LAND USE CLASSIFICATION
CARROLL AND HEARD COUNTIES, GEORGIA

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Executive Summary

The purpose of this land-use classification study of Carroll and Heard Counties, Georgia is to provide an up-to-date assessment of land use patterns for the West Georgia Watershed Assessment.

The classification was accomplished using satellite imagery acquired by the Landsat 7 ETM+ vehicle on October 1, 2001 as the primary data source. Thematic map layers from the Georgia Environmental Atlas, such as roads and hydrographic coverages, were used to enhance the satellite data. Direct observation helped to provide final ground truthing for the analysis.

The land-use classification was developed using the following steps:

1. Establishment of land-use classes to describe the obvious features of the ground surface in the study area.
2. Identification of type areas for each of the classes, using both the satellite imagery and direct ground observations
3. ERDAS Imagine 8.5 image processing software was used to gather spectral characteristics of each type land-use area.
4. A parametric maximum-likelihood supervised classification was then performed using Imagine 8.5.
5. Field checks were performed to verify the accuracy of the classification.
6. The pixel-based raster classification was then converted to a vector-based thematic map, and final adjustments to the classification were performed.
7. The final adjustments included reclassifying areas of rural industry to agricultural land use and the masking of smoke-obscured areas in the west portion of the study area.

Ten land-use classes were established for the study area. These classes are: medium density residential, urban/industrial/commercial/institutional, commercial/agricultural, transportation, overgrown clear-cut/pasture, recent clear-cuts/bare ground, evergreen forest, deciduous forest, nonforested wetland, streams/ponds/reservoirs.

An accuracy assessment of the land-use classification was performed. The assessment was conducted by comparing the classification map with direct field observations of land-use and land cover. An accuracy rate of 85% was determined for this study. This rating is considered excellent for Landsat-based image classifications.

The end result of this study is a land-use classification map that displays the ten classes established, and it is enclosed in this report as a hard copy plot and in digital raster format and digital vector format.

Introduction

In December, 2001, the Center for Water Resources and the Geospatial Applications Research Center at the State University of West Georgia were contracted by Hayes, James and Associates to perform an up-to-date land-use classification of Carroll and Heard Counties in West Georgia to support the hydrologic modeling phase of the West Georgia Watershed Assessment. Since the land use classification maps currently available from the State of Georgia are now more than seven years old and are relatively non-specific, it was clear that a more current and regionally-focused land use classification foe West Georgia was needed.

This report forwards the results of the new land use classification study. This written portion discusses methodology and rationale for the study, while the actual classification is contained in digital image files, as well as paper maps, which accompany this report.

Project Background

The land-use classification of Carroll and Heard Counties was performed using remotely-sensed satellite imagery as well as direct human observations from the ground. The satellite imagery was captured on October 1, 2001 by the Landsat 7 Enhanced Thematic Mapper (ETM) vehicle currently in orbit. Fieldwork was accomplished during the period December 2001 through March 2002.

Seven spectral bands accompany Landsat imagery, each comprising a distinct data layer within a single photographic image. Bands 1-3 are in the visible light spectrum, bands 4, 5, and 7 are in the infrared region, and band 6 is a thermal band. The resolution of bands 1-5 and 7 is 30 meters (each pixel therefore represents a square portion of the Earth's surface 30 meters along each side). For this study, band 6 was not utilized.

Image processing software uses three color "guns" (red, green, and blue, or RGB) to visually display spectral data from various remote sensing tools. By displaying different combinations of the spectral bands, different features of the ground surface can be emphasized. For example, an RGB combination of bands 4, 5, and 3 emphasizes physiographic features of the ground surface; an RGB combination of bands 5, 4, and 2 emphasizes vegetation and cultural features. For this study, most visual appraisals of land use were accomplished using the 5, 4, 2 band combination, as displayed on a desktop computer screen.

Quantitative analysis of the Landsat scene was accomplished using software that statistically processed the spectral qualities of each pixel and grouped the pixels into classes based on their similarity. By judiciously choosing pixels that represent different land-use or land-cover types and training the software to use these types as its model, a land-use classification can be created.

Study Area

This study encompasses Carroll and Heard Counties, Georgia. A rectangular bounding area that extends slightly beyond the map extents of the two counties (including all portions of both counties) was established. The Universal Transverse Mercator (UTM) coordinates of the margins of this rectangular bounding area are:

Southeast corner:	705,902E/3,664,744N
Southwest corner:	650,528E/3,664,744N
Northeast corner:	705,902E/3,745,684N
Northwest corner:	650,528E/3,745,684N

These coordinates were established in reference to the 1983 North American Datum (NAD83).

