Impervious Surface Feature Extraction – 10.3

PURPOSE

This demo will show how to extract impervious surface features from multispectral imagery and then compute the total square footage of impervious feature per parcel. Many local government institutions use impervious surfaces to calculate the storm water bill for a property. The demo will showcase object-oriented feature extraction tools now available at ArcGIS for Desktop 10.3 and ArcGIS Pro. The demo involves dynamic on-the-fly image processing using raster functions. These image functions are a preliminary step to refine the optimum parameters in extracting the features of interest. Once the settings and parameters are optimized, geoprocessing will be used to process the results to disk.

Impervious surfaces are considered to have the following characteristics:

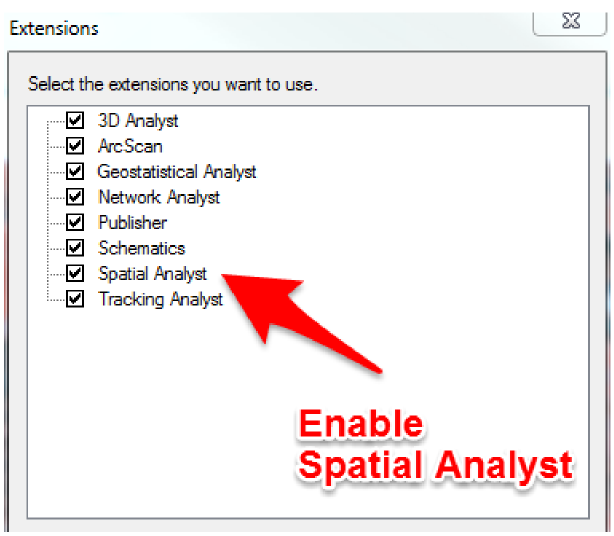
- Constructed surfaces such as buildings, roads, parking lots, brick, asphalt, and concrete.
- Areas of man-made compacted soil or material such as mining or unpaved parking lots (no vegetation present) can be considered impervious

Non-impervious surfaces can be defined as:

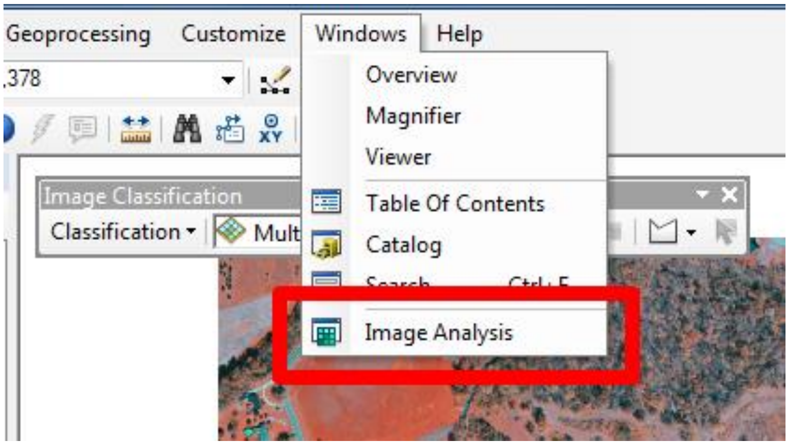
- All vegetated areas, natural and man-made
- Water bodies and wetland area
- Ski runs
- Natural occurring barren areas (i.e. rocky shores, sand, bare soil)

DEMO SETUP

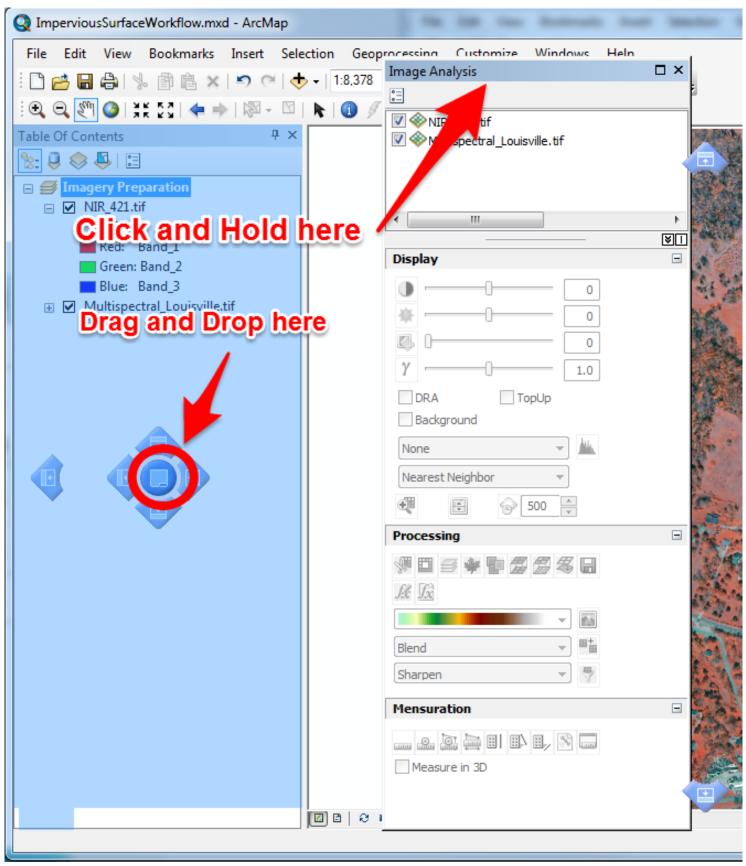
1. Make sure you enable the Spatial Analyst extension first. To enable the extension from the ArcMap toolbar select Tools > Extensions … and check on the Spatial Analyst extension.



