

Hybrid Classification – Pervious vs. Impervious Surfaces

Project Summary

A hybrid classification approach (i.e., use of supervised and unsupervised classification methods) in ArcGIS 10 was used to investigate the proportional areas of pervious and impervious surfaces in a Sacramento County neighborhood. Approximately 150 supervised training samples were acquired for 10 land cover types, including several land cover types representing pervious and impervious surfaces. The resulting unsupervised classification resulted in identifying 12 classes, including shadows, asphalt, concrete, roofs, metal, pools, trees/vegetation, grass, and dirt/mulch. Excluding land cover types that could not be identified as pervious or impervious (e.g., shadows), the neighborhood encompassed by the Citrus Heights SW Quadrant was comprised of about 42% pervious surfaces, and about 58% impervious surfaces.

Purpose

The purpose of this project was to utilize both unsupervised classification methods and supervised classification methods, including the use of dendograms, to develop a detailed land cover classification scheme in a Sacramento County neighborhood to calculate the relative area of pervious surfaces and impervious surfaces. Pervious surfaces represent land cover types that absorb water, such as trees and vegetation, and impervious surfaces represent land cover types of the built environment that repel water.

Methods

Study Area and Imagery

The study area of this project was the Citrus Heights SW Quadrant, an area in northeast Sacramento County encompassing part of North Highlands to the north, portions of Carmichael and Fair Oaks to the south and east, and a portion of the Arden-Arcade area to the west.

Aerial imagery from the U.S. Department of Agriculture was downloaded from the Cal-Atlas website (atlas.ca.gov), referred to as “2009 Combined NIR NAIP” for the Citrus Heights SW Quadrant (**Figure 1**). This imagery is comprised of four bands, including near infrared (NIR).

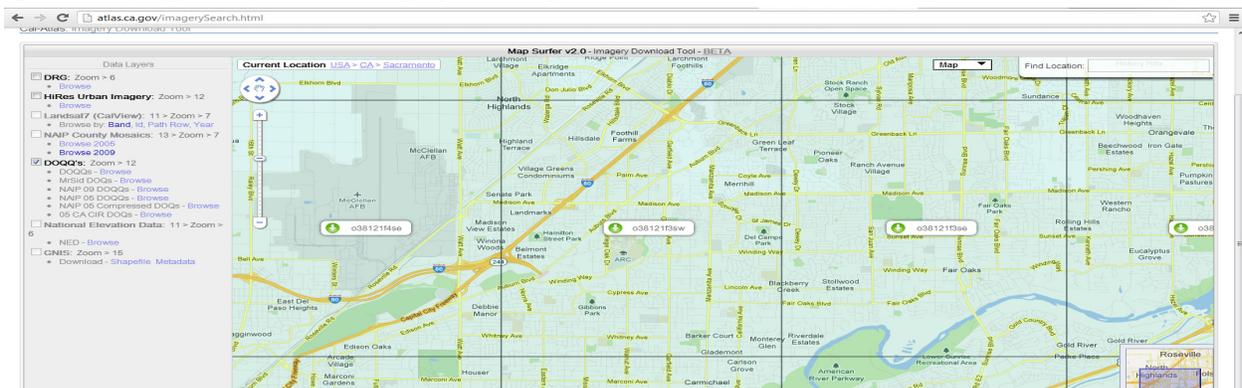


Figure 1. Citrus Heights SW Quadrant NAIP aerial imagery downloaded from Cal-Atlas website.

Exploratory Unsupervised Classification

An exploratory unsupervised classification was first conducted using 10 classes, and resulted in three cover types representing trees and vegetation, four cover types representing rooftops and concrete, two cover types representing roads and rooftops, and one class representing dirt and dry grass (**Figure 2**).

