analysis Options by selecting the little menu button on the upper left corner of the Image Analysis window. Choose NDVI as the tab.

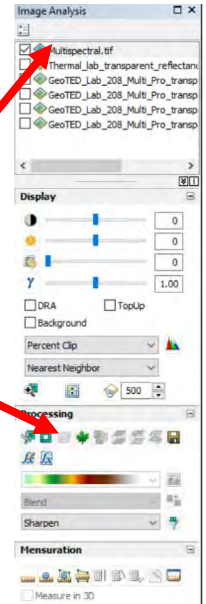




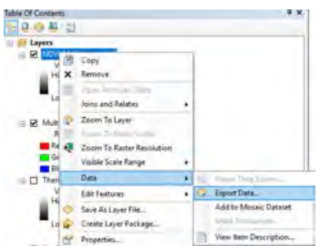
11. To calculate NDVI, specify the correct bands for Red and NIR. Make sure the "Use Wavelength" option is unchecked, because we did not put any wavelength information into the metadata. Check the scientific output box (as above) to ensure that the output is -1 to 1 as expected, and not a scaled integer value. Now that the options are set, you can go to the next step to calculate the index.

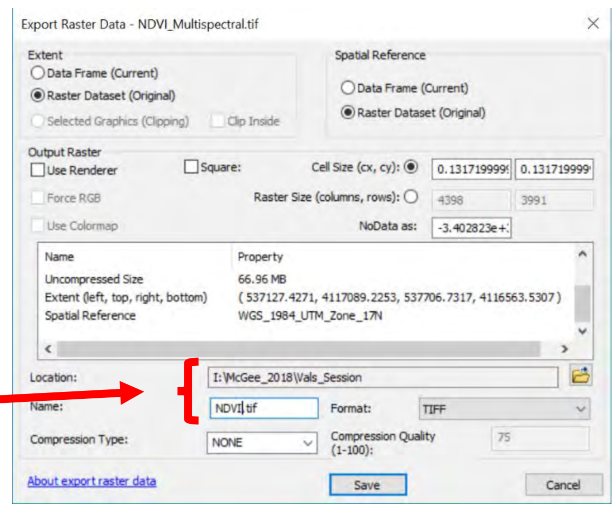
12. Close the options window, make sure your Multispectral file is highlighted and click the NDVI button, which looks like a leaf. This creates a temporary file in the table of contents and displays the image as a greyscale image.





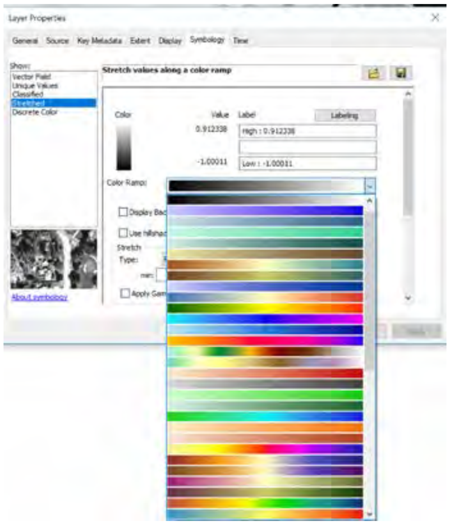
13. Save the file by right clicking on the file name in the Table of Contents/Data/Export Data.

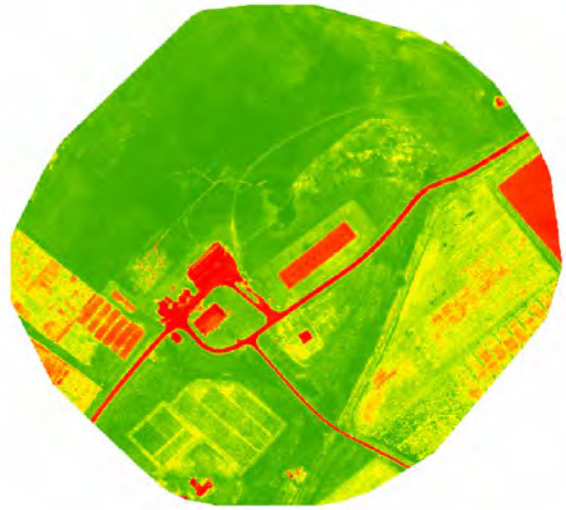




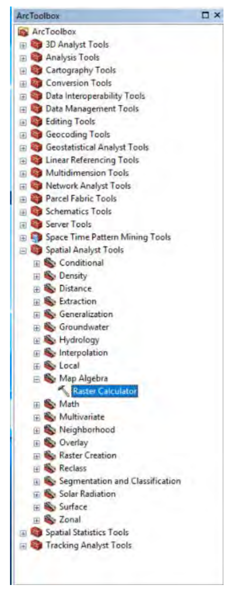
14. Give the file a logical name, specify the location, and save it. You can leave the other settings as the default.
15. Repeat steps 10-14, but specify the appropriate bands and naming convention for NDREI.

