INTERMEDIATE OBIA
USING DEFINIENS PROFESSIONAL 5 (“ECOGNITION”)

In this exercise, you will learn more advanced segmentation and classification strategies and tools available in Definiens Professional 5.0 (formerly known as “eCognition”). You will use freely-available aerial imagery available through the National Agriculture Imagery Program (NAIP) of a small area in Napa County, California. The imagery is true-color, which means that it has three bands only (red, green, and blue) with no near infrared (NIR) band. Not having a NIR band can make it difficult to separate vegetation from non-vegetation, but since much of the freely-available aerial photography is true-color, it is useful to build experience using this type of imagery. The NAIP imagery has a pixel size of 1 meter, and was flown for all of California in the summer of 2005. For more information and to download, see http://giif.cnr.berkeley.edu/naip.html. Additional data includes LiDAR bare-earth elevation data (1-m resolution) from the NCALM Project (http://ncalm.berkeley.edu), slope raster computed from the LiDAR data, and clipped Napa County parcel geometry in shapefile format.

In this exercise, you will perform 4 lessons:

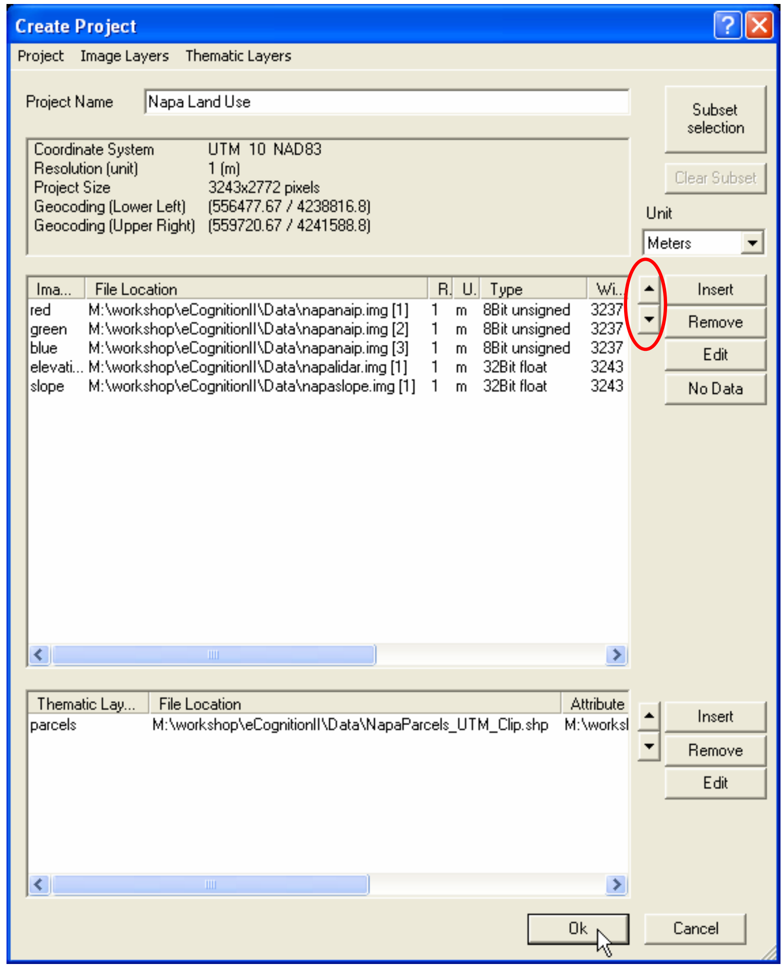
1. Image segmentation
2. Knowledge-based Fuzzy Rule Sets
3. Feature Space Optimization using Training Samples
4. Manual editing

***** START THE EXERCISE ON THE NEXT PAGE! *****

These are important points that you should read before you go any further!

These are informative tips that may help you in the future!

Lesson 1: Image segmentation



1. Start Definiens Professional, and click **File|New project**. Navigate to **C:/Workspace/EcognitionII/** folder.

2. Load the data.

   a. Add the following image data:
      - napanaip.img
        (1) → red
        (2) → green
        (3) → blue
      - napalidar.img → elevation
      - napaslope.img → slope

   b. Add the following vector data with aliases:
      - NapaParcels_UTM_Clip.shp → parcels

   c. Order the layers as shown in the picture to the right. If you need to move and layer up or down in the order, use the arrows (circled here).

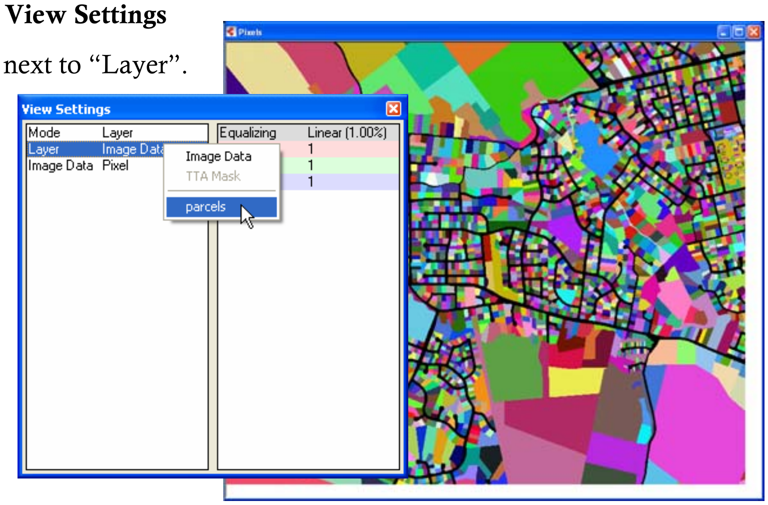
   d. Make the project name "Napa Land Use" or something like that.

Vector data are converted into a raster layer during import and are applied as a thematic layer.

   e. Go to **View|Edit Image Layer Mixing** or click on  button in the toolbar. The **Edit Image Layer Mixing** window opens. Assign the following bands to the corresponding color pens:

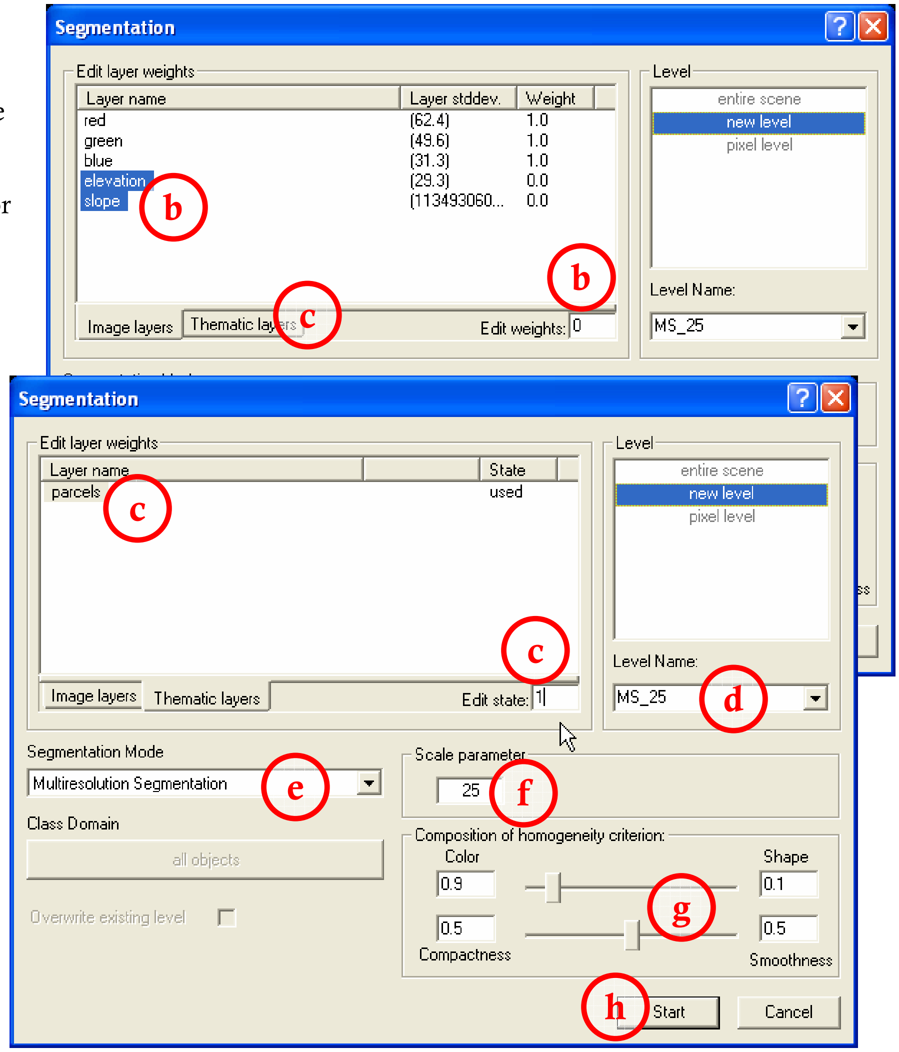
Image Layer	R	G	B
red	○		
green		○	
blue			○
elevation			
slope			

3. To view the vector **parcel** data, click on the **View Settings** button , and click on the "Image Data" next to "Layer". In the drop-down menu that pops up, choose to view **parcels**.



4. Perform first segmentation.

There are several strategies for segmentation that will help you get the best objects possible for your image.



a. Go to **Image Objects | Segmentation** or click on the  button to perform segmentation.

b. Weight **elevation** and **slope** as **0**. As a result, these layers will not be considered in the segmentation. Keep all the other image layers as 1.

c. Click on the **Thematic layers** tab under the Layer name list. Select **parcels**, and edit the state to be **1**. Notice how the state changes from "not used" to "used." Vector data don't have weights, only states, because they are either used (state set to 1) or not used (state set to 0) in the segmentation. When they *are* used in segmentation, their boundaries are strictly followed when creating segments. They don't *have* to be used in segmentation; you can always choose to use them only in the classification.

d. Type **MS_25** as the Level Name to represent a Multiresolution Segmentation with Scale parameter of 25.

e. For Segmentation Mode, select **Multiresolution Segmentation**.

f. Enter **25** for the Scale parameter.

g. In the Composition of homogeneity criterion, leave the defaults for Color and Shape (0.9 and 0.1) and for Compactness and Smoothness (0.5 and 0.5).

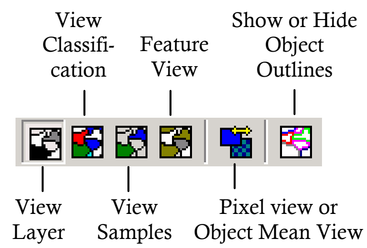
h. Click **Start**. It will take a few moments for the segmentation to complete.

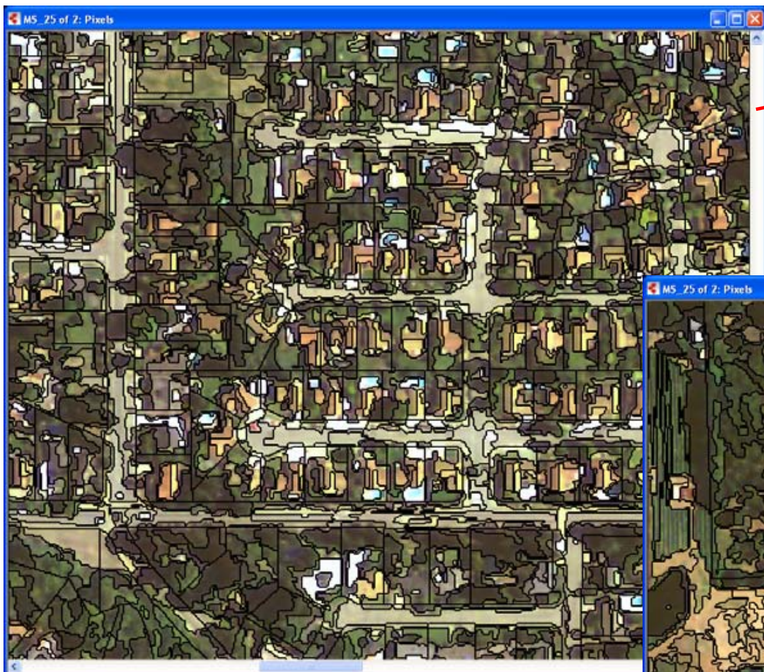
This segmentation may take about 5 minutes. Long wait times can happen (even on small images) when you choose to first segment using a small scale parameter.

