Using Color-Infrared Imagery for Impervious Surface Analysis.

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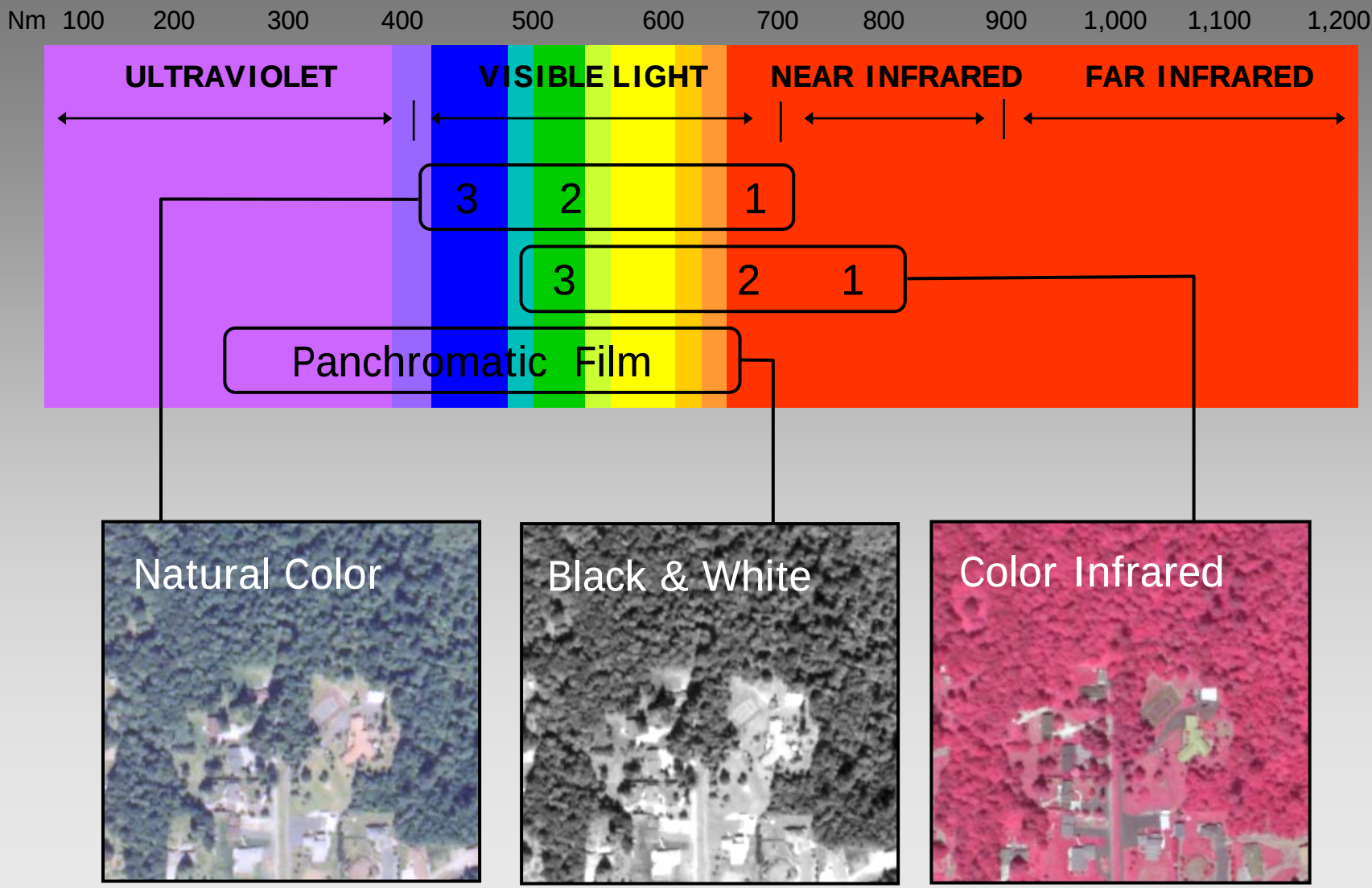
NW GIS Users Group - March 18, 2005

