LAND COVER MAPPING
FOR IMPERVIOUS SURFACES

STATEMENT OF THE PROBLEM

Monitoring the extent of impervious areas within the limits of the City of Columbia is a requirement of the city government to support:

1) Estimates of urban development and
2) The use of hydrologic and water quality models applied to urban watersheds.

PRESENT SITUATION

The City of Columbia wants to have an estimate of the impervious area as a measure of urban development. The same information is also needed as an input parameter to hydrologic models.

POTENTIAL BENEFITS

Monitoring of the extent of impervious surface areas in the City of Columbia provides city management with a basic parameter to measure urban development and helps the efforts to meet the more strict EPA regulations of water quality in urban watersheds.

TECHNICAL APPROACH TAKEN

The project was carried out using as data source the four IKONOS-2 multispectral bands (0.45–0.53 μm, 0.52 – 0.61μm, 0.64 – 0.72 μm, 0.77 – 0.88 μm) with a 4 m spatial resolution. The IKONOS-2 data was obtained on 30 April 2000 at 10:48 AM. Sun azimuth was 138.74 degrees and sun elevation was 60.74 degrees. The nominal data collection azimuth was 352.42 degrees and the nominal data collection elevation was 62.89 degrees.
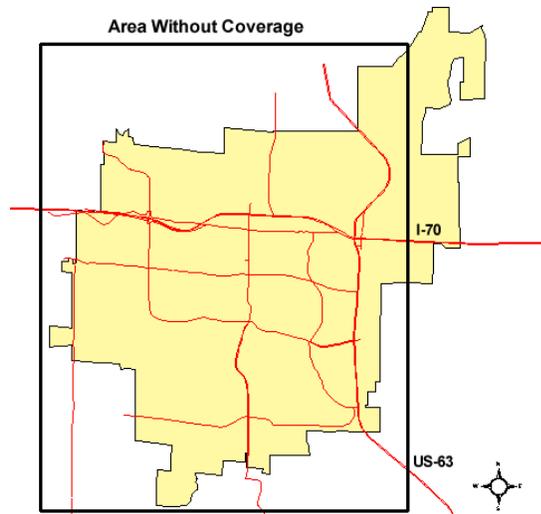
Figure 1. Map showing the outline of the City of Columbia and the IKONOS coverage used for impervious surface mapping.
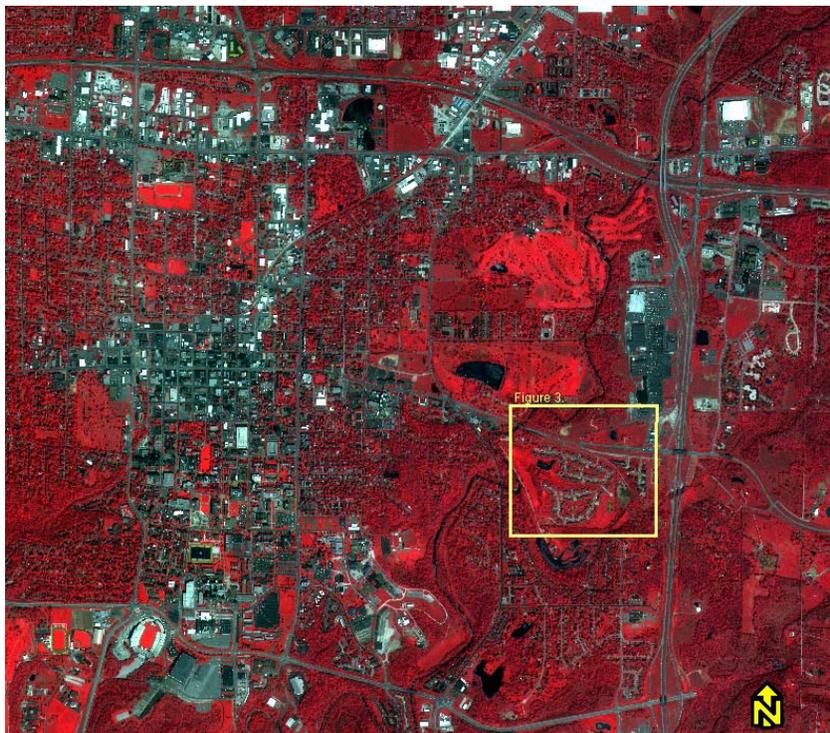

Figure 2. Multispectral IKONOS image (RGB=4,3,2) with 4 meter spatial resolution sharpened with IKONOS 1 meter panchromatic image of part of the City of Columbia. Inset box shows outline of image used in Figure 3.