2. Turn on the Image Classification toolbar from the ArcMap menu. Select Customize > Toolbars > and check **Image Classification**
3. Launch the Image Analysis Window (IAW) from the ArcMap menu. Select Windows > Image Analysis



4. Dock the IAW next to the Table of Contents



5. Launch the Search window from the Geoprocessing menu. Select Geoprocessing > Search for Tools
6. Doc it on the right side of ArcMap next to the catalog window

DEMO SCRIPT

Hello. In this demo I'll will show you how to extract impervious surface features from multispectral imagery and then compute the total square footage of impervious feature per parcel. Many local government institutions use impervious surfaces to calculate the storm water bill for a property. We'll be using an object-oriented feature extraction method to accomplish this.

Impervious surfaces are considered to have the following characteristics:

- Constructed surfaces such as buildings, roads, parking lots, brick, asphalt, and concrete.
- Areas of man-made compacted soil or material such as mining or unpaved parking lots (no vegetation present) can be considered impervious

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- Water bodies and wetland area
- Ski runs
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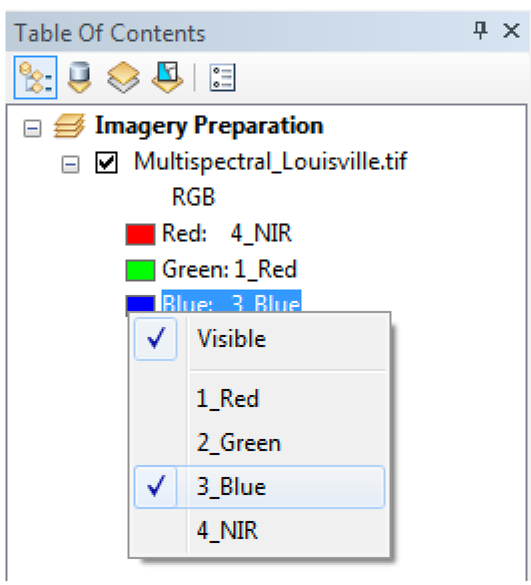
This is a multispectral image just outside of Louisville Kentucky provided by the Louisville/Jefferson County Information Consortium (LOJIC). This is ideal for performing detailed feature extraction of impervious surfaces. It's a 6-inch resolution aerial photograph from XXXXXX and contains a NIR band

- Zoom into the scene by using a bookmark. From the ArcMap menu, select Bookmarks > Subdivision
- Change the band combination of the image to see it as false color by clicking the band color box and selecting the desired combination. Choose the following band combination:
  - Red = 4_NIR
  - Green = 1_Red
  - Blue = 3_Blue



- Zoom in and out to explore the scene

It is important to choose a band combination to visually discriminate your features of interest. For impervious features this combination is a good choice to start with.

IR – to detect, extract and eliminate vegetation
Red – important for discriminating bare soil
Blue – important for discriminating urban features, especially concrete

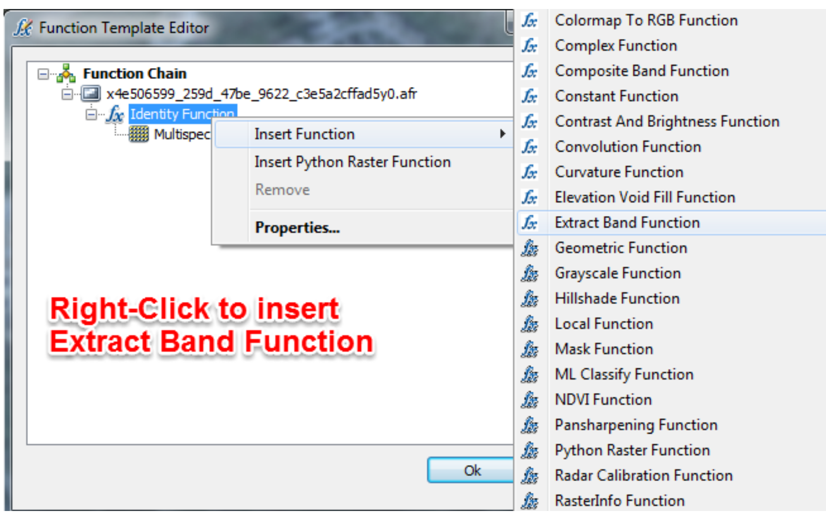
Other useful band combination – Blue, Green, NDVI (or SAVI)

- When you're done exploring the image in false color, change it back to true color RGB (1-Red, 2-Green, 3-Blue. Now you'll create the false color products using a raster function.