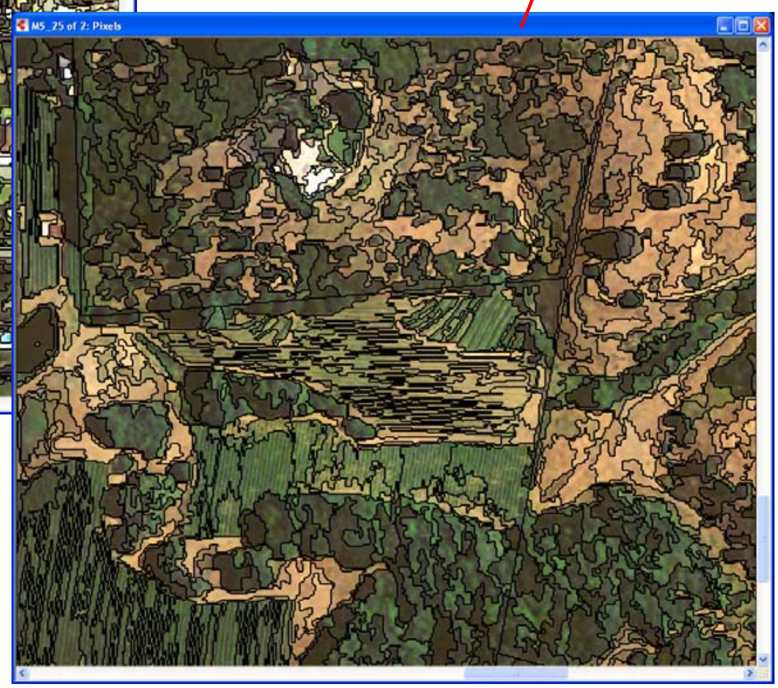
Segmentation Strategy #1: Weight layers differently.

- If you have elevation, slope, or another layer that represent landscape characteristics, try weighting them less than 1.0 (set them to 0 or 0.5, for example). This will allow for the spectral properties of the objects to have the most influence in segmenting around objects of interest on the ground.
- If you have data with a larger pixel size than your high-resolution data (for example, your elevation or thermal layers are at a coarser resolution than your other data), try weighting them as 0 for the segmentation. That will avoid choppy object boundaries that blend both large and small pixels, and the object boundaries will be smoother and follow objects on the ground better. You can, of course, still use those layers for the classification!
- Weight vector differently for different segmentation levels. This allows for vector boundaries to be honored during some segments (parcels used in Step #4 here), but then similar areas can be merged in larger objects (parcels not used in Step #5 here).

5. When the segmentation is finished, zoom in, use the View Settings toolbar to explore the image objects.







Pictured here are a few example areas from the segmented image. **Above**: Notice in the image how the parcels vector data is influencing the objects by forcing parcel boundaries to be part of the segments. This is great for this small level because we can easily separate roofs from cement roads. However, for our next segmentation, we will *not* use parcel data because we want to merge similar polygons, such as trees, roads, and roof segments. **Right**: Notice how the scale parameter was small enough to even pull out individual bushes, vineyard links, and trails! This detail is great at this level, because now we will segment up using the spectral difference segmentation mode, which will merge adjacent spectrally-similar objects, while certain objects like individual bushes will remain separated from the surrounding grasslands.

6. Perform a second segmentation.

We will perform a second segmentation with larger segments, *building* on the one we just did. Outlines in the previous segmentation will be topologically maintained, which essentially means they will share boundaries.

a. Click on  button to perform another segmentation.

b. Keep the image layer weights the same as the previous segmentation.

c. Click on the **Thematic layers** tab under the Layer name list. Select **parcels**, and edit the state to be **0** so that it is not used in this segmentation.

d. Click on **new** level *on top of* **MS_25** to create segments called **SD_15**.

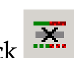
e. In the field Segmentation Mode, select **Spectral Different Segmentation**.

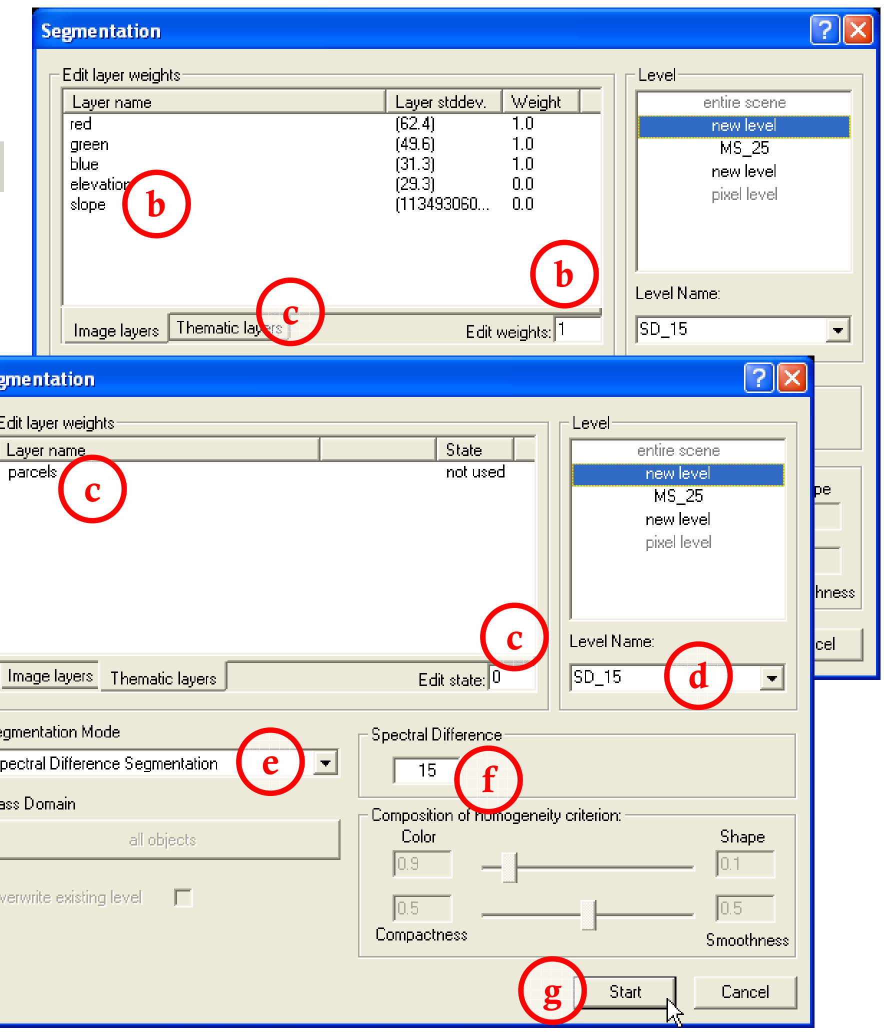
Spectral difference segmentation is a segmentation mode that takes segments that are already produced and merges them based on spectral different between segments, so that only those adjacent segments that are spectrally similar will be merged into a larger object. Spectral difference segmentation cannot be applied to the pixel level; in other words, it is always applied *on top of* another existing segmentation level – it is a method of merging objects so that you retain those small very-spectrally-different objects and merge those other spectrally-similar objects.

Segmentation Strategy #2: Use combination of segmentation modes.
Multiresolution segmentation is the most commonly used segmentation mode. It uses the scale parameter as its primary parameter, which determines the size and number of resulting objects. However, trying other segmentation modes, such as **Spectral Difference**, can improve segments results. It uses a spectral difference as its parameter, which is completely unrelated to the scale parameter in Multiresolution segmentation. Therefore, a segmentation level with a spectral different of 15 can be made on top of a multiresolution segmentation level with a scale parameter of 25, 50, 500, etc.

f. Enter **15** for the Spectral Difference.

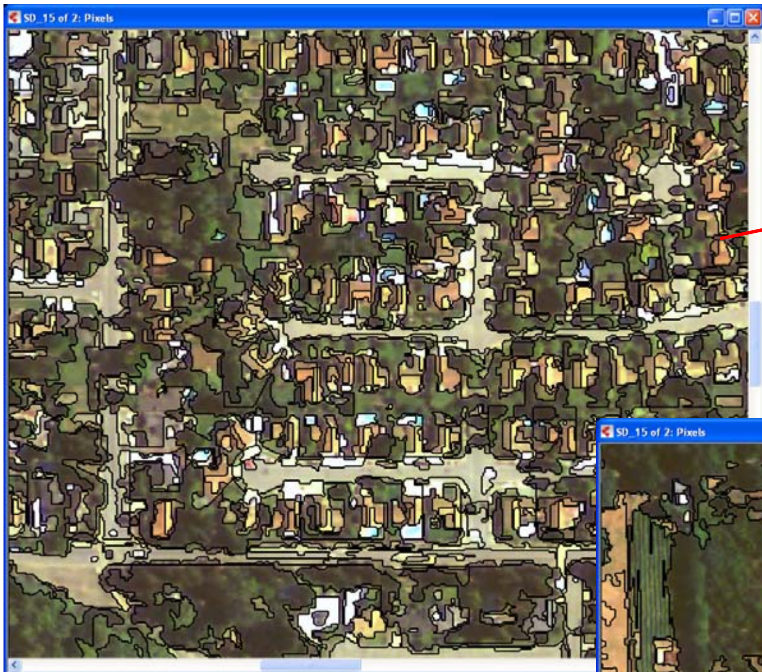
g. Click **Start**. It will take a few moments for the segmentation to complete.

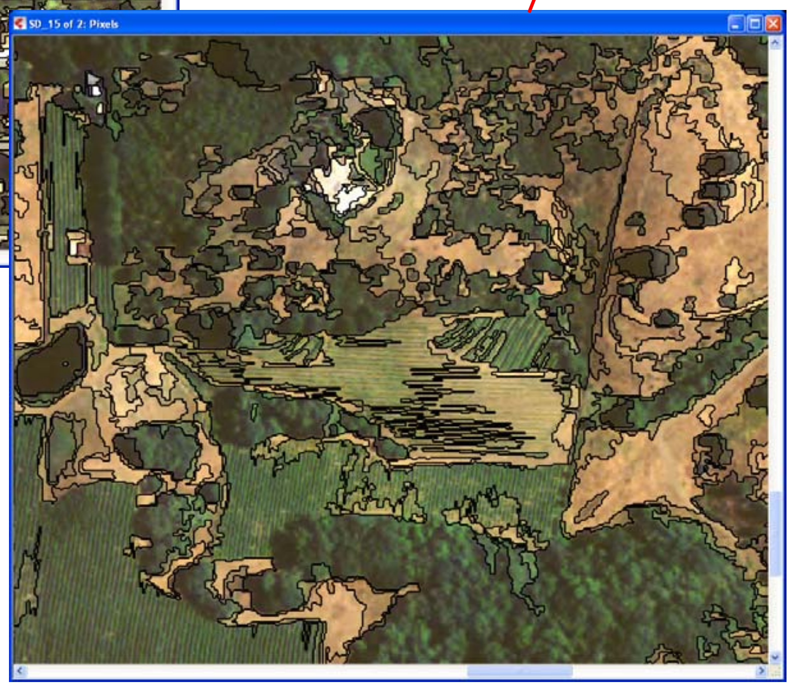
If you ever need to delete a segment, click  and then click the segmentation level that you wish to delete.



