Michael Baker
INTERNATIONAL
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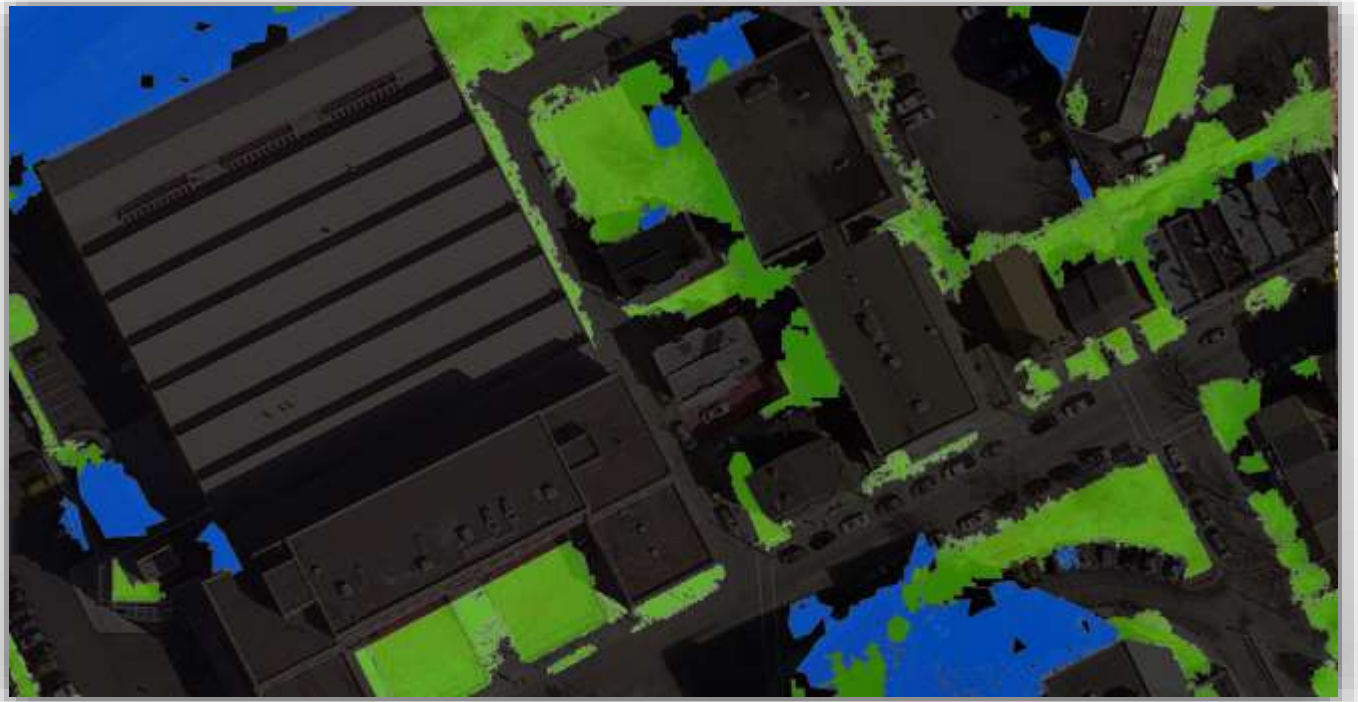


Methodologies to Determine Storm Water Fees Using GIS

2017 Ohio Storm Water Management & Drainage Conference

Today's Presentation

Speaker

- Jeremy Jurick
- GIT Technical Manager
- Michael Baker International

Goal

- Provide an overview on how to use GIS to determine…

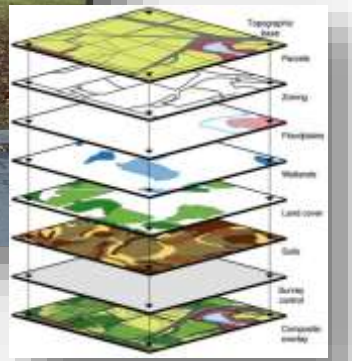
"How much impervious area exists in my jurisdiction?"

Storm Water Fees

- Becoming popular nationwide
- Used as a strategy to recoup costs of infrastructure instead of…
  - Raising taxes
  - Increasing water/sewer rates
- Many factors are behind the actual fee:
  - Is new equipment necessary?
  - Will new full or part time employees be needed to handle customer service?
  - How much runoff occurs?

