GST 105: Introduction to Remote Sensing Lab Series

Lab 5.2: Supervised Classification

Document Version: 2013-09-24 (Beta)

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The development of this document is funded by the Department of Labor (DOL) Trade Adjustment Assistance Community College and Career Training (TAACCCT) Grant No. TC-22525-11-60-A-48; The National Information Security, Geospatial Technologies Consortium (NISGTC) is an entity of Collin College of Texas, Bellevue College of Washington, Bunker Hill Community College of Massachusetts, Del Mar College of Texas, Moraine Valley Community College of Illinois, Rio Salado College of Arizona, and Salt Lake Community College of Utah.

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Introduction

The supervised classification method is another of the two commonly used "traditional" image classification routines. This method (as well as the unsupervised method) is often used with medium (> 20m) and coarse (> 1km) resolution multispectral remotely sensed imagery. More commonly, the unsupervised and supervised classification methods are used together to form a hybrid image classification process to categorize pixels into land cover or land use types.

The primary difference between the unsupervised and the supervised methods is the supervised classification process requires a spectral signature file (sometimes referred to as the "training samples" or "training signatures"). This lab will provide an opportunity for students to learn how to create and evaluate spectral signatures that can be used in a supervised image classification.

Your instructor may require that you provide screen captures, exported files and/or responses to review exercises. The review exercises included throughout the lab can also be found in the Review Exercises section. Please check with your instructor for the requirements specific to your class.

The **Spatial Analyst** Extension must be activated to use the Image Classification toolbar and the other image classification related tools found in the Spatial Analyst toolbox.

Objective: Perform the Primary Tasks of a Supervised Classification

Students will be introduced to the supervised classification method (**Maximum Likelihood Classification**) and the **Image Classification Toolbar**. In addition, students will be introduced to the Training Sample Manager and be able to create and evaluate an individual class as well as an entire group of spectral signatures.

The primary objectives of this lab are:

1. Create and Evaluate Spectral Signatures
2. Perform a Supervised Classification
3. Recode Spectral Classes to Information Classes

Lab Settings

Required Virtual Machines and Applications

Windows Machine User Account	Train
Windows Machine User Password	Train1ng$

The image to be classified, **tm_sacsub.img** is available in the *Lab 5* folder.

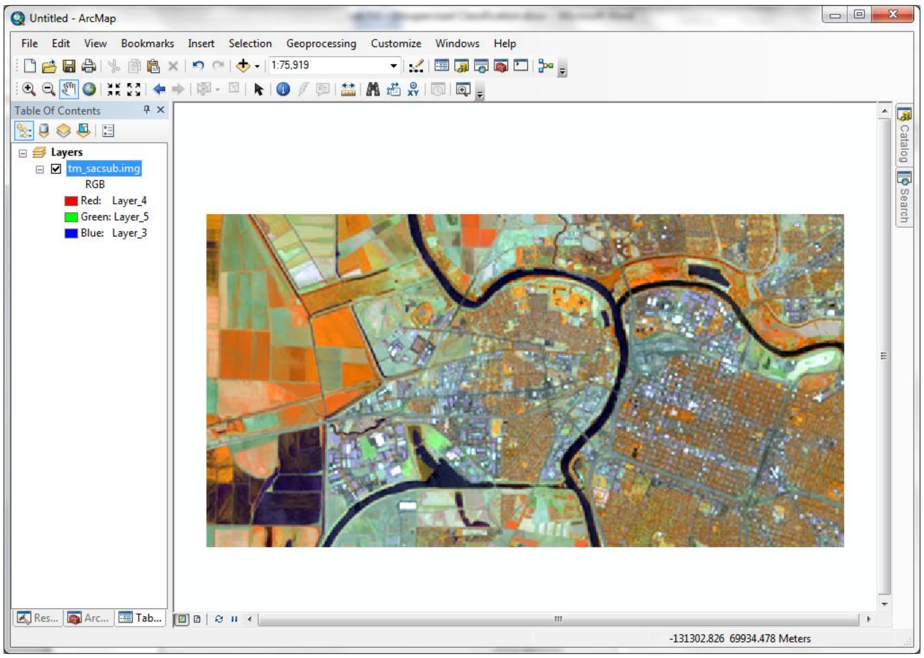
A simple classification scheme will be used for the lab:

1. Water
2. Agriculture
3. Grassland
4. Forest
5. Urban

1 Load the Image to Classify and the Classification Toolbar

1. Log into the computer, using the information provided in the Lab Settings section.
2. Load the **tm_sacsub.img** image into ArcMap. Change the band combination of the R, G, and B color display planes to the values shown in the table below.

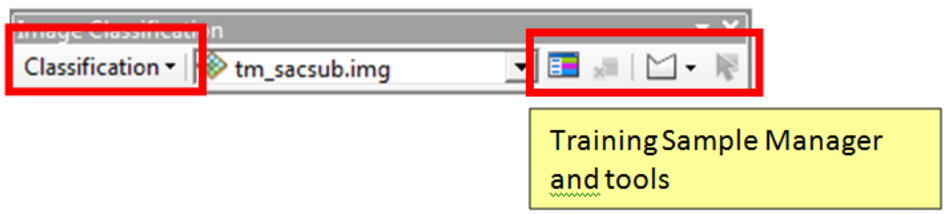
Color Display Plane	Band
Red	Band 4
Green	Band 5
Blue	Band 3



The Image Classification toolbar is used for image classification and creating spectral signatures (Training Sample Manager).

3. Load the **Image Classification** toolbar by right-clicking in the toolbar area and choose **Image Classification**.

The Image Classification Toolbar is shown below.