16. If you want to change the color scheme from greyscale to something where high values are green (i.e., vegetation), you can do this in the properties. Right click on the file name in the Table of contents, click Properties/Symbology and choose a color from the color ramp.

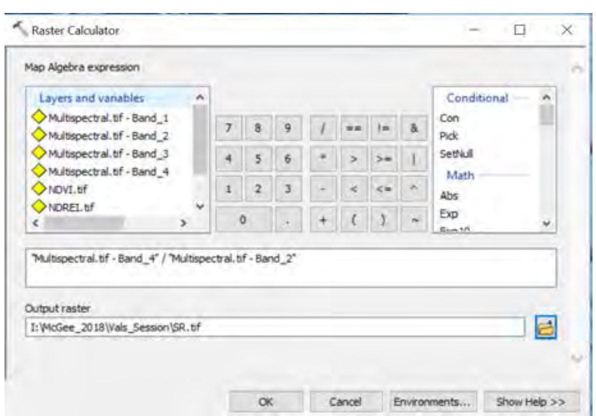




17. Unfortunately, the Image Analysis tool only allows you to calculate indices in the form of a normalized index. If you want to try a different type of index, such as a ratio or difference index, you need to use the raster calculator. To do this, you need to have the individual bands loaded into ArcMap. This might already be the case, if you left them open as you proceeded in the above steps. Alternatively, you can open the files individually (Vals_session/Multispectral) or reload your composite image, but double click on the name of your multispectral image to get to the individual band list. For simple ratio, you need the NIR and the Red band (Bands 4 and 2 in the above steps). Load the individual bands and open the raster calculator. Raster calculator is in the Arctoolbox/Spatial Analyst Tools/Map Algebra/Raster Calculator.



18. To calculate SR, enter in the ratio of NIR/Red, by clicking on the appropriate layer and mathematical operator. Save the output to your folder (use the .tif extension so that it saves as a tif and not an esri grid). When it is finished calculating, it will automatically load.



Question 4. *Does vegetation look relatively dark or relatively bright for each of the indices?*

NDVI ___________________________

NDREI __________________________

SR _____________________________

19. Query the image using the "Identify" button. Based on your interpretation of the image, choose a vegetated area and the road. Fill in the following table. Note: you can list the values in all indices by specifying "<all layers>" in the Identify From dropdown menu.

Index	Vegetation	Road
NDVI		
NDREI		
SR		

Question 5. *Why is there such a difference between NDVI and SR for vegetation?* ____

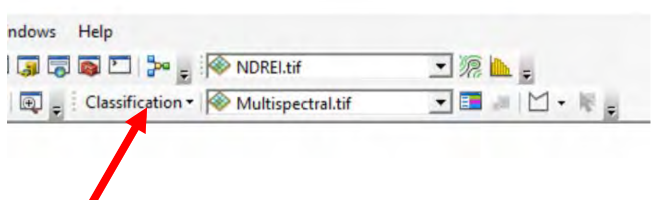
Question 6. *Why are there areas of "nodata" in the SR on the rooftop of the barn?* ____

Objective 3. Multispectral Classification

ArcMap allows for 2 types of image classification: unsupervised and supervised. We'll try both.

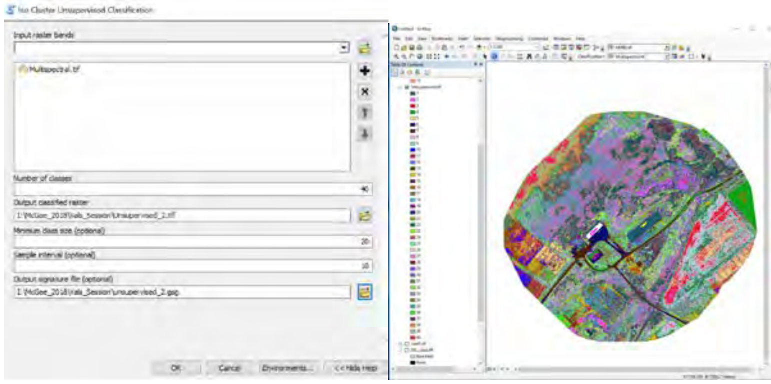
Unsupervised classification.