Outline

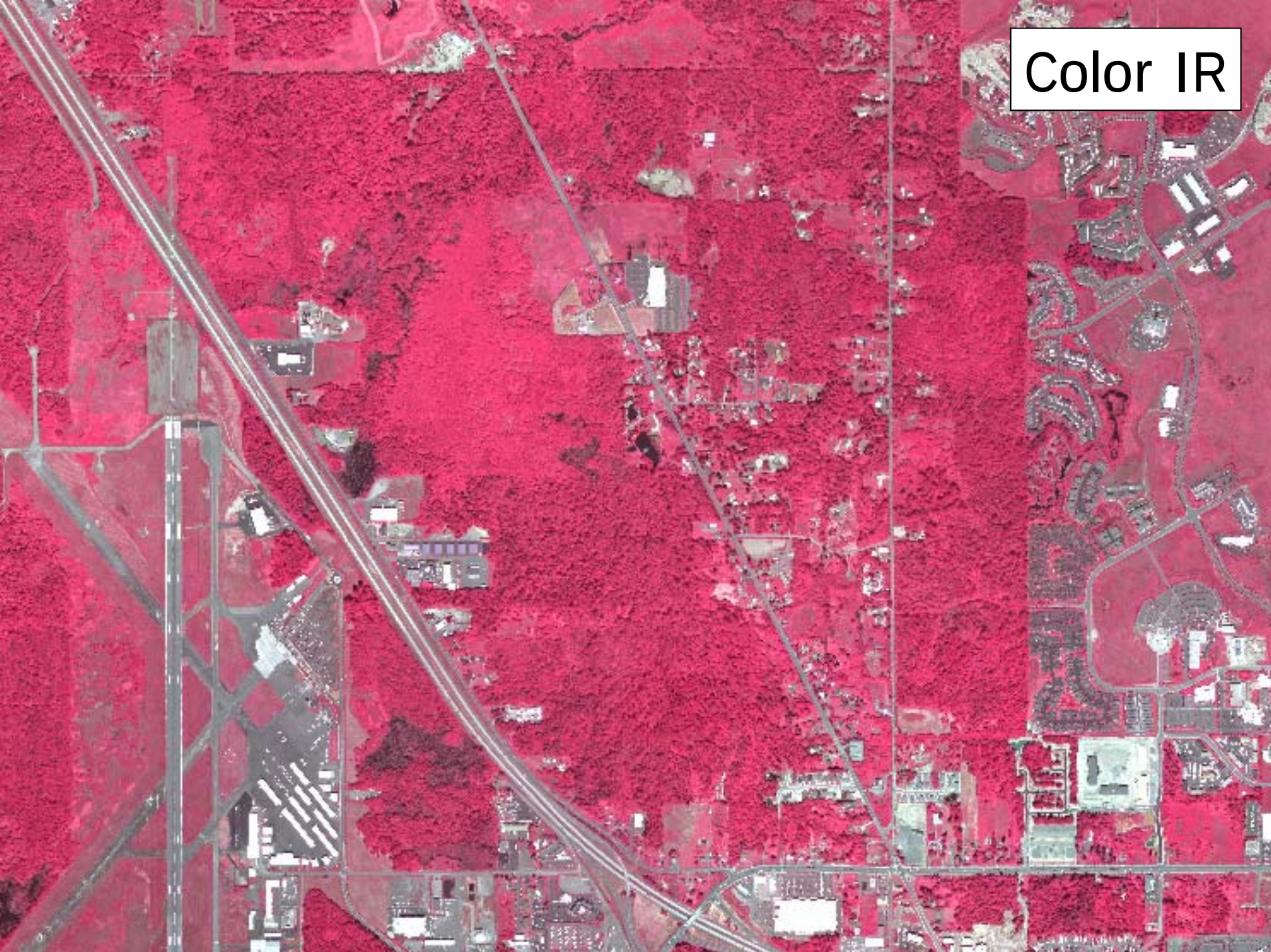
- What is Color Infrared Imagery?
- Vegetation Indices (NDVI)
- Building an Impervious Surface Layer
- Results
- Generating a natural-color image from Color IR