A Supervised Maximum Likelihood Classifier was used to map impervious surfaces. Training sites were defined initially for ten classes. Impervious surfaces were included into two classes of concrete surfaces (roads and parking areas) and one class for asphalt surfaces. The other seven classes that were defined included two classes with different types of types of bare ground (associated with different exposed soil horizons and poorly developed grass), two classes for grass (well and fairly well developed grassland), two classes for water bodies (identified by the presence or absence of sediments in suspension) and woodlands. Single-pixel training sets (Gong and Howarth, 1990) with approximately 100 pixels in each were established for each class. The classification results were combined into six major classes. The impervious areas were combined into one class. Bare soil was kept in two classes. One of them could be associated with urban and rural areas where the ground surface was in part covered by vegetation consisting of a mixture of poorly developed grass and stressed or dead crops and the other was associated with construction sites alone. Woodlands and water were the other two classes in the final ground cover map.

Figure 3 is a representative area outside downtown Columbia that illustrates in more detail the six land cover/land use classes used to present the results of the supervised classification to detect impervious classes. When this figure is evaluated in reference to Figure 4 that displays the classification results it is possible to show the significance of the spatial resolution in obtaining good classification results. All the impervious surfaces within the apartment complex are identified with great accuracy. The same can be said for the major roads located in the area.

Figure 3 : IKONOS 4-meter multispectral image sharpened with IKONOS 1-m panchromatic band showing the Broadway Village apartment complex in east Columbia.
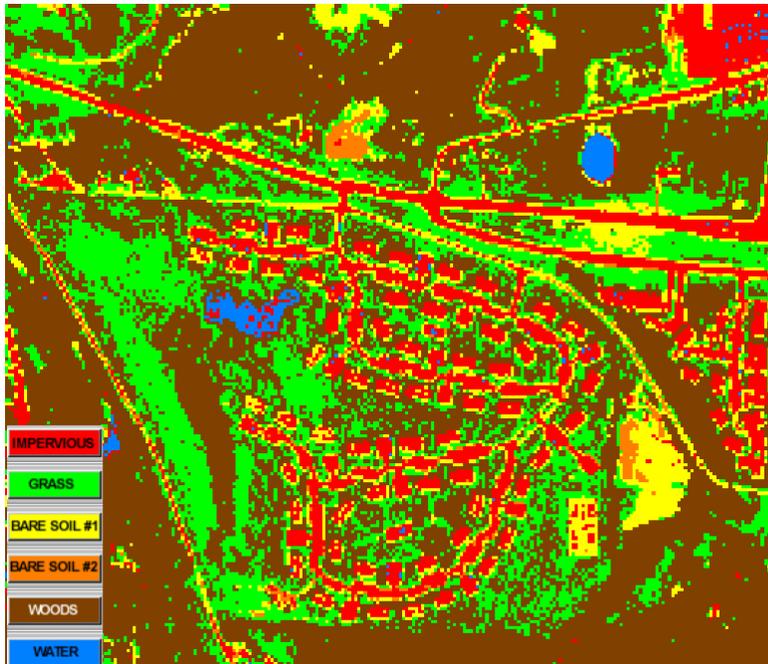
Figure 4 – Result of supervised maximum likelihood classification of IKONOS multispectral images (4 meter) showing impervious surfaces (red). The overall accuracy of this classification is approximately 91%.

Accuracy assessment was based on the evaluation of classification results for the pure pixels selected a priori throughout the image. The confusion or error matrix produced for the Columbia area had an overall accuracy level of 91%.

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Raw Count Confusion matrix for:
            Hydrologic Land Cover Mapping

Overall Accuracy: 90.968% from 310 observations

Kappa statistic: 0.892

-----------------------------------------------------------------------
Classified File\Reference File
-----------------------------------------------------------------------
                Impervious    Grass Bare soil  Bare soil      Woods
                ----------    ----- ---------- ----------     -----
Impervious          46          0        0          0           0
Grass                0         41        0          0           1
Bare soil #1         2          0       54          3           0
Bare soil #2         0          0        4         47           0
Woods                0          9        0          0          49
Water                2          0        0          0           0
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Table 1. Confusion or error matrix for the classification of impervious surface in the City of Columbia using IKONOS multispectral data (30 April 2000).

ANTICIPATED IMPLEMENTATION PROBLEMS IN URBAN GOVERNMENT

The government agency interested in implementing this approach to be used on a routine basis should have the appropriate image processing hardware and software in place. Once the training and testing sites for supervised classification of impervious surface have been defined, it will be possible to produce land cover maps cover maps from IKONOS multispectral data sets showing impervious surface with more than 90% accuracy.

ADDITIONAL WORK

The information contained in IKONOS pan band ($0.45 – 0.90$ μm) still has to be evaluated in combination with the multispectral bands.

PROJECT PARTICIPANTS

Dr. Aderbal C. Corrêa and Mr. Janggam Adhityawarma of the Center for Environmental Technology (CENTECH), Department of Civil and Environmental Engineering, carried out the project for ICREST.