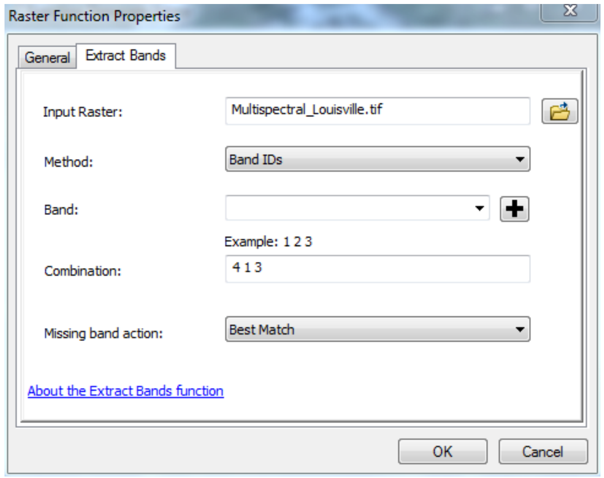
Step 1 – Prepare the imagery for classification

The segmentation raster functions require a 3-band 8-bit image for the input. To create a 3-band false color product I'll apply a raster function to our multispectral image. We can apply raster functions from the Image Analysis Window (IAW) by selecting the image or raster, then clicking the Add Function button to enable the Function Template Editor.

- Enable the IAW and select **Multispectral_Louisville.tif.**
- With the image selected, click the Add Function tool under the Processing pane
- In the Function Template Editor dialog, right-click the node that says Identity Function > Insert Function > **Extract Band Function**



- In the Raster Function Properties dialog box type **4 1 3** with a space between the numbers in the Combination box so it looks like the screenshot below (Same band combination we used earlier).



- In the General tab, make sure 8-bit unsigned is selected as the Output Pixel Type
- Click OK, then OK again to apply the process.

We now have a 3-band product displayed in our map that we'll use as input into the analysis. (Optionally compare to the Multispectral_Louisville.tif using the swipe tool in the IAW)

- Rename the new image in the table of contents by double-clicking the layer in the TOC to open the Layer Properties > General tab. Type **NIR_413** in the Layer Name box

Step 2 – Segment the image

Now that we have a 3-band image we can begin the segmentation step. Segmentation is the process where pixels in close proximity and having similar spectral characteristics are grouped together into a segment. Segments exhibiting certain shapes, spectral, and spatial characteristics can be further grouped into objects. During this classification process, we're classifying the segments not pixels.

We'll use both raster functions and geoprocessing tools in this workflow. Raster functions are used to assess and preview the results. When we're satisfied we'll use geoprocessing to save the results to disk.

Running this function is highly CPU intensive. It's recommended to zoom to the raster resolution before applying the function.

- Using the Bookmarks menu zoom to **Detailed Homes**
- Go back into the IAW, select NIR_413, right-click > Properties > Function tab to open the Function Template Editor
- Right-click the Extract Band Function > Insert Function > Segment Mean Shift Function. Enter the following parameters:

Spectral Detail = 12
For spectral detail, a higher value equates to more segments. For our scene, 12 captures roofs into a few class and merges subtle changes where shadows exist from roof pitch

Spatial Detail = 2
Smaller values create spatially smoother outputs. For our scene a lower value helps distinguish features such as roof from driveway or driveway from road segments.

Min Segment Size in Pixel = 10
Set this value higher for higher resolution data (e.g., 1 foot or 6 inch). For our scene, a value of 10 merges changes from features like chimneys on the roofs into one segment.

Segment boundaries only = 0
0 creates objects while a value of 1 displays the segments as contours

- Click OK, then OK again to apply and dismiss the dialogs. (Record the parameters above. You'll use them later in this exercise)

Be patient as the process computes.

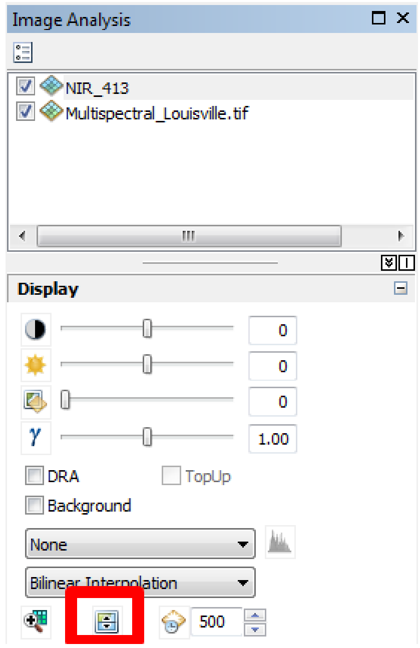
Optional Exercise:
Because we're focused on buildings and pavement surfaces, the combination above works best. If our goal was to capture the differences in vegetation species, we might add more segments and more detail.

