Datamining Imaginary Maps

A Mathematical Investigation of Cellular Artwork

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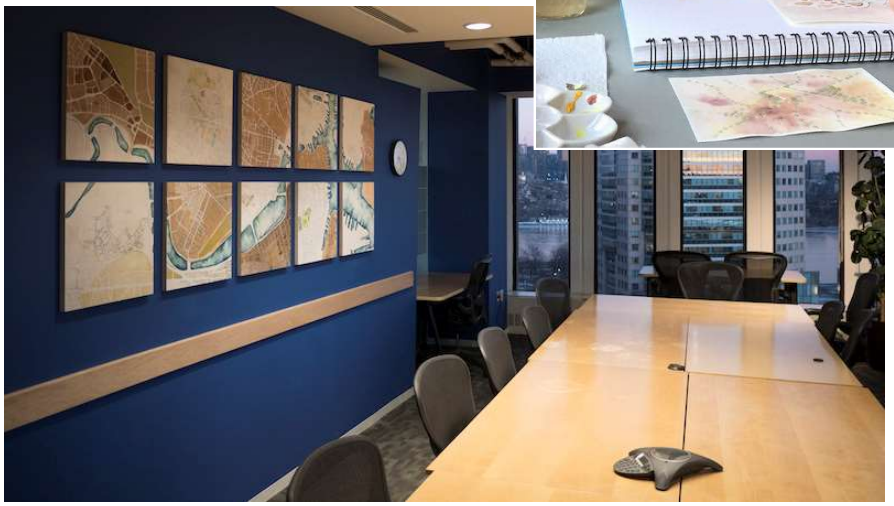
New York City

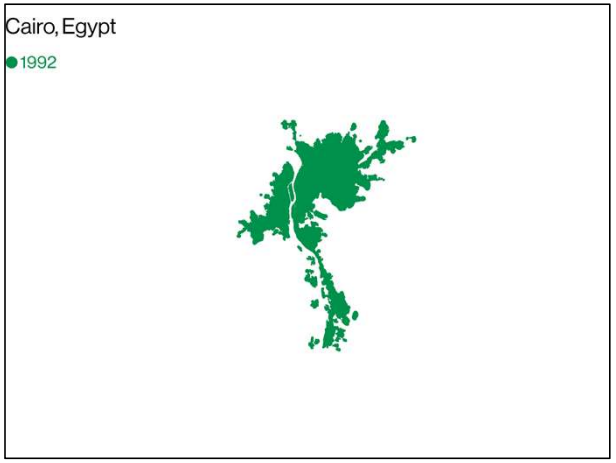
emilygarfield.com

Emily Garfield

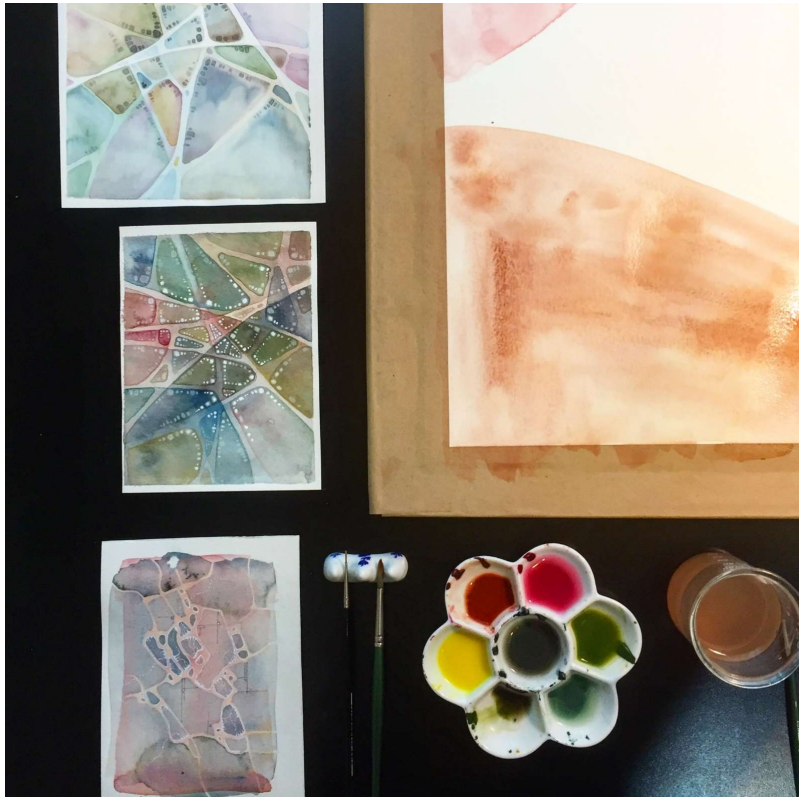
- Full-time artist working on studio art and commissions
- Abstract, procedurally-drawn maplike artwork
- Inspired by networks in the natural/human world