Spectral Ranges of Typical Aerial Imagery



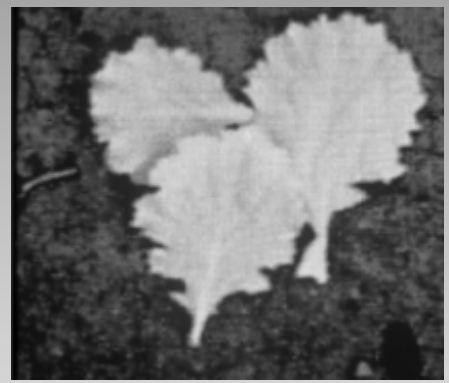
Black & White

Natural Color

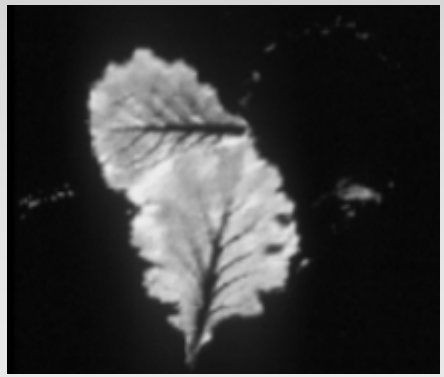

Color IR

How a Vegetation Index Works

Red light image. Red light is strongly absorbed by photosynthetic pigments (i.e. chlorophyll a) found in green leaves. Here we have an image of 2 green kale leaves and a 3rd kale leaf that yellowed with just a spot of green remaining.

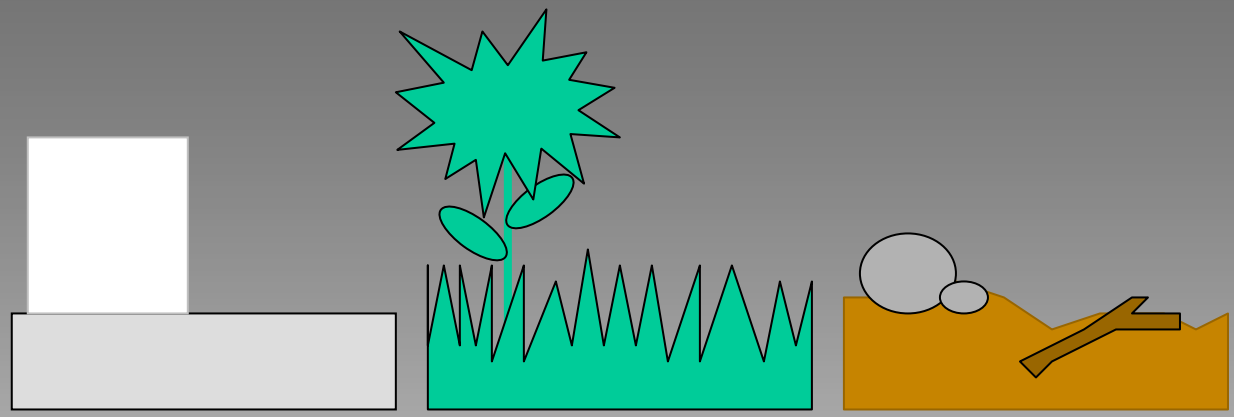


Near-infrared image. IR light either passes through or is reflected by live leaf tissues regardless of their color. Note that the background soil (non-vegetated area) appears similar to the red light image.



Vegetation index image. If we subtract the red light image from the near-infrared image, everything that has about the same brightness level in the two wavelengths becomes dark, and everything that is brighter in the near-infrared becomes light. Notice that even the ribs of the leaves disappear since there is no chlorophyll in that part of the leaf. The small green patch is the only part of the yellowed leaf that is still visible.

For Example:



	Buildings & Pavement	Living Vegetation	Rocks/Soil/Dead Vegetation
Near Infrared Band	200	215	75
Red Band	225	45	65
NIR - Red	-25	170	10

Normalized Difference Vegetation Index (NDVI)