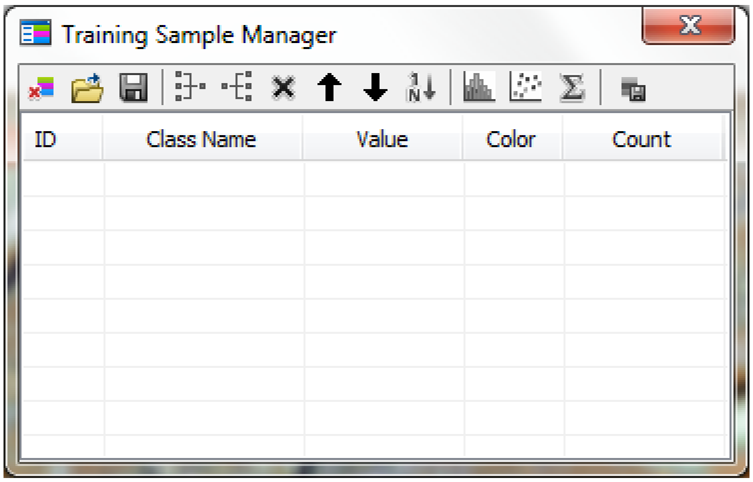


2 Spectral Signatures

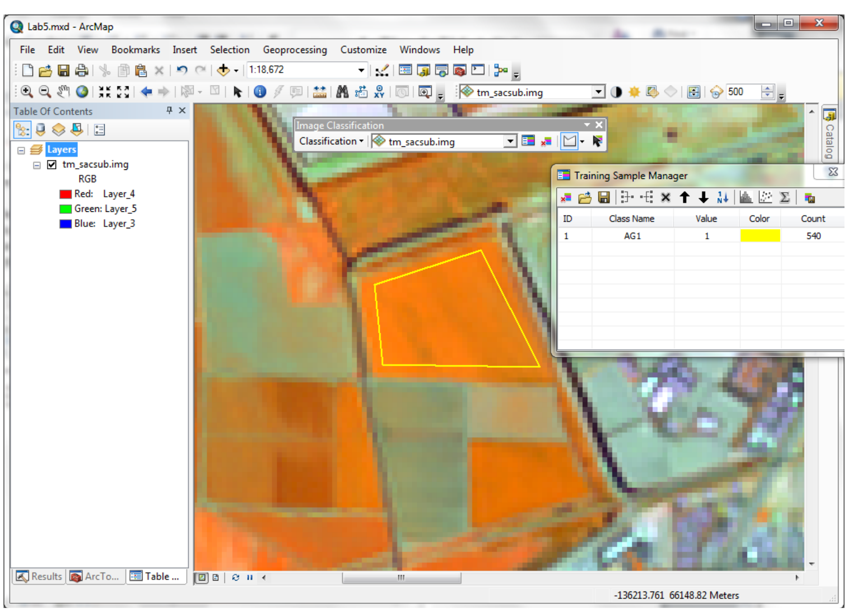
In this section, we will discuss creating and evaluating spectral signatures.

2.1 Create a Spectral Signature

1. Open the **Training Sample Manager** using the tool on the Image Classification toolbar.



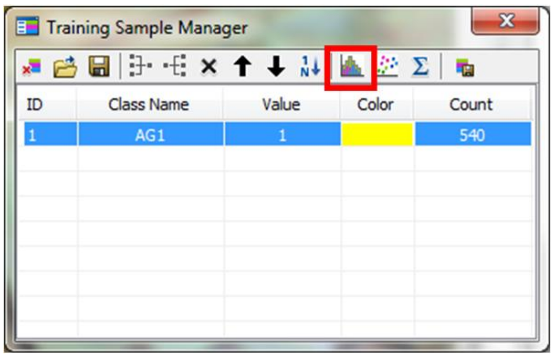
2. Use the polygon tool to create a spectral signature on the image.
    a. Zoom to the field shown below.
    b. Using the polygon tool from the Image Classification toolbar, draw a polygon similar to that shown below.
    c. Change the color in the Training Sample Manager so that the spectral signature can be easily seen.
    d. Name the spectral signature (under Class Name) **AG1**.



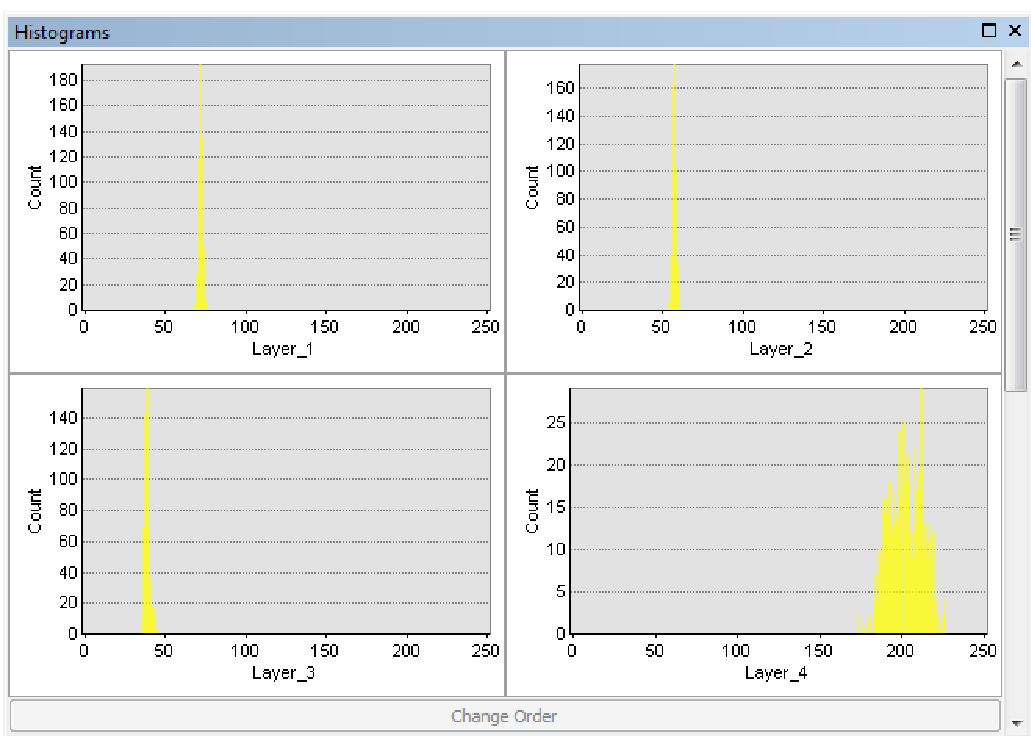
2.2 Evaluate a Spectral Signature

Once the spectral signature is created, it can be evaluated to see if it looks like a high quality signature (that is, one that has a single bell-shaped histogram, and small standard deviations, and variances for each band).

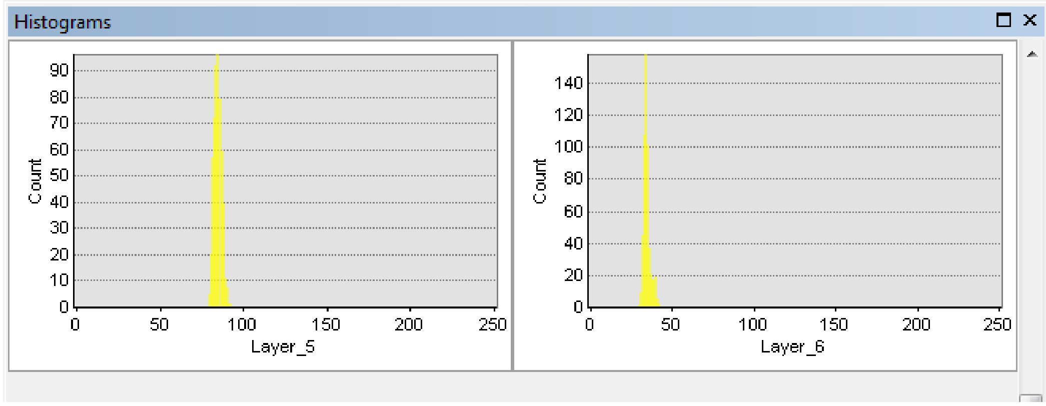
1. Highlight the spectral signature **AG1** and then choose the Histogram tool from the Training Sample Manager to see the histograms for each image band.