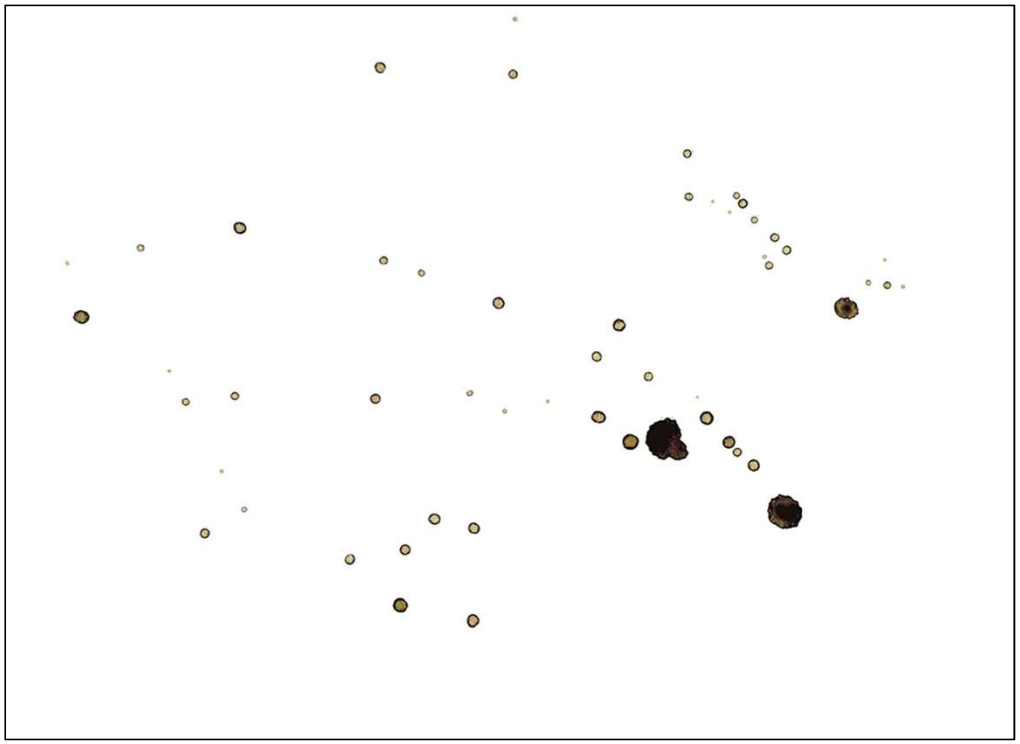


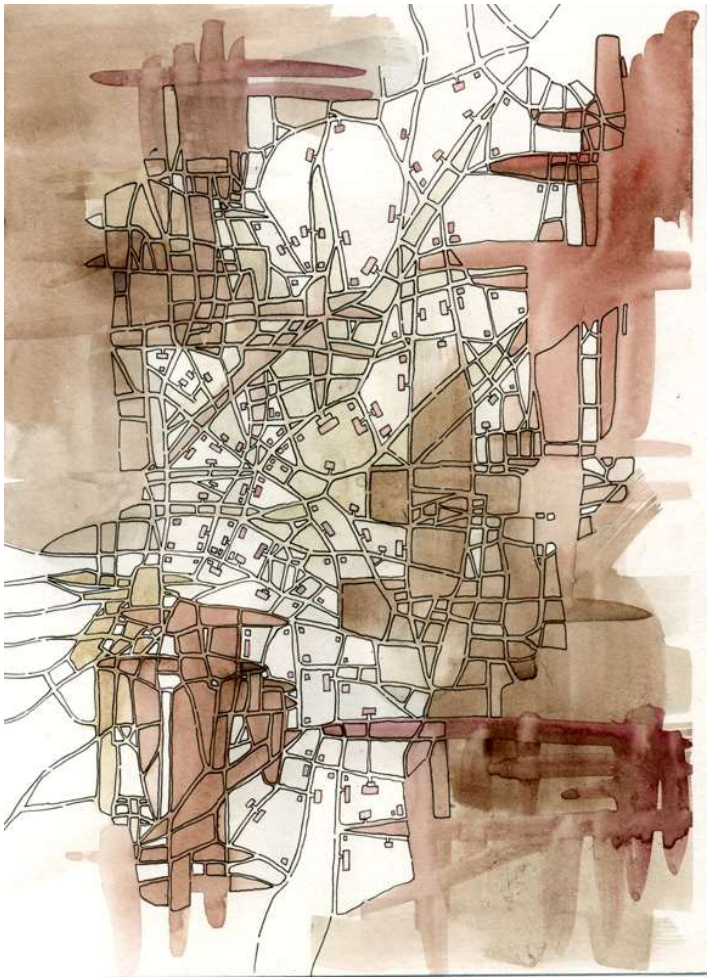
Inspiration

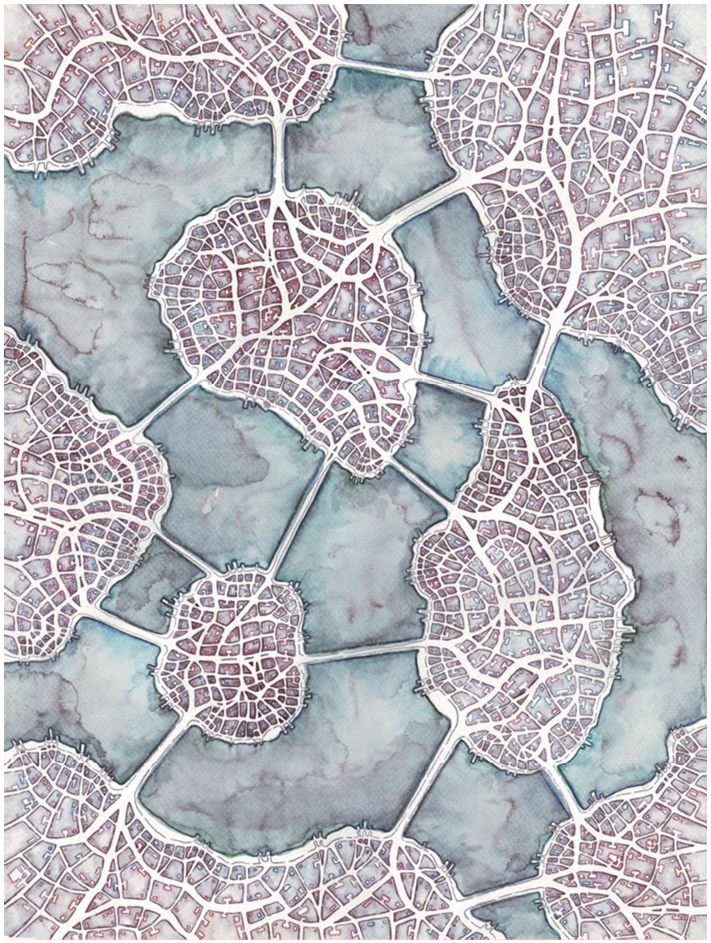


Materials and Process





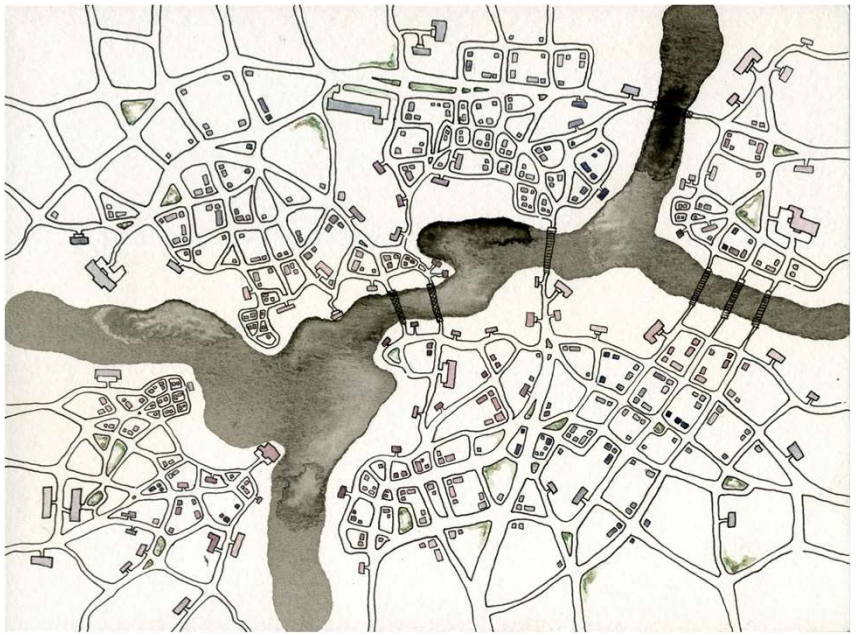




Traveling into Garfield's World

Motivation

- What makes these "mappy"?
- What is life like there?



Emily Garfield – Cityspace #267

Traveling into Garfield's World

Motivation

- What makes these "mappy"?
- What is life like there?

- Fractal analysis of artwork

Jackson Pollock 1952

Taylor et al., Authenticating Pollock Painting using Fractal Geometry, 2006

Traveling into Garfield's World

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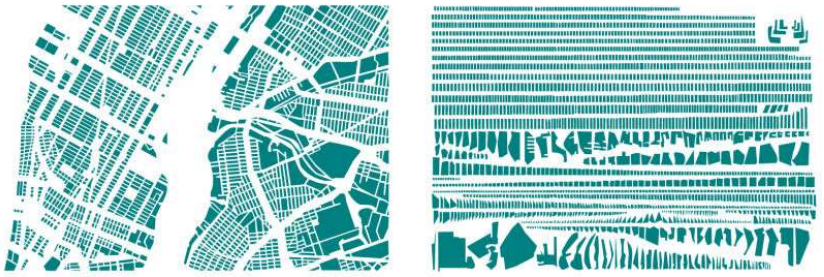
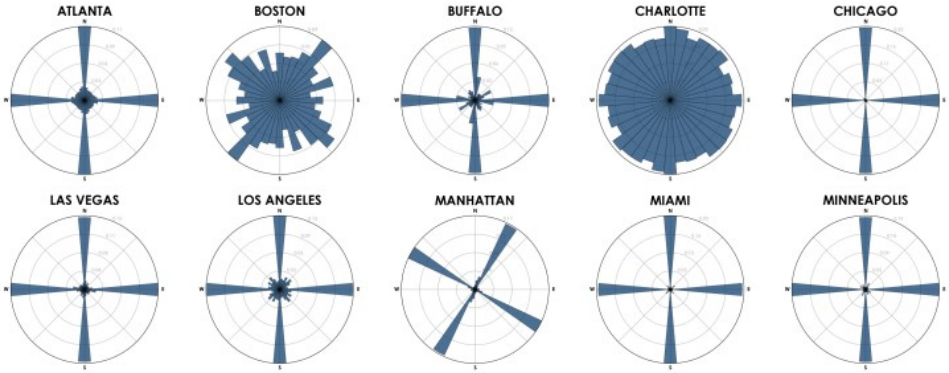


New York Deconstructed

Armelle Caron 2005/8

- Fractal analysis of artwork
- Data visualization of cities



Geoff Boeing 2018

Traveling into Garfield's World

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- What is life like there?
- Fractal analysis of artwork
- Data visualization of cities

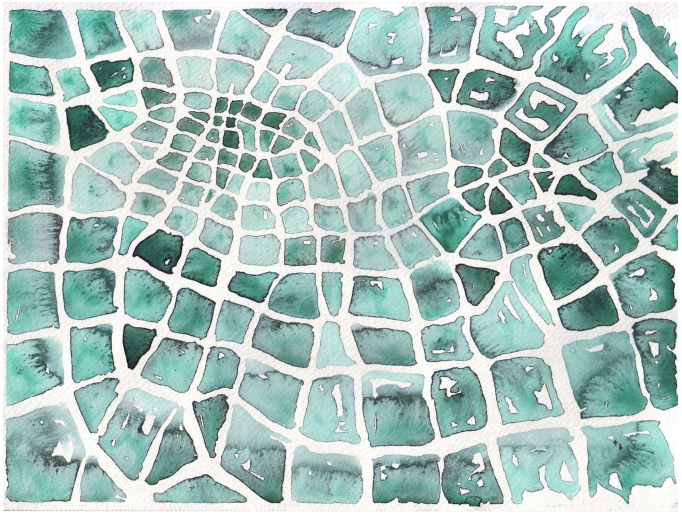
Questions

- Color Palette
- Block and Road Structure
- Neighborhood analysis
- Fractal qualities
- Generative map

What makes a map?

Importing into Mathematica

- Convert image to Black and White



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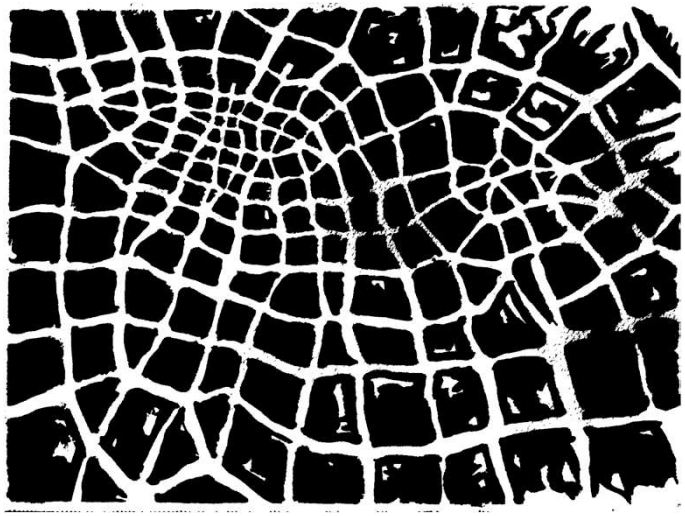

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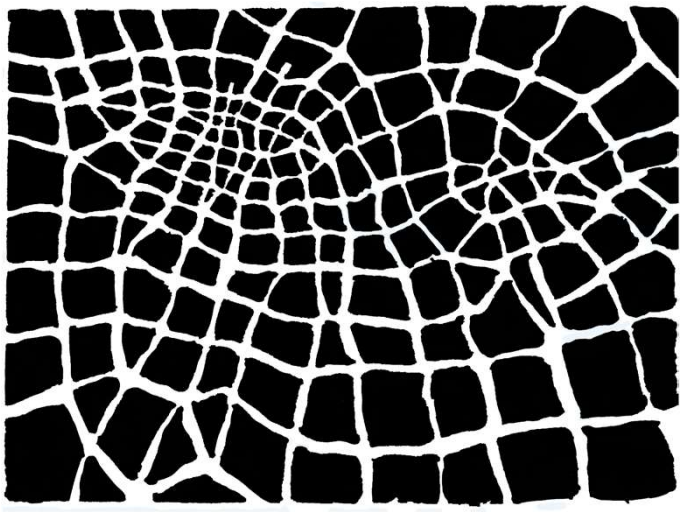
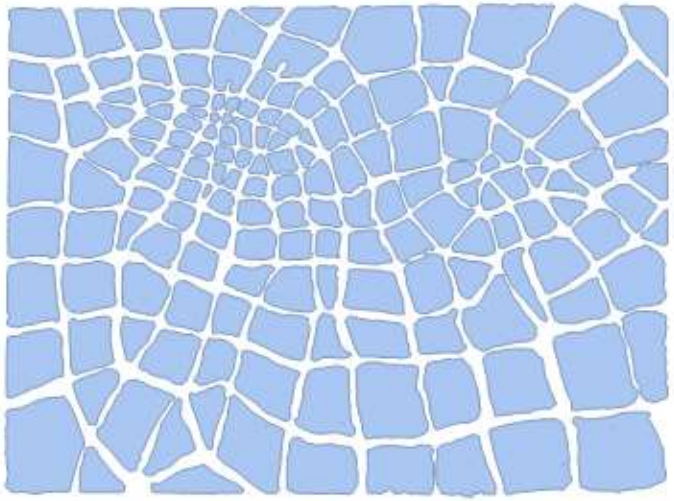