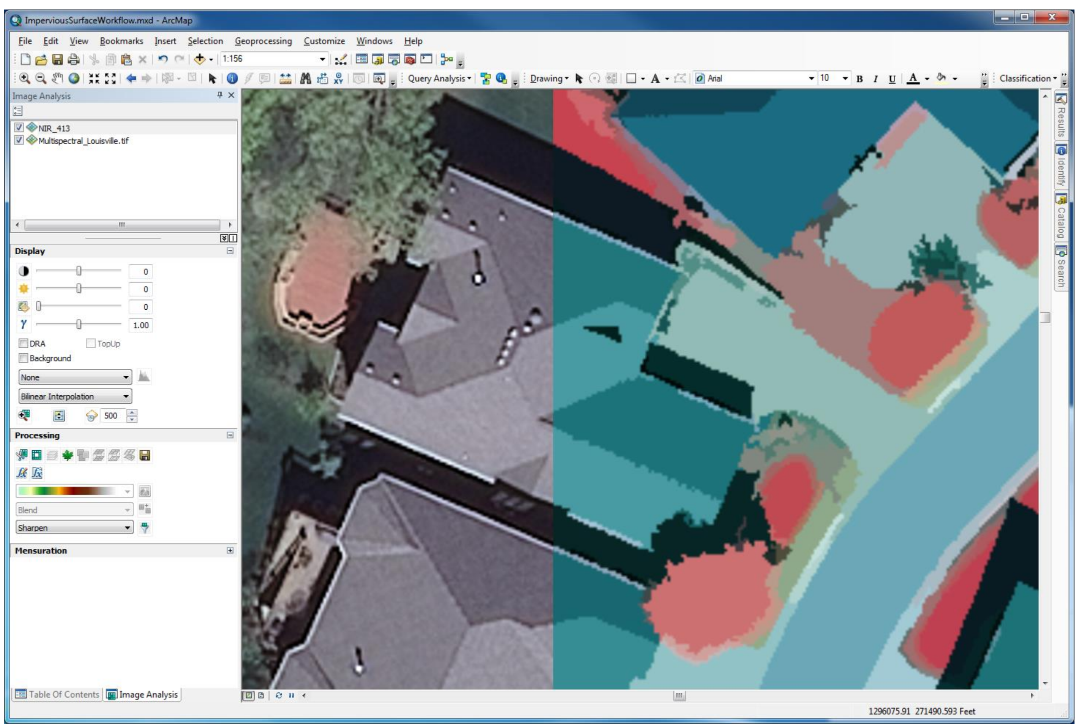
- Go back and experiment with different parameters to see how the values entered change the segments (Try 15, 3, 18, 0 respectively)
- Return them back to 12, 2, 10, 0 to proceed with the exercise after you've experimented with the values

We now have a segmented image. We can compare it with the Aerial image by swiping back and forth using the swipe tool on the IAW.

Remember to turn off the segmented image before panning and zooming around. It will reprocess each time and you'll have to wait.

- In the IAW, select the NIR_413 layer and click the swipe tool to compare it to the image below





Assuming you are satisfied with the results, we'll now run the Segment Mean Shift geoprocessing tool to save the segmented image to disk. We'll use the same parameters above from the raster function.

***This step is very cpu intensive. It took about an hour with an Intel CORE i7 processor @ 2.70 Ghz and 16 Gb of RAM. It is recommended to run before the live demo.**

- Using the Search tool that's docked to the right side of the ArcMap screen, search for **segment mean**
- Open the Segment Mean Shift tool

- For Input Raster, Navigate to: <Install Drive>\LOJIC_Impervious\Imagery and select **NIR_413.tif**
- For Output Raster Dataset navigate to <Install Drive>\LOJIC_Impervious\FeatureExtraction\segmentation folder and name it **Seg_NIR_413.tif**
- Enter the same parameters you used on the function editor

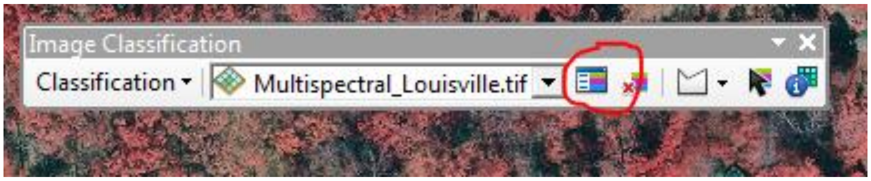
  Spectral Detail = 12
  Spatial Detail = 2
  Min Segment Size in Pixel = 10

- Click OK
- When the process completes it should load in the TOC. Add it if necessary
- Turn off the NIR_413 layer and turn on Seg_NIR_413.tif

Step 3 - Create Training Samples

In this portion of the demo, we'll create training samples over features in the image. We'll collect impervious features such as roofs, driveways and roads, as well as pervious features such as trees, grass and exposed dirt. The Training Sample Manager tool will be used to create and save our training samples. The training samples will be used later in the process

- Open the Training Sample Manager from the Image Classification toolbar



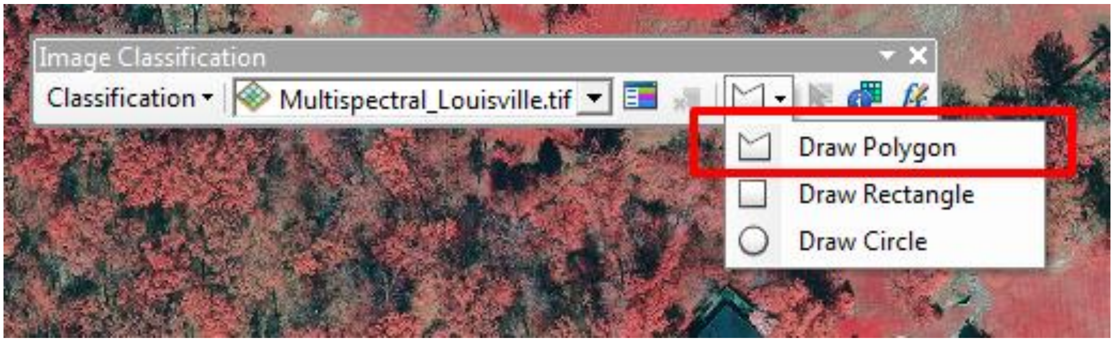
We'll load training samples previously created to save time. For the exercise we'll add a few of our own to demonstrate the process of capturing training samples.