Surface Runoff + GIS

- Geographic Information Systems (GIS) are used to evaluate if a surface is:
  - Impervious
  - Pervious



GIS Methodologies to Find Impervious Surfaces

- ✓Color Infrared Analysis
- ✓Use Planimetric Layers

GIS Methodologies to Find Impervious Surfaces

Color Infrared Analysis

- Unsupervised
  - "OK Computer, here is the data now do the best you can"
- Supervised
  - "OK Computer, here is how I want you to classify this information"

Planimetric Data

- These are layers for…
  - Buildings
  - Parking Lots
  - Road Edge of Pavement
  - Driveways
  - Sidewalks
  - Decks/Patios
  - Recreation Surfaces

Color Infrared Analysis

- What is Color Infrared Imagery?
  - **Color-infrared** (CIR) imagery uses a portion of the electromagnetic spectrum known as near infrared that ranges from 0.70 µm to 1.0 µm (0.7 to 1.0 micrometers or millionths of a meter), just beyond the wavelengths for the color red.
  - Typical imagery has three bands
    - Band 1: Red
    - Band 2: Green
    - Band 3: Blue
  - With color infrared imagery, a fourth band is captured
    - Band 4: Near Infrared

Color Infrared Analysis

RGB

CIR

Color Infrared Analysis

Color Infrared Analysis

Feasibility Study

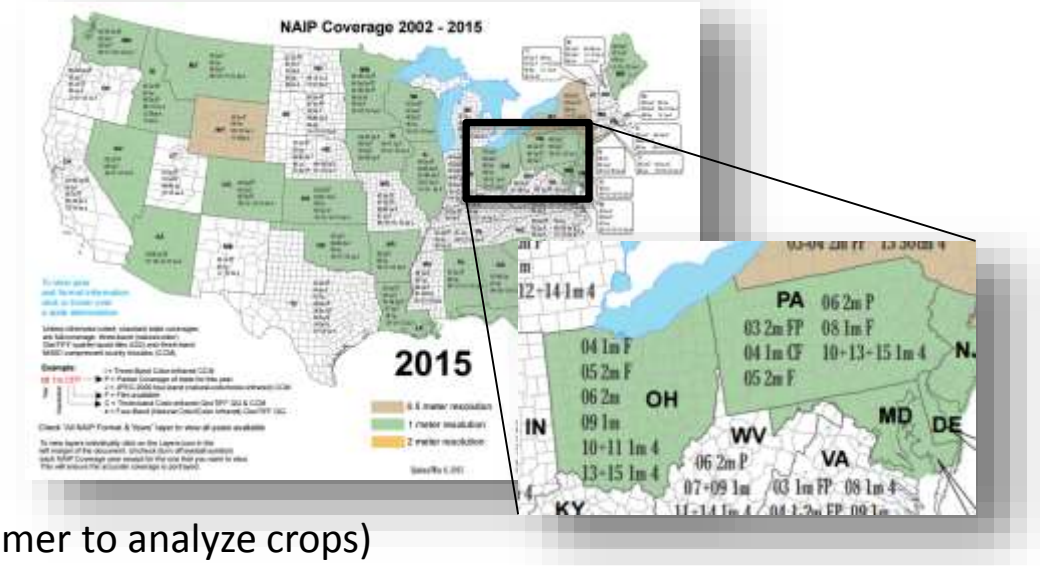
- Can Use NAIP Imagery
  - National Agriculture Imagery Program
  - Free Data!
  - Unsupervised Classification

Implementation Phase

- Use Better Imagery
  - Pay to fly or…
  - If lucky, County or State has flown already
  - Supervised Classification

Color Infrared Analysis

- Case Study
  - …Large City in Pennsylvania
  - Feasibility study
  - NAIP Imagery
    - Positives
      - Free!
      - Fast Processing time
    - Downsides
      - Tree cover (flown in Summer to analyze crops)
      - 1 meter pixels (too large -- a lot can be going on in 1 square meter)
      - 10% cloud cover



Color Infrared Analysis for Feasibility Study

Impervious Surface | Unsupervised | Suggested Mapping Approach for ERU Determination