Importing into Mathematica

- Convert image to Black and White
- Compute the block boundaries (ImageMesh)
  - Block size and shape



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  - Average color of each block

Importing into Mathematica

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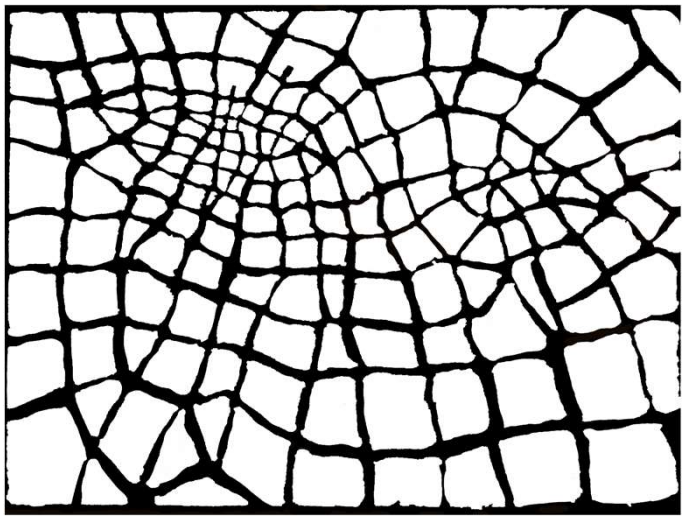
- Infer the road network – **** INTENSIVE***



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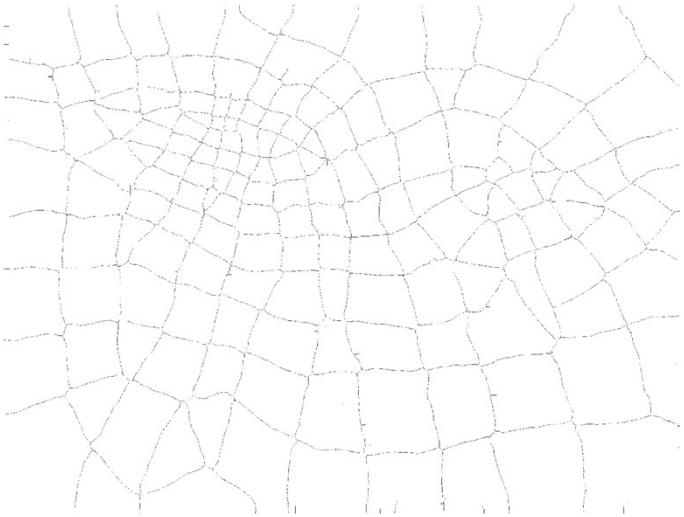
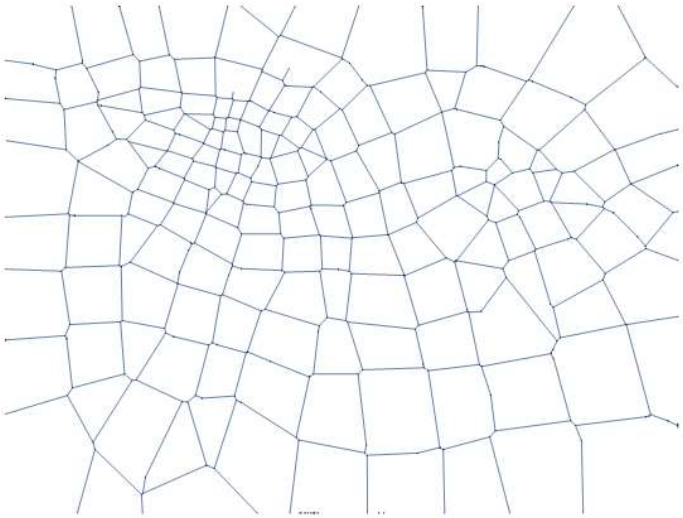


Importing into Mathematica

- Convert image to Black and White
- Compute the block boundaries (ImageMesh)
  - Block size and shape
  - Average color of each block
- Infer the road network (MorphologicalGraph)



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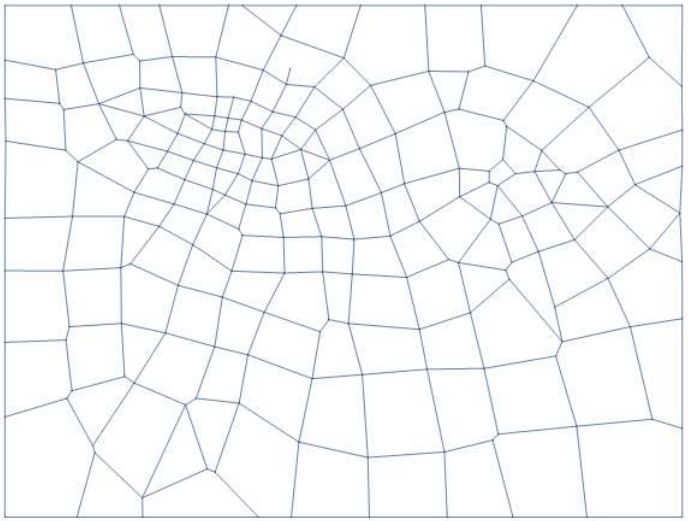

Importing into Mathematica

- Convert image to Black and White
- Compute the block boundaries (ImageMesh)
  - Block size and shape
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- Infer the road network (MorphologicalGraph)
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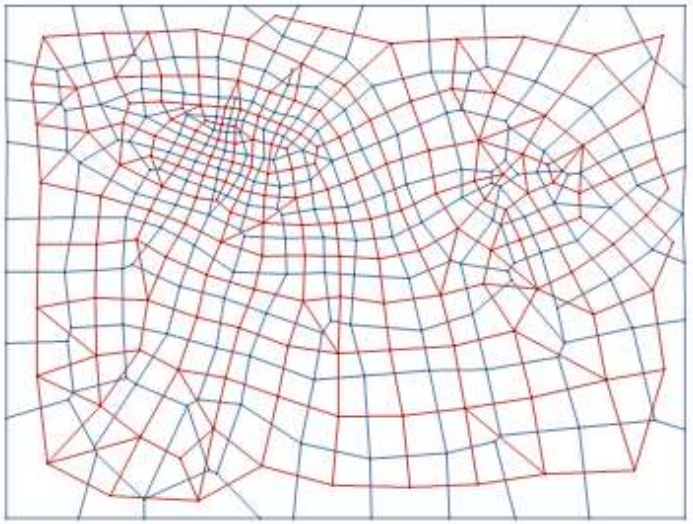

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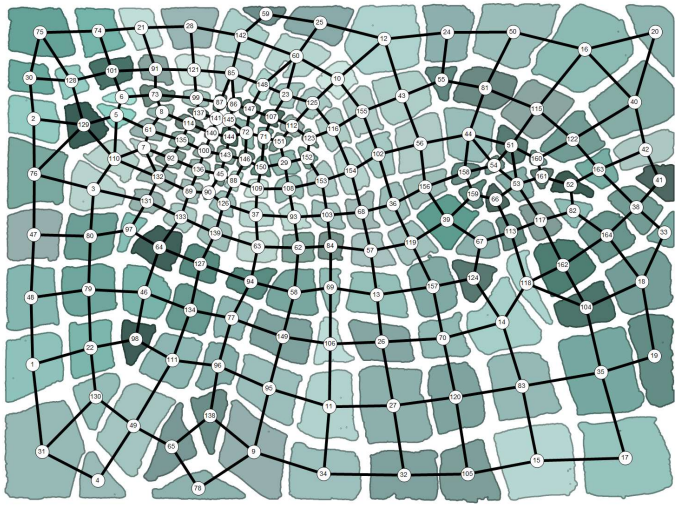
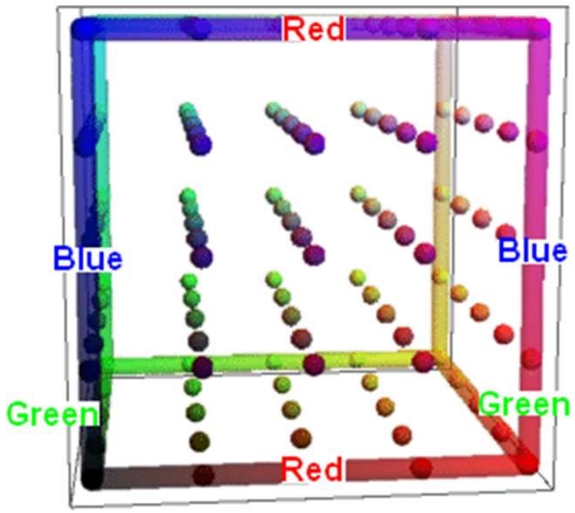
  - Block size and shape
  - Average color of each block
- Infer the road network (MorphologicalGraph)
  - Dual graph (IGraph/M)
  - Block adjacencies