This technique is very simple for the user to complete, and is used when you don't really know how many classes are in your image. The algorithm will classify pixels based on their statistical characteristics. It is common as a data exploration tool, and <u>I think it is potentially very valuable for UAS applications, particularly for agriculture.</u>



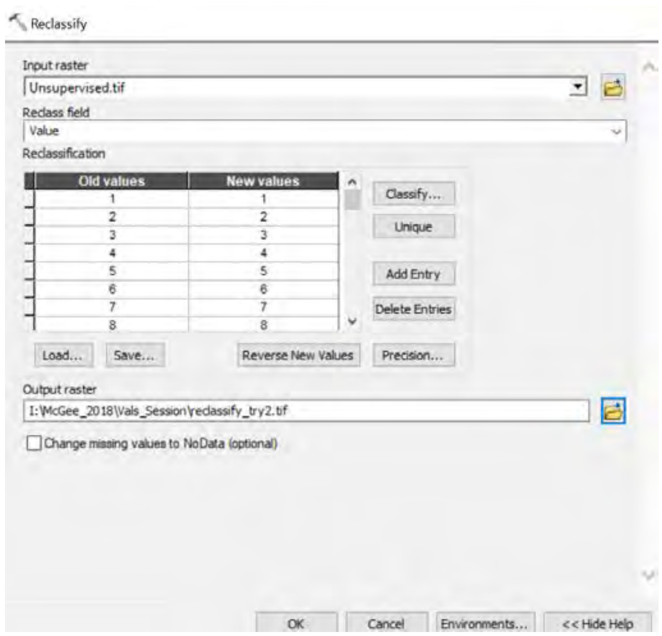
20. Choose Iso Cluster Unsupervised Classification and fill out the template. Then click OK and the classification will run. Note, for the number of classes, a rule of thumb is to start with 10 times the number of bands (in our case 40). This allows you as the user to

combine classes however needed in the output image. KEEP IN MIND: For UAS data, there can be many subclasses. There is a tradeoff between desired subclasses versus work to merge classes in post classification processing.



21. Post-classification merging of clusters and assignment to a land cover class (optional). This requires exploration to determine which of the created spectral clusters belong with your desired land cover themes. One easy way to change the colors to a more logical scheme, and then use the “reclass” option to reclassify according to your new scheme.

22. Once you’ve determined which classes you’d like to merge, you can reclass. This is under spatial analyst tools/reclass/reclassify, and specify your old and new classes. Make sure that the “reclass field” is VALUE.



23. If you wished to, you could convert your reclassified raster to a polygon file, and manually edit the polygons. This, to me, seems like overkill, but might be necessary if very high classification accuracy is required.

Question 7. It is unusual for multispectral imagery from satellites (such as Landsat, etc) to result in 40 classes in an unsupervised classification. What is unique about UAS data that might have caused this result?

____

Question 8. Because there are so many spectral groups, as is evident when examining the unsupervised classification, what sorts of subclasses could you imagine UAS data providing insights to?

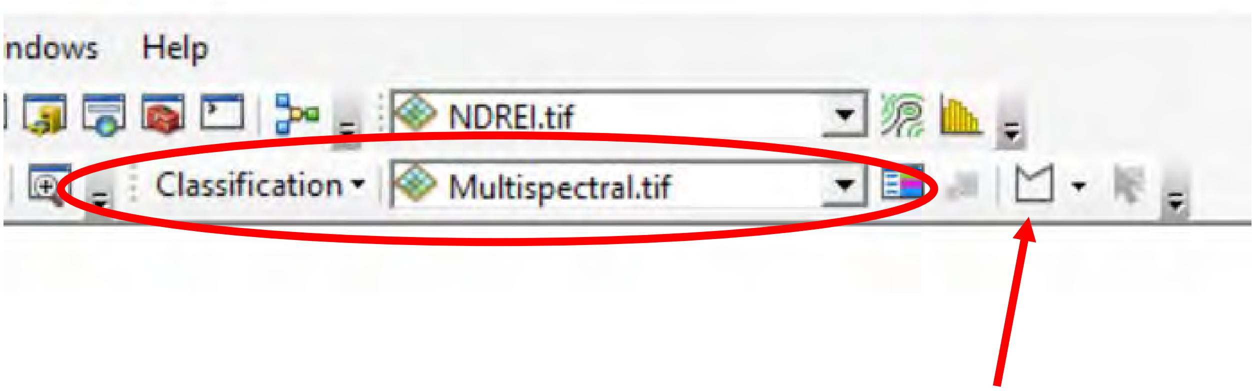
____

Supervised classification.

