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Geography 342: Remote Sensing

Land Cover Mapping of a Housing Subdivision in Elk Grove, California

Abstract

The widespread conversion of agricultural land to urban environments has caused an exponential increase in water impermeable surfaces like rooftops, streets, and sidewalks. Water impermeable surfaces, or impervious surfaces, do not absorb as much surface water and greatly increase the risk of urban flooding and negatively affect local watershed ecology. This project compares two supervised classification methods, an ENVI workflow and an ArcGIS workflow, used to map land cover change from 2002 to 2011 in a housing subdivision in Elk Grove, California. The author found that both methods produced similar results for the 2011 classification, but significantly different results for the 2002 classification. The ArcGIS workflow experienced considerable difficulty distinguishing sparsely vegetated agricultural land from bare earth. An accuracy assessment was not performed, so it is difficult to evaluate which method produced more accurate results. However, based on visual observations, it appears that the ENVI workflow produced slightly more accurate results for both images.

Introduction

As of 2008, half of the world's population (over 3.2 billion people) was living in urban centers, and by 2030 urban centers will support over 4.9 billion people (UN 2005). Minimizing the impact of this rapid urban growth and sprawl will be one of the greatest and most important environmental challenges of the 21st century.

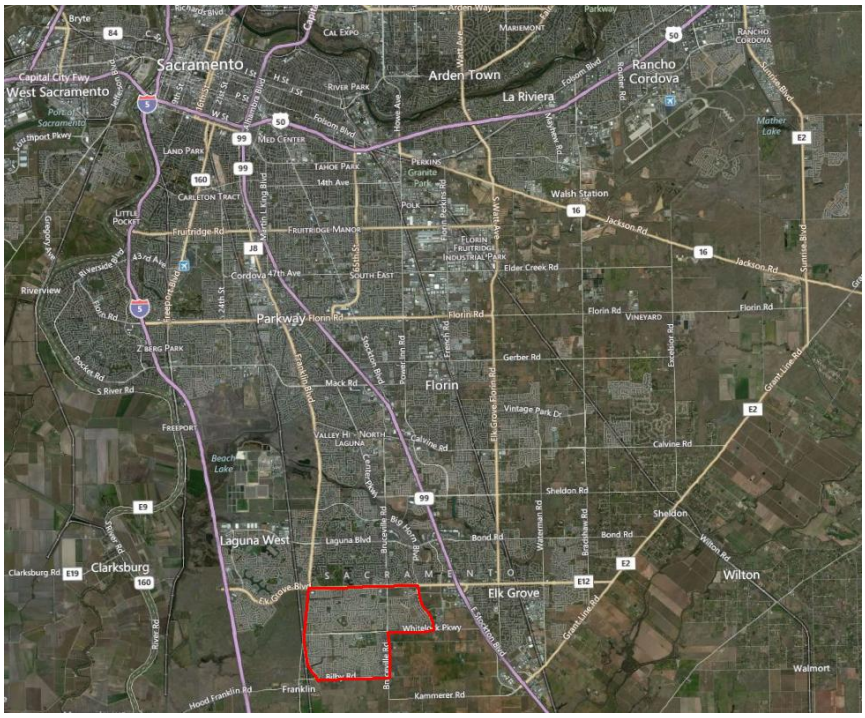

Figure 1. Project boundary.

Rapid urbanization of the world's population over the last century has resulted in the replacement of natural landscapes with impervious surfaces such as roads, houses, buildings, and parking lots (Weng 2012). These impervious surfaces are constructed of water impermeable substances like concrete, asphalt, bricks, and stone and have a significant impact on hydrology, geomorphology, and watershed ecosystems (Konrad 2003). Impervious surfaces have been shown to increase the risk of urban flooding and the frequency of 1-2 year floods (Konrad 2003). The adverse effects of impervious surfaces can be reduced by more effective research, urban planning, and urban design.