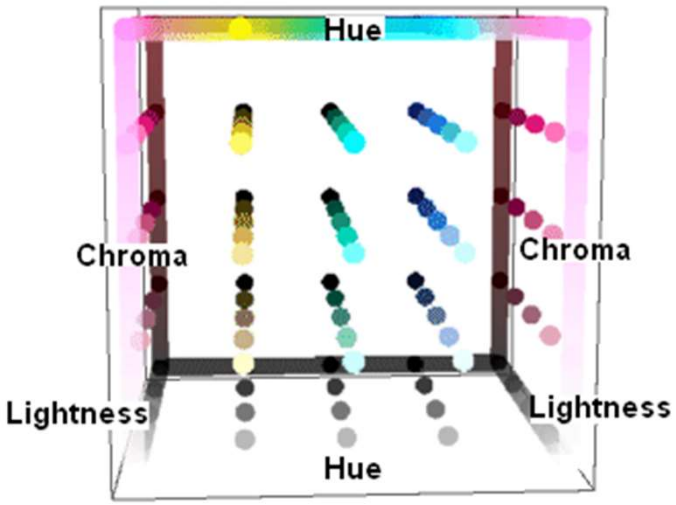


Color Analysis

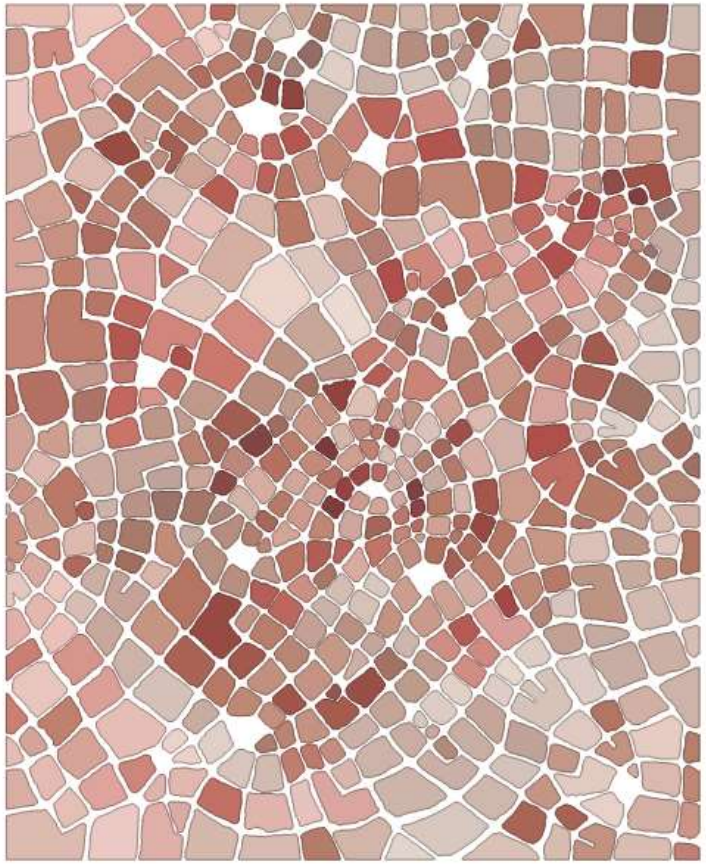
RGB Colors



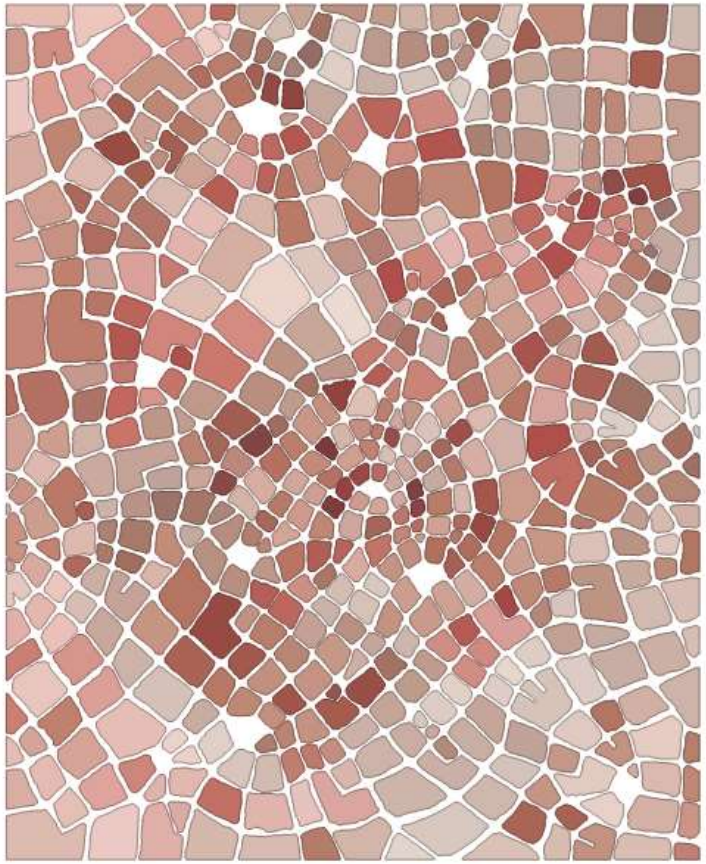
LCH Colors

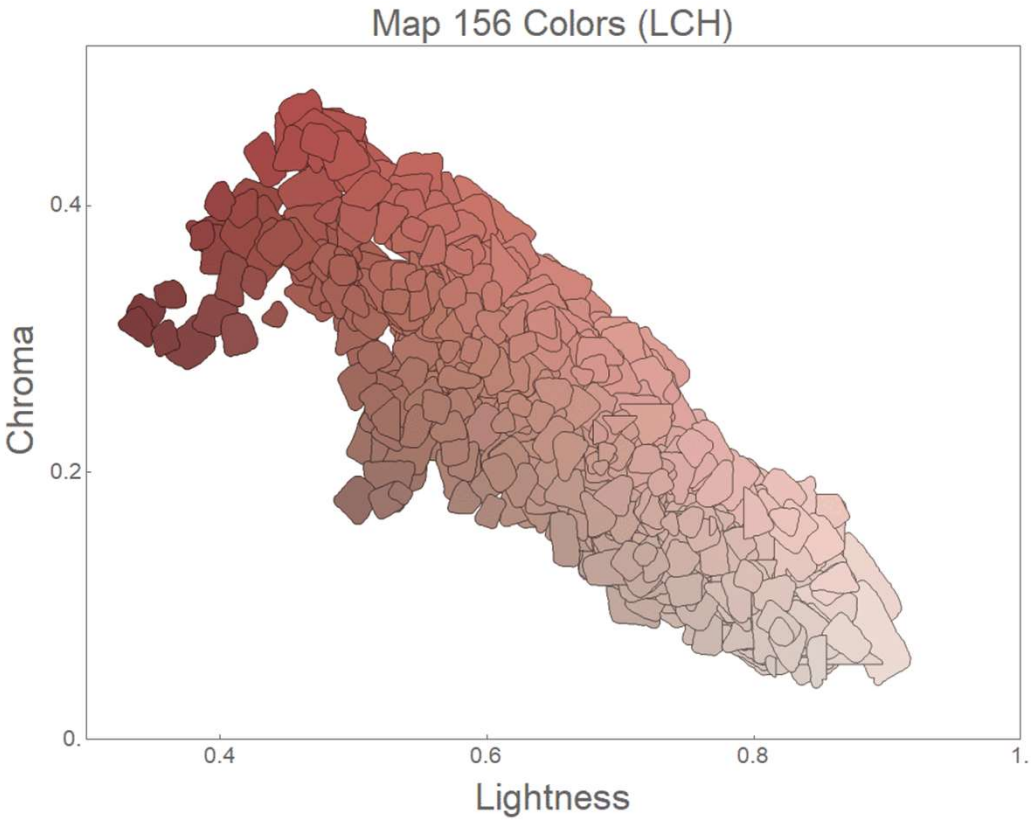


Color Analysis – Cityspace #156

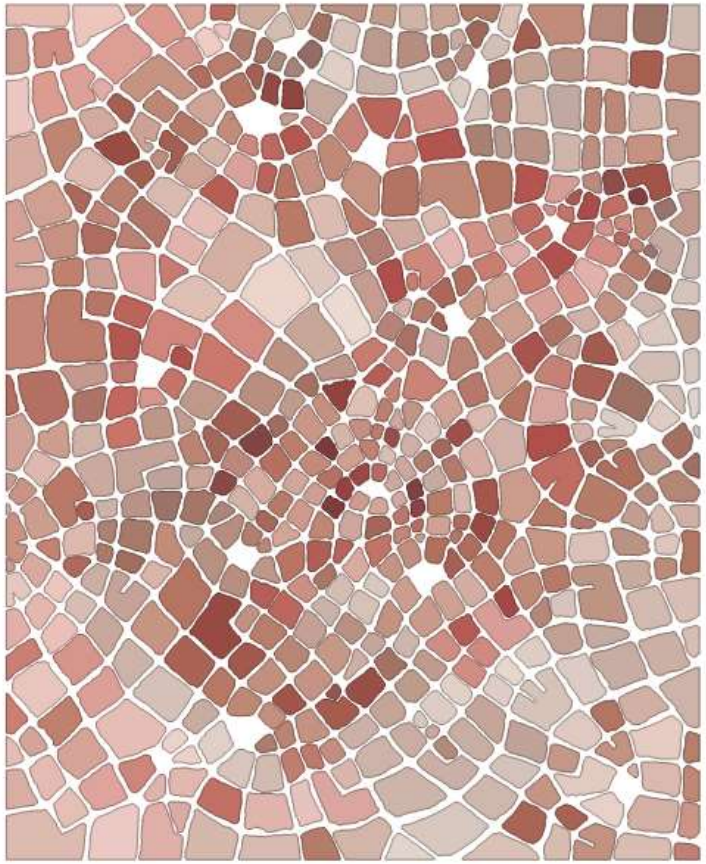