- When the Training Sample Manager opens, click the button with the folder icon. Navigate to **LOJIC_Impervious\FeatureExtraction\training** and select Training_Samples.shp

Note: To save time even more time, there is a completed training samples file TrainingSamplesFinal.shp in ***LOJIC_Impervious\FeatureExtraction\training\bak.*** *This can be used instead of Training_Samples.shp if you want to skip the collection steps below. If not, proceed with the next bullet*

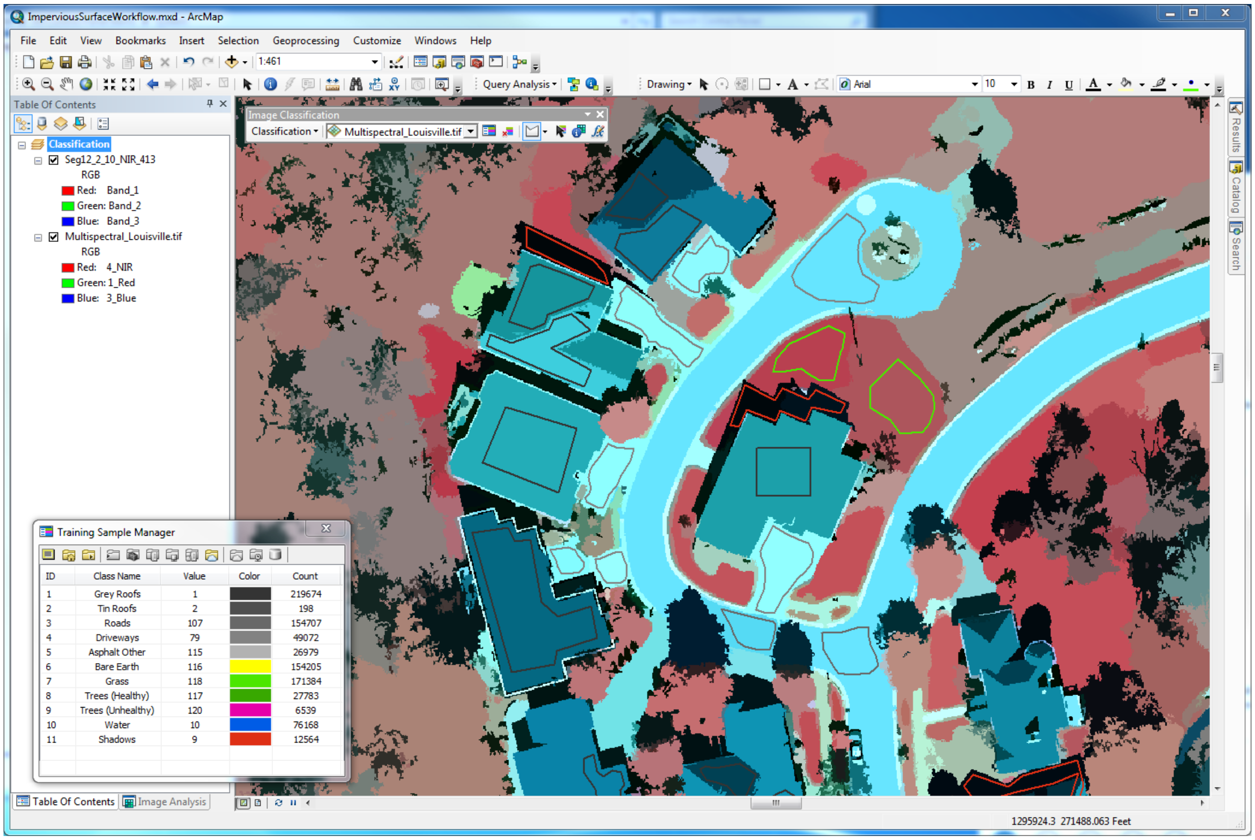
This is a legend that can be used with most urban scenes.

- Using the Bookmarks menu zoom to **Highly Detailed Homes**
- On the Image Classification toolbar, click on the Draw Polygon tool



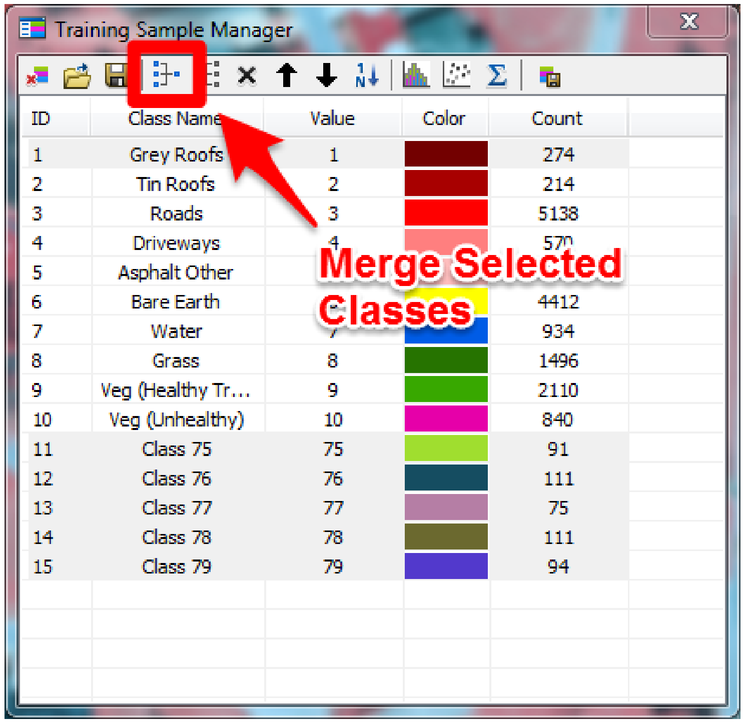
- Make a few shapes over some of the grey roof houses. Use the screenshot below as a rough guide

NOTE: when digitizing training sample polygons, toggle between the pixel and segmented image to make sure that the training polygons are contained within the desired segment(s) and do not overlap with other segments.