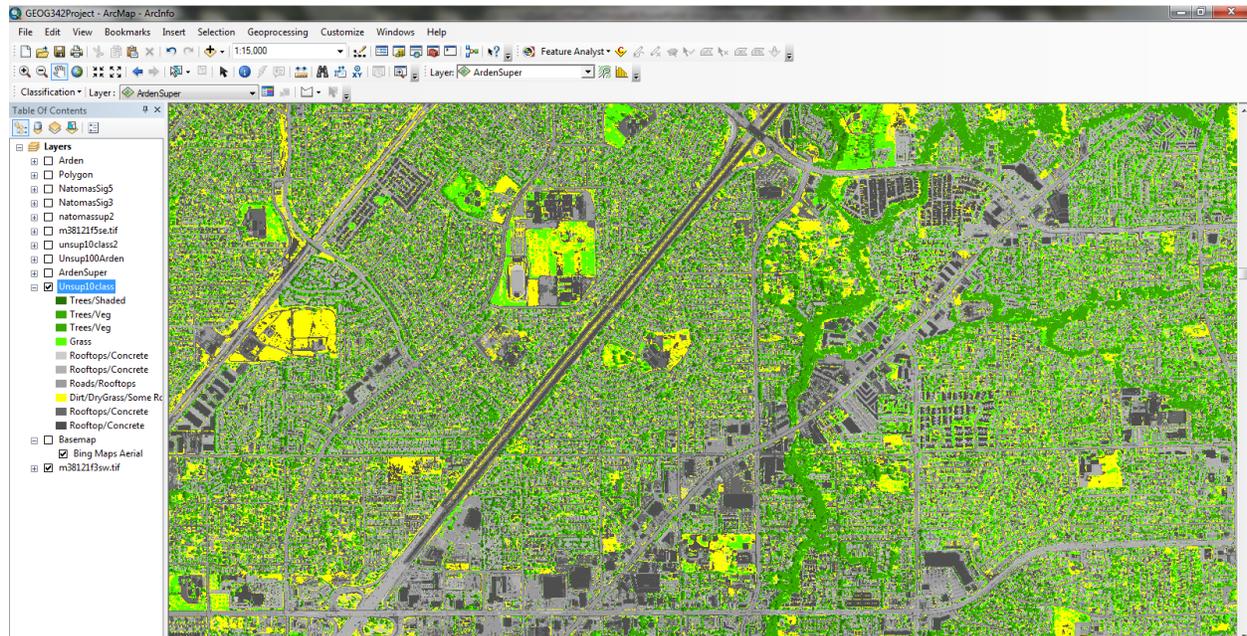


Figure 2. Resulting unsupervised classification using 10 classes.

Results of this exploratory unsupervised classification indicated that the following land cover types were mixed together:

- Asphalt and concrete
- Residential roofs and asphalt
- Commercial roofs, flat residential roofs, and driveways
- Dry grass/dirt, and asphalt
- Clay tile roofs and dirt/dry grass

While some of these cover types likely were mixed together due to similarities in surface composition (i.e., asphalt roofs and asphalt roads, clay tile roofs and dirt), other classes were simply mixed together due to a lack of classes used in this classification scheme.

Supervised Classification

Training samples were delineated in ArcGIS, with the assistance of Bing aerial imagery, for the following land cover types. Emphasis was placed on particular classes based on the results of the exploratory unsupervised classification described above.

- Dirt/dry grass (22 samples)
- Asphalt road (19 samples)
- Concrete (6 samples)
- Residential roof (30 samples)
- Commercial roof (22 samples)
- Trees (31 samples)
- Green grass (14 samples)
- Shaded road (6 samples)
- Sidewalk (8 samples)
- Pool (15 samples)

A subset of the resulting training classes are shown in **Figure 3**. Approximately one-third of the training classes were set aside for potential future use in an accuracy assessment.