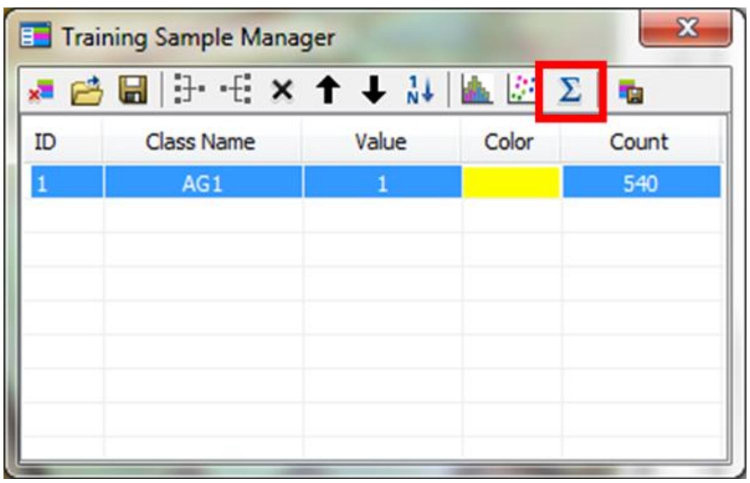
2. The following histograms should appear. You may need to un-dock or move and expand the histogram displays to make them more readable. Shown here are the histograms for the AG1 spectral signature for the first four image bands.



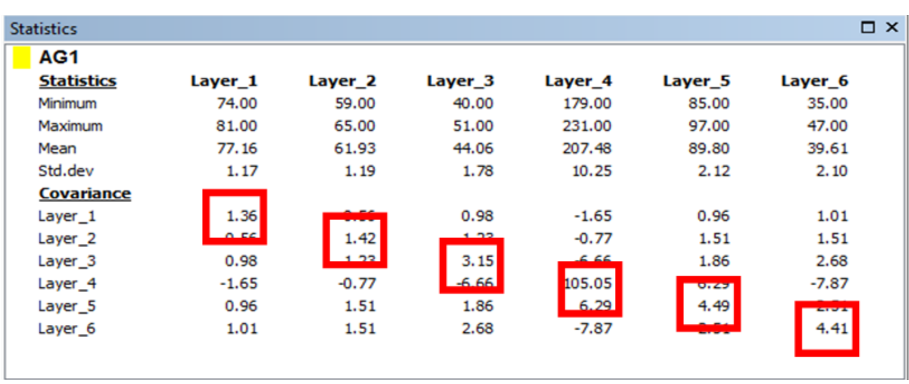
3. Scroll down to see the other two bands (bands 5 and 6).



4. In addition, the Signature Statistics can be viewed by selecting the Signature Statistics tool.



5. A table appears that shows the spectral statistics for all of the image bands (again, you may need to undock or expand the window to see all the values). Remember, the covariance matrix shows both the variance (the diagonal values outlined in red below) for a specific image band as well as how the spectral signature varies between different image bands (off-diagonal values). Your values may vary slightly due to differences in the shape of your polygon.

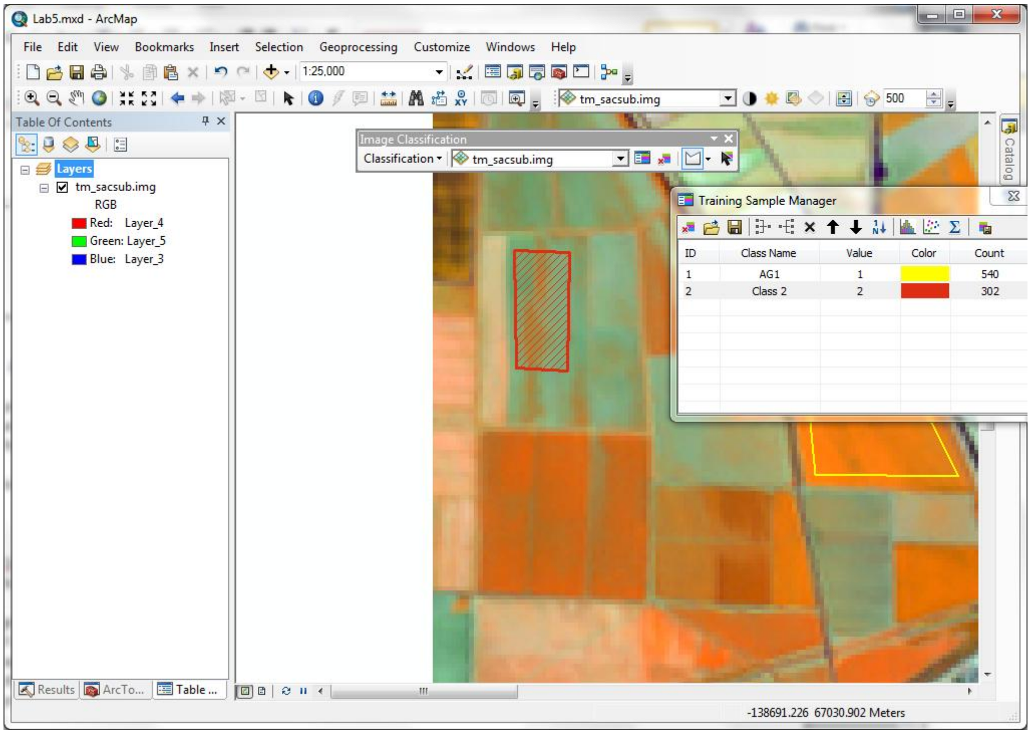


Statistics

AG1

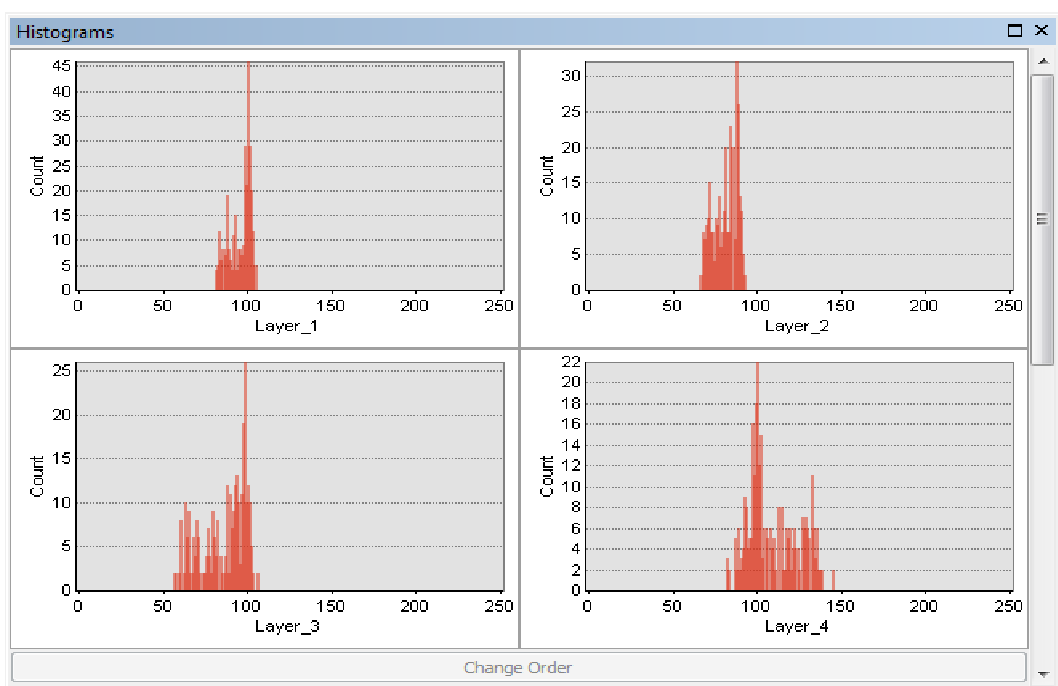
Statistics	**Layer_1**	**Layer_2**	**Layer_3**	**Layer_4**	**Layer_5**	**Layer_6**
Minimum	74.00	59.00	40.00	179.00	85.00	35.00
Maximum	81.00	65.00	51.00	231.00	97.00	47.00
Mean	77.16	61.93	44.06	207.48	89.80	39.61
Std.dev	1.17	1.19	1.78	10.25	2.12	2.10
Covariance						
Layer_1	1.36	[illegible]	0.98	-1.65	0.96	1.01
Layer_2	[illegible]	1.42	[illegible]	-0.77	1.51	1.51
Layer_3	0.98	[illegible]	3.15	[illegible]	1.86	2.68
Layer_4	-1.65	-0.77	-6.66	105.05	[illegible]	-7.87
Layer_5	0.96	1.51	1.86	6.29	4.49	[illegible]
Layer_6	1.01	1.51	2.68	-7.87	[illegible]	4.41

Shown below is an example of a “poorly chosen” spectral signature.