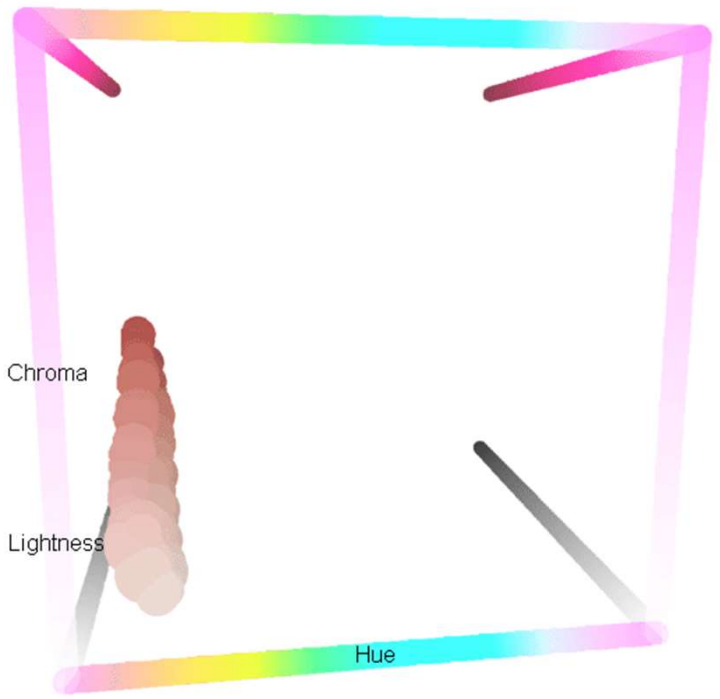
Color Analysis





Color Analysis





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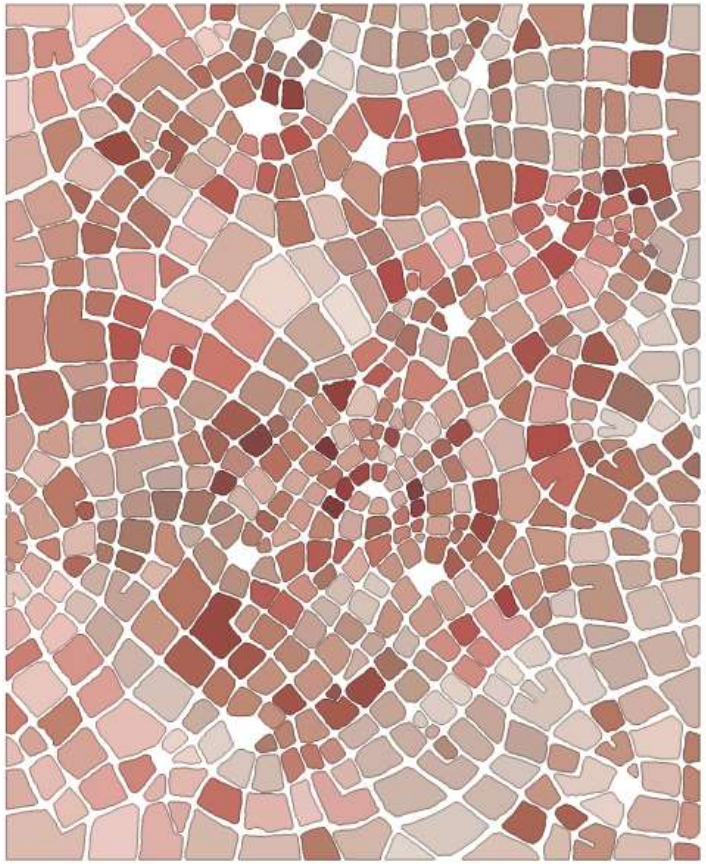
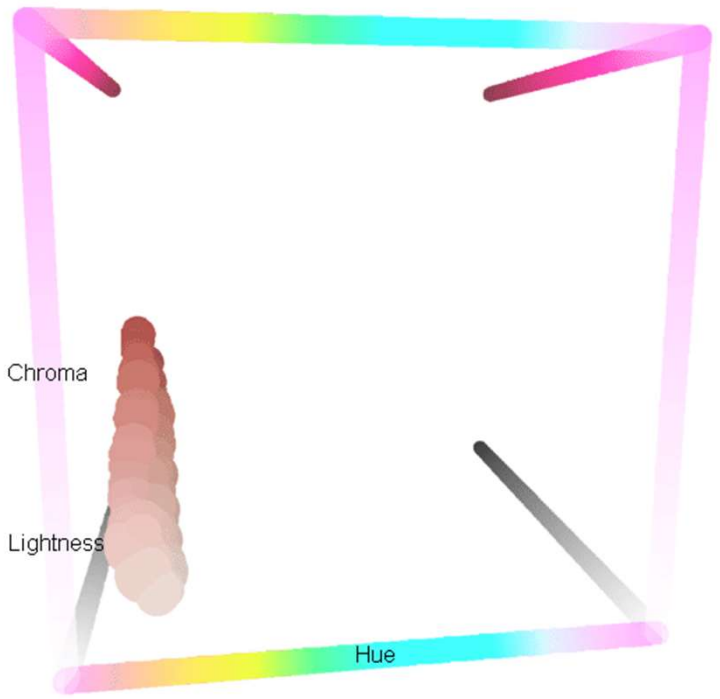
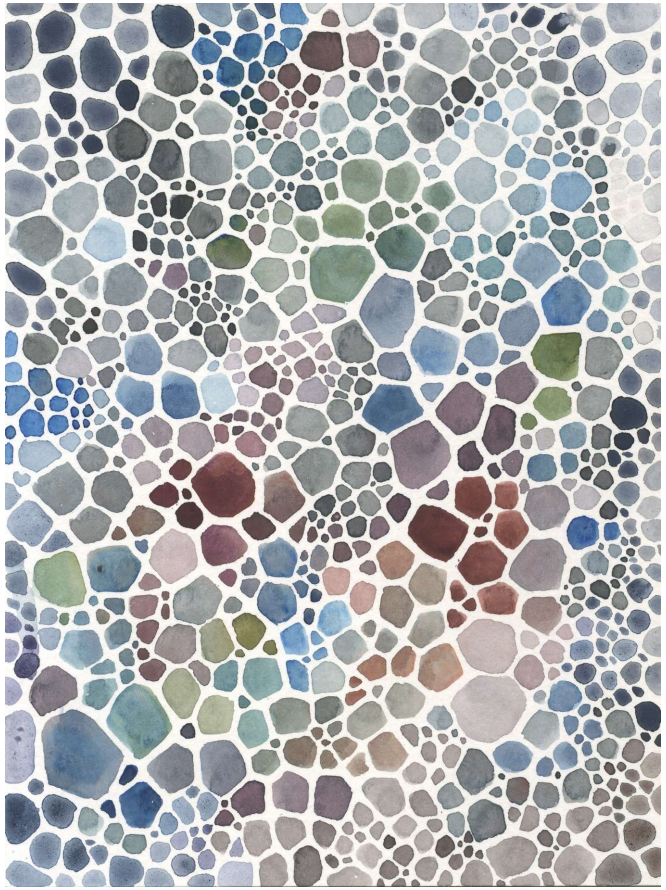
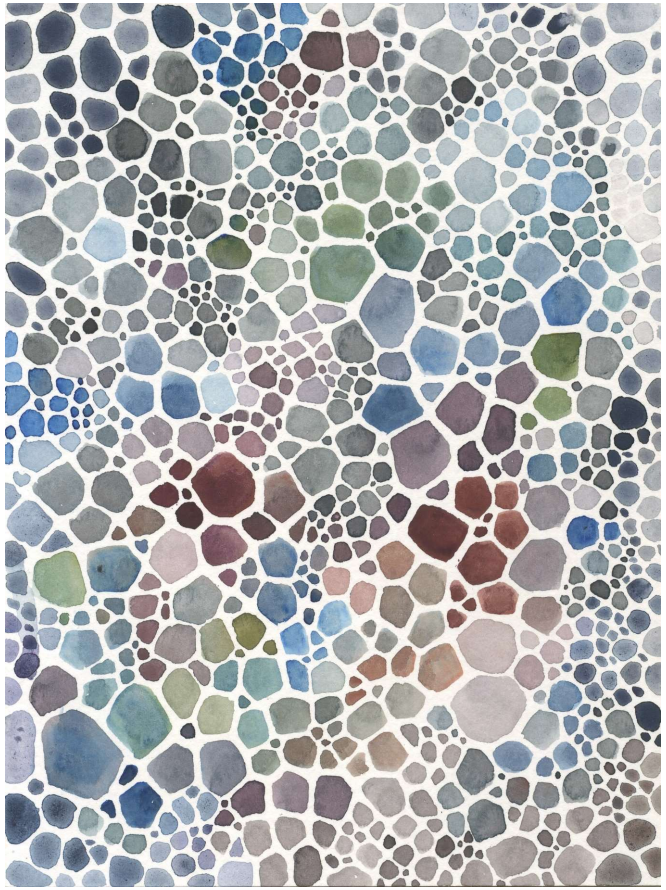