We can merge classes together in the Training Sample Manager

- Merge all the training samples you just captured by selecting the Grey Roofs class at the top of the list, then hit the control button on the keyboard and select all the training sample polygons you created
- Click the Merge button



- Using what you just learned, capture and merge additional training sample polygons for Roads, Driveways, Shadows, Grass, Bare Earth and Water. You can use the screenshot above as a guide and also capture your own in other parts of the image
- When you're done, click the icon with the floppy disk to save your training samples. Name it **TrainingSamplesFinal.shp**.
- Close the Training Sample Manager

Step 4 – Generate Analysis Metrics

Now that we've created a segmented image and some training samples, we have the required inputs to generate a classifier definition file (.ecd file). The .ecd file captures attributes and statistics about the segmented image. In this step we'll use a Support Vector Machine (SVM) classifier to analyze the data and help recognize patterns in our dataset.

For an explanation on how an SVM classifier works see this link.

- On the Search menu, search for Train Support
- Open the Train Support Vector Machine Classifier geoprocessing tool
- For Input Raster select **Seg_NIR_413.tif** which should be in your TOC
- For Input Training Sample File select the **TrainingSamplesFinal.shp** you created in Step 3
- For Output Classifier Definition File, save to the folder **LOJIC_Impervious\FeatureExtraction\training\classifier**
- Name it **SVM_NIR_413.ecd**
- For Additional Input Raster select **NIR_413.tif located in LOJIC_Impervious\Imagery**
- For Max Number of Samples Per Class use -1. This will use all training samples when working with a segmented raster dataset
- Under Segment Attributes, click the Select All button
- Click OK to run the tool

Step 5 – Classify the Image

We'll now create a classified image based on the segmented image and the SVM classifier. In the same way we segmented the image to assess and preview the results using raster functions, we'll do the same here. When we're satisfied we'll use geoprocessing to save the results to disk.

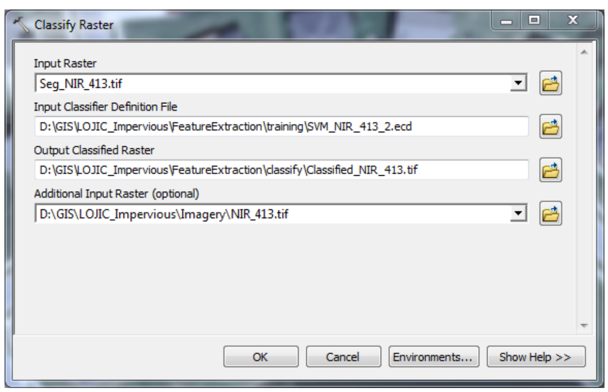
- Enable the IAW, select Seg_NIR_413, then click the Add Function button in the Processing pane to open the Function Template Editor window
- Right-click the Identify function > Insert Function > Classify Function
- Enter the following parameters:

  Input Definition File: SVM_NIR_413.ecd you created in Step 4
  Input Raster 2: NIR_413.tif located in \LOJIC_Impervious\Imagery

- Click OK, then OK again to apply and dismiss the dialogs
- Compare the classified image to the RGB image

Now perform the geoprocessing equivalent of classifying our image and save our results to disk.

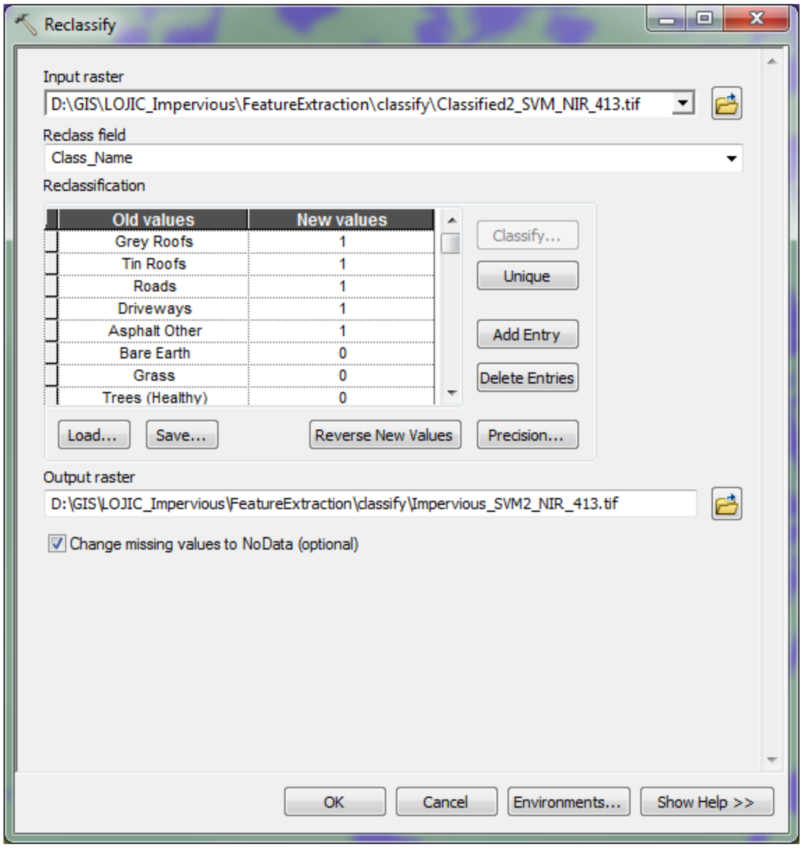
- On the Search window type classify
- Open the Classify Raster tool
- For Input Raster select the **Seg_NIR_413.tif** file from the dropdown
- For Input Classifier Definition File, select the **SVM_NIR_413.ecd** file
- For Output Classified Raster, save to: LOJIC_Impervious\FeatureExtraction\classify and name it: **Classified_NIR_413.tif**
- Under Additional Input Raster navigate to LOJIC_Impervious\Imagery and select **NIR_413.tif**
- Click OK