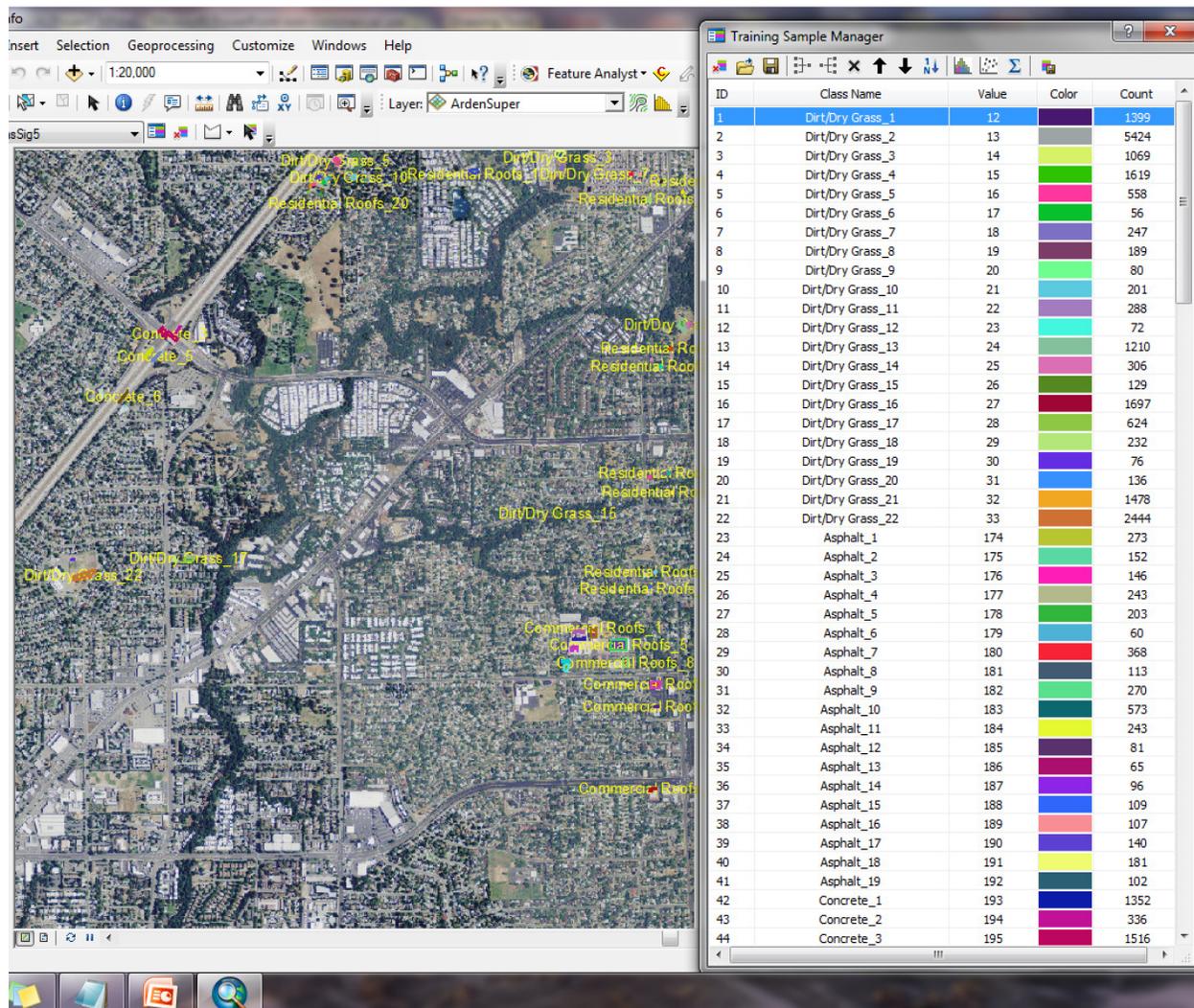


Figure 3. Training samples created for a supervised classification.

Unsupervised Classification

An unsupervised classification was executed in ArcGIS using approximately 100 classes. The resulting classification is shown in **Figure 4**.