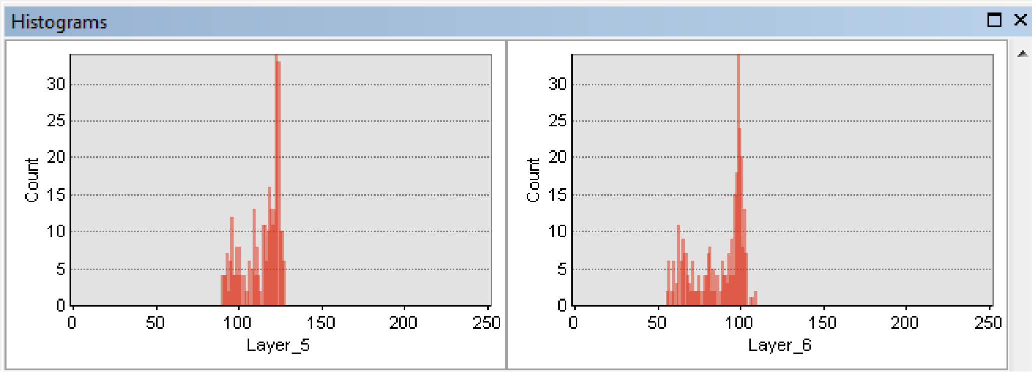


The signature above was chosen nearby the first sample and could represent a single field that has been recently planted. Note that the crop is growing differently through the extent of the field.

Taking a look at the histogram the following is observed.



And for bands 5 and 6.



Note that the histograms do not appear to have a small spectral range and in some bands (especially the IR bands), the histogram has a bimodal distribution (has two groups of relatively taller spikes).

Looking at the spectral statistics, the following is observed.

Statistics

Class 2

Statistics	**Layer_1**	**Layer_2**	**Layer_3**	**Layer_4**	**Layer_5**	**Layer_6**
Minimum	87.00	72.00	62.00	88.00	95.00	61.00
Maximum	110.00	98.00	111.00	150.00	132.00	114.00
Mean	101.13	86.64	91.27	114.64	118.57	92.82
Std.dev	6.47	7.05	13.31	14.95	11.02	14.71
Covariance						
Layer_1	41.89	[illegible]	84.11	-87.72	69.41	93.04
Layer_2	[illegible]	49.66	[illegible]	-86.96	75.59	98.64
Layer_3	84.11	[illegible]	177.06	[illegible]	144.38	191.00
Layer_4	-87.72	-86.96	[illegible]	223.63	[illegible]	-205.61
Layer_5	69.41	75.59	144.38	[illegible]	121.33	[illegible]
Layer_6	93.04	98.64	191.00	-205.61	[illegible]	216.52

This spectral signature has standard deviations and variances that are much larger for each band than the previous spectral signature. Both of these pieces of information support that this signature may be comprised of more than one cover type. In this case, the non-uniform growth of the recently planted field is influencing the spectral response that makes up the spectral signature. In this case, the analyst would want to choose a more homogenous area that would better represent this cover type.

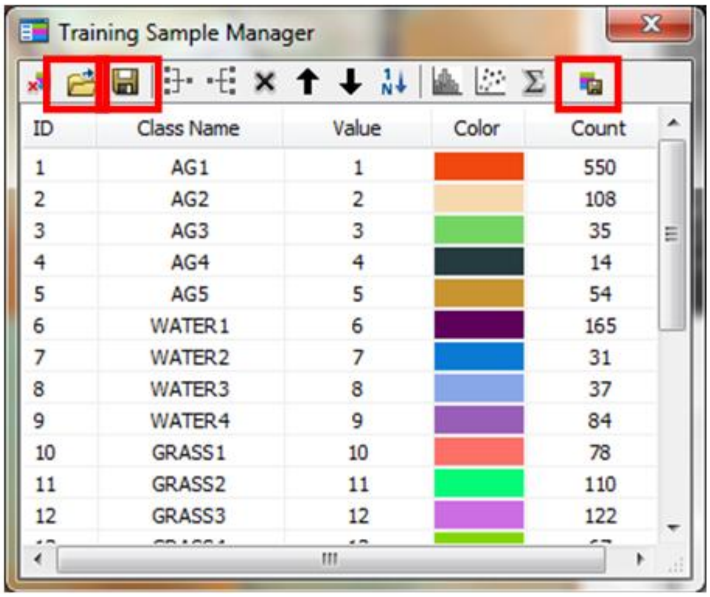
Exercise A: *Describe the characteristics that define a "high quality" spectral signature.*

2.3 Add Additional Spectral Signatures

Additional spectral signatures can be added and evaluated using the same processes described in the previous sections.

1. Practice by creating at least 5 more spectral signatures (see section 2.1).
2. Evaluate to determine if the histograms and spectral statistics seem reasonable for representing a "high quality" spectral signature (see section 2.2).

Once a full set of spectral signatures has been created and evaluated, they can be saved as a "signature file" by using the **Create Signature File** tool.



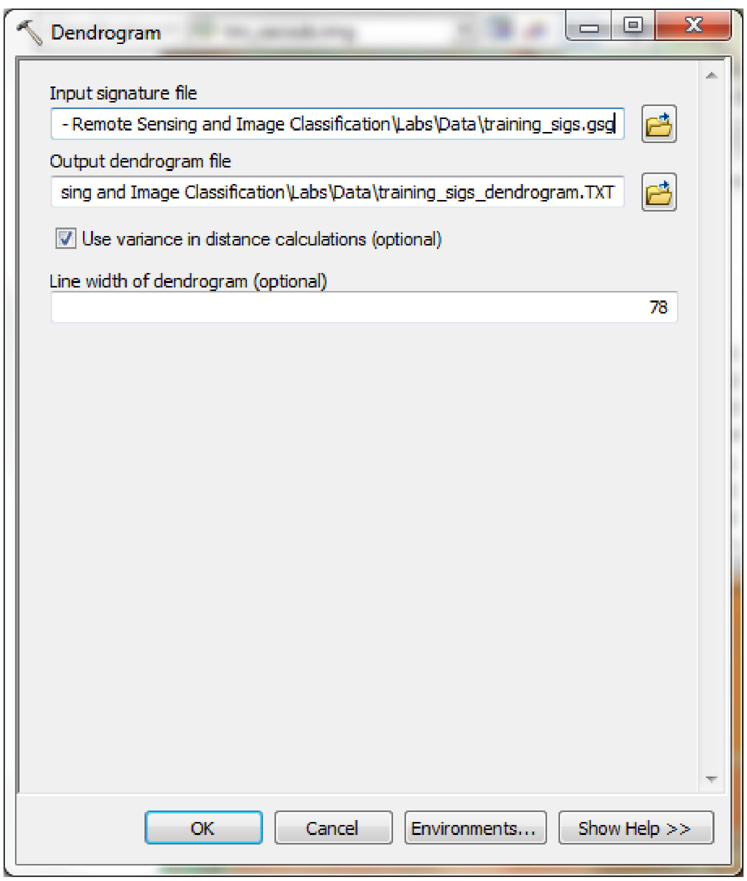
In addition, the spectral signature file can be exported to a shapefile or geodatabase feature by selecting the **Save** button. A feature class that has been saved from within the Training Sample Manager can be imported into the Training Sample Manager by choosing the **Load Training Samples** tool (the Open Folder button).