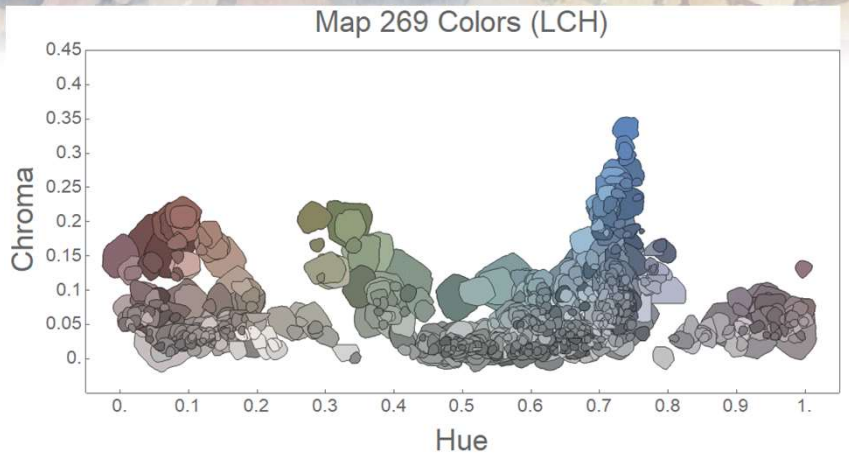


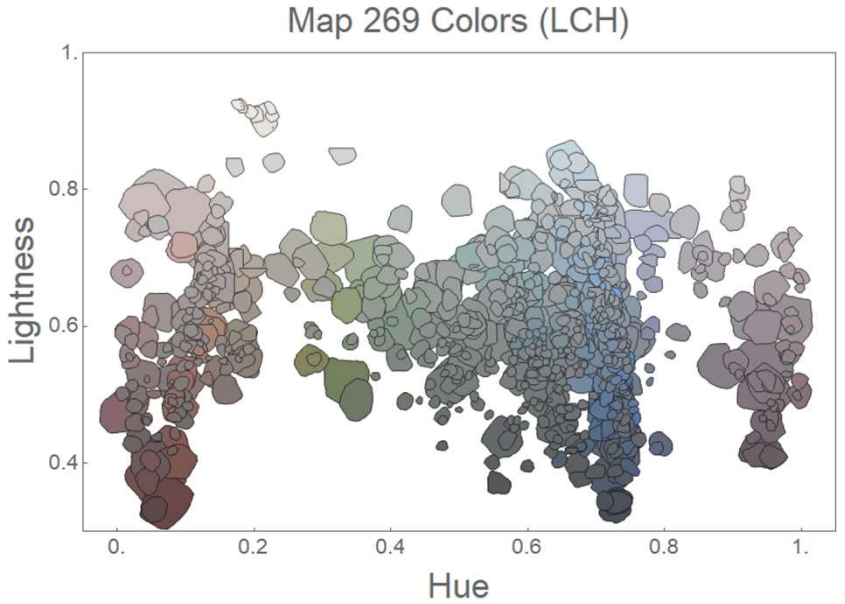
Color Analysis – Cityspace #269



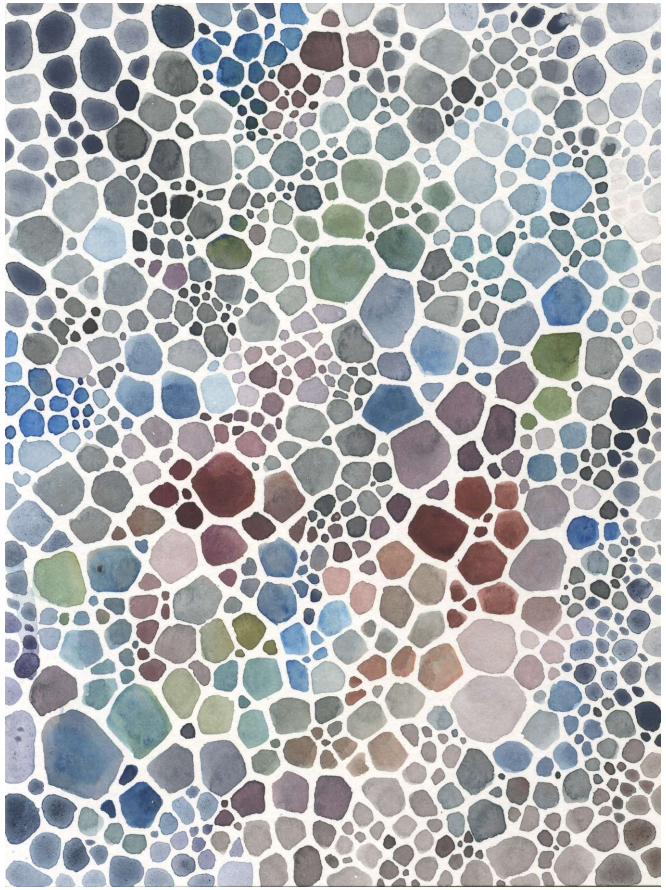
Color Analysis

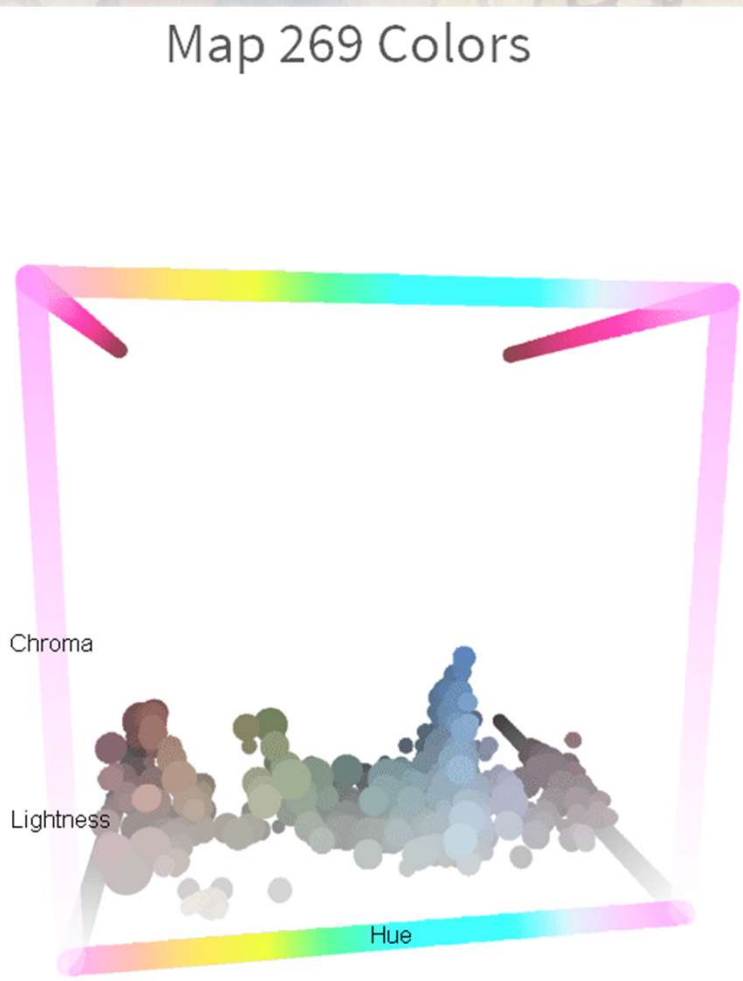




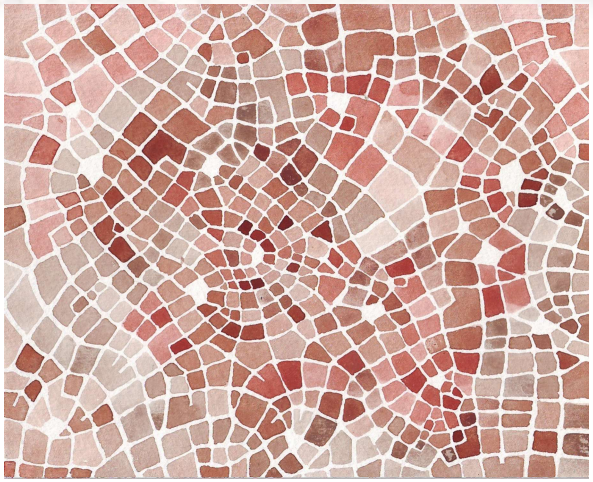


Color Analysis





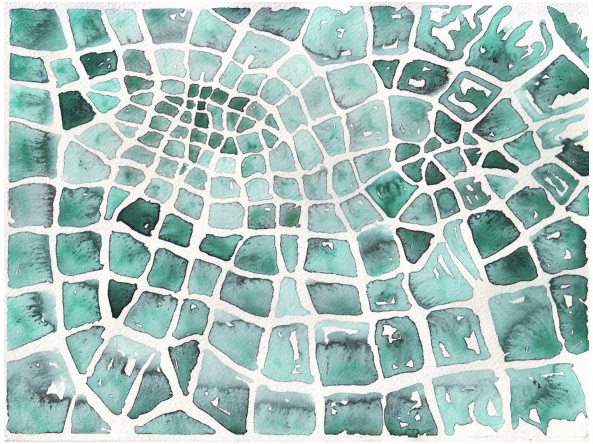
Cityspace #156



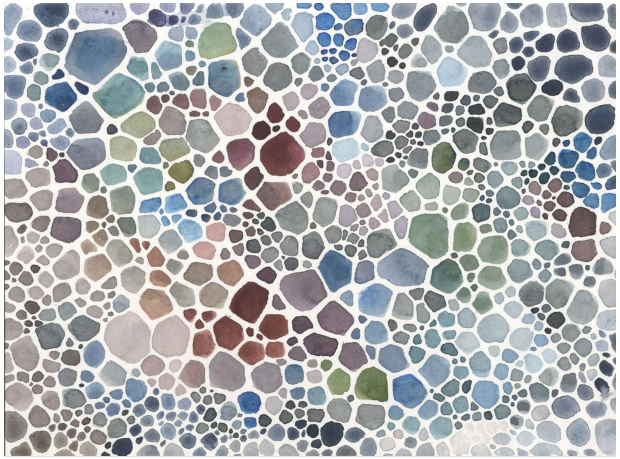
Cityspace #268

Cityspace #297

Cityspace #199

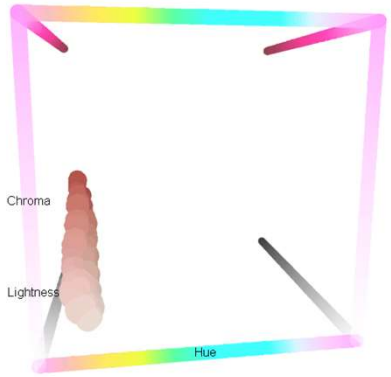


Cityspace #269

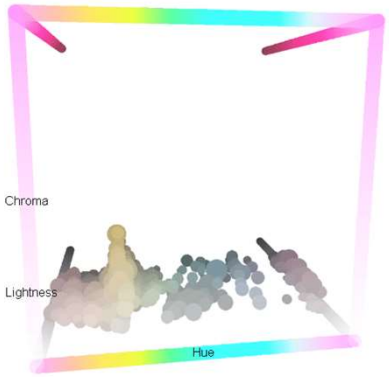


Cityspace #311

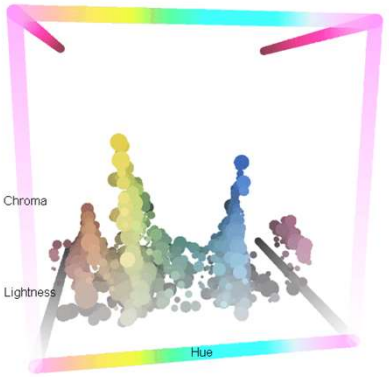
Map 156 Colors



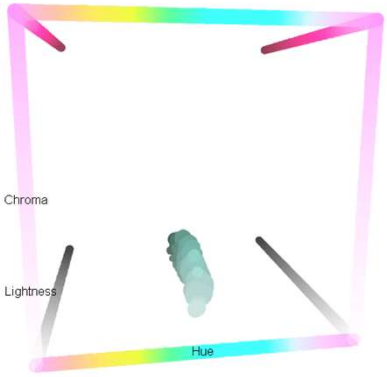
Map 268 Colors



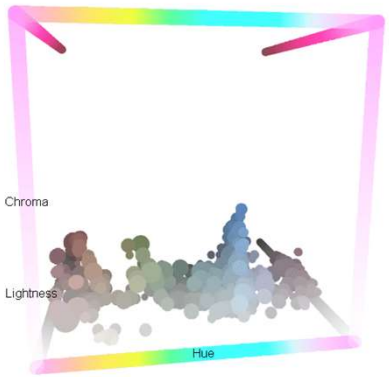