The city of Elk Grove, located in central Sacramento County, California, was named the fastest growing city with a population over 100,000 in the U.S. in 2004-2005 (U.S. Census Bureau 2000). During that time period, the city population increased by 12%. This project uses two different supervised classification methods, an ENVI based workflow and an ArcGIS based workflow, to independently assess land cover change on a tract of land in Elk Grove. The project area, located in the southern portion of Elk Grove, is located west of Highway 99 and is approximately 2959 acres and was in the initial stages of housing development in 2002.

Methods

High resolution orthorectified photographs were used as the base layer for image classification. An orthorectified image has been corrected for distortions caused by the shape of the camera lens, terrain relief, and camera tilt. Two sets of high resolution orthorectified photographs were used, one acquired in May 9, 2002 and the other on April 9, 2011. The two image sets were acquired during the same season in an attempt to reduce variability in vegetation. All imagery was acquired from EarthExplorer (earthexplorer.usgs.gov/) and has a 2-foot resolution.

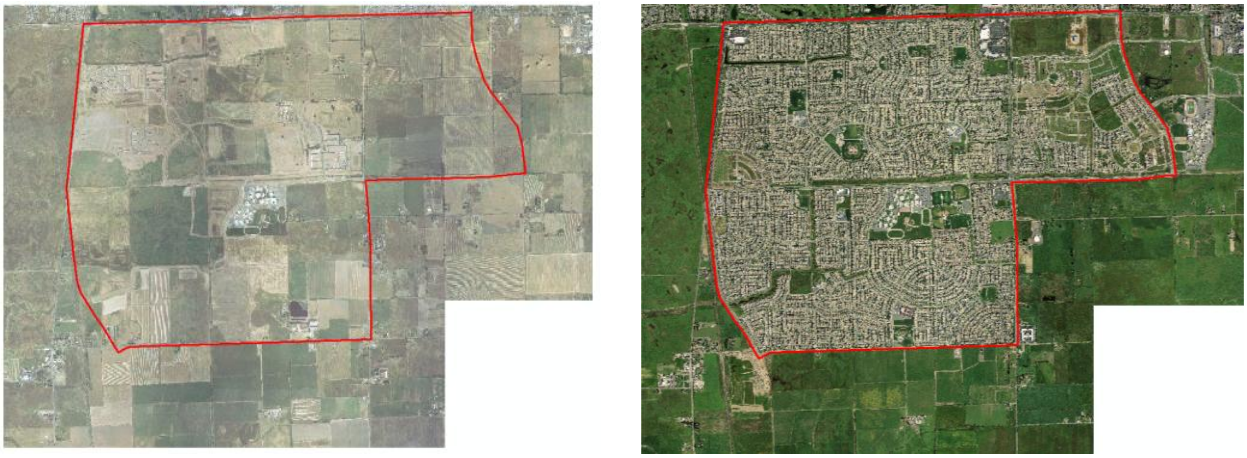

Figure 2. 2002 mosaicked image on left, 2011 mosaicked image on right.

A large part of this project was obtaining and preparing the imagery for classification. Each set of imagery (May 2002 and April 2011) is composed of 11 scenes that were downloaded in batches and then mosaicked together. I ran two sets of supervised classifications, one with the ArcGIS Image Classification toolbar (Interactive Supervised Classification) and the other using ENVI. I chose five different land cover classes: urban, bare earth, water, shadow, and vegetation. The urban classification largely consisted of parking lots, rooftops, and sidewalks.

I used the Image Classification toolbar in ArcGIS to create 25 training sites (when applicable) for each land cover class for the 2002 image and then completed the same task for the 2011 image. The 2002 image, as seen in Figure 2, features almost no water within the project site and consists largely of bare earth and mixed vegetation. When choosing the training sites, care was taken to ensure that each training site provided a valid and homogeneous representation of the land cover. Training sites were grouped by land cover class and saved as shapefiles.

