“Rapid Reconnaissance” for Muddy Creek: A feasibility test of a low-cost method for creating a large-detail GIS land coverage for a small watershed application

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Purpose
To understand land-use water quality linkages at the small watershed scale, land coverage data is needed at fairly high resolution—much higher than what is typically available from public sources such as the National Land Coverage Dataset (NLCD) or other Landsat-derived coverage. But customized high-resolution land coverage data is prohibitively expensive. The purpose of this study is to develop and test a method of creating our own high-resolution land coverage by combining several different free publicly available data layers and then field-checking these using what we termed “rapid reconnaissance” ground truthing.

Land Use and Water Quality
According to the US-EPA, it is estimated that about two-thirds of the pollution in America’s rivers and streams comes from “nonpoint” sources—that is, from stormwater runoff as it moves over city streets, parking lots, agricultural fields, industrial sites, and other areas where pollutants may accumulate. The EPA now actively advocates a watershed approach to water quality, which considers the relationship between land use and water quality. Geographic Information Systems (GIS) can be used to compare patterns of land use with water quality measurements to identify potential nonpoint sources. At present, there are several land use layers that are both free and publicly available, but the problem is that these datasets are typically derived from Landsat satellite imagery, which has a 30-meter pixel resolution. While this resolution is quite useful for large areas such as a state or multi-state region, it is too coarse for application to a small community watershed scale.

Muddy Creek
Muddy Creek is a 4th-order watershed located in the eastern portion of Madison County in central Kentucky. The watershed is approximately 44,000 acres in size, and contains a total of about 52 miles of streams. The watershed is largely rural with cattle grazing and scattered suburban development as the primary land uses. The watershed is a good site for this study because a multidisciplinary science team has been conducting a variety of water quality tests throughout the watershed; including stream chemistry and aquatic biology (see Jones, et al 2007). These ongoing tests ensure adequate water quality data to compare with land use if a sufficient land use dataset can be developed.

Fig 1: Example of the Gap Analysis Project (GAP) land use layer for a portion of the Muddy Creek Watershed. Note the coarseness of the 30-meter pixel resolution.
Fig 2: A digital orthophotograph of the same area from the National Agricultural Imagery Project (NAIP) imagery.
Fig 3: The hand-corrected field map for the same area, showing the combination of the GAP and NAIP layers, and the hand-drawn field-corrected polygons, that were later digitized in the lab.
Methodology

This technique involves the use of two main map layers that are free to the public and manipulating them using GIS to create a series of field observation maps. The two main mapping layers used were (a) the Gap Analysis Program (GAP) (see Figure 1) and the National Imagery Program (NAIP) (see Figure 2). The GAP is a 2002 raster-based coverage Landsat thematic mapper imagery at a 30-meter pixel resolution that has a land cover classification assigned to each pixel originally created to display and analyze habitat and vegetation at the state scale and the NAIP is a 1-meter aerial photograph from 2004 that contains no land cover information and must be interpreted by the viewer.

The pixilated GAP land coverage was overlaid on the NAIP imagery to create a hybrid map that was used to generate a series of field maps with coarse identifications of land use from the GAP layer, and a more accurate depiction of the actual landscape from the NAIP imagery. By adding a road mapping layer, a series of site observation points from which to view the surrounding landscape was then generated along the major roadways. The maps were then taken into the field and then field team stopped at each identified point. From that point, the researcher was able to compare the landscape visible from that point with the field map and first (a) confirm the GAP land use classification visible from the point, (b) make any notes or alterations based on land uses too small for observation at the GAP 30-meter scale or land use changes made subsequent to the GAP imagery, and (c) use the NAIP Orthophotography images as a guide to hand-draw new polygons correctly labeled according to the GAP classification scheme (see Figure 3).

The hand-drawn polygons were then digitized using GIS to generate a new, ground-truthed land cover layer (see Figure 4). The process was repeated along all of the major roadways throughout the watershed to create a new land use layer for the entire watershed (see Figure 5).

The “Rapid” in “Rapid Reconnaissance”

The main purpose of the study was to determine whether the combination of the NAIP and GAP layers onto field maps would provide sufficient field information for a relatively small field crew (in our case, no more than 2) in a fairly short time, to quickly visually inspect a large area and be able to create an updated land use coverage with some confidence that the resulting map would be more representative of land use in a small watershed.

The entire process – from GIS map preparation to field reconnaissance to redigitization – took about two months, with one student researcher (Hunter) working about 15 hours per week on the project either in the GIS lab or the field. Compared with the cost of obtaining similarly detailed data from a commercial provider, the technique appears to be a viable one for creating a relatively high resolution dataset for use at the local watershed scale at a very reasonable cost.

Limitations and Future Research

While limiting the study to areas accessible by major public roadways clearly limited the entire land use area covered, the study was a successful “proof of concept.” The GAP/NAIP combination produced very acceptable field maps which minimized the observation time necessary in the field and enable a very small field team with very little training to cover a great deal of land area in a very short time.

Future studies are planned to apply the technique to an entire watershed. Additionally, tests are planned of the relative accuracy of the resulting land coverage by comparing the relative change in area in the a-priori GAP maps and the resulting field-corrected maps.

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