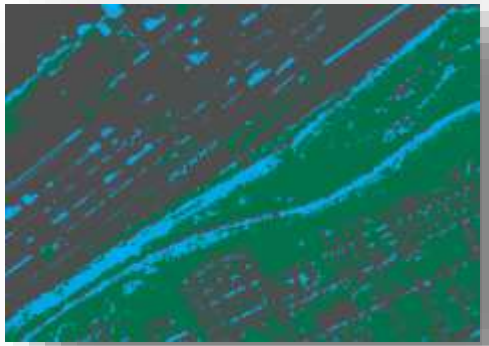
Overview map of study area

2015 NAIP* Imagery Derivatives

Color Infrared

Normalized Difference Vegetation Index

Initial Vegetation & IA



Legend

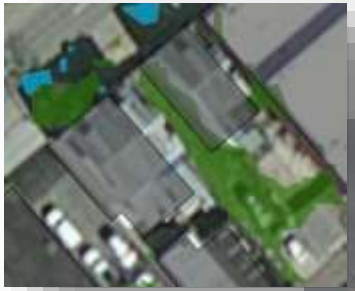
- Pervious Surface
- Impervious Surface
- Shadow

* NAIP (National Agricultural Imagery Program) | Flown September 14, 2015 1 Meter Pixels | 4-band with color infrared

Color Infrared Analysis for Feasibility Study

Impervious Surface | Unsupervised | Suggested Mapping Approach for ERU Determination

Initial Vegetation & IA Analysis



Overlay Buildings layer to remove tree canopy over roofs

Color Infrared Analysis for Feasibility Study

Impervious Surface | Unsupervised | Suggested Mapping Approach for ERU Determination

Parcel Overlay

$$IA\%^{*} = \frac{\text{Impervious Sq ft}}{\text{Impervious Sq ft + Pervious Area Sq ft}}$$

$$= \frac{7{,}769'}{7{,}769' + 9{,}595'}$$

$45\%\ Impervious$

* Impervious Area Percentage calculation removes “shadow” square footage from numerator and denominator

Color Infrared Analysis for Feasibility Study

Impervious Surface | Unsupervised | Suggested Mapping Approach for ERU Determination

Parcel % Impervious Area

Same area as Color Infrared

Color Infrared Analysis for Feasibility Study

Impervious Surface | Unsupervised | Suggested Mapping Approach for ERU Determination

Result of Analysis

Property Description	Number of Parcels	Impervious SqFt	Pervious SqFt	Percent Impervious
CHURCHES, PUBLIC WORSHIP	18	130,368	56,215	69.87%
COMMERCIAL GARAGE	4	21,609	1,591	93.14%
COMMUNITY SHOPPING CENTER	1	68,099	509	99.26%
OFFICE-ELEVATOR -3 + STORIES	1	13,885	4	99.97%
OFFICE - 1-2 STORIES	6	62,553	8,048	88.60%
OFFICE/APARTMENTS OVER	2	7,568	63	99.17%
OFFICE/WAREHOUSE	22	744,614	97,430	88.43%
OTHER COMMERCIAL	2	5,768	19,921	22.45%
OTHER FOOD SERVICE	2	6,248	0	100.00%

Color Infrared Analysis for Feasibility Study

Impervious Surface | Unsupervised | Suggested Mapping Approach for ERU Determination

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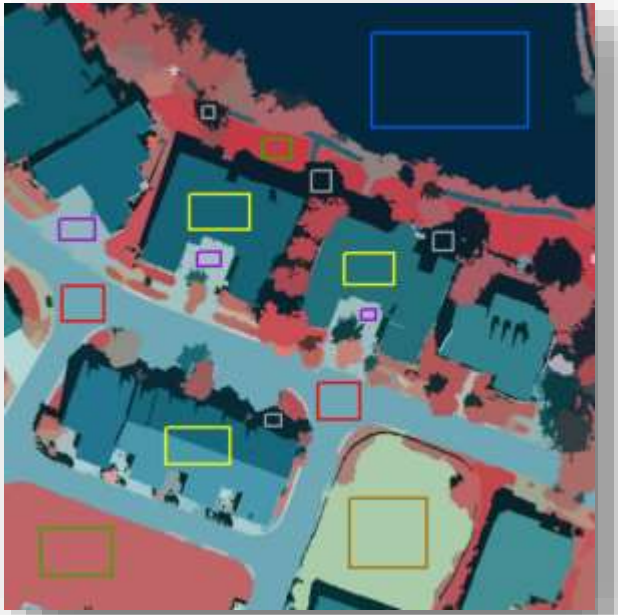
- Going from feasibility to implementation
- Recommend better IA data for public release