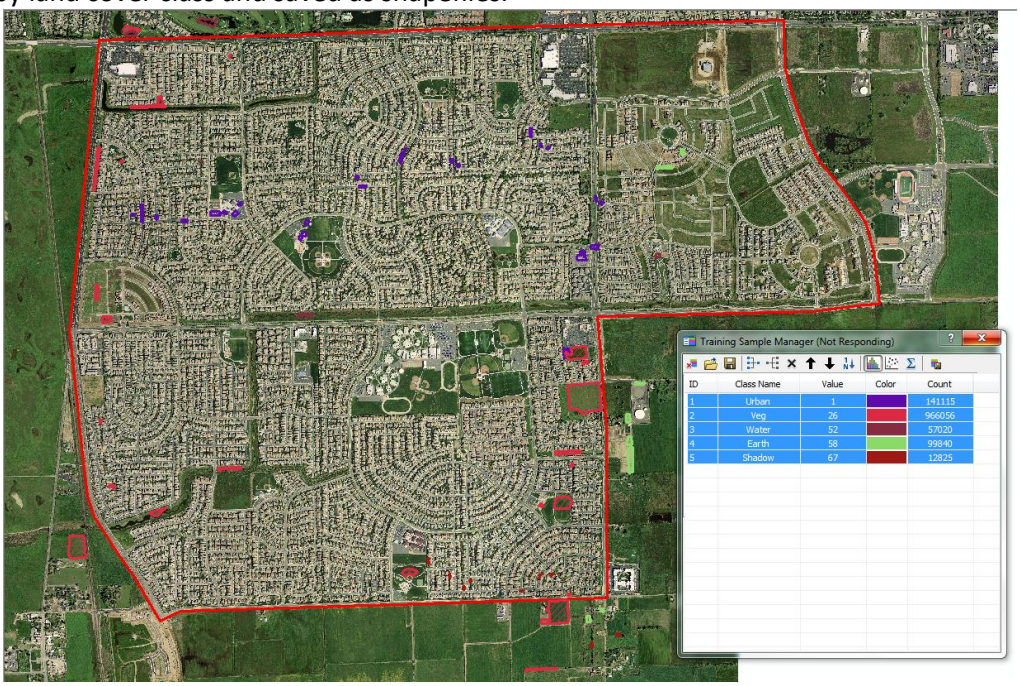

Figure 3. Creating training sites using the image classification toolbar in ArcGIS..

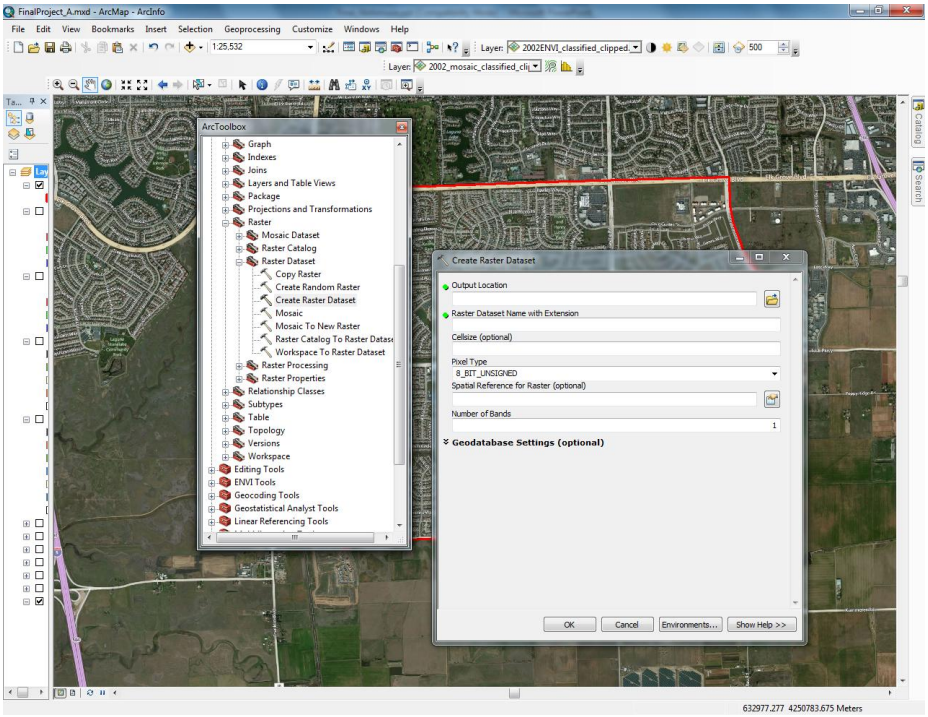

Figure 4. ArcGIS supervised classification workflow.