Supervised classification is when you define known land cover classes and attempt to map them. There are several common steps to supervised classification, regardless of the software package. These include: a) creating training areas, b) generating signature statistics for each class, c) classifying, and d) optionally – validation and accuracy assessment.

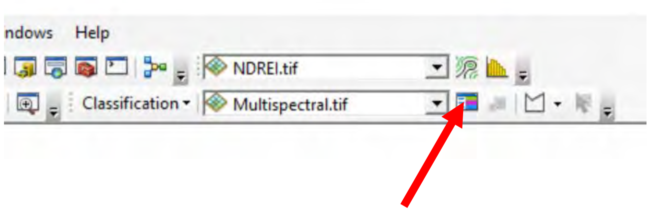
24. Create training areas and explore class statistics.

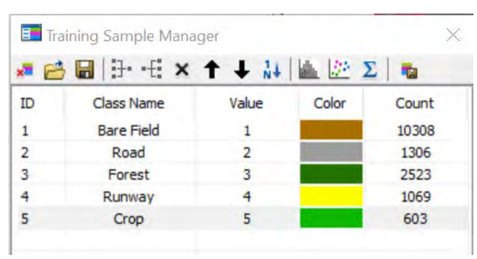
In the classification toolbar, make sure your image composite is listed in the dropdown window, as follows.



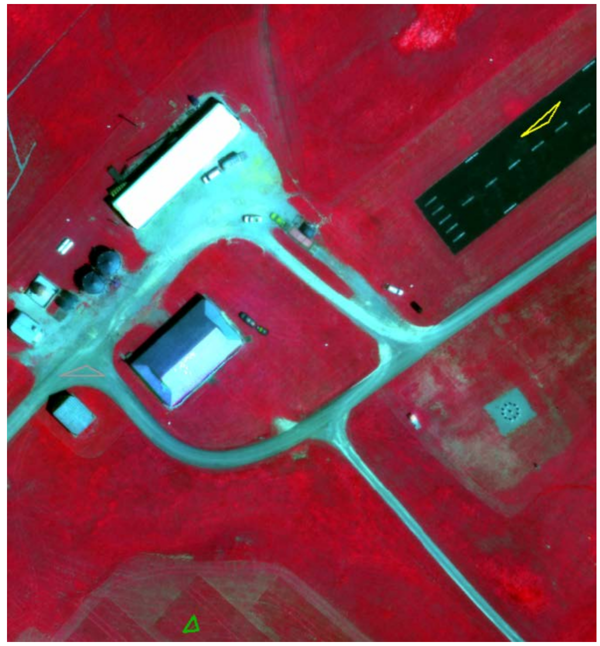
Draw polygons on areas with known land use (click the "draw polygon" button indicated with arrow.

25. Each time you draw a polygon, a new class will form. Open the Training Sample Manager so that you can edit your class name, give it a color, etc.

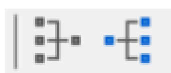




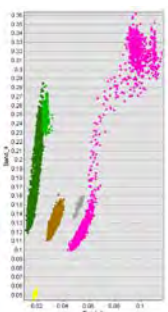
Rules of thumb for training areas:



- Ideally, you want multiple polygons per class, spread across the image. This helps to capture the variance of reflectance within the class.
- Ideally, you should have a similar number of pixels per class. This is not the case in my example (Bare Field has many more pixels) – which might bias the results toward over classification of bare field.
- You can Merge multiple polygons into the same class by clicking the "merge training samples" button. Or you can split a class, if it has more than one polygon, with the tools below:



ArcMap gives you several tools to explore the reflectance statistics for your classes. You can create historgrams or display the classes in scatterplots, that show the reflectance in one band versus another. For example, a graph of NIR versus Green for all classes shows separability, but a difference in class variance.