Remember! If your different

segmentation levels look *exactly* the same, it's most likely because, in this case, you clicked on the **new level** *below* instead of *above* a previous segmentation level. When creating a segmentation level under or over an existing level, ***you must place it in the correct place in the Level List***. For example, you must place a new *smaller* segmentation level under other segment levels according to their scale parameter. The exception is segments created with the Spectral Difference segmentation mode, since that uses a spectral difference and not a scale parameter. Spectral Difference segmentation uses *only* the level directly *below* the new Spectral Difference level (this is why Spectral Difference cannot be performed on the pixel level).





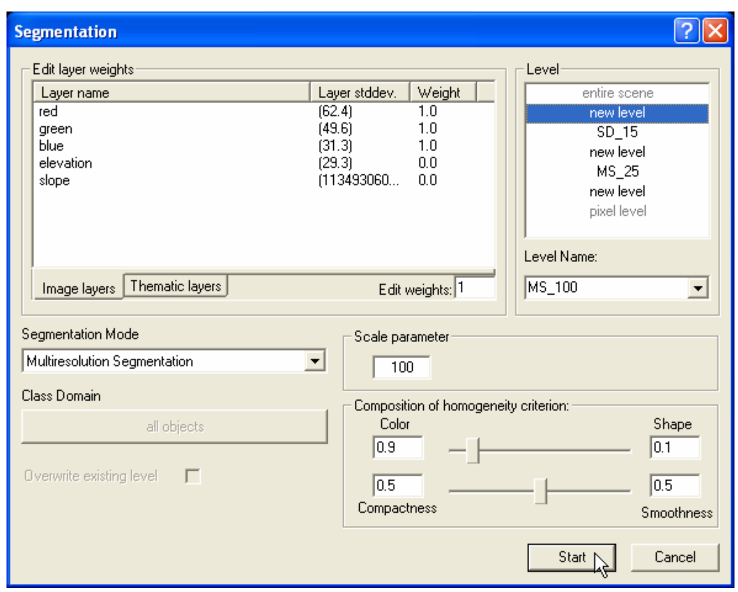
Pictured here are a few example areas from the second segmentation. **Above**: Notice how the segments no longer follow the parcels strictly, but the streets are well separated from the driveways and roofs – this wouldn't have been possible without the parcels data! The lawns have been merged together, as have the trees. **Right**: Notice how the many of the vineyard rows have been merged, but some still exist – we'll try another spectral difference segmentation to see if that helps. Also, the spectrally-similar grassland objects have been merged together, while small shrubs and tree objects are still separated in their own objects.

7. Perform a third segmentation.

We will perform a third segmentation with larger segments, using the Multiresolution Segmentation again.

a. Click on button to perform another segmentation.

b. Keep the image layer weights the same as the previous segmentation, including no weight to the parcels vector layer.



In fact, notice how we can no longer weight parcel vector data since they weren't used in the previous segmentation. To use them, we'd have to insert a segmentation level at a lower level than the segmentation level where we did not use them.

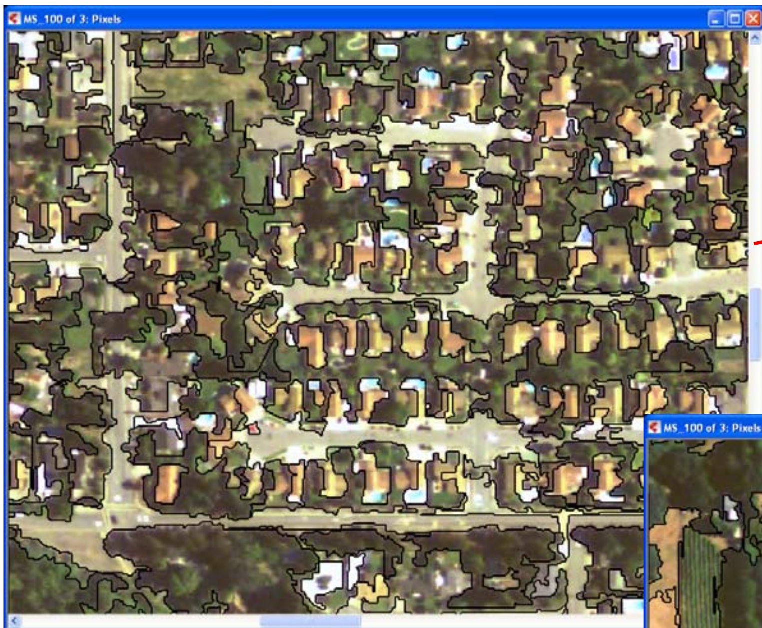
c. Click on **new** level *on top of* **SD_15** to create segments called **MS_100**.

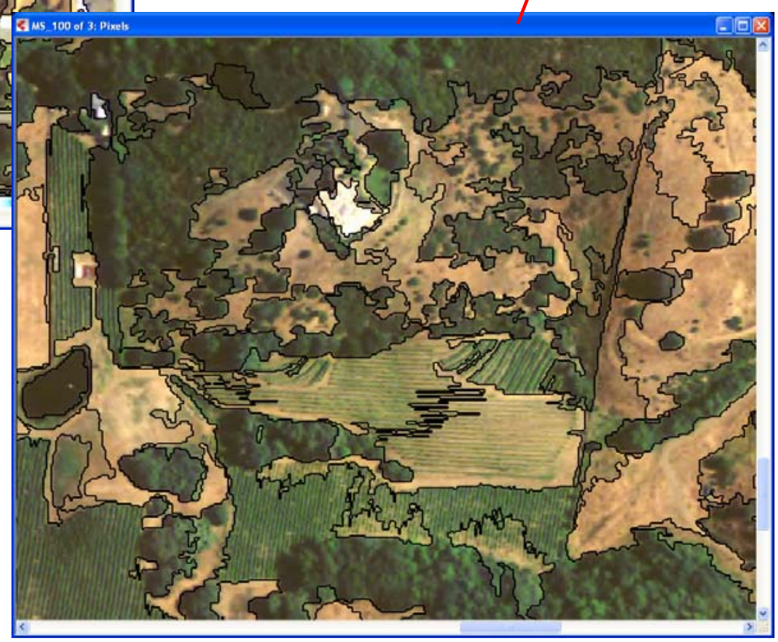
d. In the field Segmentation Mode, select **Multiresolution Segmentation**.

e. Enter **100** for the Scale parameter.

f. In the Composition of homogeneity criterion, leave the defaults for Color and Shape (0.9 and 0.1) and for Compactness and Smoothness (0.5 and 0.5).

g. Click **Start**.



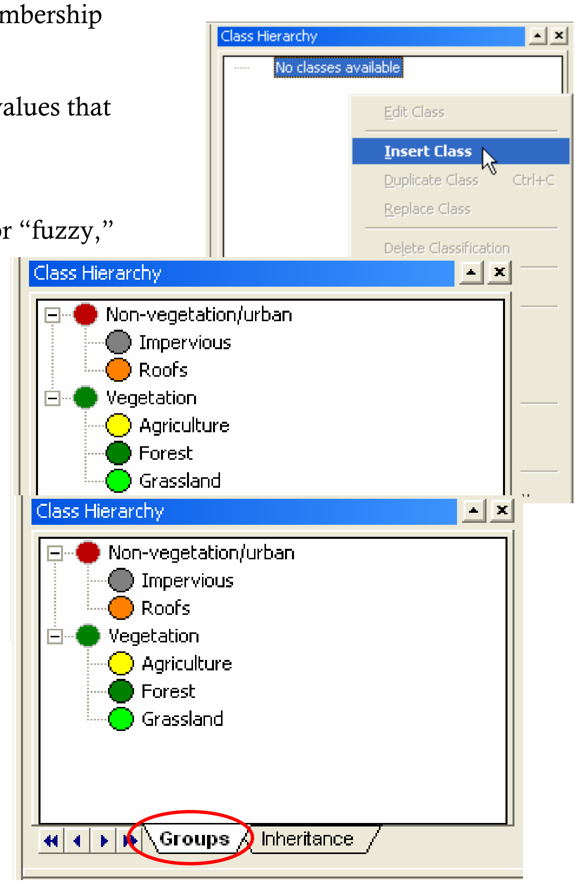


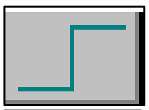
Above: Notice how in this segment level, grasses, roofs, and road are not always separated perfectly. That is okay since this larger level will be used for general land use (ag, urban, forest, etc.).
Right: Notice how the some of the smaller shrub objects were not maintained in this segmentation level. Later, we will try to extract them out of lower levels.

Lesson 2: Classifying Objects Using KNOWLEDGE-BASED RULE SETS

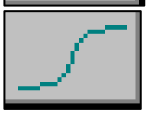
Definiens eCognition offers two different ways to classify image objects: **nearest neighbor** and **knowledge-based rule sets**. You performed a nearest neighbor classification in the introductory eCognition workshop. In this workshop, we will concentrate on the knowledge-based rule sets. However, KEEP IN MIND that the best results might come when you combine BOTH nearest neighbor (with training samples) AND knowledge-based rule sets.

Knowledge-based rule sets require familiarity with the image and site. In other words, you must know what you're looking at in the image, because you will be relying on your recognition of things in the image to form your rule sets. Knowledge-based rule sets can be in the form of either a crisp threshold or a fuzzy membership function.





Crisp thresholds define crisp cut-offs of feature values that crisply define a feature for a class:



Fuzzy membership functions define a gradual, or "fuzzy," knowledge range, that defines either a range of uncertainty of a feature for a class, or an ecotone where objects belonging to different classes may possess the same feature values.

1. Create a Class Hierarchy.
   a. If the **Class Hierarchy** dialog box is not open, go to **Classification | Class Hierarchy** or click on the icon to begin creating a classification scheme.
   b. Right-click in the **Class Hierarchy** dialog box and choose **Insert Class** to begin your classification scheme. A **Class Description** dialog box opens.
   c. Type **Agriculture** in the name textbox, select an appropriate color, and click **OK** at the bottom of the dialog box. The **Class Description** dialog box closes and the **Agriculture** class is added to the Class Hierarchy.
   d. Repeat these steps to add the following classes**: Forest, Grassland, Impervious, Roofs, Vegetation** and **Non-Vegetation/Urban.**
   e. Under the **"Groups"** tab, drag the **Impervious** and **Roofs** classes into **Non-vegetation/Urban**. Also drag **Agriculture, Forest,** and **Grassland** under **Vegetation**.
   f. Under the **"Inheritance"** tab, do the same for both.

These two tabs differ in this way:
- The **Groups** tab allows the grouping of classes into a semantic hierarchy, or an ecologically-meaningful classification, used for (a) easy viewing between different hierarchies, and (b) referral to the various group headings, such as **Vegetation** in this example.
- The **Inheritance** tab is for the inheritance of class features. For example, **Impervious** and **Roofs** are both not vegetation and will therefore share feature traits. Therefore, it is easy to group them both under the **Non-vegetation/Urban** inheritance so that they inherit whatever you assign to be the **Non-vegetation/Urban**feature traits.

Because you have to *choose* the feature to which to apply the membership function, it is necessary to first explore *which* feature(s) best separate your classes. We do this with the **Feature View** tool.