2.4 Evaluate a Full Spectral Signature Set

Once all spectral signatures have been created and individually evaluated, an entire set of spectral signatures can be evaluated by using the dendrogram tool.

A full set of spectral signatures (a signature file) has been provided that can be used to run the dendrogram routine.

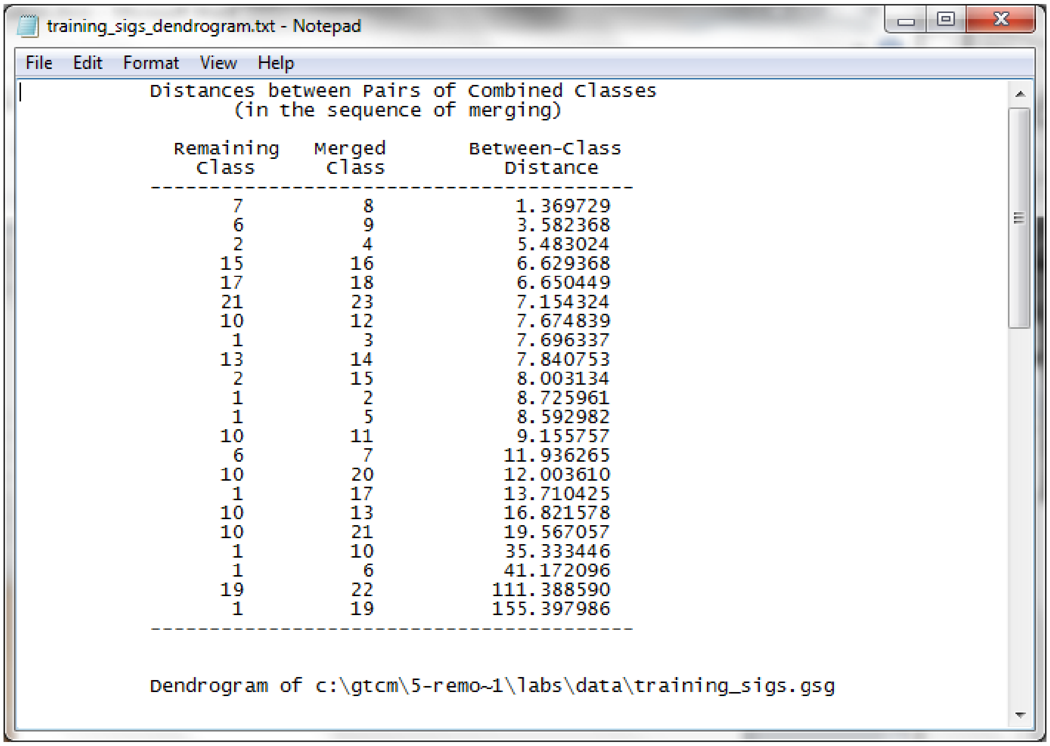
1. Import the **Lab 5\Spectral_Sigs_Training.shp** file into the Training Sample Manager.
2. Open the **Dendrogram** Tool from the **Spatial Analyst toolbox >Multivariate Toolset ->Dendrogram**.
3. Use the **Lab 5\trainings_sigs.gsg** file as the Input signature file.
4. Save the dendrogram to an output text file that is placed in *the* ***Lab 5*** folder.
5. The remaining fields should be left at their default values.
6. Click **OK**.



7. The dendrogram routine takes just a few seconds to run. After it completes, find the text file you just created and open it in Notepad.

The first part of the dendrogram output is a listing of the spectral classes that note the similarity distance between spectral class pairs. Small numbers represent spectral signatures that are more similar. Larger values indicate less similarity.

The dendrogram uses the class numbers vs. the spectral class names provided in the Training Sample Manager. The analyst may need to load the spectral signature feature class or refer to the Training Sample Manager that contains the spectral signatures used to create the signature file that is used in the dendrogram routine.


training_sigs_dendrogram.txt - Notepad

File Edit Format View Help

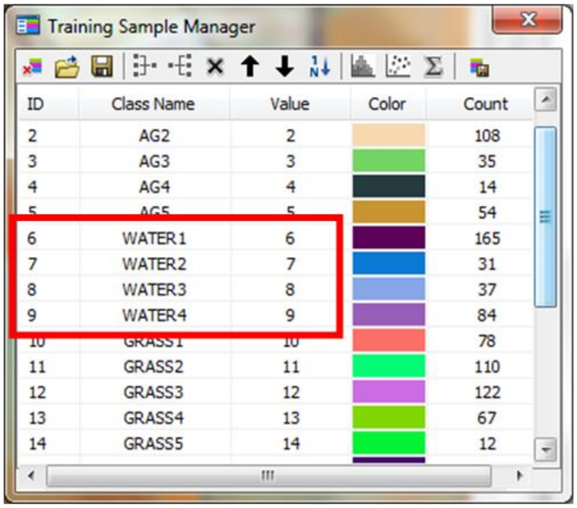
Distances between Pairs of Combined Classes
(in the sequence of merging)

Remaining Class	Merged Class	Between-Class Distance
7	8	1.369729
6	9	3.582368
2	4	5.483024
15	16	6.629368
17	18	6.650449
21	23	7.154324
10	12	7.674839
1	3	7.696337
13	14	7.840753
2	15	8.003134
1	2	8.725961
1	5	8.592982
10	11	9.155757
6	7	11.936265
10	20	12.003610
1	17	13.710425
10	13	16.821578
10	21	19.567057
1	10	35.333446
1	6	41.172096
19	22	111.388590
1	19	155.397986

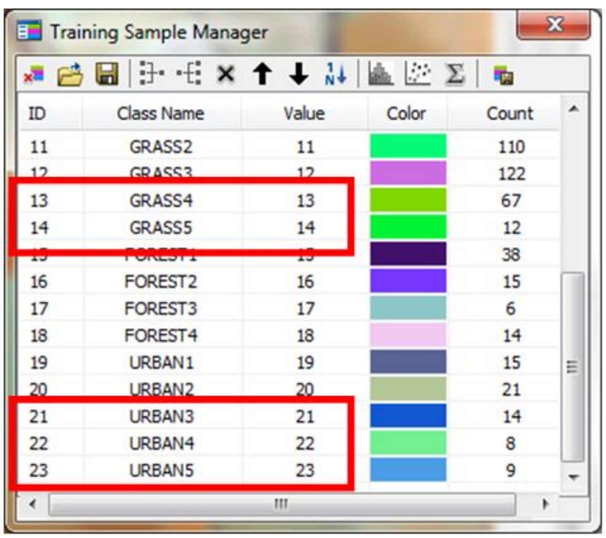
Dendrogram of c:\gtcm\5-remo~1\labs\data\training_sigs.gsg

The next part of the text file shows the dendrogram schematic that indicates graphically how similar spectral pairs are from one another. Those that have a short set of segments connecting the pair, the more similar the spectral pair is to one another. Those pairs with a longer set of connected segments indicate less similarity between pairs. The dendrogram also shows connectivity between groups of spectral signatures.