Training Sample Manager

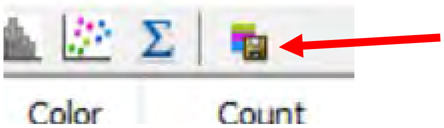
ID	Class Name	Value	Color	Count
1	Bare Field	1		10308
2	Road	2		1306
3	Forest	3		2523
4	Runway	4		1069
5	Crop	5		603
6	Building	6		8848

You can also explore all of the class statistics for each class.

Building

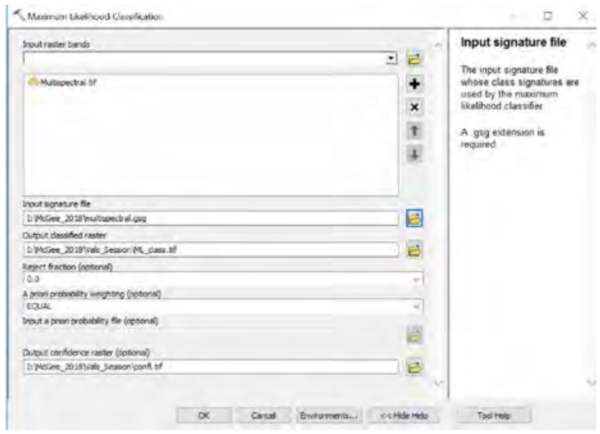
Statistics	Band_1	Band_2	Band_3	Band_4
Minimum	0.04	0.10	0.03	0.10
Maximum	0.12	0.28	0.10	0.36
Mean	0.07	0.17	0.06	0.21
Std.dev	0.02	0.07	0.03	0.10
Covariance				
Band_1	0.00	0.00	0.00	0.00
Band_2	0.00	0.00	0.00	0.01
Band_3	0.00	0.00	0.00	0.00
Band_4	0.00	0.01	0.00	0.01

26. Create signature statistics. Once you are happy with your classes, you can create a signature file that will be used in the classification. Click on the "Create a signature file" and give it a name and location. Note that ArcMap doesn't work that well saving and working on the cloud, so this location may need to be local.



27. You are now ready to classify the image. Under the classification dropdown menu, choose maximum likelihood classification. This is by far the most commonly used classifier in the literature.

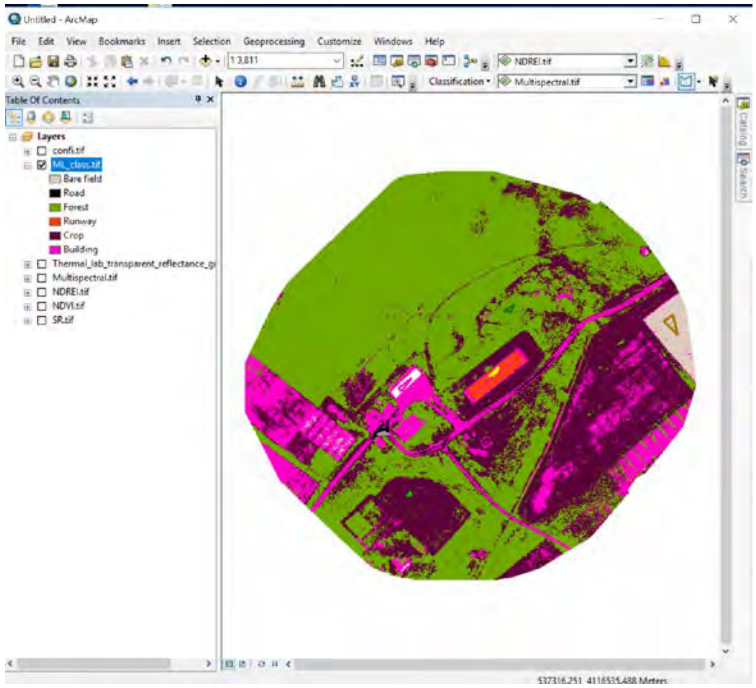
    For your first attempt, you will likely not want to change the default parameters about probability weighting etc, but you could adjust that if you know that one class would be more likely than another.



Once you click run, it will take a few minutes.

28. For some reason, ArcMap does not carry over the class name and color scheme, although the class number is the same. You can change the label and color of the classes in the layer properties.

29. Examine the results and adjust the classification scheme/training area as needed to improve results. In this example, forest and non-tree vegetation are not well separated, and there is a lot of confusion between roads, buildings, and bare fields – I would recommend more training polygons for these classes.



Question 9. Can the high spatial resolution of UAS data provide as much information as higher spectral resolutions that would be available from other systems?

Question 10. What are some limitations with supervised classification from UAS?