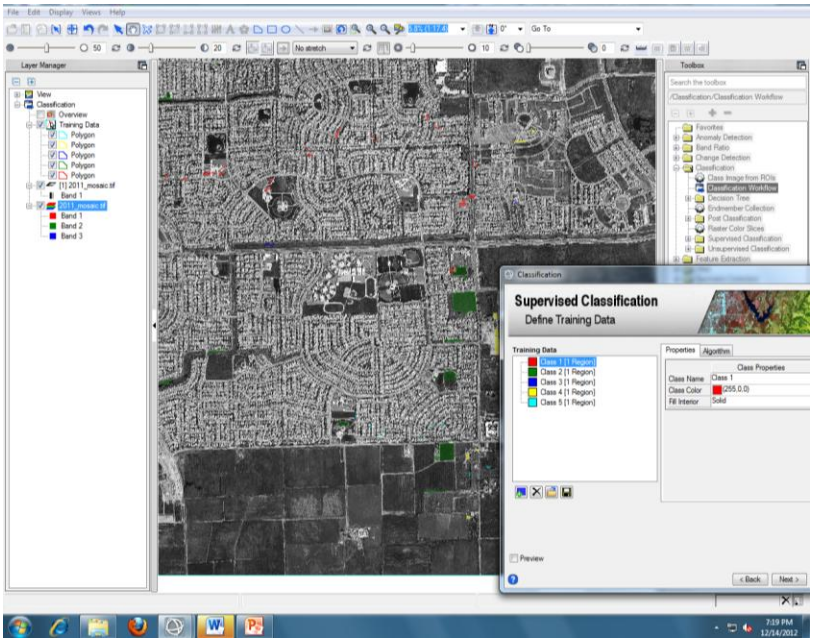

Figure 5. ENVI supervised classification workflow.

ArcGIS Supervised Image Classification

The training shapefiles were loaded for the 2002 and 2011 images and signature files were compiled. An Interactive Supervised Classification was run by inputting the correct signature file and the classified image was then clipped to the project area.

ENVI Supervised Image Classification

The supervised image classification workflow tool provides an extremely easy and straightforward method to classify an image. By following the workflow, I performed a supervised classification on both the 2002 and 2011 images using the training sample shapefiles that were created in ArcGIS as my ENVI regions of interest.

Results and Discussion

Land cover classifications from the two different methods are summarized in the Figure 6. The two methods yielded significantly different classifications even though they used the same training sites. In the 2002 image, the most significant difference was the amount of bare earth while in the 2011 image, the ENVI image classification found more vegetation and water than the ArcGIS method.

Without running an image accuracy assessment, it is difficult to say which method produced more accurate results. However, based on my previous experiences and visual interpretation, I found that the ENVI method produced more usable results and an easier workflow. I was pleased with the results of the 2011 image classification and found that both ENVI and ArcGIS produced relatively similar results, although ENVI appeared to more consistently and correctly identify shadows.

ENVI

	2002 Land Cover (%)	2011 Land Cover (%)
Urban	7.4	49.9
Vegetation	65.0	22.5
Water	0.0	7.6
Bare Earth	27.5	6.1
Shadow	0.0	13.9

ArcGIS

	2002 Land Cover (%)	2011 Land Cover (%)
Urban	14.8	50.6
Vegetation	83.4	28.6
Water	0.0	5.9
Bare Earth	1.1	7.0
Shadow	0.8	7.9

Figure 6. Land cover classification results.