2. Explore the Feature Space.

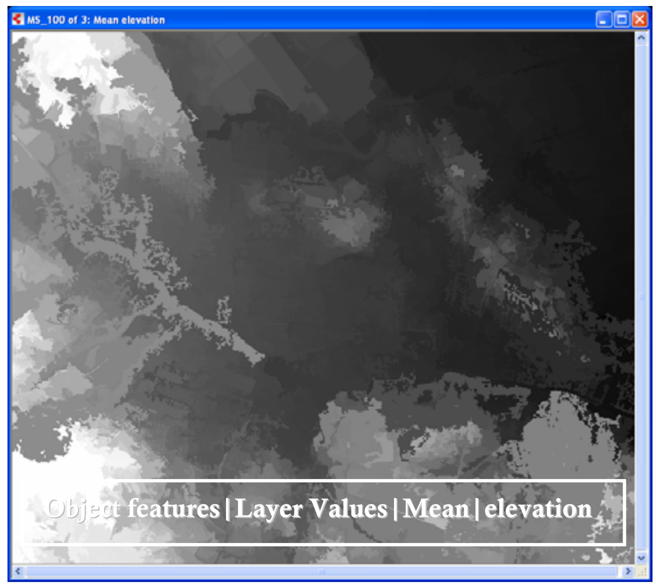
If **Feature View** dialog box is not open, go to **Tools | Feature View** or click on the button in the toolbar. You might need to anchor it to the far right side.

For each feature, double-click the feature so you view the feature (i.e. green layer mean, elevation layer mean, area, etc.) on the map, ranging from ***White*** being the highest value to ***Black*** being the lowest value.

Notice how when you double-click a feature, the view mode becomes the Feature View: . Be sure to *un-click* the outline button: so you can see that each object is displayed in a gray value according to its value in the feature that is selected for visualization. Objects displayed in red have not been defined for the evaluation of the chosen feature. Double-click various features listed in the Feature View to view the object values for that feature, so you can determine which features help to separate, or distinguish, different classes in the image.

Below are some examples of features that pull out specific classes. Explore each of these now. If you are interested in what they are, i.e. the definition, explanation, or formula for any feature, see the **Reference Book** located at Start menu | Programs | Geospatial Tools | Definiens Professional 5.0 | Reference Book.

Mean of blue pulls out some **forest** areas.



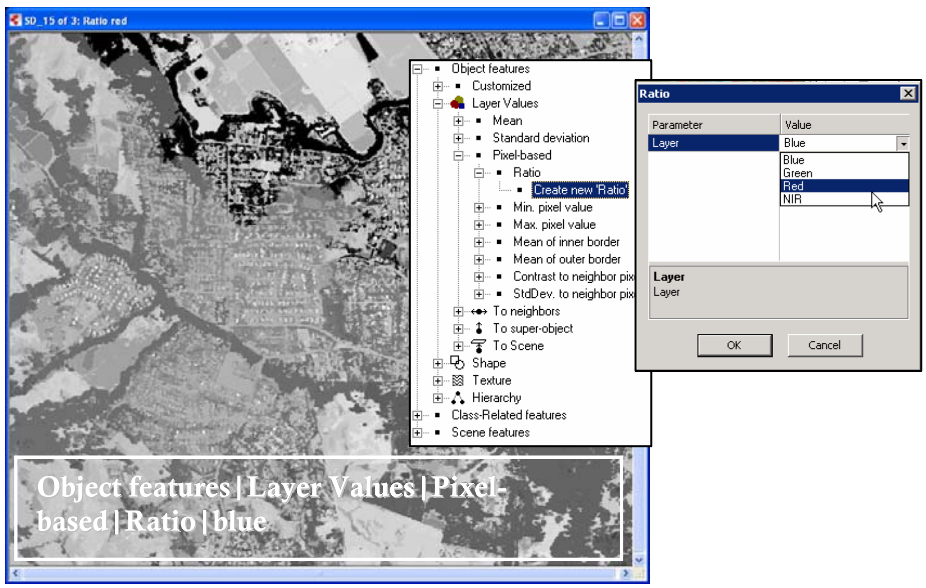
Mean of elevation pulls out the higher elevation areas that are less urbanized.

Mean of slope pulls out **urban** vs. non-urban areas.

SD of blue pulls out **vegetation** from **non-vegetation**.

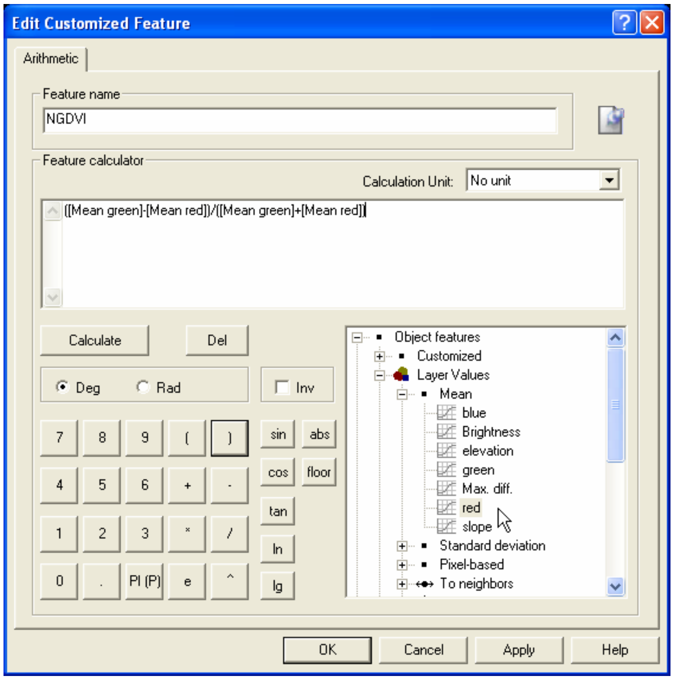
Density pulls out many of the **roads** from the rest of **urban**. Layer mean of red pulls out **forests**.

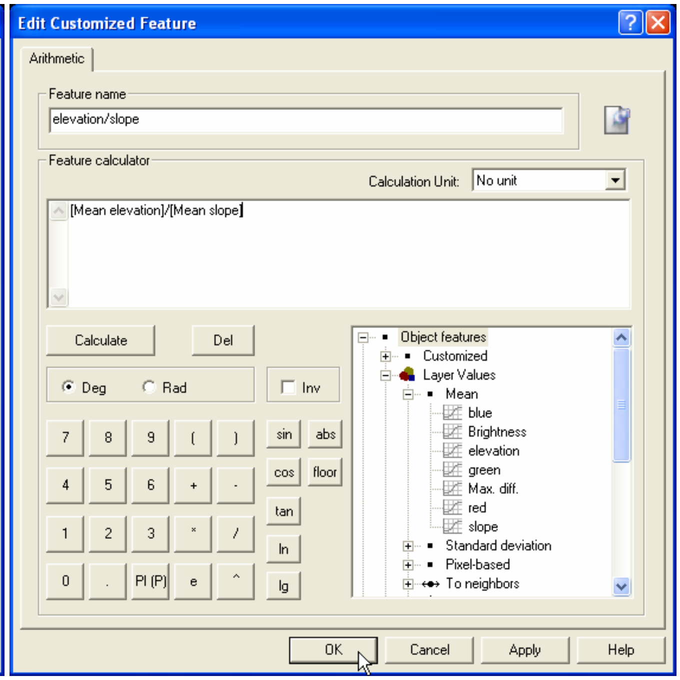
3. For the **Pixel-based** features, go to Object features | Layer values | Pixel-based | Ratio, and double-click **Create new 'Ratio'**. Choose **red** in the drop-down menu, and click OK. Repeat for **green** and **blue**. Under **Ratio,** double-click on each of these**.** You are now viewing the ratio of each band to all the other bands (red, green, and blue) for each object, ranging from ***White*** being the highest value to ***Black*** being the lowest value. Snapshots of each of these feature space explorations are on the next page to guide you. You can also view the value by hovering over an object or by using the **Image Object Information** dialog box by clicking .



4. You can also create your own customized features, using existing features and a feature calculator.
   a. Go to Object features | Customized | Create new 'Arithmetic feature'.
   b. Name your feature **NGDVI**. NGDI (Normalized Green Difference Vegetation Index) is an alternative to NDVI when a NIR band is not available, and can be useful at separating green vegetation from non-green vegetation. Unfortunately, the imagery used in this exercise has some mosaicking problems, and there is a brighter segment in the upper section, which makes the vegetation much greener in that part than other parts. These imagery errors can happen often in the remote sensing world, so it's helpful to know how to work with them.
   c. In the feature calculator, double-click on the parentheses, arithmetic functions, and the existing features to build the expression: **([Mean green]-[Mean red])/([Mean green]+[Mean red])**
   d. Repeat for **elevation/slope** (also depicted below).

The feature **elevation/slope** may be good indicator of high flat areas vs. low flat areas.





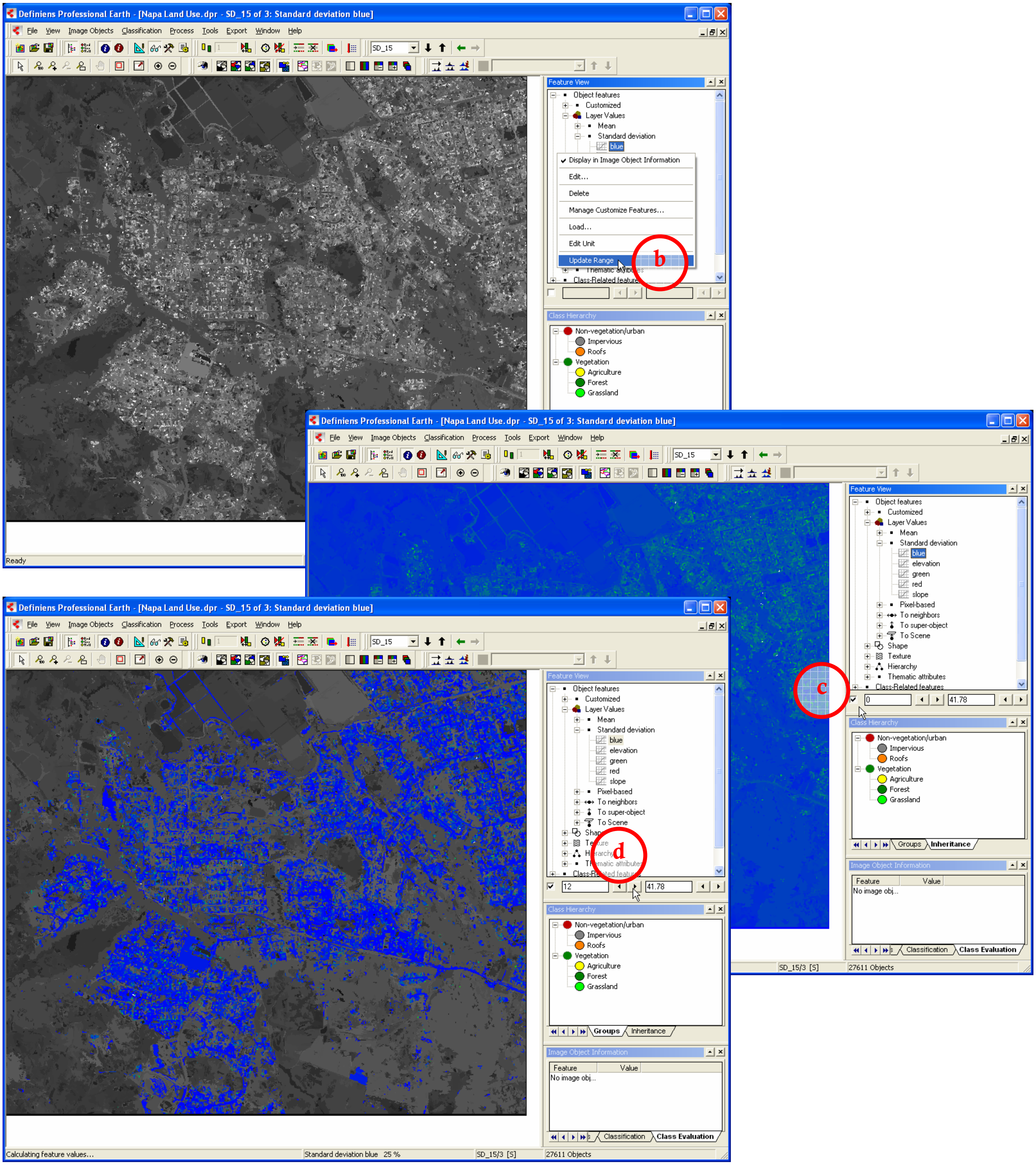
NGDVI isn't very helpful for this true-color image because of the image error from the mosaicking of the NAIP tiles.

