For submission to "Best of Feature Analyst 2003"

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From Report Titled:

Upper San Diego River Improvement Plan (USDRIP) Impervious Surface Mapping Remote Sensing Research 2002-2003

Problem Statement and Project Overview

Our objective is to estimate the average proportion of hardscape for the **Single-Family Residential** land use categories (as defined by San Diego Association of Governments, *SANDAG*) in the unincorporated areas of the County of San Diego. In order to do this, a representative area must first be used as a pilot study to test our methodology. This area of interest (AOI) is in the upper portion of the San Diego Watershed. This area is a region of interest because it contains a representative balance of urban and rural land uses found in San Diego. In this study, the AOI was classified into five size ranges of Single-Family Residential land use and then field sampled and classified as pervious/impervious (hardscape/softscape). These data were then compared to Space Imaging's IKONOS 4-meter multispectral imagery of the same area. *Visual Learning System's Feature Analyst (FA)* extension for *ESRI's ArcGIS 8.3* was used to classify the image scene into pervious and impervious surfaces. The final product details the impervious surface coefficients for the single-family residential land use by size and indicates the relative accuracy of these classifications in the AOI. In concert with other research, these impervious surface coefficients can help determine the potential storm water impact of the Single Family Residential land use in the County of San Diego by parcel size.

Results and Discussion

The initial results indicate that the FA model extracted hardscape in most circumstances in an efficient manner. It correctly classified most of the hardscape not concealed by vegetation as seen in Figure 5.2.2. Moreover, FA modeled an inverse relationship between single-family residential parcel size and impervious surface percent. FA worked well for obvious features in the imagery, like unpaved roads and large roof tops that are more spectrally and spatially consistent. However, smaller features and those hardscape features that are spectrally similar to some softscape features were misclassified.
In general, the results suggest that the model created in FA accurately predicts the impervious surface area in our study area. An overall accuracy of 96.7% suggests the model can locate impervious surfaces well. However, misclassification of areas under tree cover and in shadow is evident thereby effectively reducing the amount of impervious surface area predicted. Additional ground sampling points, collected without respect to land use type, are necessary to draw conclusions on the classification results for the entire study area. Differences between modeled and observed are most likely attributed to the loss of information using medium resolution imagery such as IKONOS 4-meter. Using enhanced or higher resolution imagery could allow for better results. Additional fine-tuning of the model could also positively affect the results.

Results of Feature Analyst by Parcel Acreage Size Group for Single-Family Residential

Size Class	Observations (N)	Area in Size Class in Acres	Percent Impervious
0--1/4	768	1956	15.30 %
1/4--1/2	562	753	7.00 %
1/2—3/4	175	476	3.81 %
3/4--1	73	355	2.11 %
Greater than 1	160	1723	1.06 %
Total	1738	3630	

Accuracy Assessment – Error Matrix and Kappa

Relative agreement between modeled results and ground reference data were assessed using an error matrix. Overall accuracy, which is computed by dividing the total correct (sum of the major diagonal) by the total count in the error matrix, was found to be 96.7%. Assessment of the user's accuracy or reliability (the probability that a feature classified in the model actually represents that category on the ground) for both categories is also described in the table. User's accuracies were found to be 100% and 93.9% for pervious and impervious classifications respectively. Conversely, this translates to 0% and 6.1% commission error (chance of incorrect classification of each category) for pervious and impervious classifications respectively. The classification product had a Kappa of 0.993 when compared to reference data for single family residential, which is in the upper limit of the range for good agreement (a Kappa of 1 is good agreement and a Kappa of less than 0.4 is poor agreement)(Fitzgerald and Lees, 1994).