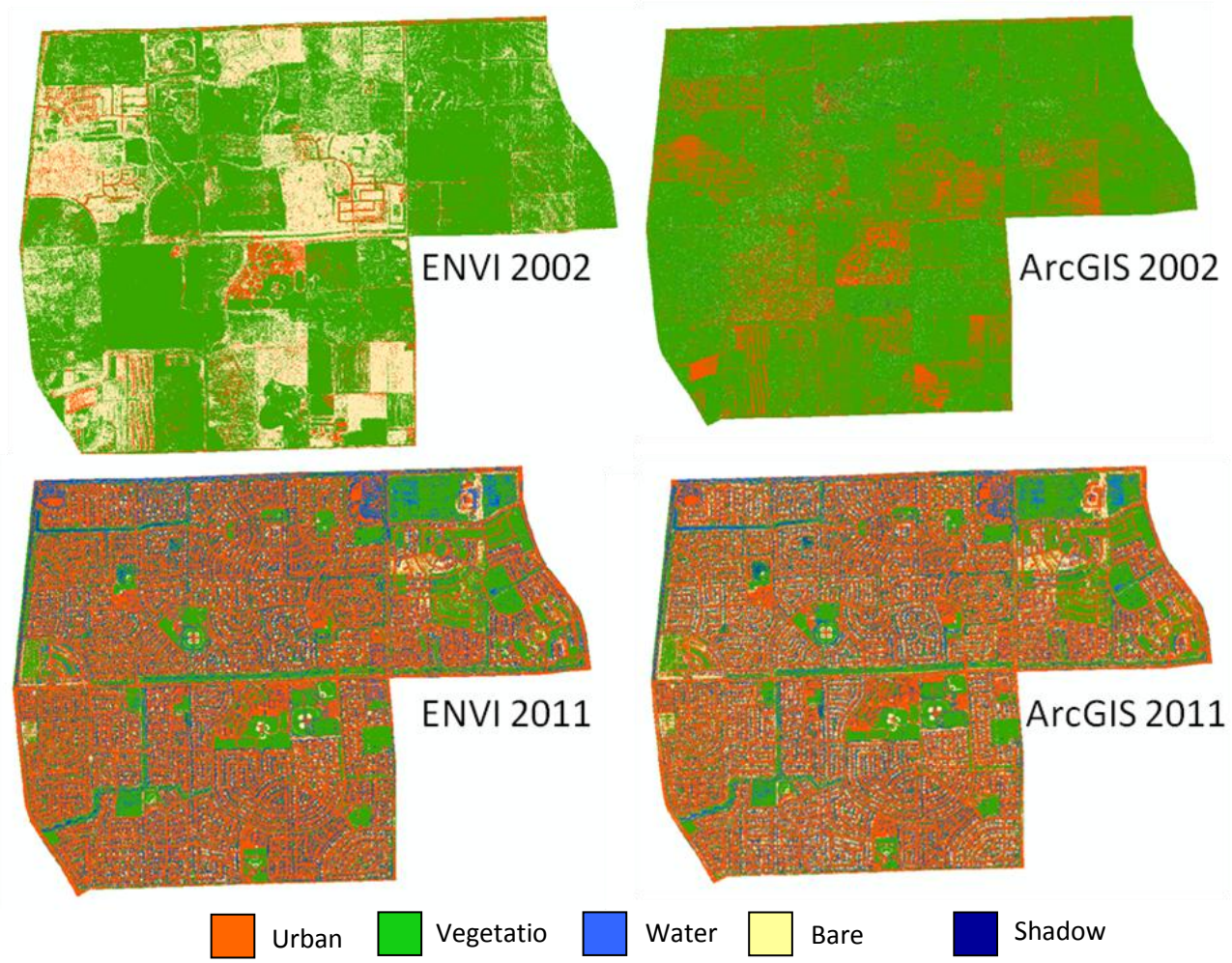

Figure 7. Land cover classification results.