The ratio of elevation to slope pulls out **urban** and **agriculture** very well.

Now that you know which features are useful at differentiating the different classes from each other, you will use the Feature View to interactively find the fuzzy ranges or crisp thresholds. We'll start with the feature: **Standard deviation on the blue band** on the segmentation level **SD_15**.

5. Interactively find the fuzzy range by:

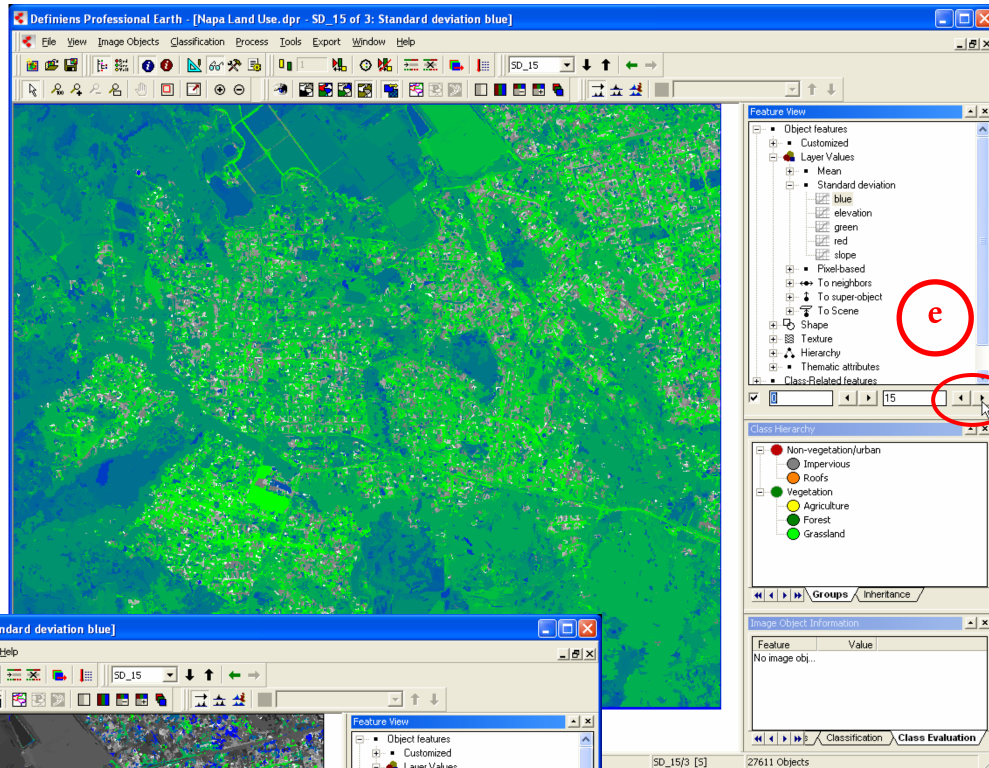
   a. Make sure that you are on the segmentation level: **SD_15**.
   b. Right-click on the **SD of blue** feature, and click "**Update Range**."
   c. Check the little check-box at the bottom of the feature view. This will display the objects in a color range from light **green** to dark **blue** (this is done with the SD_15 segmentation level). **Blue** objects are displayed for those objects with feature values at the **lower** end of the range, and **green** objects are display for those objects with feature values at the **upper** end of the range.

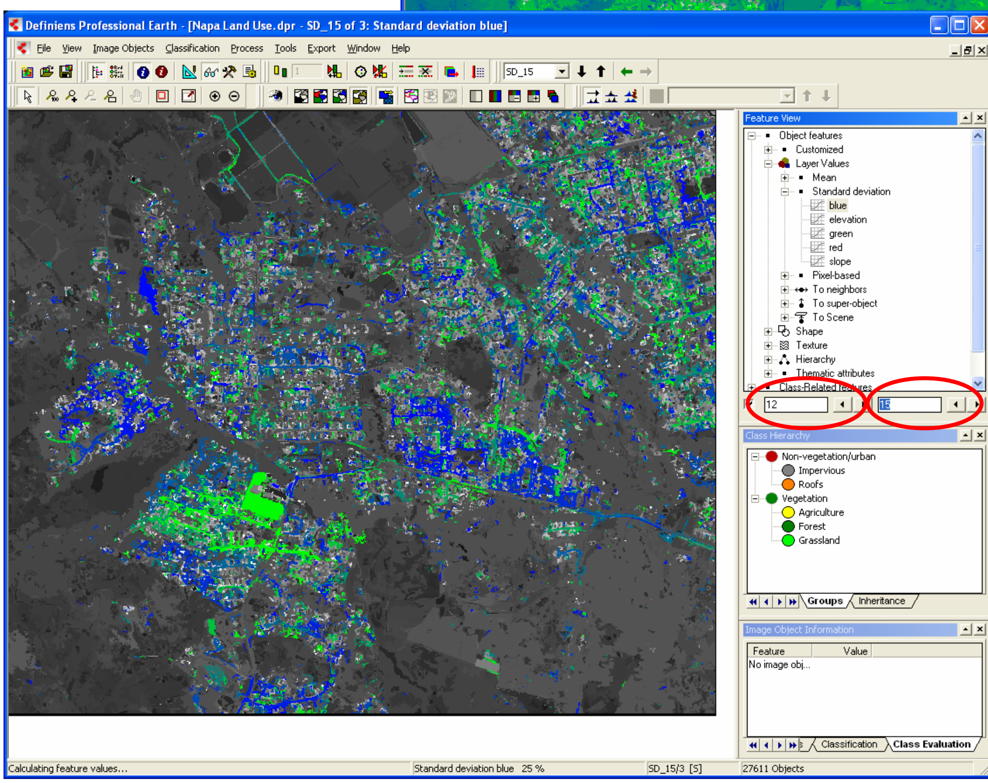


Using the arrows to the right of the check box, click to move the lower and upper limits so that you narrow down the range to the area that you have fuzzy knowledge (or fuzzy confidence) for a class or classes, in this example, **Vegetation** and **Non-Vegetation/Urban**.

d. Click the right arrow of the lower limit, until the lower limit is **12**. Notice how the blue areas that are lower than the lower limit return to the grayscale color (and not the green-to-blue color). This is the lower limit of the fuzzy range of **SD of blue** for the classes **Vegetation** and **Non-vegetation/Urban**.

e. Right-click on **SD of blue** again, and click "**Update range**" to refresh the lower and upper limits again, and then this time, click the <u>left</u> arrow of the <u>upper</u> limit, until the upper limit is **15**. Notice how the blue areas that are lower than the lower limit return to the grayscale color (and not the green-to-blue color).

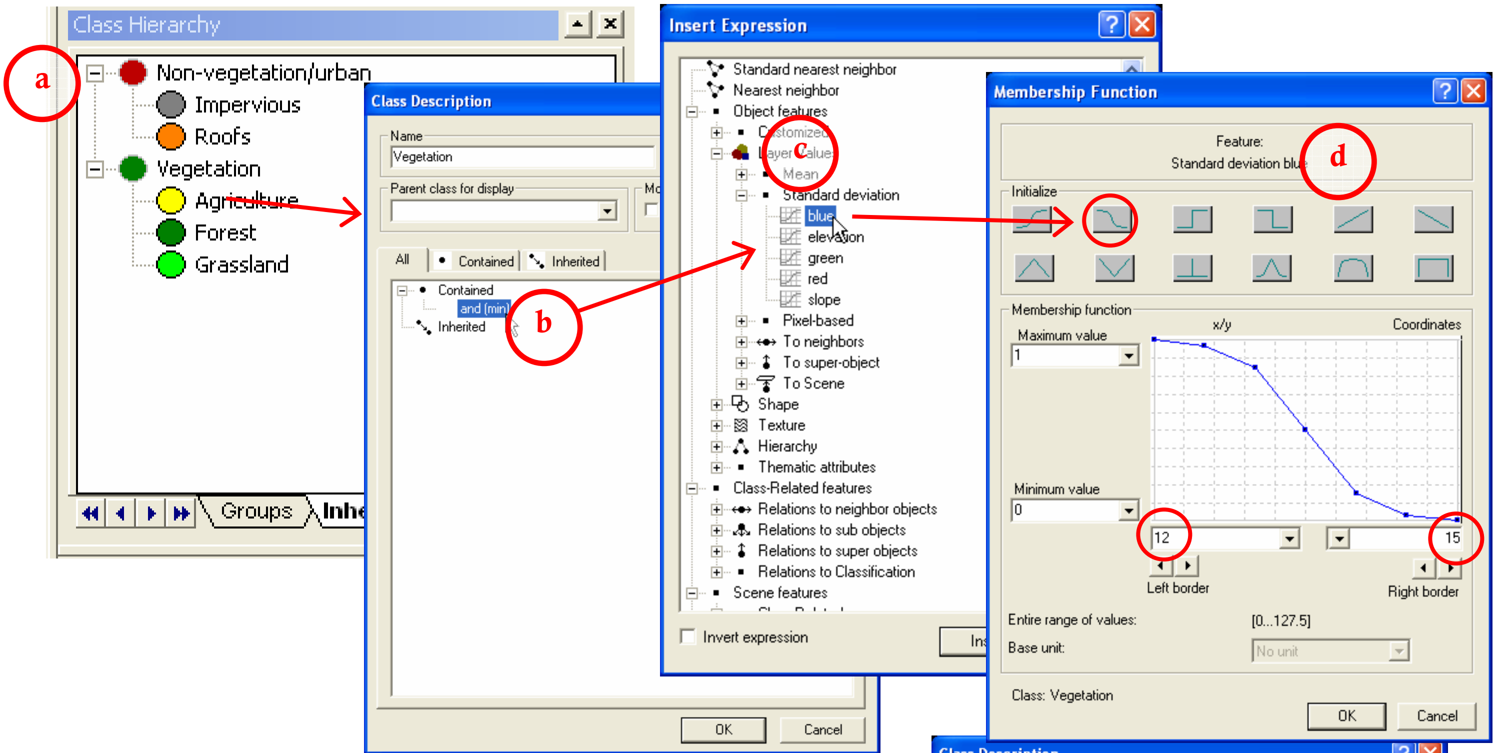


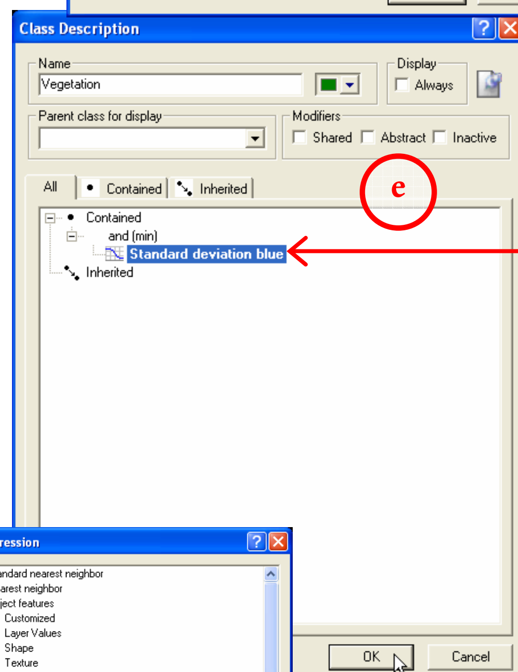


You can also choose to narrow down to the fuzzy range by changing the lower and upper limits at once (depicted below). In other words, you can interactively display the fuzzy range (depicted below), which will display which objects will be subject to the membership function's fuzzy range.