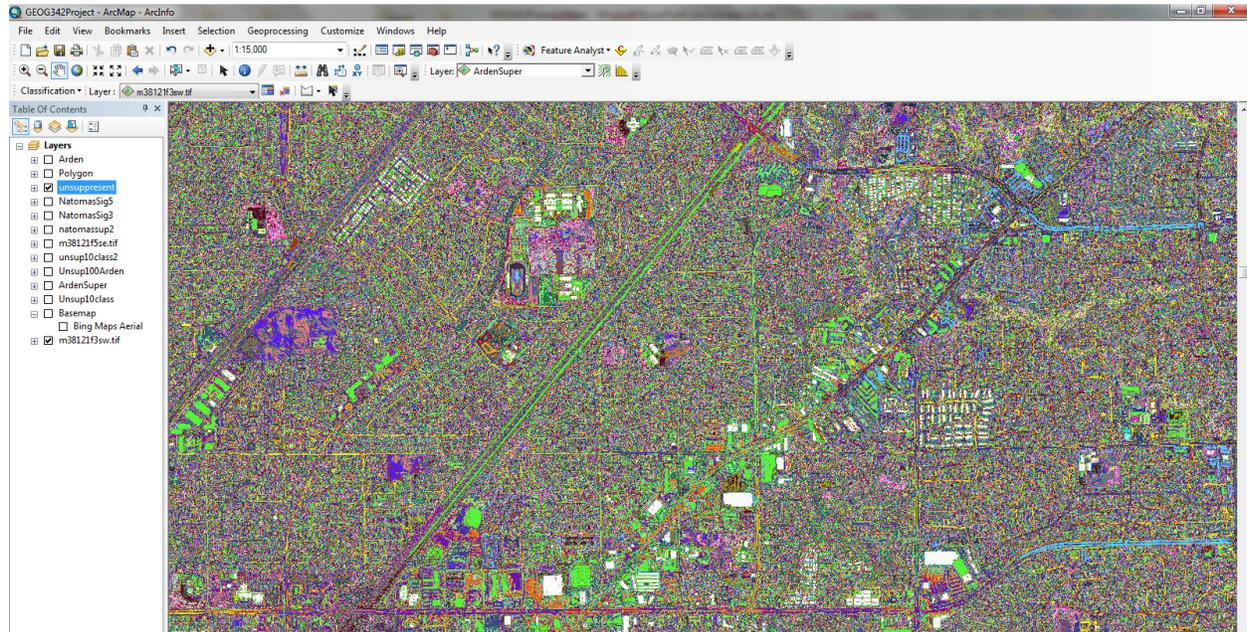


Figure 4. Resulting classification from an unsupervised classification in ArcGIS.

Evaluation of Spectral Signatures

The spectral signatures for the ~150 training samples were combined using Microsoft Notepad with the ~100 unknown spectral signatures associated with the unsupervised classification described above. The Dendrogram tool was executed in ArcGIS to identify known spectral signatures that were most similar to each of the unknown spectral signatures. Selected screenshots of the combined dendrogram are shown in **Figure 5**. Next, I removed the color associated with each of the unsupervised classes in order to go through each class individually, using aerial imagery and the results of the dendrogram to identify a land cover type associated with each of the ~100 spectral signatures. The resulting classification included 8 classes, including shadows, trees/vegetation, grass, dirt/mulch, asphalt, concrete, metal, and pools (**Figure 6**).

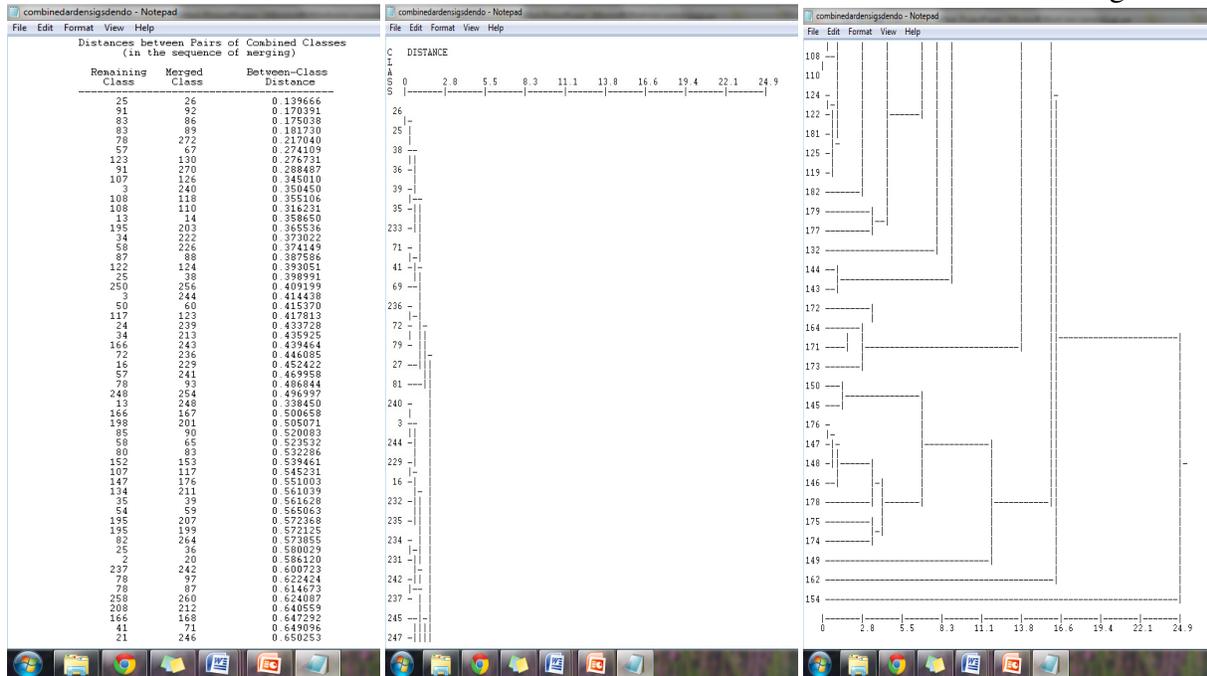


Figure 5. Selected screenshots of the combined dendrogram for the known and unknown spectral signatures.

