Advances in Estimating and Detecting Impervious Surface Areas

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Presentation Outline

• Problem Statement

• Estimation Methods:
  ➢ Estimation Tool for Impervious Surfaces (ETIS)
  ➢ Impervious Surface Analysis Tool (ISAT)

• Detection Methods
  ➢ Using CITYgreen with Classified Imagery
  ➢ Manual & Automated Imagery Classification

• Case Study: Rivanna River Basin Land Cover Study
Problem Statement:

1. How can a community determine the amount of impervious surface area with some reasonable degree of accuracy at a reasonable cost?

2. Can this process be replicated for change detection?
Why Impervious Surface Area?

Impervious areas are hard surfaces which prevent the rain and snowmelt from soaking into the ground. Impervious areas increase the amount of runoff as well as its velocity and cause:

- greater fluctuations in water levels,
- increased erosion,
- more sediment and pollutants delivered to waterways,
- degraded stream habitat (e.g. gravel spawning areas filled with sediment),
- warmer water and loss of sensitive coldwater fish,
- decline in aquatic insect diversity,
- decline in fish diversity, and
- reduced spawning of fish.

Impervious surfaces also affect groundwater quality and quantity by:

- preventing the physical filtration & natural biological processes that remove nutrients and other pollutants when water is allowed to soak into the ground, and
- inhibiting groundwater recharge.
Estimation Models:

**ISAT: Impervious Surface Analysis Tool**

- ArcGIS extension that estimates impervious surface area of user-selected geographic areas (e.g. watersheds, political subdivisions, etc.) using land cover and internal impervious surface coefficients.

- Each land cover dataset requires a specific set of coefficients. Coefficients were developed for use with the Connecticut Land Cover (CCL) 2002 data.

Estimation Models:

**ETIS: Estimation Tool for Impervious Surface**

- Allows user to calculate the amount of imperviousness for a specified area based on land cover and population density data.
- Uses linear regression equation and a set of coefficients based on the classes of the land cover map used.
- There are several sets of coefficients included with the Toolbox for Connecticut Land Cover (CCL) 2002 and National Land Cover Data (NLCD) 2001.
- ETIS also allows user to import custom sets and to demonstrate the effect of change in land cover on the amount of imperviousness.
- ETIS can estimate percent impervious cover for future land cover scenarios allowing for comparison to current conditions.

**Source:** [http://clear.uconn.edu/tools/is/etis/index.htm](http://clear.uconn.edu/tools/is/etis/index.htm)
Estimation Methods Relative Accuracy*

1. Planimetric Data: “100 %”...the “gold standard”
2. ETIS: “...the highest degree of agreement w/ NLCD”
3. ISAT: “...follows ETIS when applied to NLCD data”
4. Sub-pixel classification methods: “tend to over-estimate IS”

* Varies based on reference imagery layer resolution and land classification dataset....

“Land cover-based methods are vulnerable to the quality of the land cover dataset..one has to critically examine the quality of land cover data...as well as the model itself.”

**GWRC Land Cover Change Study**

1. Classification of 2009 30-meter LANDSAT imagery consistent with NCLD/C-CAP series by American Forests

2. Use of CITYgreen to analyze land cover change, 1996-2001-2006-2009

3. Use of ISAT to assess accuracy of model estimates compared to CITYgreen results
GWRC Land Cover Change Study

4. CITYgreen evaluation of 2009 1-meter classified imagery (NAIP) & comparison of 1-meter imagery with 2009 30-meter imagery (classified LANDSAT)

5. Comparison of ISAT results (2006) with 1-meter imagery results (2009) to determine appropriate ISAT impervious surface coefficients
Regional Land Cover Trends, PD 16

Pct Change, 1996 - 2009

Impervious Surface...... 43.4%
Tree Canopy............... -4.17%
Population............... 48.7%
Effect of Imagery Resolution on Estimate Accuracy

1. 30-meter pixel resolution:
   - LANDSAT (used in Ches Bay modeling)

2. 1-meter resolution:
   - NAIP (Nat’l Agricultural Imagery Program) (annual, e.g. 2009)
GWRC Findings:

1. ISAT hi-intensity IS coefficients most consistent with 1-meter IS estimates (in Fredericksburg case study).

2. 30-meter land cover estimates over-estimate IS by 34% & under-estimate Tree Canopy by 40% as compared to more accurate 1-meter land cover data.
Rivanna River Basin Land Cover Study
Project Partners

- The Nature Conservancy
- StreamWatch
- Rivanna River Basin Commission
- Albemarle County
- Fluvanna County
Project Goal

Develop a 1-meter land use and land cover database for the Rivanna River watershed to support on-going conservation efforts and to provide a framework for measuring future changes to the watershed’s landscape.
Land Use / Land Cover Dataset

- Contiguous Base Land Cover:
  - Deciduous Forest
  - Coniferous Forest
  - Open Space
- Hydrology
- Impervious Surfaces
- Pine Plantations
- Forest Harvest
- Orchards / Vineyards
- Bare Earth
- Golf Courses
Project Methodology

• Create training data
• Setup learning parameters
• Conduct automated feature extraction
• Refine extracted data and perform manual QA/QC
• Merge existing data overlays
• Document data and processes
Results – 1”=40,000’
Results – 1”=1000’
Results – 1”=300’
### Data Accuracy Assessment

<table>
<thead>
<tr>
<th>Modeled Data</th>
<th>Deciduous Forest</th>
<th>Evergreen Forest</th>
<th>Open Land</th>
<th>Water</th>
<th>Impervious</th>
<th>Pine Plantation</th>
<th>Forest Harvest</th>
<th>Orchard/Vineyard</th>
<th>Bare Earth</th>
<th>Golf Course</th>
<th>Totals</th>
<th>User's Accuracy</th>
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Potential Next Steps?

- Statewide or Chesapeake Bay watershed consistent land use / land cover project using 2009/2011 VBMP 4-band orthophotography
  - Classify using standardized Anderson Level 1 & 2 categories
  - 5-meter base with potential higher-resolution (1-meter) coverage for regional or local efforts
  - Replicate on 6 year cycle to monitor land cover changes
Chesapeake Bay TMDL WIP Schedule

- State government refinement of Chesapeake Bay TMDL Phase I Watershed Implementation Plan: 2010 – 2014
- Local government development of WIPs: 2014 – 2017
- Implementation of WIPs by State and local govts: 2011-2025
Questions:

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