6. Now that you know the fuzzy range for the **SD of blue** membership function for the **Vegetation** and **Non-vegetation/Urban** classes, you must add it to the **Vegetation** and **Non-vegetation/Urban** classes feature space. To do this:

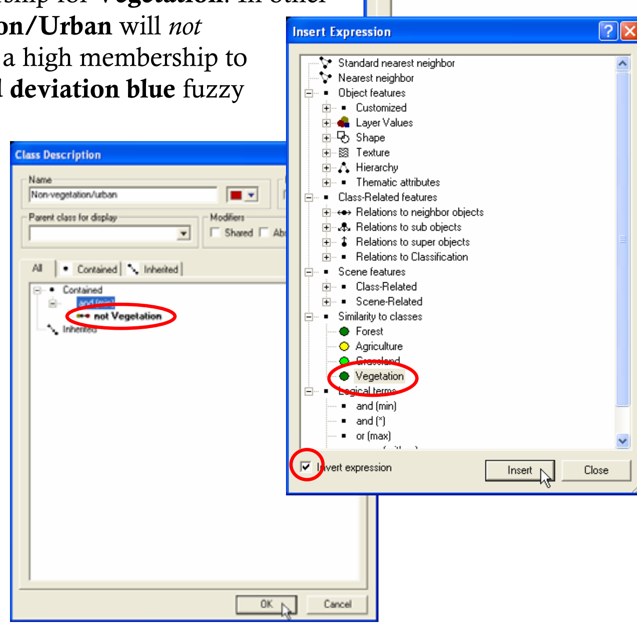
a. In the Class Hierarchy, double-click on the class **Vegetation**. The Class Description for **Vegetation** opens.
b. Double-click on **and (min)**. The Insert Expression window opens.
c. Go to Object features|Layer Values|Standard deviation, and double-click on **SD of blue** feature. The Membership Function window opens.
d. Choose the fuzzy negative membership function (top-left button), and insert the lower (**12**) and upper (**15**) values into the "Left border" and "Right border," respectively. Click **OK**.





e. In the Insert Expression window, click **Insert**, then **Close**. The **Vegetation** Class Description window should reflect the newly added **Standard deviation blue** feature (depicted to the right).
f. In the Class Description window, click OK.

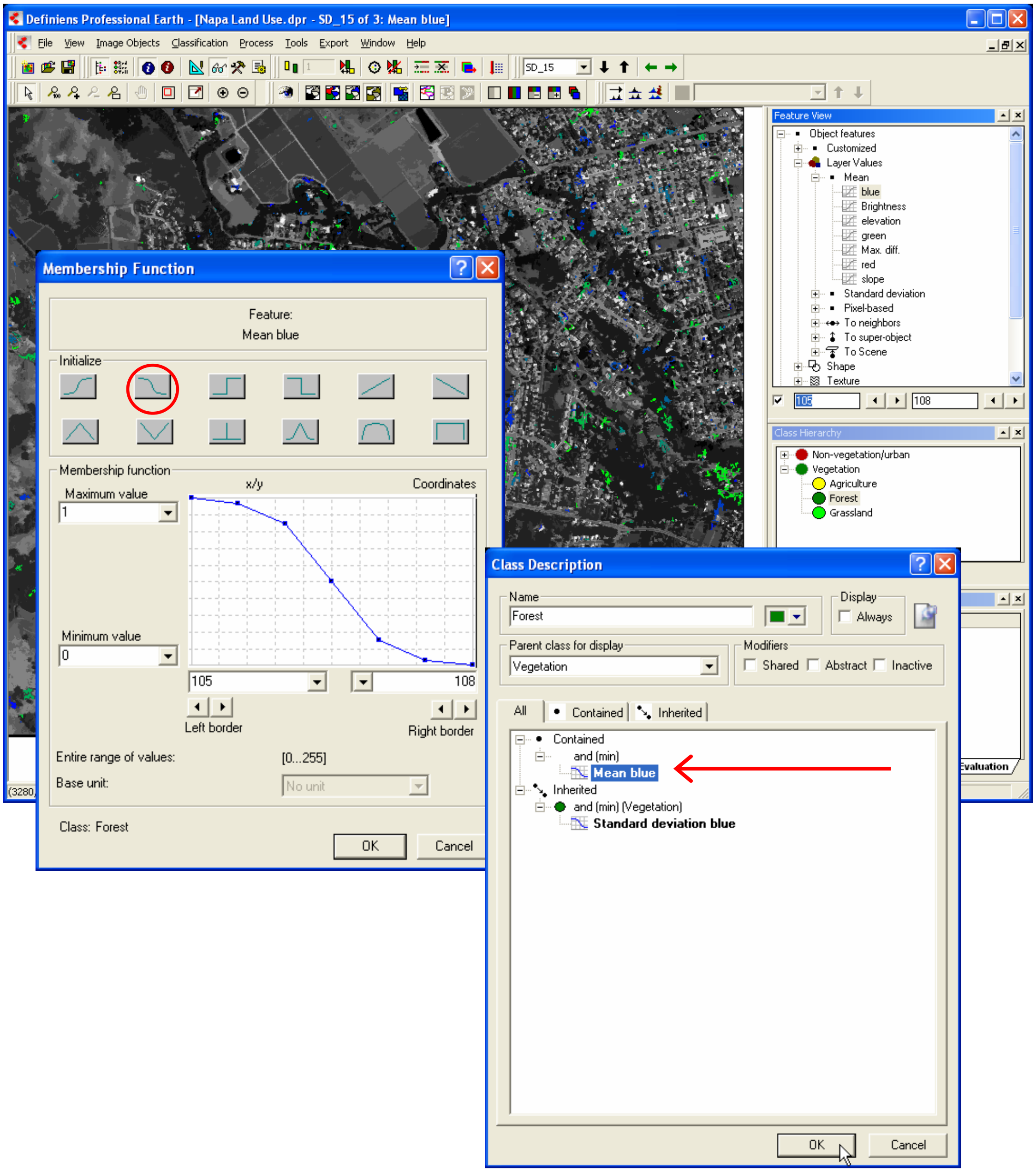
7. Make the **Non-vegetation/Urban** class the inverse of **Vegetation**:
   a. In the Class Hierarchy, double-click on the **Non-vegetation/Urban** class. The Class Description for **Non-vegetation/Urban** opens.
   b. Double-click on **and (min)**. The Insert Expression window opens.
   c. Find the feature Similarity to classes|Vegetation (depicted below), and select it, click **Insert,** check the box for Invert Expression, and then click **Close**. The feature **Not Vegtation** is added to **Non-vegetation/Urban** class features, this means that any objects that are classified with a high membership for **Non-vegetation/Urban** will not be classified with *any* membership for **Vegetation**. In other words, **Vegetation** and **Non-vegetation/Urban** will *not* compete for those objects that receive a high membership to **Vegetation** as a result of the **Standard deviation blue** fuzzy membership.
   d. Click OK in the Class Description window.



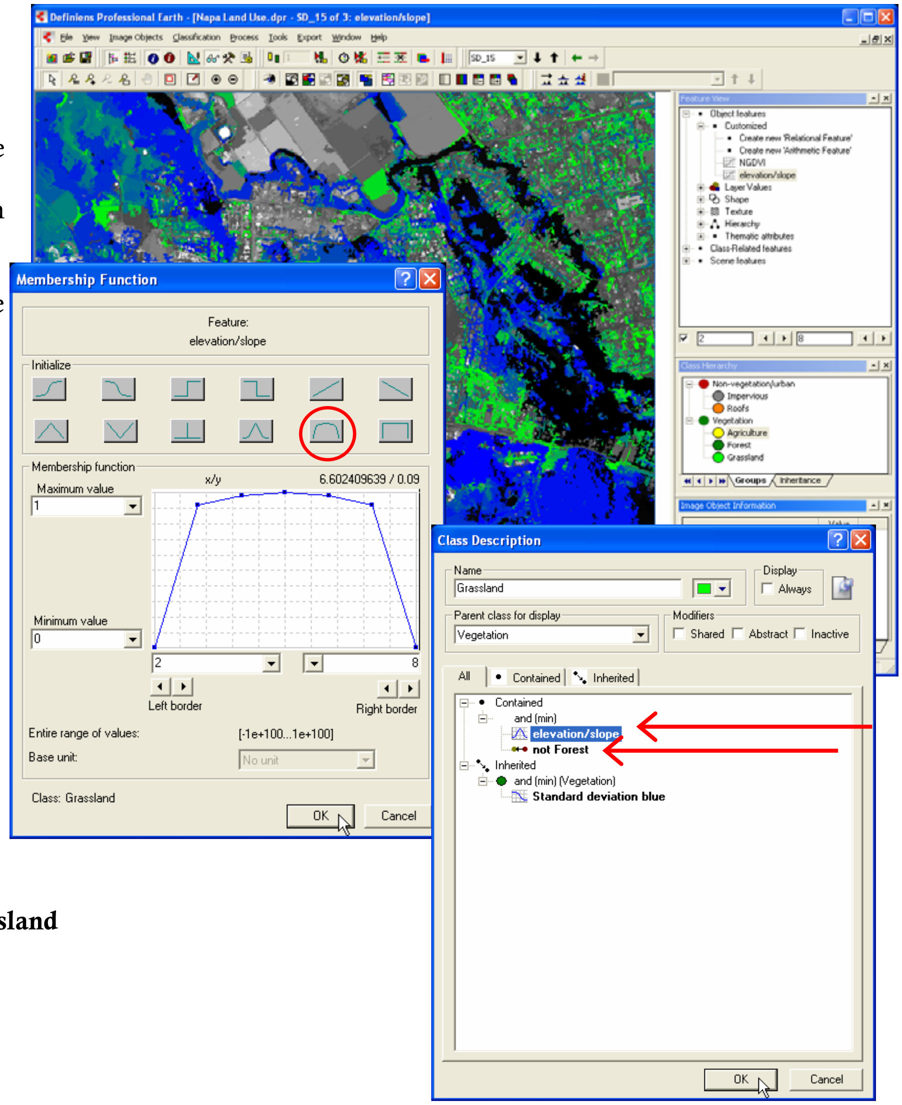
8. Next, let's use the **Layer Mean of Blue** to pull out **Forest**.

a. Use the interactive feature view to find that the lower limit is **105** and the upper limit is **108**. Depicted here are the objects subject to the fuzzy range for this feature.

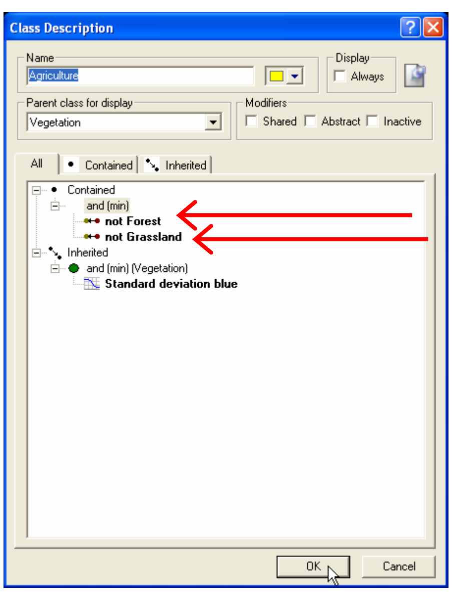
b. Add this fuzzy membership function to the **Forest** class, using the fuzzy negative relationship.



9. Next, let's use **elevation/slope** to pull out **Grassland**.
    a. Use the interactive feature view to find that the lower limit is **2** and the upper limit is **8**. Depicted here are the objects subject to the fuzzy range for this feature.
    b. Add this fuzzy membership function to the **Grassland** class, using the fuzzy range relationship.
    c. In addition, add a **not Forest** feature into the **Grassland** class.