Data Sources

A Landsat 7 ETM+ scene captured on October 1, 2001 was selected because of its near-current date-of-capture and because no clouds were present on the scene. This image formed the foundation of this study, and is included in digital format as an attachment to this report (WGWA Land-Use V1\L71019037_037210011001.tif).

Derived data layers, in the form of Arc/Info coverages, were used to help interpret visible features on the satellite image and spectral signatures in the laboratory:

Political boundaries data were acquired from the Georgia GIS Data Clearinghouse (www.gis.state.ga.us), distributed as county-wide coverages. Roads data were acquired from Environmental Systems Research Institute (ESRI) as statewide data, and were clipped to county boundaries. County-wide hydrographic data layers were acquired from Hayes, James and Associates as linear and polygonal streams coverages. National Wetlands Inventory data were acquired from the Fish and Wildlife Service as 7.5-minute quadrangle coverages. The coverages were joined and clipped to county boundaries.

Methodology

Three broad steps were taken to produce the land use classification in this study. The initial step was to analyze the satellite data using specialized image processing software. The resulting product was then field checked. Finally, the analyzed data were converted to a GIS-compatible format where refinements to the analysis were executed.

Image processing

ERDAS Imagine 8.5 was the image processing software chosen for this study. Imagine 8.5 has the advantage of displaying multiple image types and GIS data layers simultaneously, and has the full range of analytical tools capable of performing a broad range of image processing tasks.

Using Imagine 8.5, a rectangular subscene encompassing the area of interest (see Exhibit 1; also enclosed in digital format: WGWA Land-Use V2\tif\westga2001_sub.tif and WGWA Land-Use V2\img\westga2001_sub.img) was clipped from the full Landsat 7 ETM scene and projected to UTM Zone 16 parameters, referenced to the NAD83 datum and Geographic Reference System 1980 (GRS80) spheroid. Units were defined as meters.

Initially, land use categories were determined prior to analyzing the satellite image. First-hand knowledge of the study area as well as a review of prior land-use studies in the area contributed to the development of a class list.

The second step involved choosing representative or type areas on the ground for each of the land-use classes. Once at least one type area for each class was identified, the type area was located on the satellite image and a spectral signature for the class was determined.

The spectral signature of a given land-use class is determined by defining the range of color values for the group of pixels that define the type area. In Imagine 8.5, the spectral signature is determined by using a "region grow" command: the type area is located on the satellite image, and a region of spectrally-similar pixels is chosen within the type area by growing an area of interest that is constrained by spectral parameters defined by the analyst. For example, a lake might be chosen by the analyst to represent the land-use class "deep water." The analyst would then pick a representative pixel within the lake area, and have Imagine 8.5 "grow" an area of interest around the chosen pixel by including all pixels that have spectral values within 5 spectral units of the initial pixel in the area of interest. Since deep water shows very little variation in spectral values, a single area of interest with a narrow spectral constraint (5 units) that is grown in this fashion would successfully identify all other areas of deep water in the study area.

In type areas where a larger variation of spectral values exists, for instance in pasture or forest areas, relaxing the spectral value constraints is necessary to grow a region that better represents the class. So instead of a spectral constraint of 5 units (which was used for the deep water class), an analyst might constrain the region to pixels lying within 20 spectral units of the initial pixel's value.

Once spectral signatures for each of the land-use classes were secured, a single color-coded signature file was compiled that contained all classes within the study area. Each color in the signature file was used to distinguish each land-use class from the other.

With the signature file complete, a supervised classification procedure was then run on the study area Landsat subscene. A parametric nearest neighbor routine was applied to the dataset, and the output was verified for general agreement with the general model of land use in the area.

Several iterations of the supervised classification were required to achieve the desired end-product. To obtain the most accurate result, additional areas of interest had to be

defined to better delineate certain land use classes. For example, the "recent clear-cut/bare ground" category needed four separate areas of interest to adequately map these areas in the final classification. This can be ascribed to the high variability of the spectral characteristics of this class - fallen trees, soil, bare rock, and compacted earth all have distinct spectral signatures, and each of these land cover types can be found within the class. Therefore, representative signatures encompassing each of the land cover types needed to be collected and compiled into the final class signature definition.