Cross-tabulation Kappa test for agreement

Observed * Modeled Crosstabulation

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
CLASS_ID * samp_class	60	100.0%	0	.0%	60	100.0%

CLASS_ID * samp_class Crosstabulation

			samp_class		
			Impervious	Pervious	Total
CLASS_ID	Impervious	Count	31	2	33
		Expected Count	17.1	16.0	33.0
		% within CLASS_ID	93.9%	6.1%	100.0%
	Pervious	Count	0	27	27
		Expected Count	14.0	13.1	27.0
		% within CLASS_ID	.0%	100.0%	100.0%
Total		Count	31	29	60
		Expected Count	31.0	29.0	60.0
		% within CLASS_ID	51.7%	48.3%	100.0%

Symmetric Measures

		Value	Asymp. Std. Error(a)	Approx. T(b)	Approx. Sig.
Measure of Agreement	Kappa	.933	.046	7.244	.000
N of Valid Cases		60			

a Not assuming the null hypothesis.

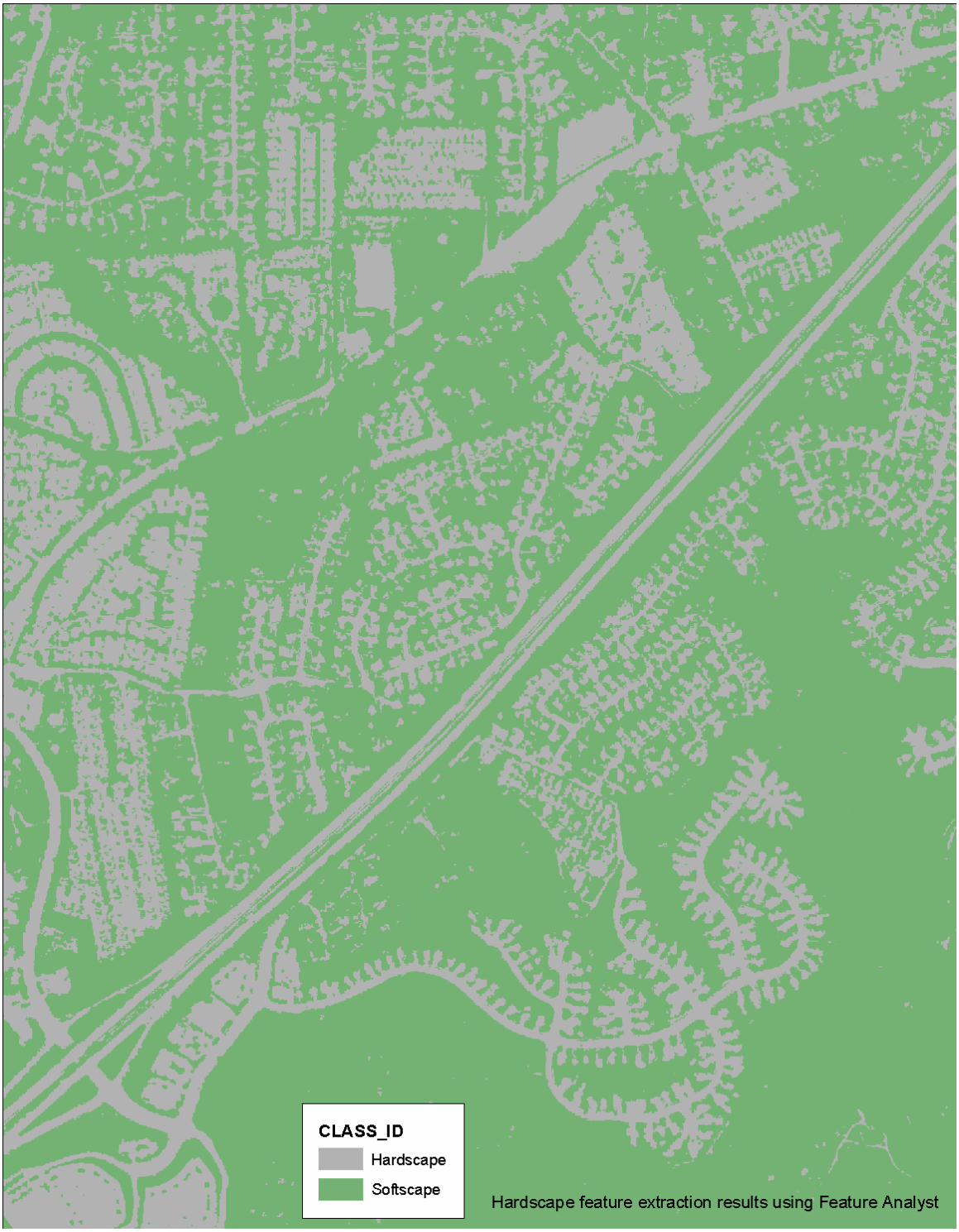
b Using the asymptotic standard error assuming the null hypothesis. *The proportion of agreements after chance has been excluded is 93%, kappa (N = 395) = .933, p < .0005