10. Add a **not Forest** feature and a **not Grassland** into the **Agriculture** class as well.

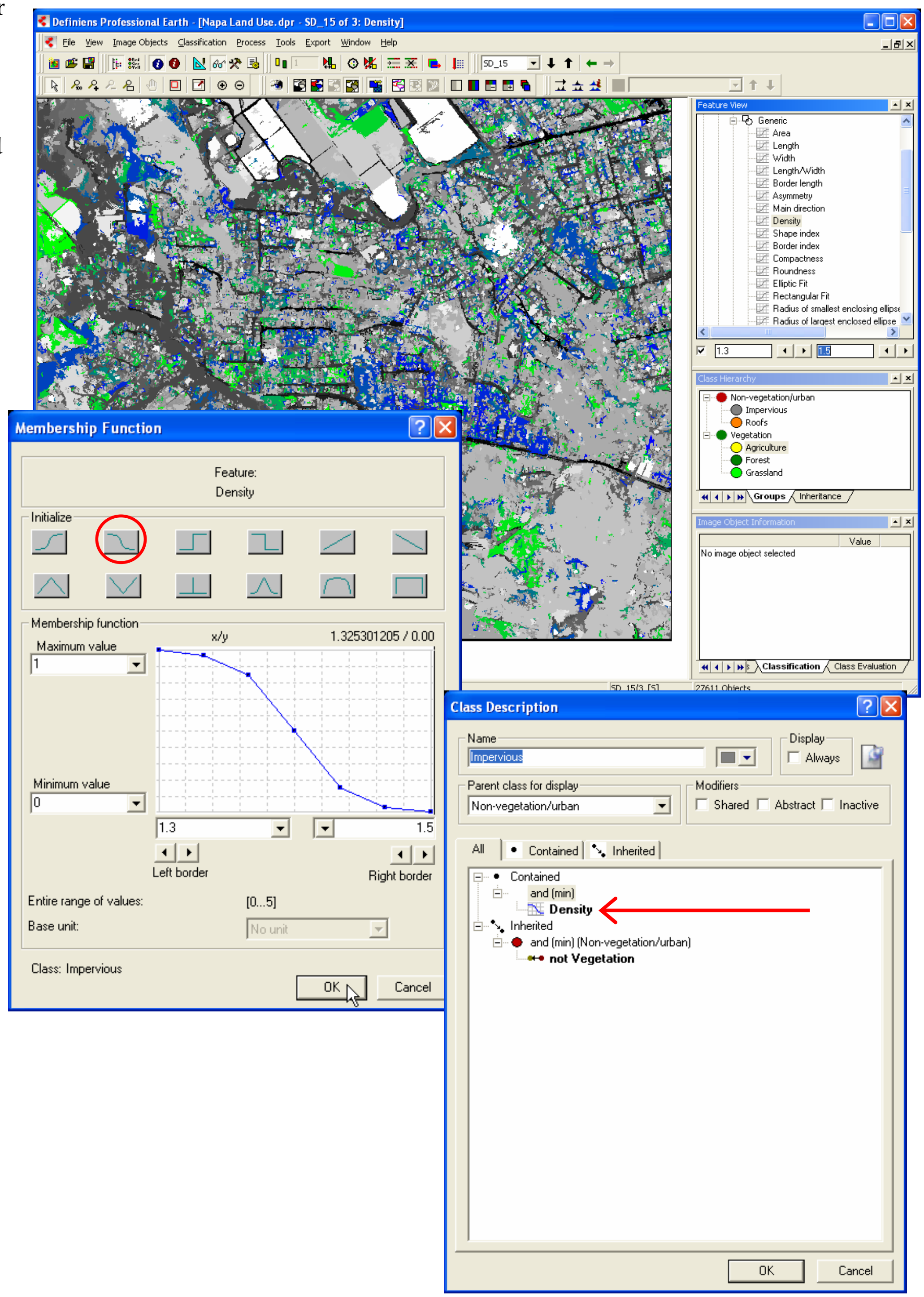


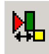
11. Next, let's use **Density** (under Object features|Shape|Generic) to pull out **Impervious**.

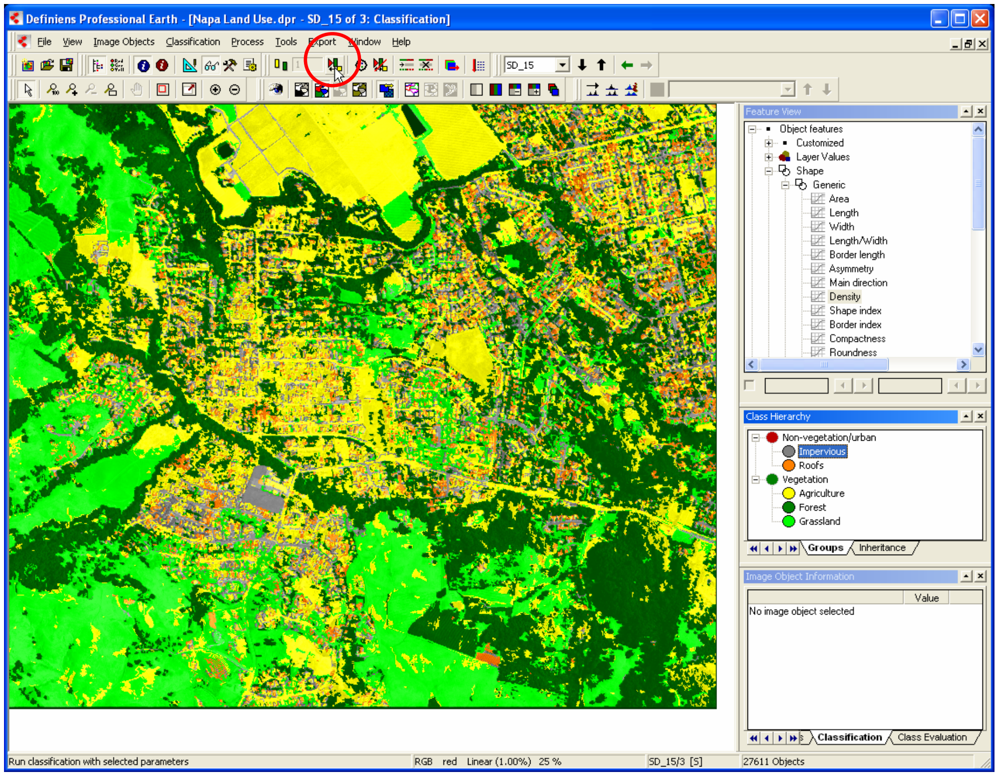
   d. Use the interactive feature view to find that the lower limit is **1.3** and the upper limit is **1.5**. Depicted here are the objects subject to the fuzzy range for this feature.

   e. Add this fuzzy membership function to the **Impervious** class, using the fuzzy range relationship.

In addition, add a **not Impervious** feature into the **Roofs** class.

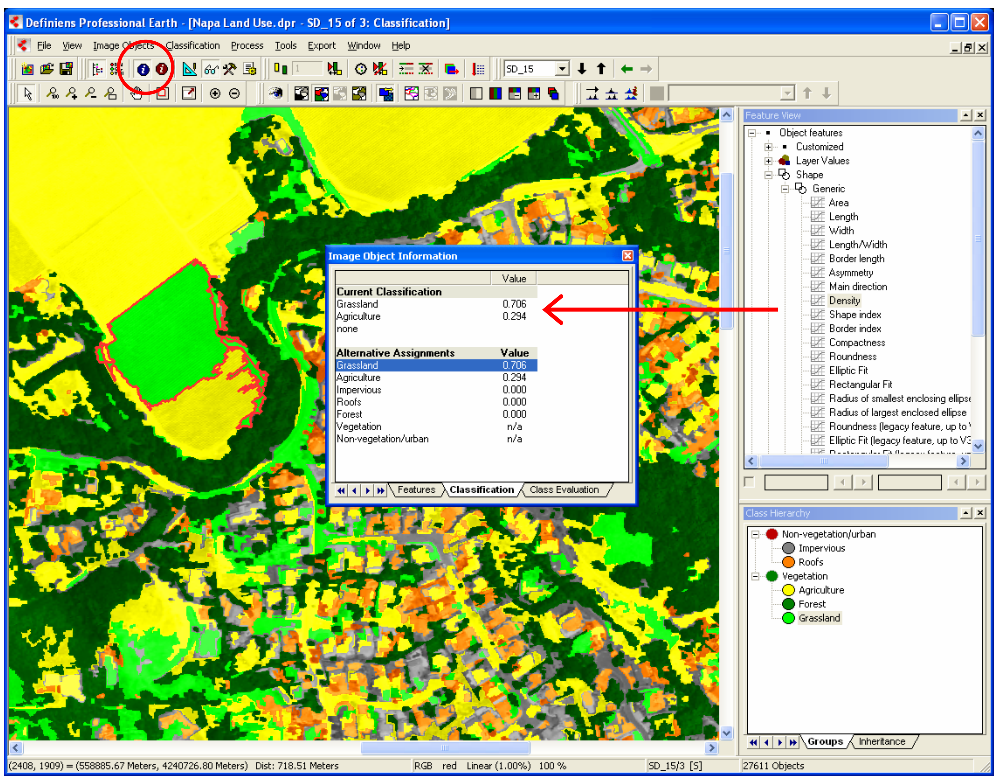


12. Click the Classify button  and the classification result comes up.

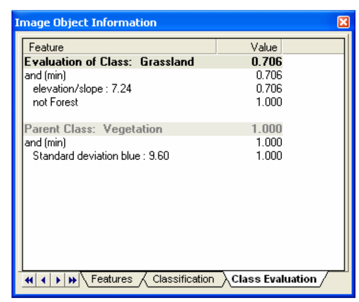


Examine your classification results. Use the Image Object Information window (accessible by ) to explore the reasons why your classification is not working in some places.

For example, the picture below shows a selected object that is classified as **Grassland**, but should be classified as **Agriculture**. Looking at the Image Object Information window, under the Classification tab, we can see that the membership into the **Grassland** class is **0.706** and the membership into the **Agriculture** class is **0.294**.