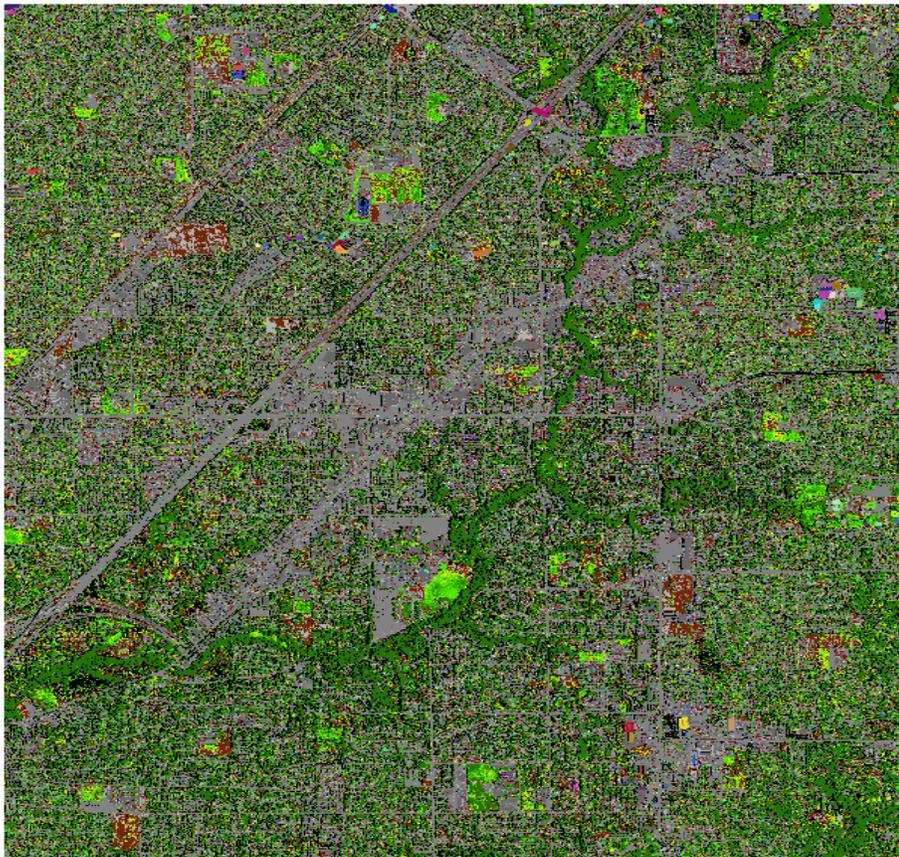


Figure 6. Resulting classification of the unknown spectral signatures.

Reclass

The Reclass tool in ArcGIS was used to combine and organize the spectral signatures into information classes. Twelve classes resulted, including one for shadows, one for trees/vegetation, one for green grass, one for asphalt, one for metal, one for pools, one for dirt/dry grass, two for concrete, one for mixed impervious surfaces, and one unknown class (Figure 7).