Color Infrared Analysis for Implementation

Impervious Surface | Supervised | Suggested Mapping Approach for ERU Determination

- The difference between supervised and unsupervised is that I tell the computer how to classify the imagery
- No surprises (…kind of)
- Train the classifier
- More time to complete



Color Infrared Analysis for Implementation

Impervious Surface | Supervised | Suggested Mapping Approach for ERU Determination

Unsupervised - 1 meter pixels

Supervised - 6 inch pixels

Methodologies

- ✓ Color Infrared Analysis
  - ✓ Supervised
  - ✓ Unsupervised
- ❖ Use Planimetric Layers

Planimetric Data

- GIS layers
  - Buildings
  - Parking Lots
  - Road Edge of Pavement
  - Driveways
  - Sidewalks
  - Decks/Patios
  - Recreation Surfaces

Planimetric Data

- To use this methodology, data must be accurate and current
- Typically, some data does exist – yet it will need updated and quality checked
- Warning! – Updating existing data is sometimes more difficult than recreating it!

Planimetric Data

- Data is typically collected two ways:
  - Photogrammetric 3D capture
  - Heads up digitization

Planimetric Data

- Case Study
  - City of Lancaster, Pennsylvania

Planimetric Data

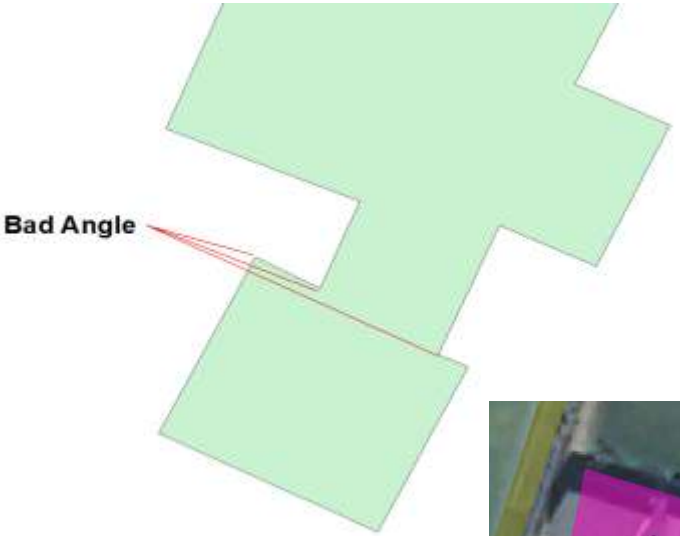
- Data collection challenges
  - Buildings
    - Building Lean
    - 90° Angles
    - Size to collect
  - Pavement
    - Is it impervious or not?
    - Size/Length to collect

Planimetric Data

- Building lean
  - Can appear incorrect, but truly is accurate

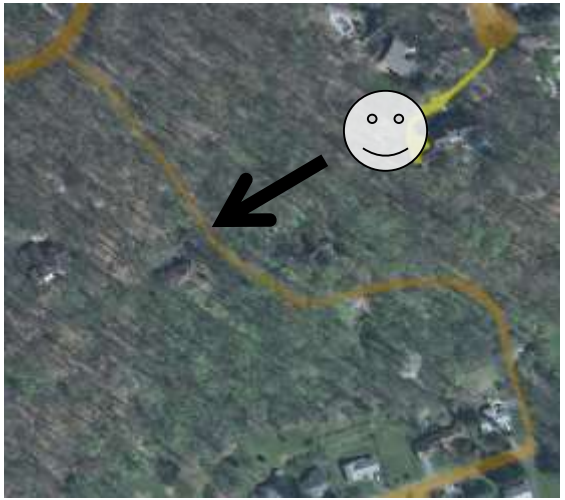
Planimetric Data

- Building angles
  - Unless you hired this carpenter, you're house is likely built with 90° Angles