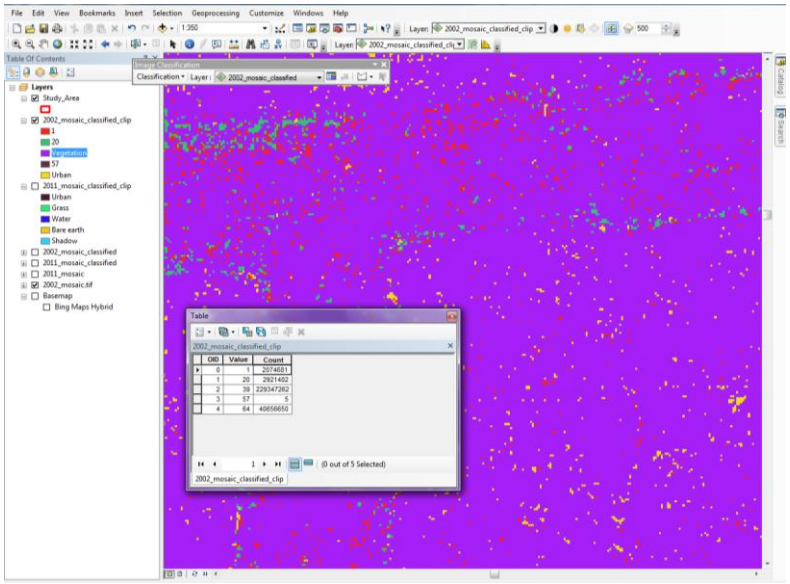

Figure 8. Isolated pixels created in the ArcGIS workflow.

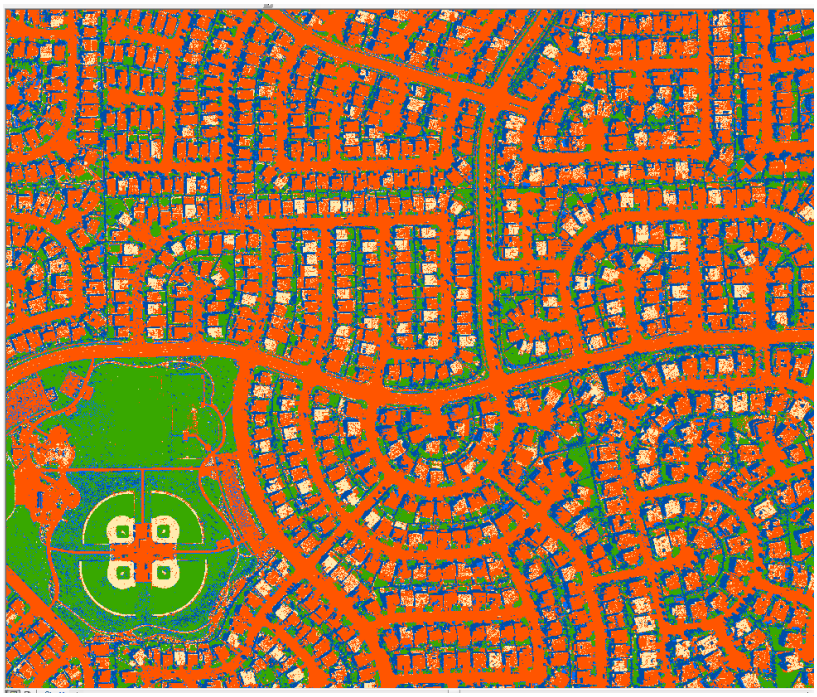

Figure 8. Close up of ENVI 2011 classification.

Both the ENVI and ArcGIS workflow struggled to differentiate between bare earth and vegetation in the 2002 image. In this situation, using a false color satellite composite would have worked perfectly to spectrally differentiate these two classes. In addition to the sparsely vegetated agricultural fields, I noticed that terra cotta tile roof tops were commonly categorized as bare earth in both the ENVI and ArcGIS workflows. This could possibly be remedied in the future with additional training sites.

Figure 8 depicts the high level of accuracy produced in the ENVI 2011 supervised classification. Shadows cast by houses and trees are easily distinguishable and the bare earth in the baseball field is also identifiable. I was extremely pleased with the ENVI 2011 supervised classification results. If I were to attempt this project again, I would try to acquire higher resolution satellite imagery for classification. I initially attempted a basic land cover classification of Sacramento County using false color LANDSAT 4-5 TM imagery (30-meter resolution) and was disappointed with the inaccurate results. In particular, urban areas with high canopy density like the midtown and downtown regions of Sacramento City produced the poorest results. While using satellite imagery would have more easily distinguished bare earth from vegetation, the low resolution satellite imagery would have probably produced extremely inaccurate results for such a small project area.

References

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