The classification was initially judged for accuracy in the lab, prior to field checking. Using first-hand knowledge of the study area, the analysts were able to judge whether or not much of the classification was realistic. Once a reasonably accurate classification was obtained, field checks were performed.

Field Checks

Field checks of the accuracy of the classification were performed on at least three different dates, during February and March, 2002. The procedure involved traveling through the study area by car and verifying the accuracy of the classification by direct observation of features on the ground by comparison with a hard-copy map of the classification.

Final Image Processing

The field-checked classification map was next simplified by using a neighborhood algorithm to reclassify isolated pixels. If a single classified pixel was surrounded by pixels of a different value, the single pixel was reassigned a value equal to the dominant pixel value. For example, if all eight neighbors of a single deciduous forest pixel belonged to the evergreen forest class, the single pixel was reclassified as an evergreen forest pixel. The algorithm was applied universally across the map area, and impacted all established land-use classes. The result is a more homogeneous map, with a less "speckled" appearance. It also reduced the coverage file size from 484 MB to about 85 MB (wgwa_rs_disk2\ wgwaluse.img).

GIS Processing

When the accuracy of the classification was deemed sufficient and the image was simplified using the neighborhood algorithm, the raster-based classification image was exported to a vector-based format by initially using Imagine 8.5 to write the raster file to an ESRI-compatible grid stack. This file was then converted to an Arc/Info coverage using Arc/Info Workstation 8.1.

Once the vector file of the classification map was created, final adjustments to the classification were made. These adjustments included manually reclassifying urban/industrial polygons unassociated with population centers and transportation corridors to the agricultural land-use class. The rationale for this operation was to move commercial/industrial polygons that had a high probability of being agricultural

operations (such as confined-feeding barns or poultry-house operations) into their own class. Field checking of this reclassification was limited to several operations in the vicinity of Carrollton.

A second adjustment to the classification involved removing two portions of the study area obscured by smoke from the classification. A polygon-based shapefile of the smoke plumes was created using ArcView 3.2. This shapefile was converted to an Arc/Info coverage and unioned with the classification coverage file. The resulting coverage was queried for the smoke attribute and all affected polygons were reclassified as "smoke/obscured." The reclassified coverage was then dissolved on the land-use attribute.

The rationale for reclassifying the smoke-affected areas was to preserve data accuracy. The spectral characteristics of the smoke-obscured ground most closely resemble medium-density residential land use, and resulted in an unreasonable classification for the affected areas. A small portion of Heard and Carroll Counties was affected by this reclassification; the bulk of the affected areas, however, lie to the west of the study area, in the state of Alabama.

The final classified map was converted from an Arc/Info coverage to an ESRI shapefile using Arc/Info Workstation 8.1.

Land-Use Classes

The land-use classes for this study were developed in cooperation with Hayes, James & Associates. A total of ten classes were defined. An eleventh, non-land-use, category (smoke/obscured) was created to mask inaccurately classified areas caused by negative atmospheric conditions.

The ten land-use classes are defined in the following section:

Medium density residential

This class represents single-family homes built in clusters or as discrete subdivisions. The spectral character of this class is defined by a mix of rooftop, ground-level pavement, grass, shrubbery, forest margin, and tree canopy.

Three signatures were collected in the study area to define the "medium density residential" class:

1. Carrollton, near Lake Carroll and Bankhead Highway, Carroll County (UTM 680,326E/3,718,766N). This area represents an older, established residential development of single-family homes on approximately 1/3-acre lots.

2. Bar J Road at Interstate 20, south of Temple, Carroll County (UTM 684,239E/3,732,854N). This area represents a recently built subdivision (less than two years old) of single-family homes on approximately 1/4-acre lots.

3. Lake Paradise Road near North Van Wert Road, Villa Rica, Carroll County (UTM 689,521E/ 3,737,105N). This area represents a recently built subdivision (less than one year old) of single-family homes on approximately 1/4-acre lots.

Urban/industrial/commercial/institutional

This class represents large buildings surrounded by ground-level pavement or gravel. All polygons with this spectral character that are located within city or town limits or along major transportation corridors were assigned to this class.

1. A large group of individual signatures for this class was collected in the vicinity of the US 27 and GA 166 interchange on the south side of Carrollton, Carroll County (UTM of the approximate centroid of these is 678,888E/3,714,762N). The signatures were taken from industrial and commercial enterprises that include Southwire, Holox, Target, WalMart, Publix, and Home Depot. These signatures were compiled into a single signature that was used to define the class.