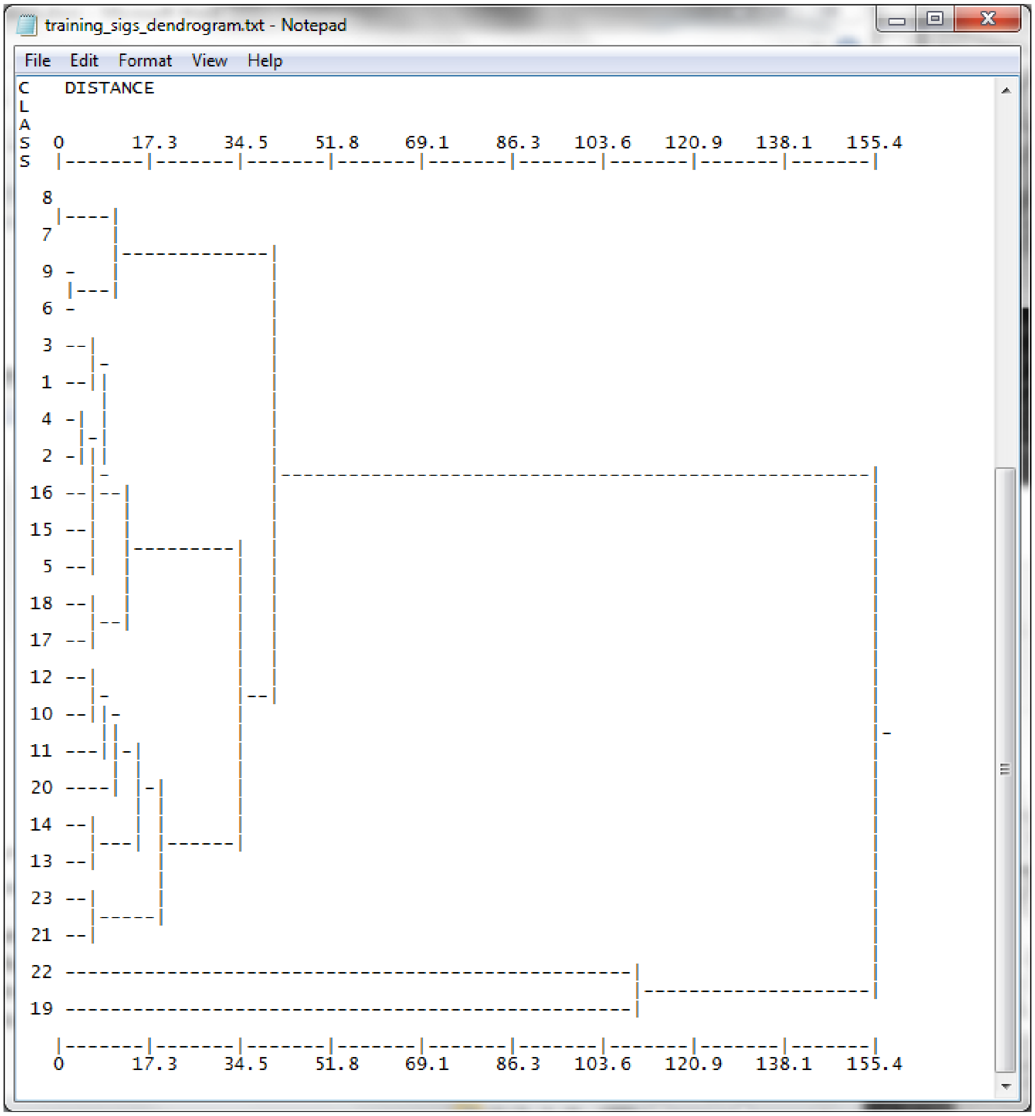
Spectral classes 6, 7, 8, and 9 (all spectral signatures representing water) shown below represent signatures that have very similar spectral characteristics. Refer to the **Spectral_Sigs_Training.shp** (above) in the Training Sample Manager.



Spectral classes 14, 13, 23, and 21 are less similar, but still seem related. Signatures 13 and 14 are grass, whereas, signatures 21 and 23 are urban. Based on the dendrogram, there may be some confusion between grass and urban signatures.



Spectral classes 22 and 19 are related, but probably have a loose spectral similarity. These two signatures also appear to be much different from the other spectral signatures in the entire set.



The dendrogram can be a helpful tool to evaluate an entire set of spectral signatures. Typically, in a real-world image processing project, over a hundred or more spectral signatures are created. The dendrogram provides a useful method for an analyst to quickly review and identify where potential confusion may occur between spectral signatures. The analyst can decide to review the individual spectral signatures or take new signatures, delete signatures, or merge signatures using the Training Sample Manager. After revising the spectral signature set, the dendrogram routine can be run again.

In some cases, spectral confusion may occur no matter how much effort is spent refining the spectral signatures. This is OK, it just means that some land cover types may have very similar spectral characteristics and the number of bands the sensor has does not have enough spectral information to distinguish the land cover types. This confusion may matriculate through the image classification process and show up as mis-classified areas on the final land cover classification. If all efforts have been made to create a set of high quality spectral signatures, then the confusion will need to be explained in a written report and will likely be noted in an accuracy assessment error matrix.

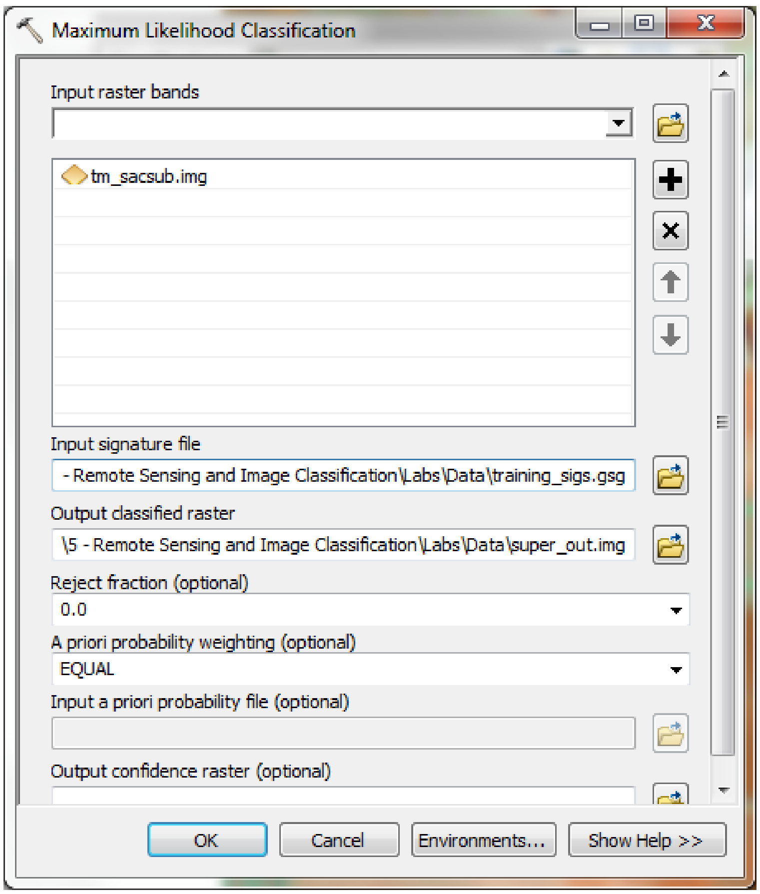
Exercise B: *What is the primary purpose of using a dendrogram routine to evaluate a spectral signature set?*