This is one of the most commonly used indices. The difference in reflectances is divided by the sum of the two reflectances. This compensates for different amounts of incoming light and produces a number between 0 and 1. The typical range of actual values is about 0.1 for bare soils to 0.9 for dense vegetation. NDVI is thought to be more sensitive to low levels of vegetative cover

$$NDVI = \frac{(NIR - Red)}{(NIR + Red)}$$

Red Band

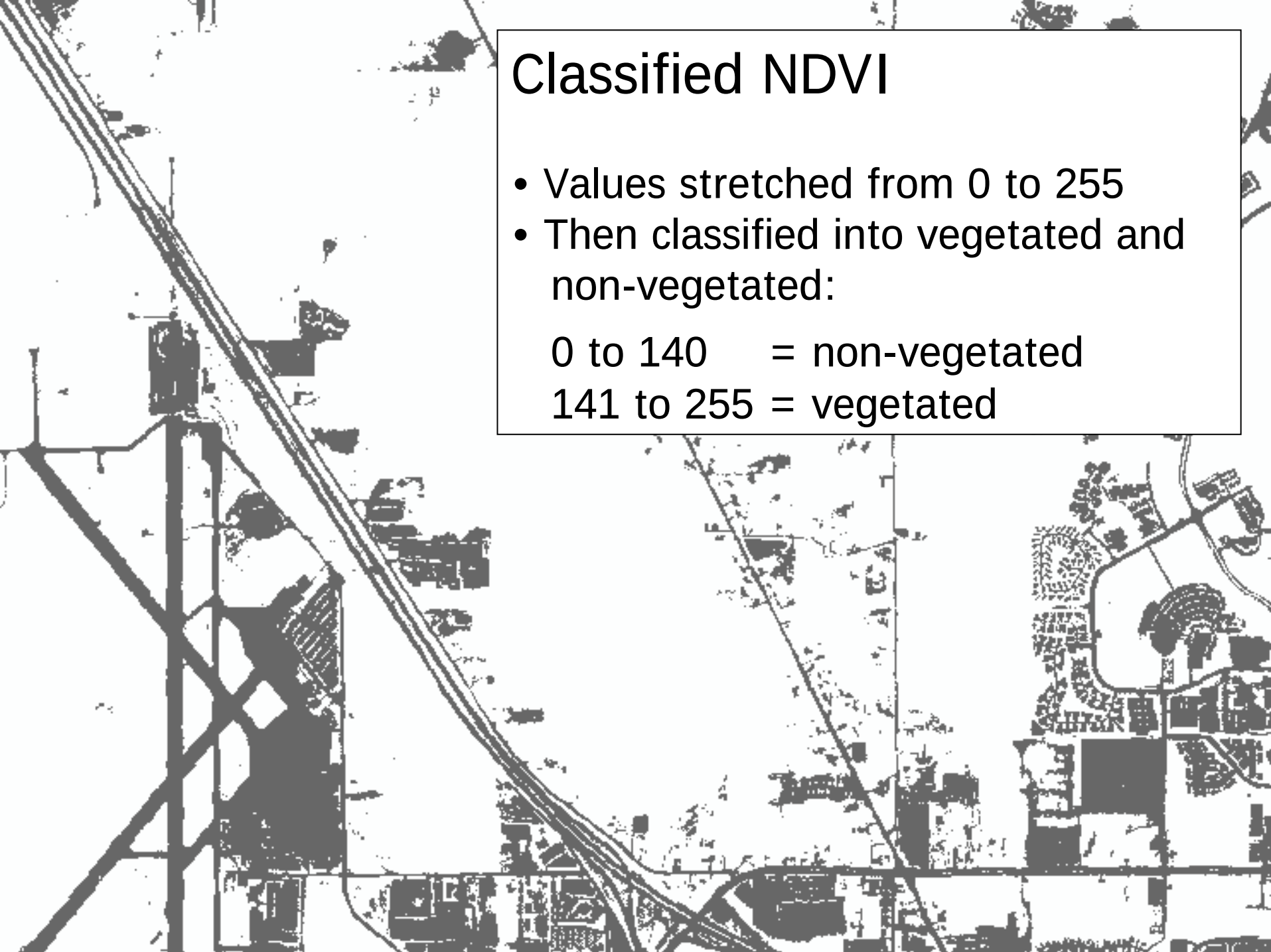
NIR Band

Veg Index

Building an Impervious Surface Layer

- Generate NDVI Vegetation Index (raster)
- Classify NDVI into “vegetated” and “non-vegetated”
- Assemble vector “non-veg” layers from GIS
- Create composite Impervious Surface layer

Raw NDVI
Values from -1 to +1



Classified NDVI

- Values stretched from 0 to 255
- Then classified into vegetated and non-vegetated:

  0 to 140 = non-vegetated
  141 to 255 = vegetated

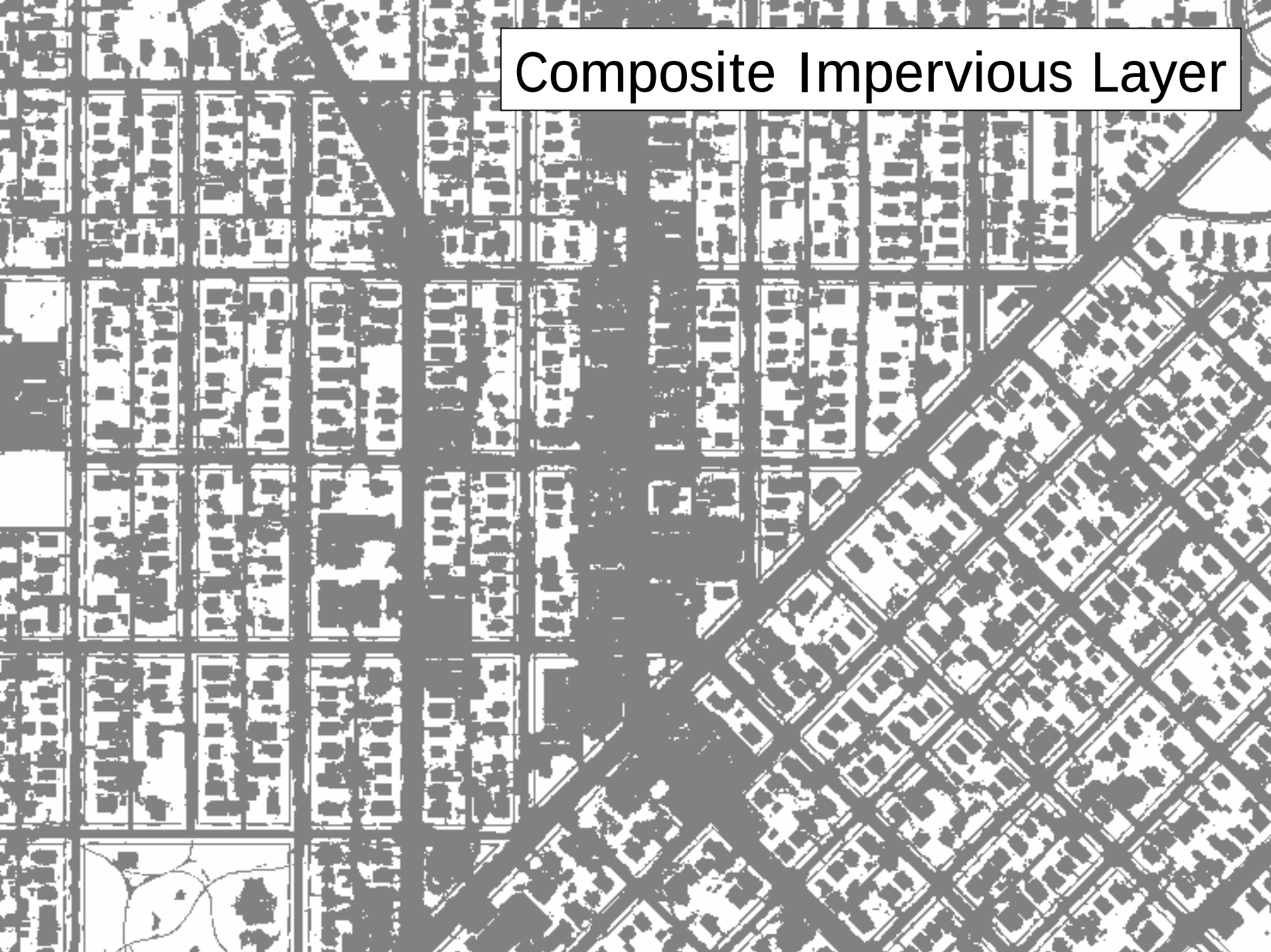
Classified NDVI

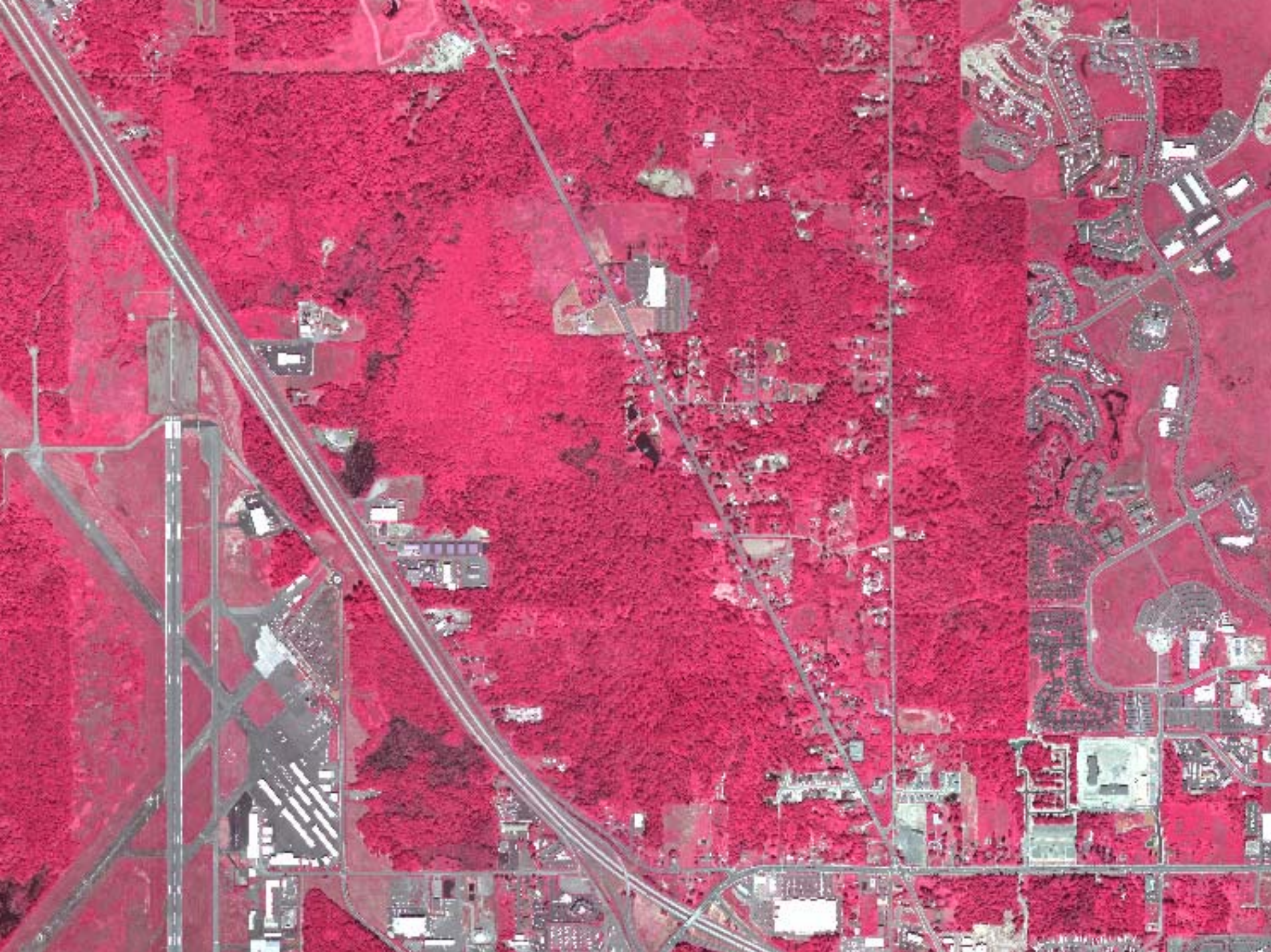
Alleys

Streets

Sidewalks & Trails

Buildings


Composite Impervious Layer



Results

- Within city limits of Bellingham (28 square miles)
- 33% Impervious
- 58% Vegetated (pervious)
- 9 % Open water

Accuracy

- Based on sample of 100 one-acre sites.
- Captured @90% of impervious surfaces where GIS vector layers were available (City & UGA)
- Captured @80% of impervious surfaces where GIS vector layers were not available (imagery only).
- Spectral variability between image frames also contributes to misclassification of cover types.