Map 297 Colors



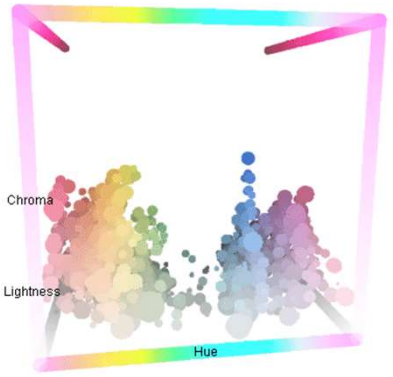
Map 199 Colors



Map 269 Colors



Map 311 Colors



Block Analysis – Provides a Fingerprint

- Size – What is the area?
- Density – How dense is the neighborhood?
- Shape – How rectangular is it?

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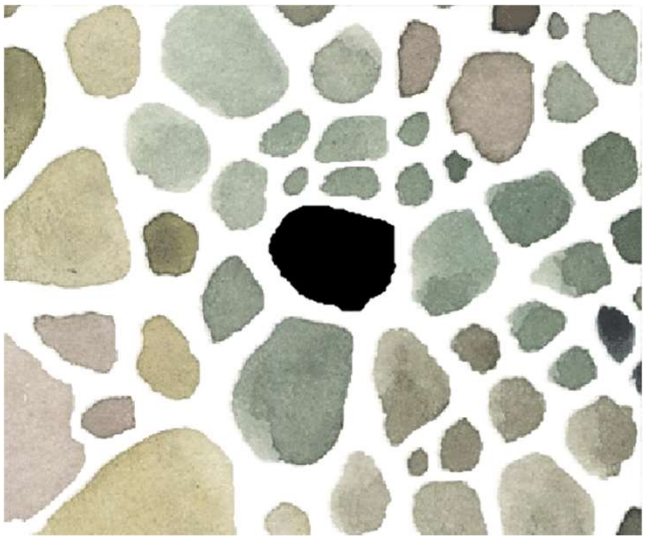

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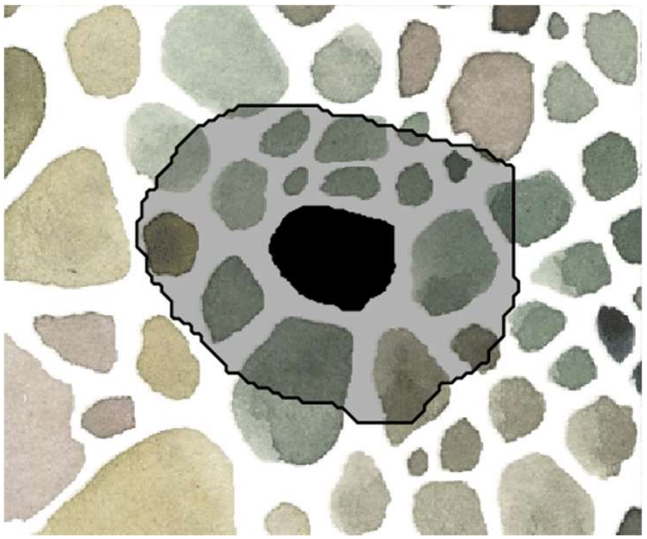

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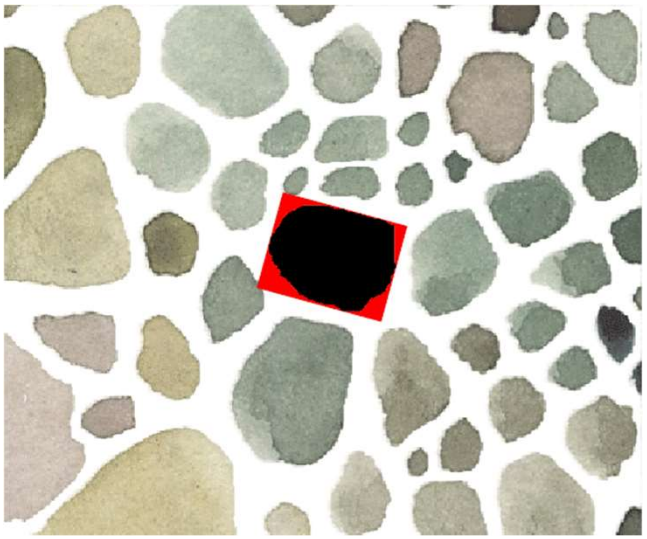
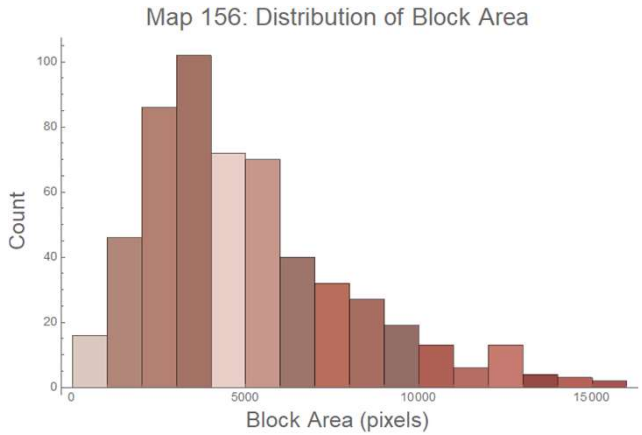
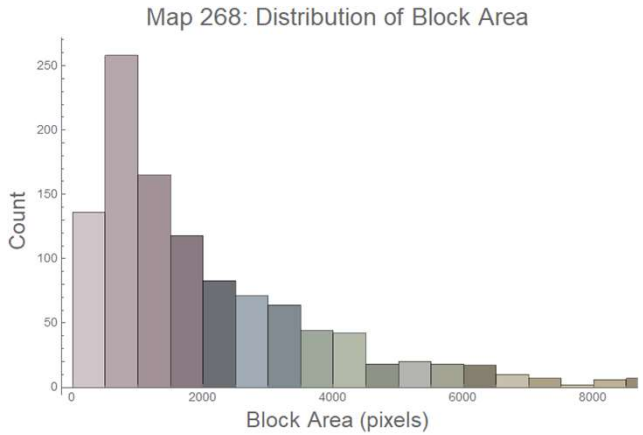
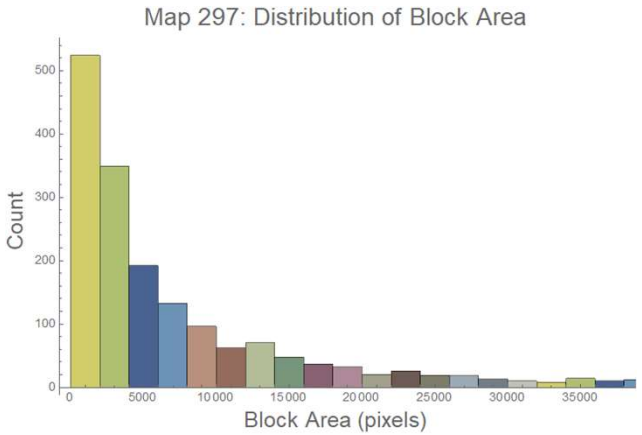
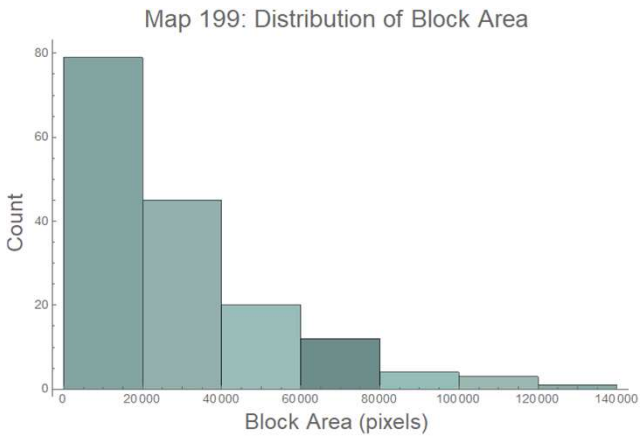