Exercise C: *Why is it important in a supervised classification process to have a full set of high-quality spectral signatures?*

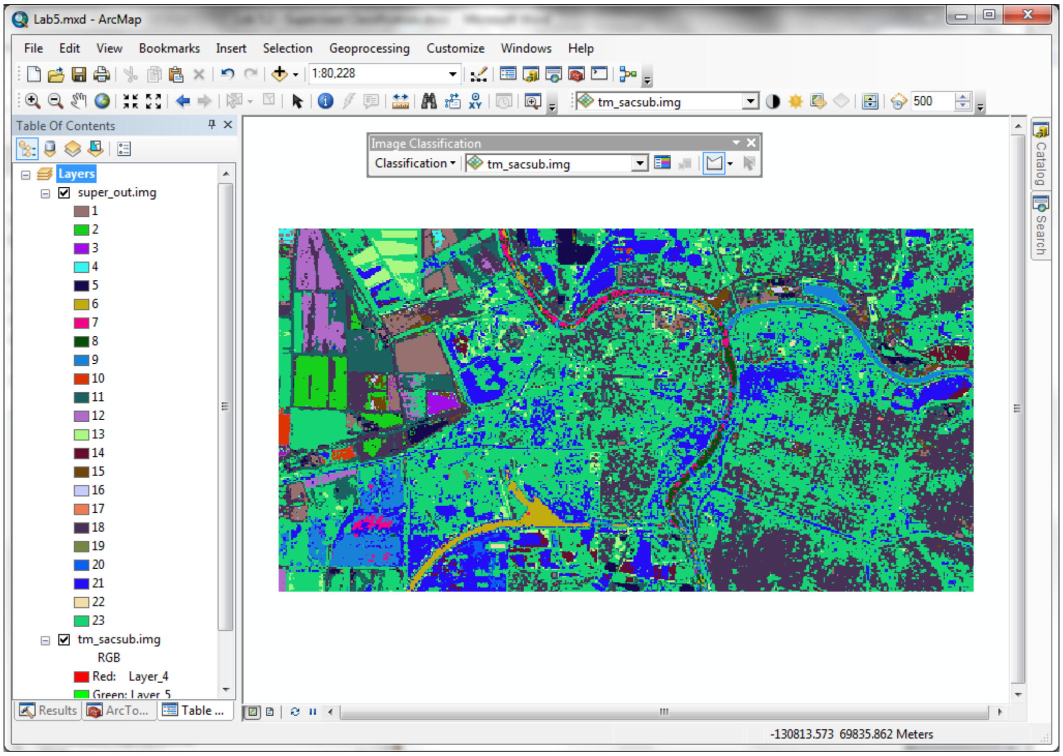
3 Perform a Supervised Classification

After a spectral signature file has been created and evaluated, the next step is to use the spectral signature file in a supervised classification. The **Maximum Likelihood Classification** option can be used from the Image Classification toolbar dropdown.

1. Use the **tm_sacsub.img** file as the input raster.
2. The signature file (**training_sigs.gsg**) has been provided for use as the Input signature file for this task.
3. Provide an output image file (for example **super_out.img**). Save the file in the *Lab 5* folder.
4. The rest of the fields should remain at their default values.
5. Click **OK**.



After a few seconds, the supervised classification output will appear in the Table of Contents. The output image will contain the colors that were used in the training sample or random colors will be assigned. The output will look similar to the image below.



The colors do not provide any real meaning at this point and remember that each color represents a specific spectral signature. The output classification represents spectral classes. (For example, all of the output classes 1 through 5 represent the agricultural land cover type). See the spectral signatures in the Training Sample Manager if needed.

The Symbology tab could be used to change the colors for all of the same type of land cover type. However, a more appropriate method is to recode the spectral classes to information classes. This will be done in the next task.

4 Reclassify Spectral Classes to Information Classes

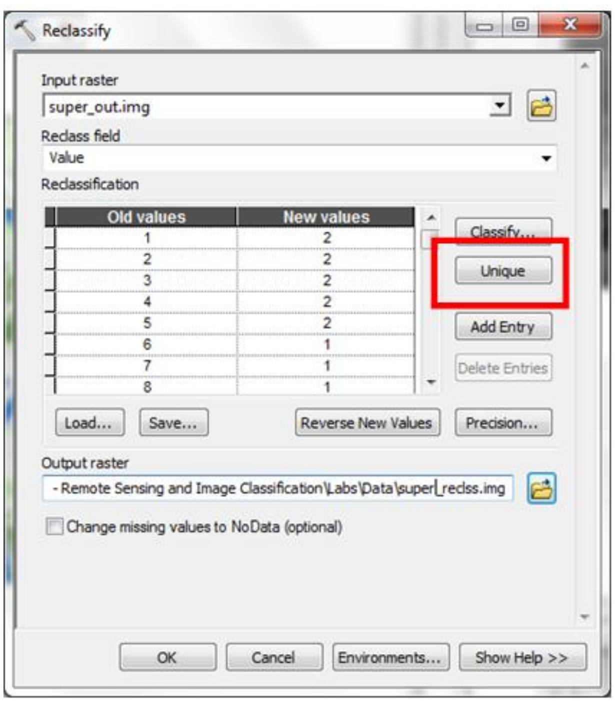
The final step in an image classification (and before an accuracy assessment is conducted) is to reclassify the spectral classes that represent the same land cover type to information classes (a single class for each unique land cover type).

The Reclassify tool requires use of the image that contains the spectral classes (i.e. the output from the supervised classification). Recoding the spectral classes to information classes can be accomplished by using the **Reclassify** routine in the **Spatial Analyst toolbox -> Reclass toolset**.