Generating a Natural-Color Image from Color-Infrared

GIS project managers are often forced to choose between purchasing natural-color imagery that will look like the “real world” and serve as an effective communication tool with the public; and color-infrared imagery that works well for classifying vegetation but is disorienting to the casual user.

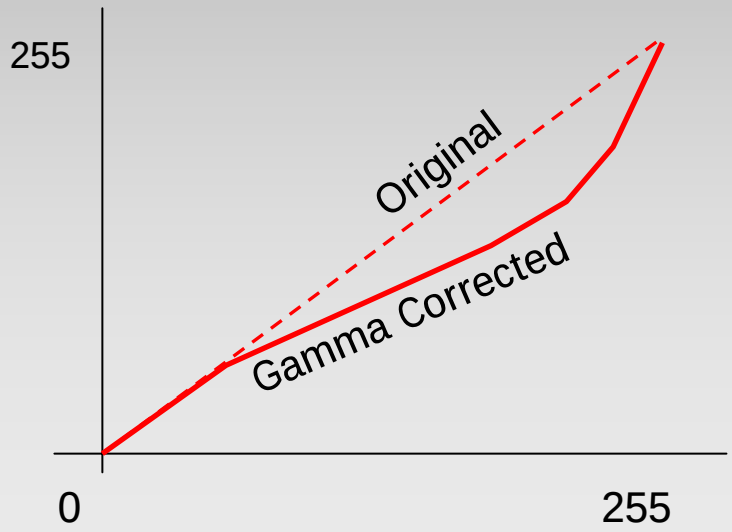
Here is a method for generating pseudo-natural color imagery from standard color-IR.

Pseudo-Natural Color

Red = Band2 from Color IR composite (gamma corrected*)

Green = 65% of Green (Band3) + 35% of Infrared (Band1)

Blue = 85% of Green (Band3) - 15% of Infrared (Band1)



* Gamma correction provides a variably manipulated stretch to avoid disturbing purple and pink tones for water and other “bluish” features.

```
/* AML for ArcInfo GIS - Using GRID
/*
/* Creates natural color image composite from color-infrared image composite
/*
/* Red    = Band2 from ColorIR composite (gamma corrected)
/* Green  = 65% of Green (Band3) + 35% of Infrared (Band1)
/* Blue   = 85% of Green (Band3) - 15% of Infrared (Band1)
/*
/* Written July 15, 2004 - C. Behee

grid

tempgc1x = reclass(slice(cirgc2,eqinterval,200,55,0,255),gamma.rm)
tempgc2x = (icirgc3 * 0.85) + (cirgc1 * 0.15)
tempgc3x = slice(((cirgc3 * 0.85) - (cirgc1 * 0.15)),eqinterval,200,55,0,255)

makestack tempg list tempgc1x tempgc2x tempgc3x

q

gridimage tempg # %input%nc.tif tiff none

/*kill tempg all

&type Image conversion complete.
```

Natural Color

Color IR

Pseudo-Natural Color

Technical Specs

- Flown June 16-17, 2004 (West 1/2 flown June 16th between 11:00am and 12:30pm during -1.6 Tide)
- Coverage area includes City, UGA & Lake Whatcom Watershed (140 square miles total)
- Imagery collected and processed by Emerge Inc.
- Imagery delivered as 3-band digital geo-tiff format orthophotos.
- Airborne digital sensor with on-board differential GPS.
- Collected as 3-band color-infrared data using a 4000x4000 pixel CCD array.
- Band 1 = Near Infrared (800-900 nanometers)
- Band 2 = Visual Red (600-700 nm)
- Band 3 = Visual Green (510-600 nm)
- Color depth = 8-bit (0-255)
- Image resolution = 0.6m (2 feet)
- Image spatial accuracy = +/- 1m for City and +/- 2m for Lake Whatcom Watershed.
- Projection = Washington Stateplane, North Zone, NAD27, feet.
- To facilitate natural-color display, a simulated “blue” band was created by City GIS staff.