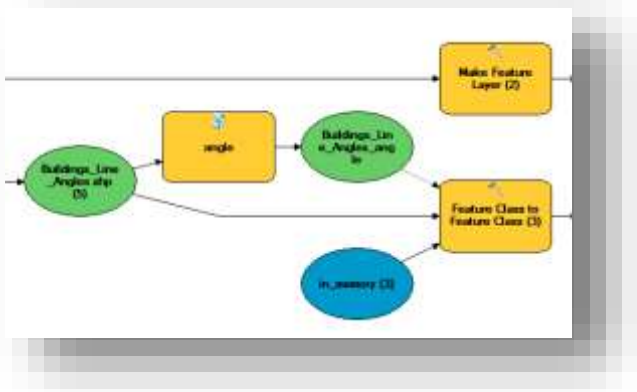
Planimetric Data

- Pavement – Is it Impervious?



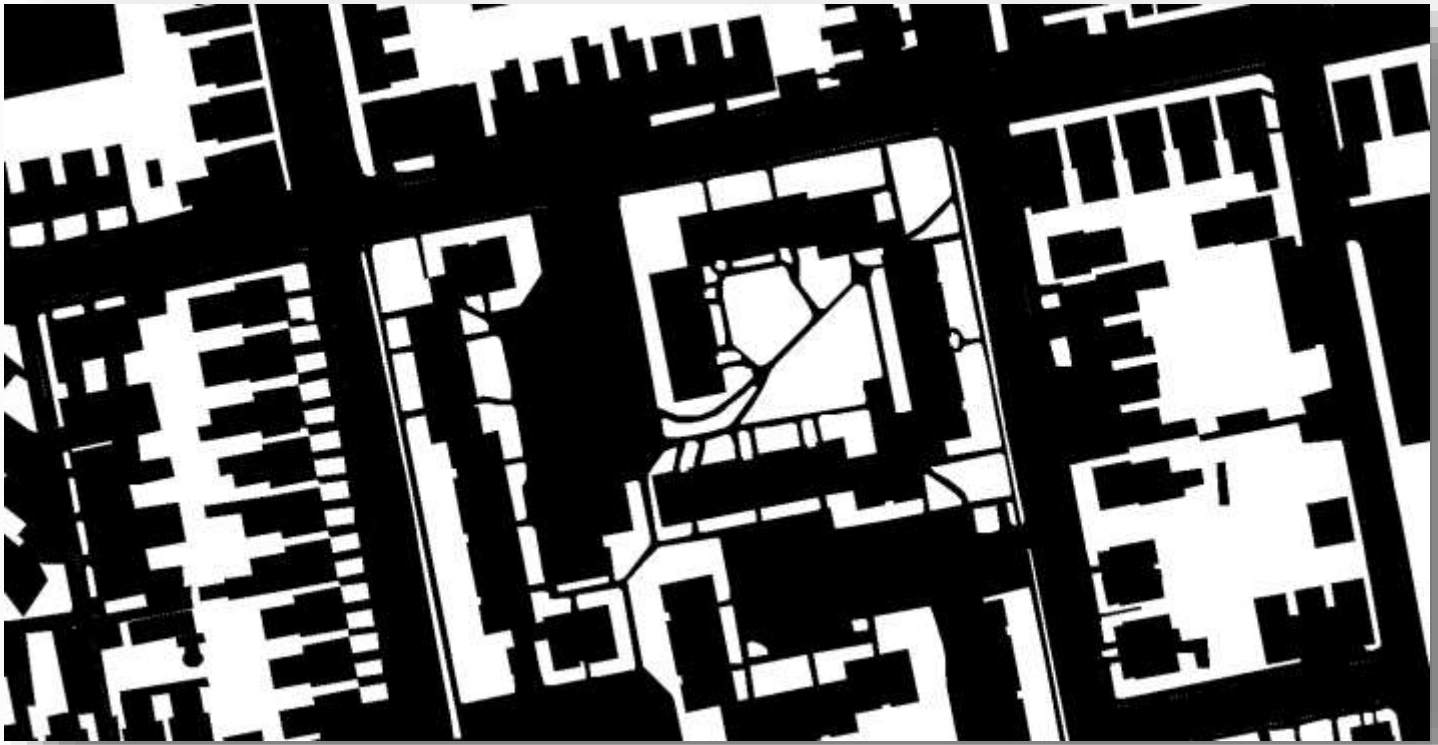
Planimetric Data

- Solution to issues - create a custom, automated QC tool in GIS
- Built with Model Builder and Python to catch the following:
  - Buildings Less Than 100 Square Feet
  - Buildings accidentally deleted
  - Building attribute should be ‘Modified’
  - Building attribute should be ‘Updated’
  - Buildings intersecting
  - Building vertices with no Z value
  - Buildings with non 90° corners