Commercial/agricultural

Like the "urban/industrial/commercial/institutional" class described above, this class represents large buildings surrounded by ground-level pavement or gravel. All polygons with this spectral character that are located outside of city or town limits or away from major transportation corridors were assigned to this class.

The spectral signature set that defines this class is identical to the "urban/industrial/commercial/ institutional" class described above. The discriminating character of this class is location.

Transportation

This class represents paved highways and road rights-of-ways wider than approximately 60 meters (2 pixels). The spectral signature includes both concrete and asphalt surfaces.

Five signatures were collected to define the "transportation" class in the study area:

1. GA Highway 166 (Carrollton Bypass) east of Carrollton, Carroll County (UTM 681,730E/3,718,192N). This area is a north-south-oriented stretch of four-lane asphalt-paved limited-access highway.

2. GA Highway 61 about 3 miles south of Villa Rica, Carroll County (UTM 690,745E/3,729,643N). This area is a northeast-southwest-oriented stretch of four-lane asphalt-paved open-access highway.

3. US Interstate Highway 20 southwest of Bremen, Carroll County (UTM 669,650E/3,728,961N). This area is an east-west-oriented stretch of four-lane concrete-paved limited-access highway.

4. US Interstate Highway 20 east of Villa Rica, Carroll County (UTM 696,942E/3,733,286N). This area is an east-west-oriented stretch of four-lane concrete-paved limited-access highway.

5. US Highway 27 north of Centralhatchee, Heard County (UTM 674,337E/3,698,421N). This area is a northwest-southeast-oriented stretch of two-lane asphalt-paved open-access highway.

Overgrown clear-cut/pasture

This class represents established pastures, hay fields, vegetated forest clearings, power-line and pipeline rights-of-ways, and aging clear-cuts where an herbaceous ground cover is well-established.

Five signatures were collected to define the "overgrown clear-cut/pasture" class:

1. Hayfield north of intersection of GA 113 and Spence Road, Carroll County (UTM 679,842E/3,723,286N). This area was maintained as a closely-cropped hayfield in the early autumn of 2001, when the Landsat image used for this study was captured.

2. Hayfield southwest of Spence Road, Carroll County (UTM 679,469E/3,723,668N). This area was maintained as a closely cropped hayfield in the early autumn of 2001.

3. Electric power line right-of-way, south of Otis Ransby Road, Heard County (UTM 686,465E/ 3,684,725N). This is a relatively broad easement that is vegetated with grass and perennial herbs.

4. Pasture southwest of Jim T. Mickle Road, south of Frolona, Heard County (UTM 666,797E/ 3,685,061N). This is a pasture actively grazed by a large cattle herd.

5. Clear-cut southwest of Mason Road, Randolph County, Alabama (UTM 661,130E/3,683,001N). This is an aging, overgrown clear-cut that was heavily vegetated with perennial herbs approximately four feet high during the autumn of 2001.

Recent clear-cuts/bare ground

This class represents areas of recent clear cutting where vegetation has not yet returned as well as areas of disturbed ground associated with construction activity. Inevitably, some overgrazed pasture and very closely cropped hay fields, where a degree of bare earth is exposed, were classified into this category. In addition, three rock quarries were hand-attributed to fall into this class: these are the Vulcan Materials quarries west of Douglasville in Douglas County, on Flat Rock Road in Carroll County, and southeast of Franklin on GA 100 in Heard County.

Four signatures were collected in the study area to define the "recent clear-cuts/bare ground" class:

1. Southwest of the intersection of Macedonia Church and Old Tennessee Roads, Heard County (UTM 663,494E/3,690,537N). This is an area of recent clear cutting; equipment was observed removing trees from the lot during July of 2001.

2. North of the intersection of Pike and Edwards Roads, southeast of Franklin, Heard County (UTM 681,530E/3,680,217N). This is an area of recent clear cutting approximately one-year old, where very limited herbaceous vegetation has returned. The ground surface is mostly loose rock and soil with some wood debris.

3. North end of runway at West Georgia Regional Airport, northwest of Carrollton (UTM 671,075E/3,723,848N). Construction of the runway extension at this facility was underway at the time the Landsat image was captured. This area of interest was largely bare soil.