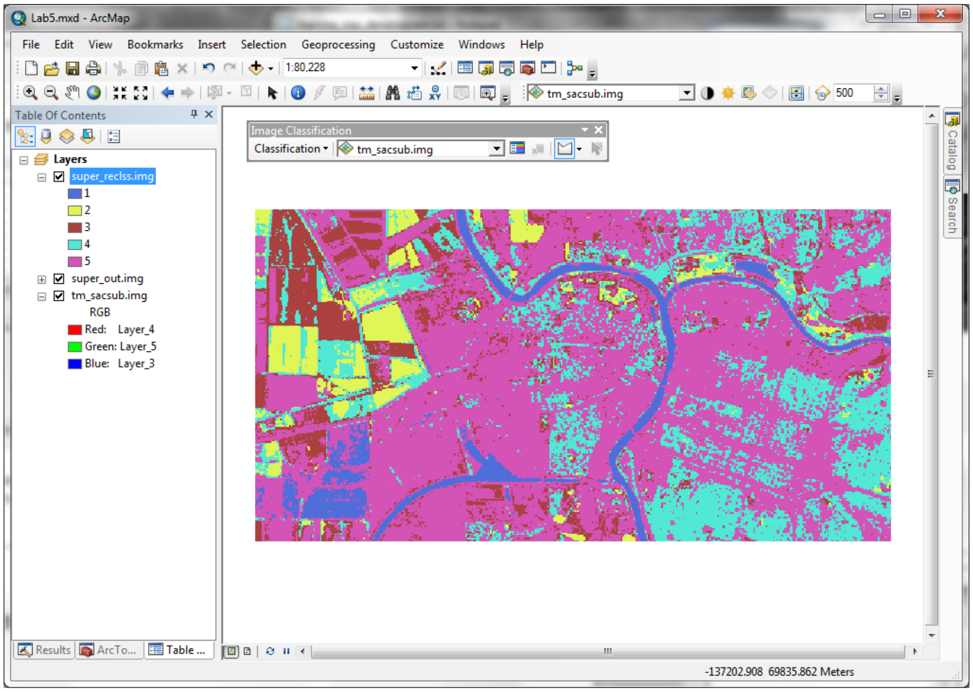
The following table contains values to reclassify existing spectral classes to information classes.

Spectral Class Number	Information Class Number	Description
1-5	2	Agriculture
6-9	1	Water
10-14	3	Grass
15-18	4	Forest
19-23	5	Urban

1. Use the recoding scheme above to fill in individual values for the **New Values**.
2. Make sure to select the **Unique** button to enter the values.

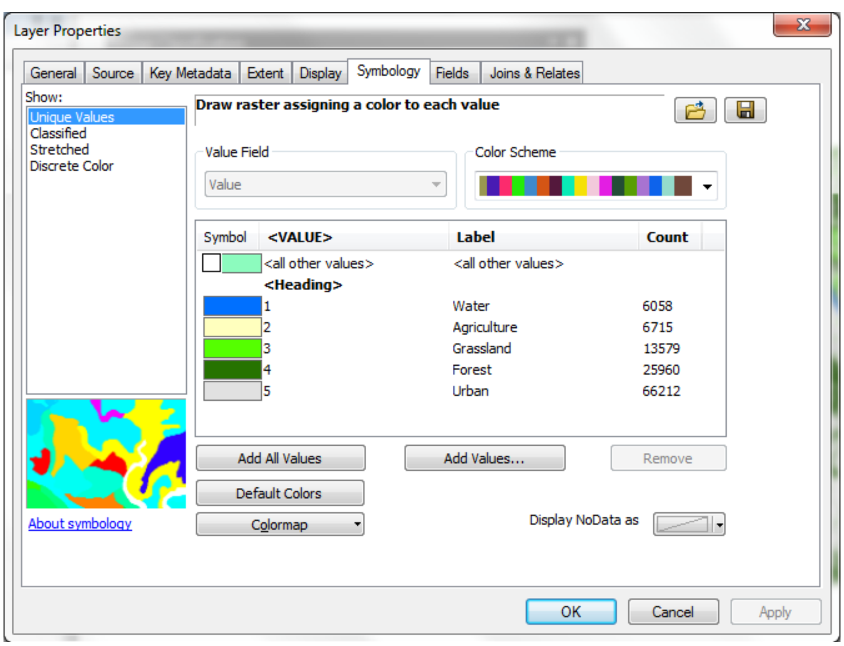


Once the reclassified output is completed, the output will have only five unique values (vs. the 23 individual spectral classes from above).

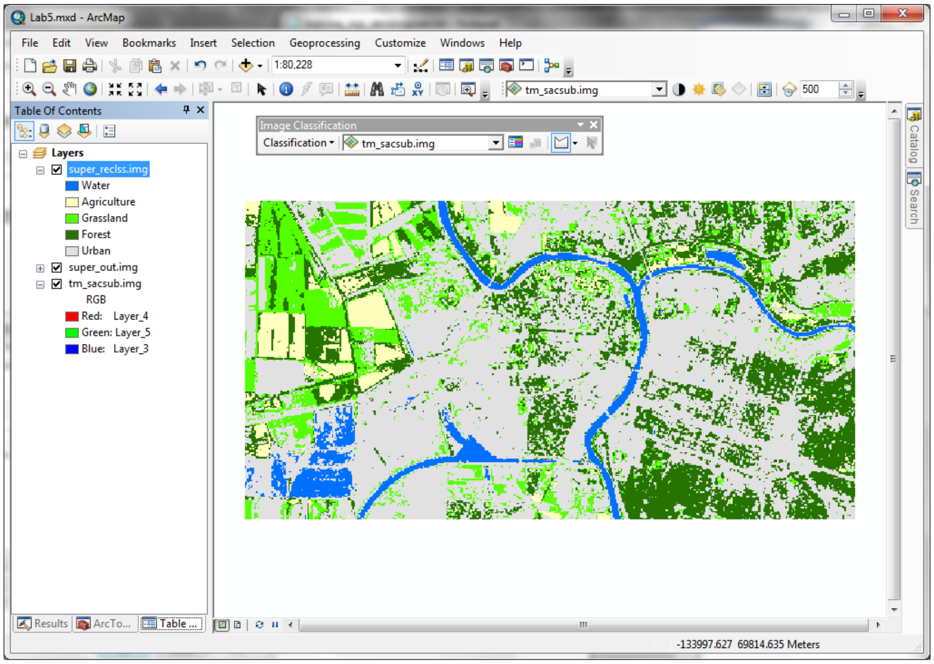


The colors do not make much sense, since they are randomly assigned. Since each value represents one of the unique land cover types in the classification scheme, the colors (as well as the names can be changed in the Symbology tab. In addition, the user can add an attribute field for the “Class_Name” and put in the specific class names, if desired. This is not required, but is often added as part of the final classified image dataset.

3. Make the color changes and label the classes as shown in the image below.



The reclassified image will look similar to this.



The supervised classification is now complete and ready for accuracy assessment (see the next lab for details).

Exercise D: *What is the purpose of performing a recode or reclassification routine?*

Conclusion

This lab has introduced the primary steps to perform a supervised classification:

1. Creating and evaluating spectral signatures.
2. Using the supervised classification method with the spectral signature file.
3. Using the reclassify routine to convert spectral classes to information classes.

Students should now have a good understanding of these steps and processes required to create a categorized image based on the supervised classification method.

Review Exercises

The review exercises included throughout the lab are listed in this section. You may click the name of each exercise to link to the exercise's location within the lab.

Exercise A: *Describe the characteristics that define a "high quality" spectral signature.*

Exercise B: *What is the primary purpose of using a dendrogram routine to evaluate a spectral signature set?*

Exercise C: *Why is it important in a supervised classification process to have a full set of high-quality spectral signatures?*

Exercise D: *What is the purpose of performing a recode or reclassification routine?*