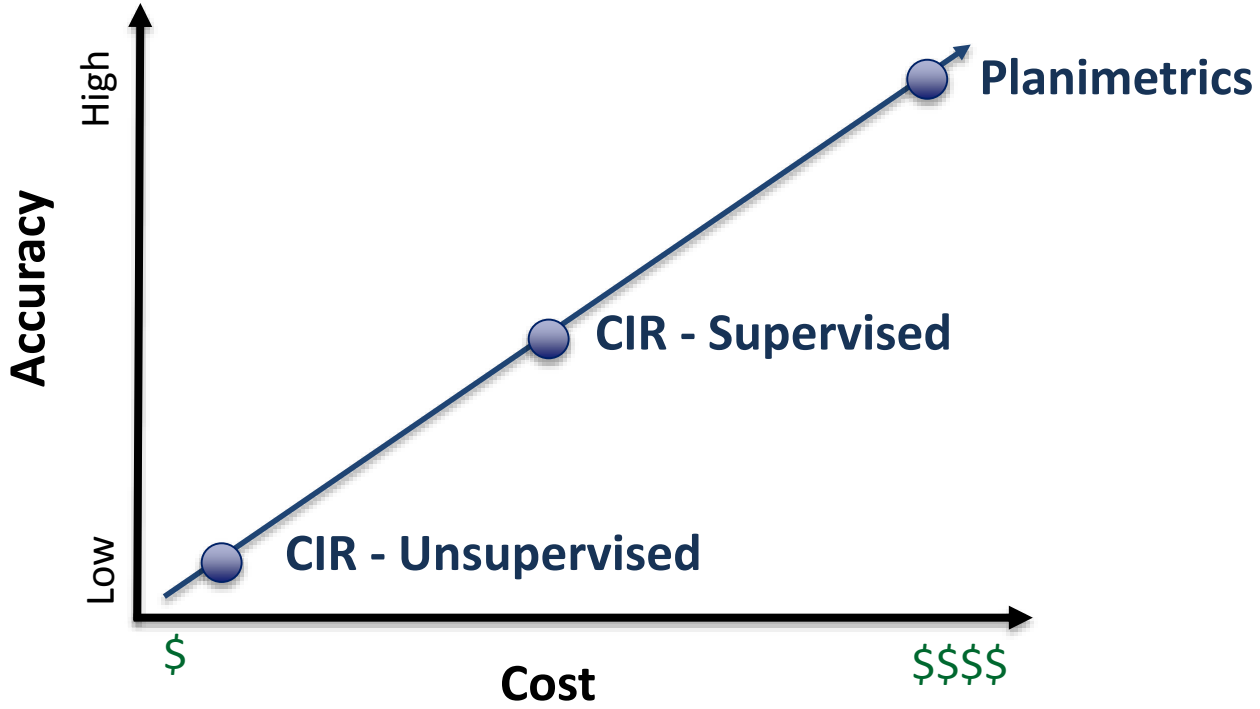

```
import arcpy, math, datetime, numpy
from arcpy import env
print "starting"
start = datetime.datetime.now() # for calculating time of process
lineFC = arcpy.GetParameterAsText(0)
LineFCOutput = arcpy.GetParameterAsText(1)
#lineFC = r"C:\Temp\Buildings_Line_Angles.shp" # input fc - with pre-added fields
"angleChng" and "AvCurv"
dsc = arcpy.Describe(lineFC)
shapeFieldName = dsc.ShapeFieldName
updateRows = arcpy.UpdateCursor(lineFC)
```

Planimetric Data



Planimetric Data

Competing Methodologies



Thank you!

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