4. North of intersection of GA Business 1 and US Highway 27, Bremen, Carroll County (UTM 671,559E/3,729,867N). This is a large construction site that appears to be the site of a future strip shopping mall. The area was bare soil at the time the Landsat image was captured.

Evergreen forest

This class represents areas of continuous-canopy mature evergreen (needle-leaved) forest.

Three signatures were collected in the study area to define the "evergreen forest" class:

1. North of Cooksville Road, northwest of Corinth, Heard County (UTM 686,785E/3,682,124N). This is an area of young pine forest, the trees no taller than about 25 feet.

2. South of Otis Ransby Road, northwest of Corinth, Heard County (UTM 686,154E/3,684,694N). This is an area of young pine forest, the trees about 50 feet tall.

3. East of Little Vine Church Road, north of Hulett, Carroll County (UTM 693,693E/3,722,816N). This is an area of mature pine forest, the trees about 80 feet tall.

Deciduous forest

This class represents areas of continuous-canopy mature deciduous (hardwood) forest.

Two signatures were collected in the study area to define the "deciduous forest" class:

1. East of Hays Mill Road, south of Carrollton, Carroll County (UTM 677,218E/3,713,664N). This area is a stand of oak and hickory forest with little understory developed.

2. North of Chapel Road, Southeast of Carrollton, Carroll County (UTM 681,506E/3,714,368N). This area is a stand of oak and hickory forest with some understory developed.

Nonforested wetland

This class represents lowland areas with limited areas of standing water and herbaceous and shrubby vegetation.

Two signatures were collected in the study area to define the "nonforested wetland" class:

1. North of Lowell Road, southeast of Carrollton, Carroll County (UTM 674,708E/3,711,656N). This area represents an open marshy area of woody shrubs, cattails, and other grasses, with small pools of standing water.

2. South of Lowell Road, southeast of Carrollton, Carroll County (UTM 674,596E/3,710,957N). This area represents an open marshy area of cattails, and other grasses.

Streams/ponds/reservoirs

This class represents surface hydrography in the study area, minus nonforested wetlands. This class shows considerable spectral variation due to the broad range of water depths and water margin types present in the study area.

Six signatures were collected in the study area to define the "streams/ponds/reservoirs" class:

1. Lake Carrollton in Carrollton, Carroll County (UTM 680,206E/3,718,974N). This area represents moderately deep water.

2. Sewage treatment plant pond, west of Carrollton, Carroll County (UTM 673,334E/3,716,465N). This area represents shallow water.

3. Plant Wansley cooling water reservoir, Heard County (UTM 681,761E/3,698,935N). This area represents moderately shallow water.

4. Lake Paradise upper pool, Villa Rica, Carroll County (UTM 688,931E/3,736,951N). This area was chosen to represent pond-margin environments.

5. Pond southeast of Bremen, Carroll County (UTM 676,484E/3,730,235N). This area was chosen to represent extremely shallow water.

6. Chattahoochee River south of Franklin, Heard County (UTM 676,579E/3,683,274N). This area was chosen to represent transitional fluvial/lacustrine hydrography.

Accuracy Assessment

The accuracy of the land-use classification was assessed by tabulating comparisons of direct field observations of land-use and land-cover with the classification map. One-hundred field observations were made. Correct classification of these areas was achieved in 85 of the 100 areas, resulting in an accuracy rating of 85%. This rating is considered excellent for Landsat-based image classifications.

The classification was found to be most accurate with the assignment of deciduous and evergreen forests and clear-cut/pasture areas, and less accurate in the assignment of nonforested wetlands (most commonly confused with overgrown clear-cut/pasture), recent clear-cut/bare ground (most commonly confused with overgrown clear-cut/ pasture) and medium density residential (most commonly confused with urban/ industrial/commercial/institutional and evergreen forest).

Final Product

The end result of this study is a land-use classification map. This is enclosed as a hard-copy map plotted at a scale of 1:100,000 (Exhibit 2). Digital copies of the raster-based classification map are also enclosed (WGWA Land-Use V2\img\wgwa_class10.img and WGWA Land-Use V2\img\wgwa_class10_simple.img as well as tagged-image format file equivalents, in WGWA Land-Use V2\tif\wgwa_class10.tif and WGWA Land-Use V2\tif\wgwa_class10_simple.tif). Vector equivalents are also enclosed, in both Arc/Info interchange file format (WGWA Land-Use V2\e00\ wgwaluse.e00) and in ESRI shapefile format (WGWA Land-Use V2\shp\wgwaluse.shp).

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