Questions regarding this project should be directed to Chris Behee
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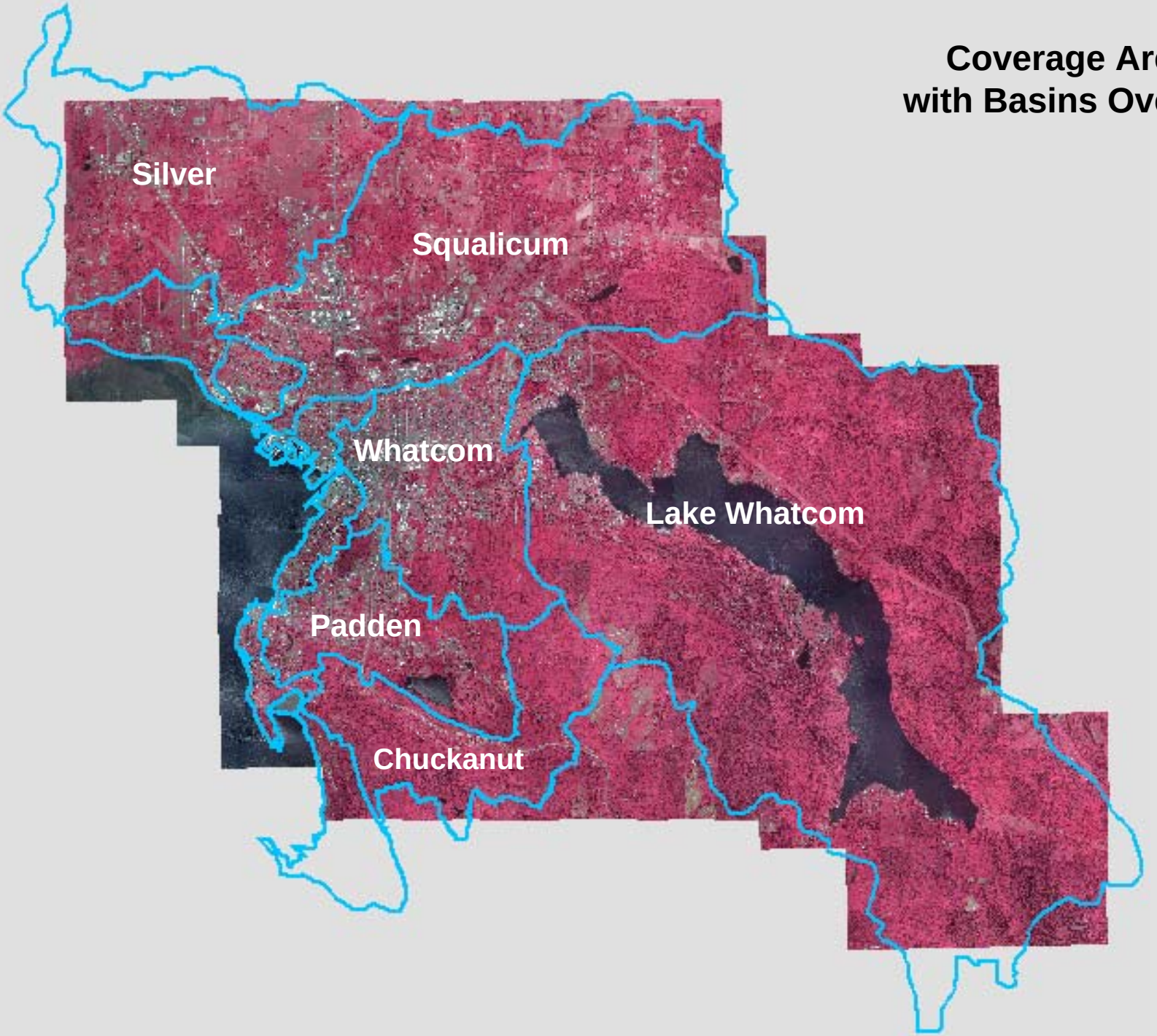
Coverage Area with Basins Overlay



Reference Material:

US Water Conservation Lab
"How a Vegetation Index Works"
http://www.uswcl.ars.ag.gov//epd/remsen/Vi/VIworks.htm

Ray D. Jackson & Alfredo R. Huete
"Interpreting Vegetation Indices" - Journal of Preventive Veterinary Medicine, 11 (1991) 185-200

NASA/Jet Propulsion Laboratory
"General information and background" - document illustrating and explaining the creation of pseudo-natural color images from LANDSAT and SPOT satellite imagery. *http://www-dial.jpl.nasa.gov/~steven/cir2nat/info.html*