Next, we'll reclassify the scene so we can see it as a classified image with only two classes representing impervious and pervious. Impervious features will have a value of 1 and pervious features will have a value of 0. We'll use the Reclassify tool to do this.

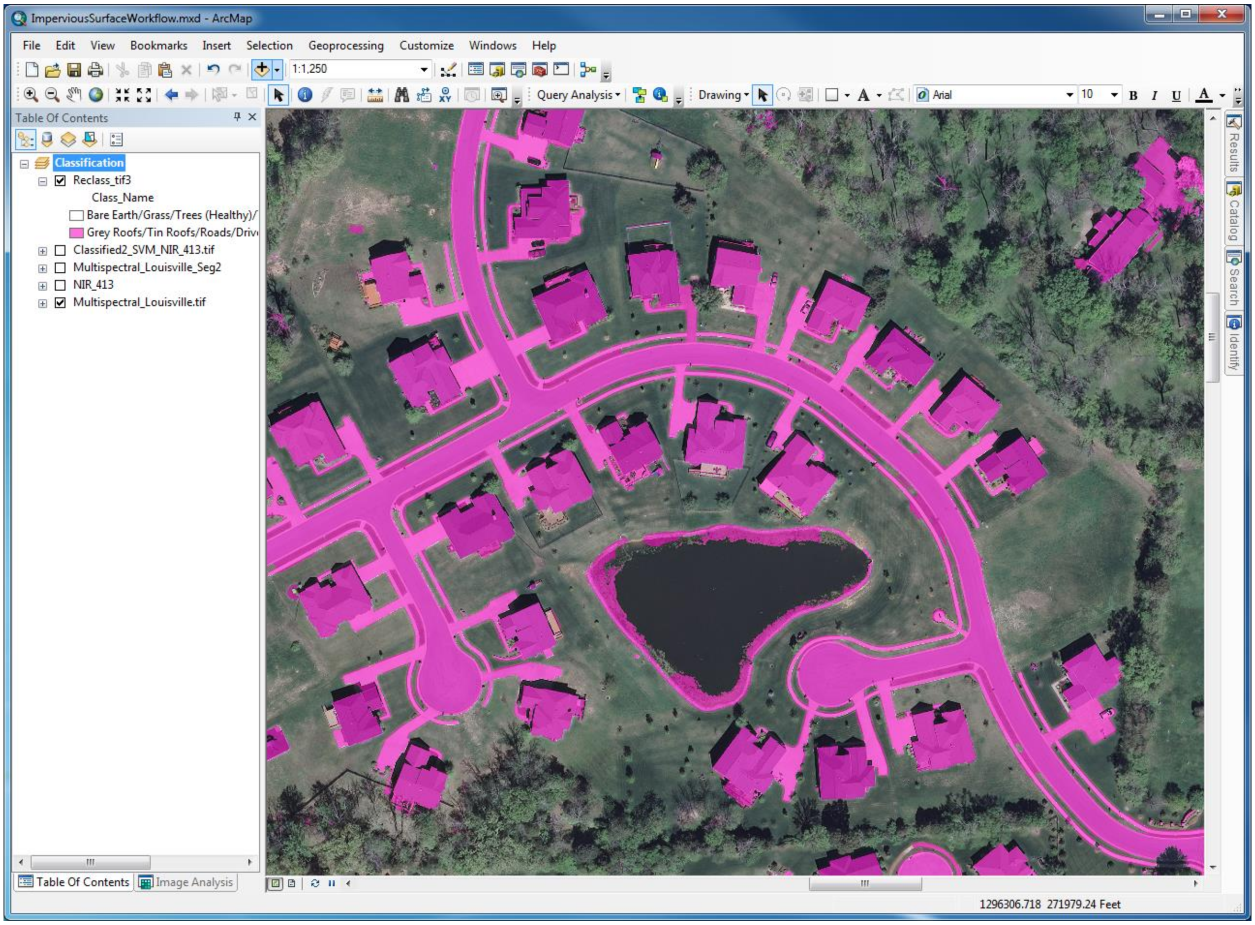
Now use the Reclassify geoprocessing tool to remap the classes.

- On the Search window type reclassify and select the Reclassify (Spatial Analyst) tool
- For Input Raster select **Classified_NIR_413.tif**
- Under Reclass field select Class_Name
- Click the Unique button to properly list the values in the table
- Now change the new values so all impervious features = 1 and pervious values = 0
- Save the output raster as Impervious_NIR_413.tif in the classify folder
- Click OK



Change the symbology to view only the impervious features.