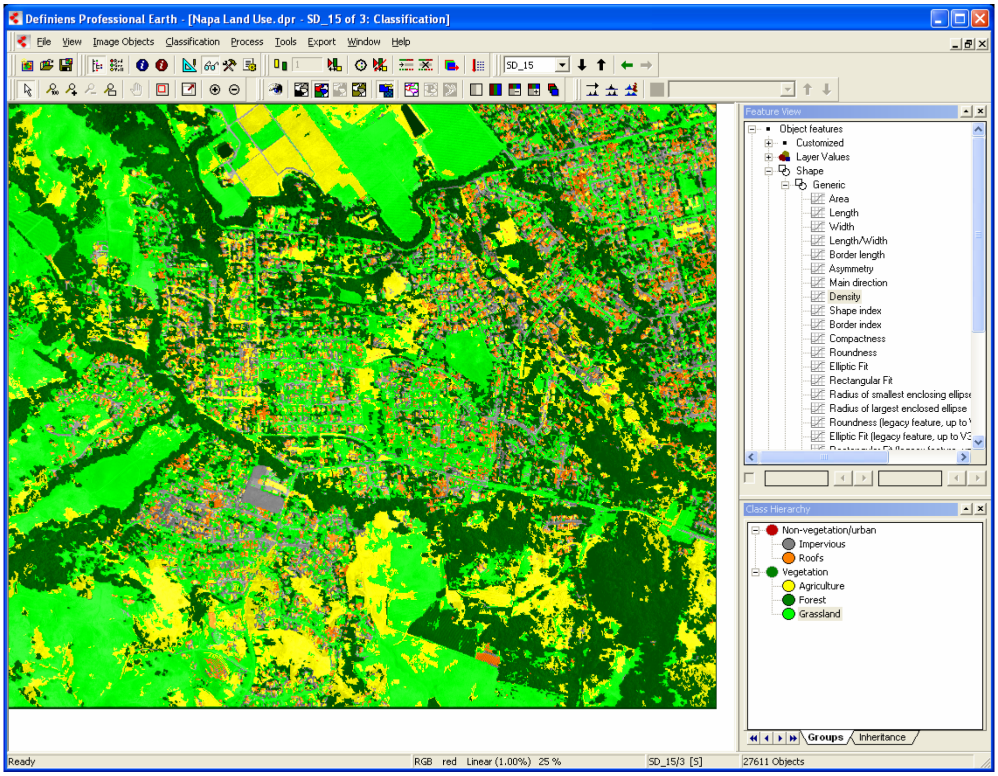


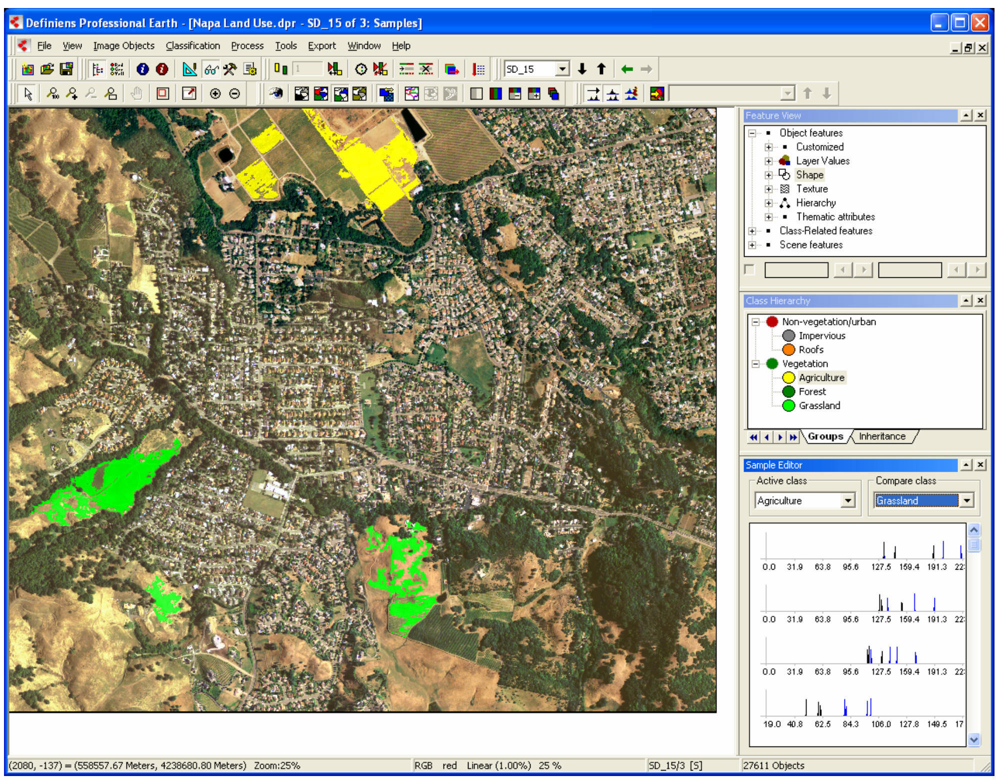
Looking at the Class Evaluation tab (pictured below), we can see that the **elevation/slope** value of 7.24 was what gave that object a **Grassland** membership of 0.706.



In addition, you might see that some objects are not classified. Since eCognition is not a wall-to-wall classifier, it will classify only the objects into the classes that it calculates a membership for; any other objects will be left blank.

Experiment with how changing your lower or upper limits in some of your fuzzy rule sets will change your classification. For example, changing the **Grassland** fuzzy range of **elevation/slope** from (**2-8**) to (**2-17**) gives the classification result below. While this classification result maps the grass in the urban better, it incorrectly classifies some of the **Agriculture** as **Grassland**.





13. You can also try adding a nearest neighbor classifier into the classification with the fuzzy membership functions, for a hybrid classification. You would do this just like the exercise in the introductory workshop – assigning samples to classes that need them (for example, **Grassland vs. Agriculture** is especially in need of them here), making sure that the samples offer *new* information to the classification, and then classifying again.

Make samples for both **Agriculture** and **Grassland** in preparation for the next lesson.

Lesson 3: Feature Space Optimization

a. Then to go **Tools|Feature Space Optimization.**

Feature Space Optimization (FSO) is an automated tool that selects features that best separate classes (based on your samples).

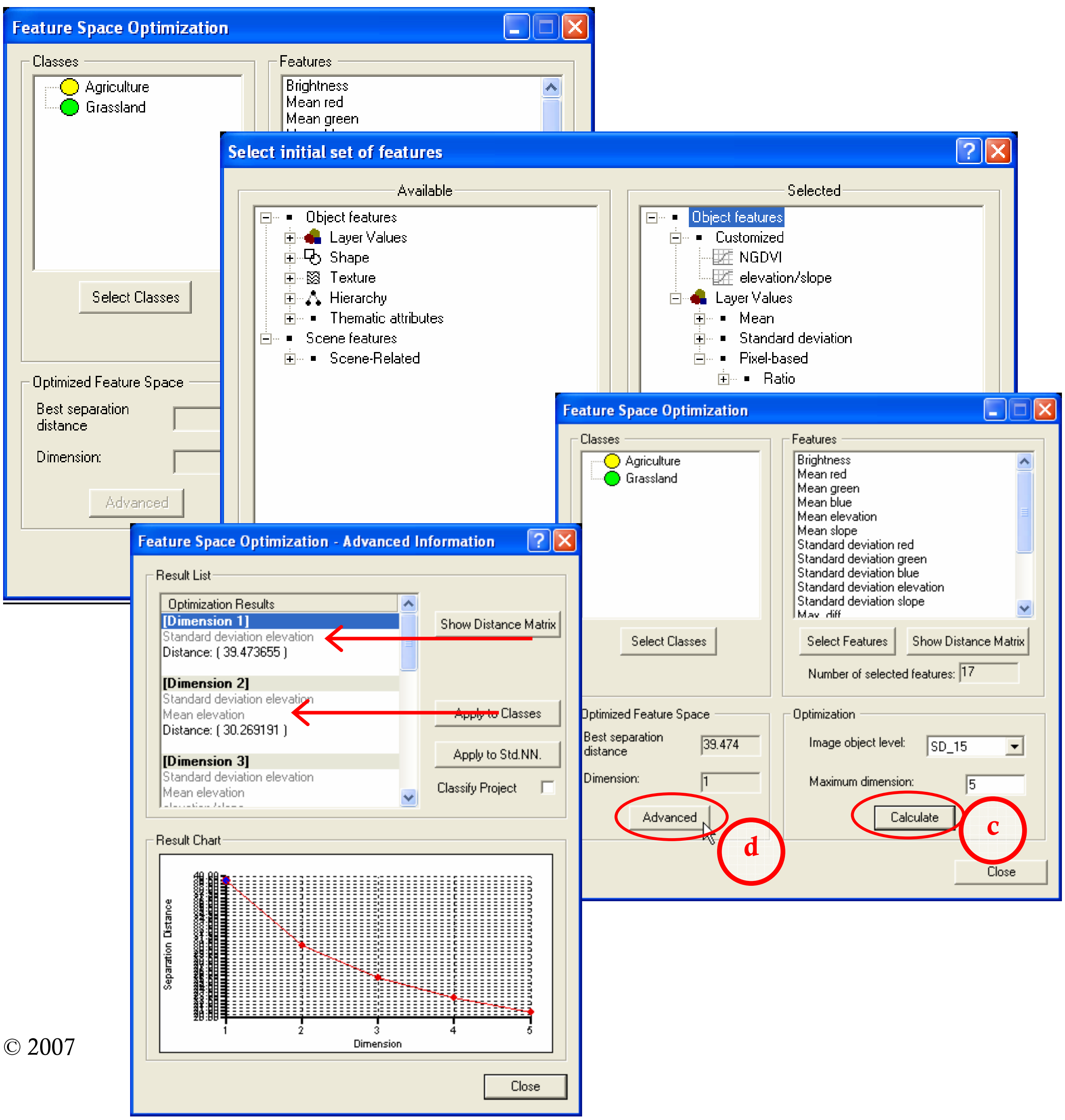
b. Click on **Select Features**, and select whichever features you want to test if they will distinguish between the two classes. Here, I've added NGDVI, elevation/slope, all the layer means, layer standard deviations, and pixel-based ratios.

HINT: Stay away from texture features for the sake of time (they take forever!) Also, don't add too many or you will be waiting a long time!

c. Choose the **SD_15** segmentation level, and **5** maximum dimensions. Then click **Calculate.**

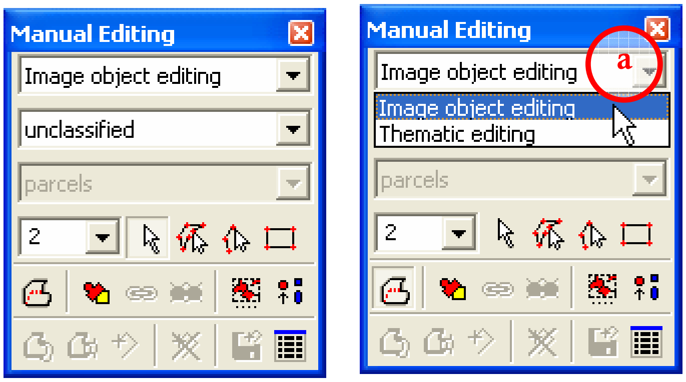
d. Click **Advanced**, and the FSO information appears, showing your most distinguishing feature (**Standard deviation elevation)**, following by the second more distinguishing feature (**Mean elevation)**, etc. These are features you can now place in the Nearest Neighbor Classifier to improve your classification between these two "problem" classes!

Obviously **Mean elevation** is best at separating these two land uses. Now remove **Mean elevation** and try again!



Lesson 4: Manual Editing of your Objects

1. When all else fails, you can always manually edit your segments and/or classified image in eCognition by simply clicking on the **Manual Editing** button to show the toolbar.



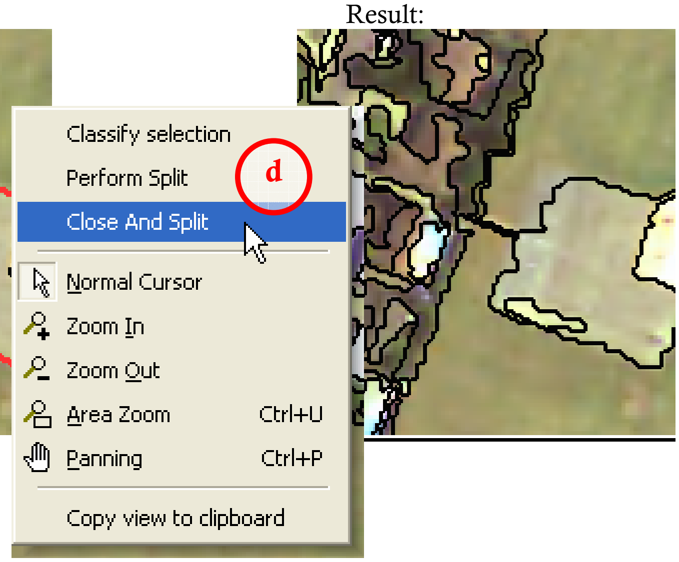
a. Choose **Image object editing** from the drop-down menu.

b. Zoom into the "problem" area that you want to manual perform a segment cutting/splitting.

c. Click on the "Cut Object Manually" tool ( ), and then click on one side of the segment boundary and then the other.

d. Right-click, and choose "Close and Split" or "Perform Split."

Result:



2. To perform a manual classification edit:

a. Choose **Image object editing** from the drop-down menu.

b. Zoom into the "problem" area that you want to manual perform a classification edit.

c. Click on the "Classify image objects" tool ( ), and then choose the class you want to change an object ***to*** from the second drop-down menu.

d. Right-click, and choose "Close and Split" or "Perform Split."