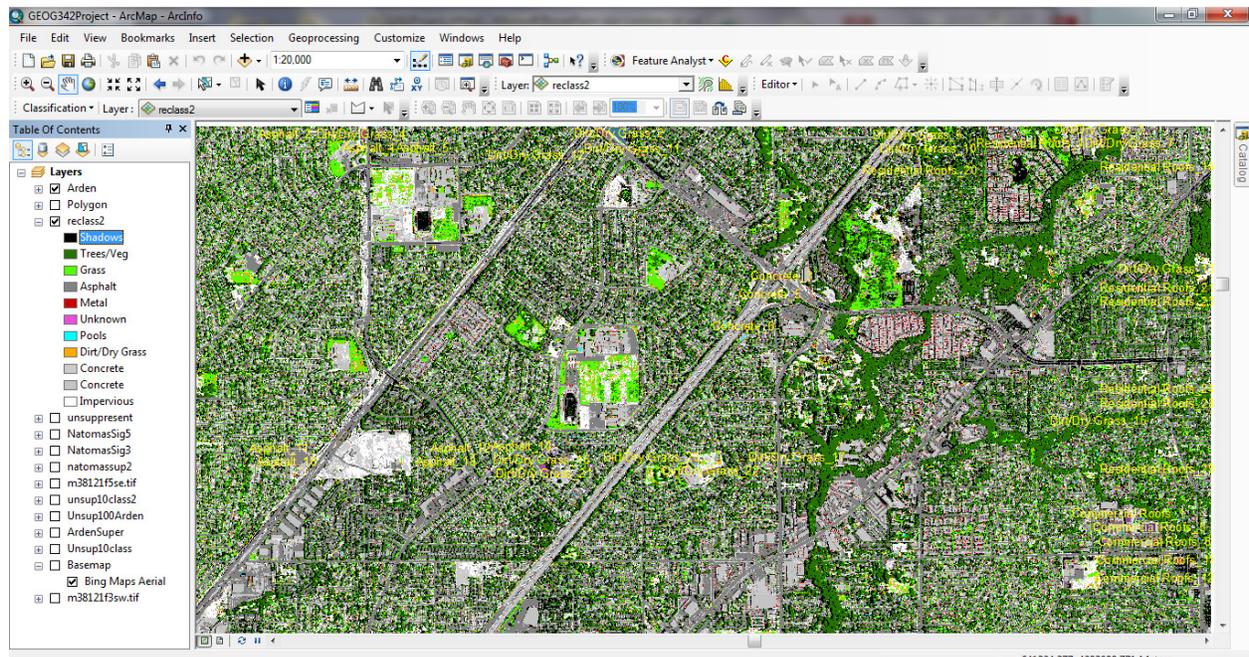


Figure 7. Resulting classification after using the reclass tool in ArcGIS.

Pervious and Impervious Surfaces

Trees/vegetation, grass, and dirt/mulch were assumed to represent pervious surfaces, while asphalt, concrete, roofs, metal, and pools were assumed to represent impervious surfaces. The shadows and unknown classes could not be identified as pervious or impervious surfaces. The areas of each of the land cover classes were acquired from ArcGIS and exported to a Microsoft Excel spreadsheet (Table 1). Asphalt represented the largest amount of area of the neighborhood (about 29%), followed by trees/vegetation (22%), shadows (18%), concrete/roofs (8%), grass (8%), concrete (5%), dirt/dry grass (2%), metal (1%), and pools and “unknown” (<1%).

Table 1 also displays the overall aerial proportions of pervious (31.8%), impervious (43.3%) and unknown (i.e., shadow and unknown classes) (24.9%) cover types. Because shadows could not be identified as representing pervious or impervious surfaces, the areas representing shadows (and the unknown class) were not used in calculating the overall percentages of pervious and impervious areas. The overall percentage areas represented by pervious and impervious surfaces was 42.3% and 57.7%, respectively (Table 1).

Table 1. Calculated areas and proportions of each land cover type, apportioned into pervious and impervious surfaces.

Individual Class Proportions			Unknown, Pervious and Impervious			Pervious vs. Impervious	
Class	Area	%	Class	Area	%	Total minus unknown =	35551051
Shadows	8354971	17.6	Unknown	11787749	24.9	% Pervious =	42.3
Tree/Veg	10525637	22.2	Pervious	15036901	31.8	% Impervious =	57.7
Grass	3613228	7.6	Impervious	20514150	43.3		
Asphalt	13659020	28.9					
Metal	675801	1.4					
Unknown	93386	0.2					
Pools	85889	0.2					
Dirt/DryGrass	898036	1.9					
Concrete	2390909	5.1					
Concrete/Roofs	3702531	7.8					
Mixed	3339392	7.1					
Total	47338800	100.0					

Difficulties

Difficulties encountered included identifying some of the unknown spectral signatures that made up very small areas in the aerial imagery. These classes required using higher resolution aerial imagery and the combined dendrogram results to identify what they represented. However, some classes could not be identified. Additional difficulties related to the “confusion” with asphalt roads and asphalt composition roofs, and also with clay tile roofs and dirt surfaces. An additional difficulty was differentiating tree surfaces and shadows between and among trees.

Discussion and Conclusions

This hybrid classification worked very well for differentiating pervious and impervious surfaces, and showed that this particular area was represented by about 42% pervious surfaces (i.e., trees, vegetation, grass, and dirt/mulch) and about 58% impervious surfaces (i.e., asphalt, concrete, roofs, metal, and pools). However, these areas exclude the areas represented by shadows, which comprised about 18% of the total area, and an additional 7% of the total area which included a mixture of pervious and impervious surfaces (i.e., roofs, asphalt, and dirt). In order to develop a more refined cover type classification, higher resolution aerial imagery would likely be needed. Additionally, an unsupervised classification of potentially 150 to 200 classes may also be desired to develop a more refined classification of pervious and impervious surfaces.