- Open the Layer Properties for Impervious_NIR_413
- Select the Symbology Tab
- Click the import folder and navigate to LOJIC_Impervious\FeatureExtraction\classify
- Select the Impervious_Symbology.lyr and click Add
- Click Ok to import the symbology
- Select the Display tab and add 45% transparency
- Click OK to apply and dismiss the Layer Properties



Step 6 – Calculate Impervious Square Footage for Parcels
This step will use some tools in the Spatial Analyst Zone toolbox to calculate the amount of impervious surface per parcel.

First step is to find out how much impervious surface from the ReClassified raster exists for each parcel. We'll use the Tabulate Area geoprocessing tool.

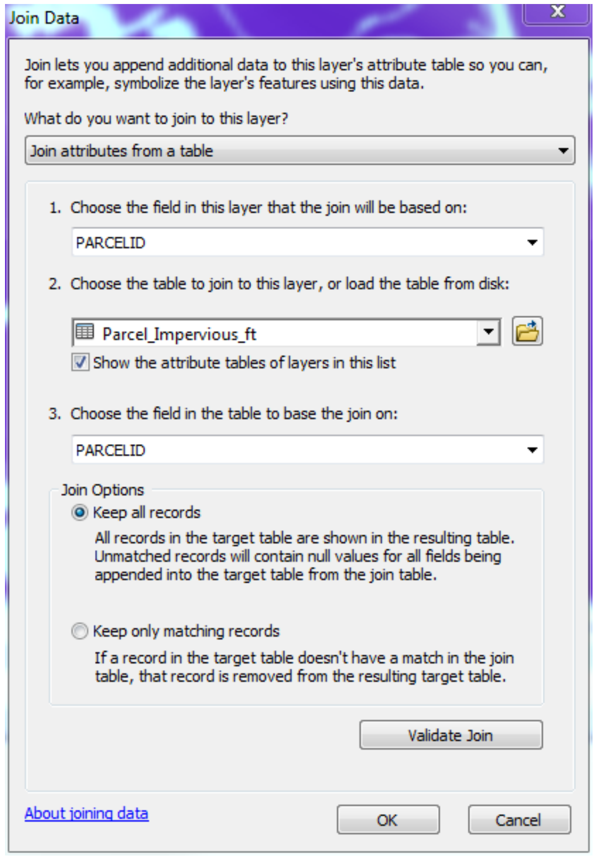
- Add the Parcel layer to the data frame by navigating to **LOJIC_Impervious\LOJIC.gdb**
- If necessary, change the symbology to a single symbol with no fill from the Symbology tab on the Layer Properties
- On the Search window type tabulate and open the Tabulate Area (Spatial Analyst) tool
- Enter the following parameters:

Input raster for feature zone data: Parcel
Zone Field: PARCELID
Input Raster or feature class data: Impervious_NIR_413.tif
Class Value: Class_Name
Output Table: **LOJIC_Impervious\LOJIC.gdb** and name it **Parcel_Impervious**

- Click OK
- In the TOC, switch to List by Source to view the newly created table
- Right-Click the table to open
- Now each Parcel ID is associated with an impervious and pervious value in square feet

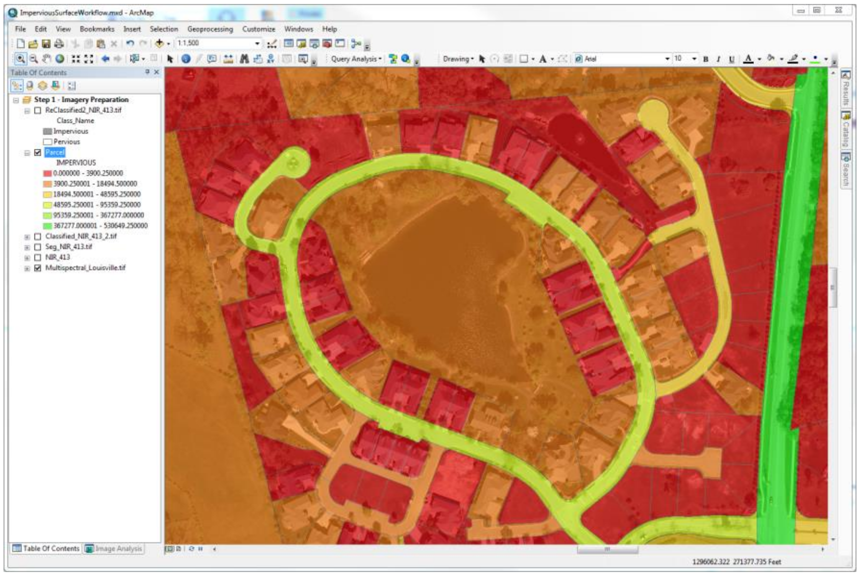
All that's left to do is join this table to the Parcel feature class based on PARCELID

- Right-Click the Parcels > Joins and Relates > Join
- In the Join Data dialog, Join to the Parcel_Impervious table base on ParcelID



Now you can change the Parcel layer symbology to view as Graduated Colors using the impervious field that's now part of the Parcels layer

- Open the Layer Properties for Parcels and select the Symbology tab
- Change the symbology to Quantities > Graduated Colors
- Choose 6 Classes and Change the Color Ramp using the Red to Green renderer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