Conclusion

The overall results of this study indicate two things. **First**, that the Feature Analyst software is a very powerful tool that requires relatively little time to refine and train in order to generate classifications which are predominately correct. These classifications of impervious surface cover are useful because they can belie the overall health of a watershed or sub-basin. **Second,** that not only is impervious surface cover tied to land use type, but that this surface is statistically linked to parcel size. This relationship should be considered when evaluating individual land use types (or their occupants) for their contribution to water quality in San Diego County.

Further assessment of the accuracy of the results would provide useful information as to the ability of the present model to adequately map impervious surface features. As mentioned previously, this could be accomplished by increasing the ground sampling points to include random samples that span the entire study area and represent both impervious and pervious surface categories in a statistically significant manner without respect to land use type. Reasonable accuracy of the results with respect to reference data would allow for the creation of impervious surface coefficients that could be applied at a regional scale. In doing so, watershed health could be estimated using coefficients developed using local data that is not derived from generic literature-based values.

Improvement of the results could be accomplished by applying the impervious surface model developed in Feature Analyst to higher resolution imagery. Although other image sources available to the County of San Diego, DPLU consist of only true color and false color infrared datasets (i.e., no multispectral bands), their high resolution with a ground resolution element of 2 to 3 feet may provide results that are superior to those presented here.



Hardscape feature extraction results using Feature Analyst

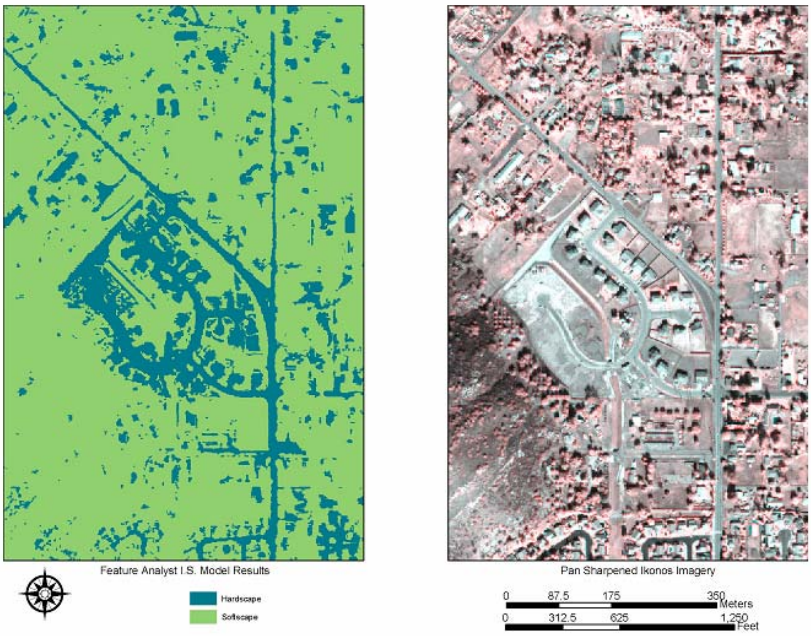


Figure 5.2.2 Impervious surfaces extracted from IKONOS 4-meter imagery using Feature Analyst.