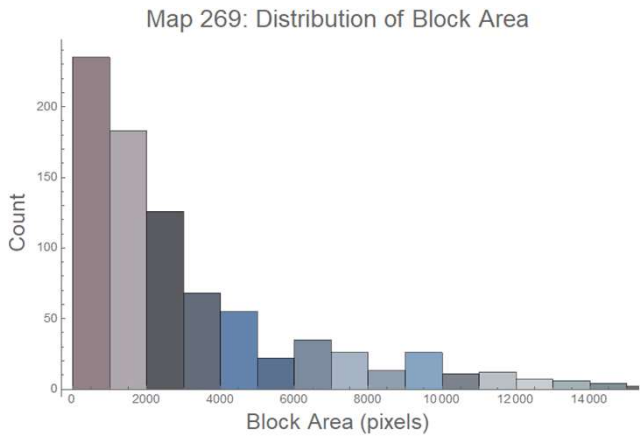
Block Size Analysis

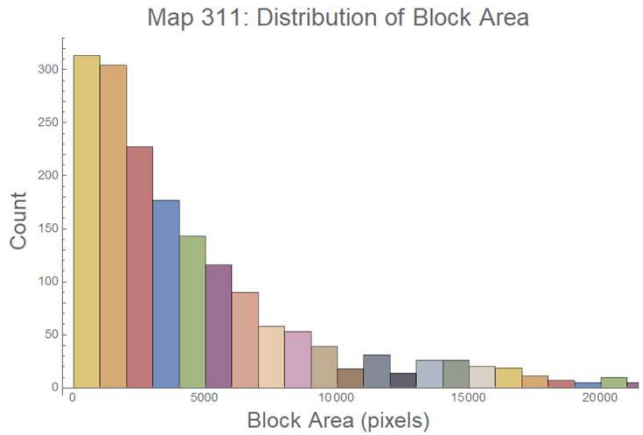




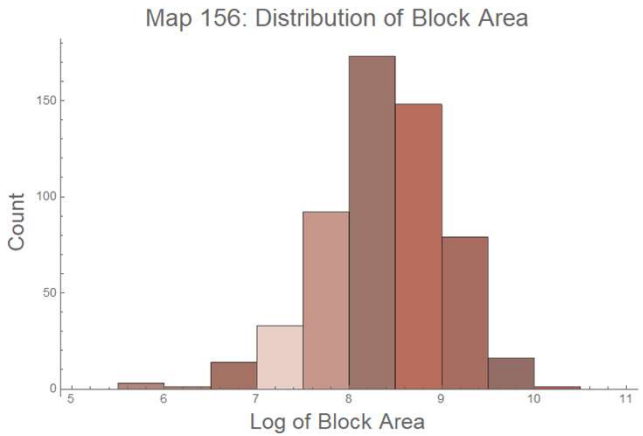


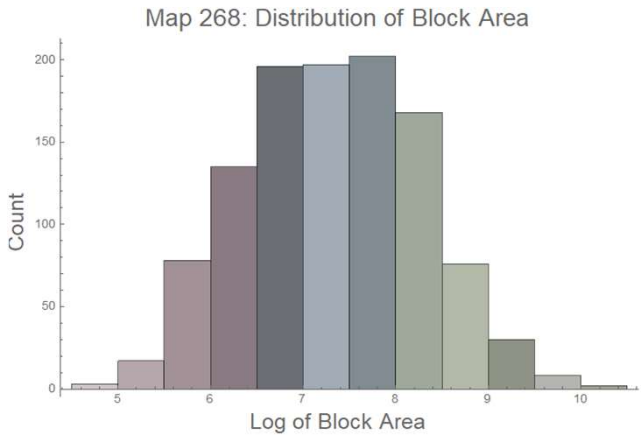


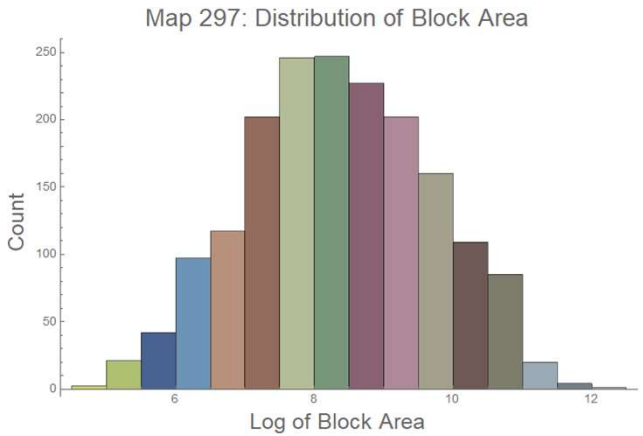


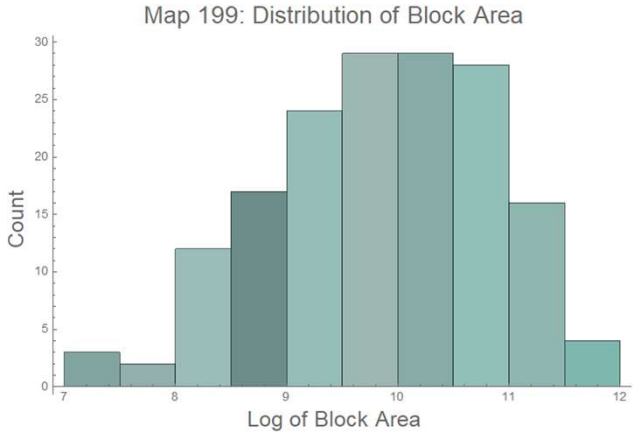


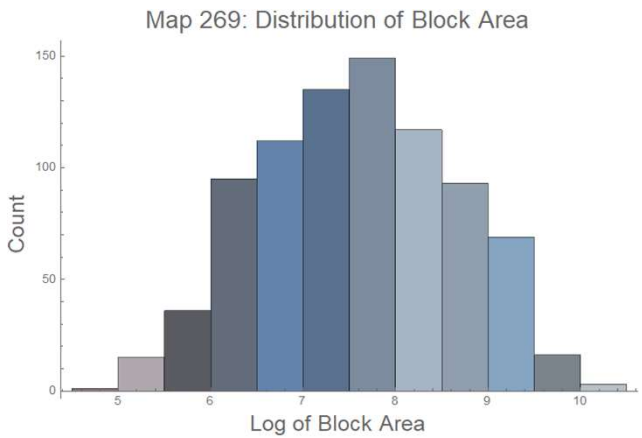
Block Size Analysis (Logarithmic)

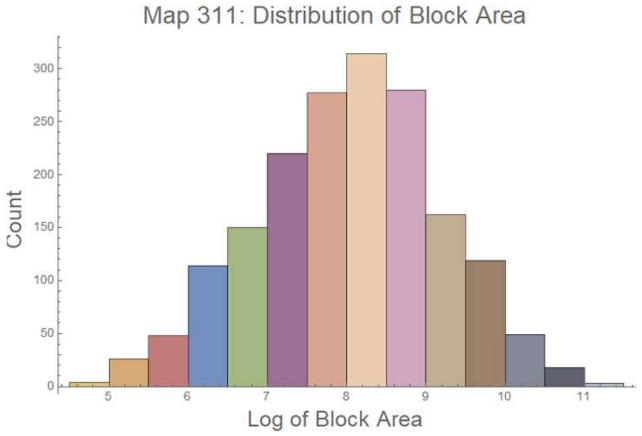




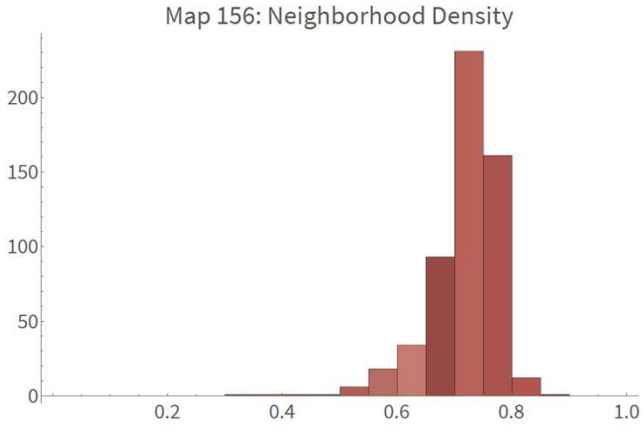


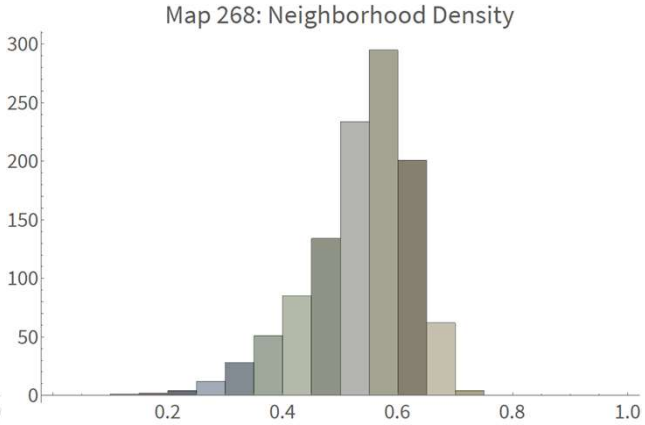


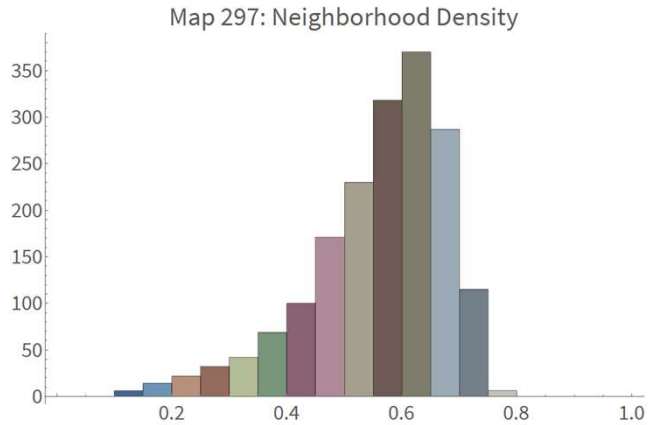


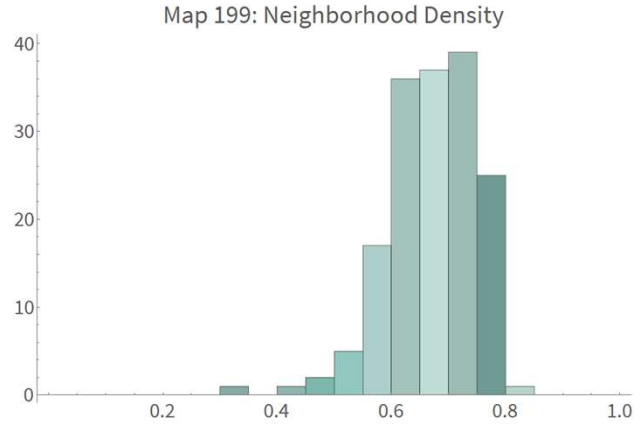


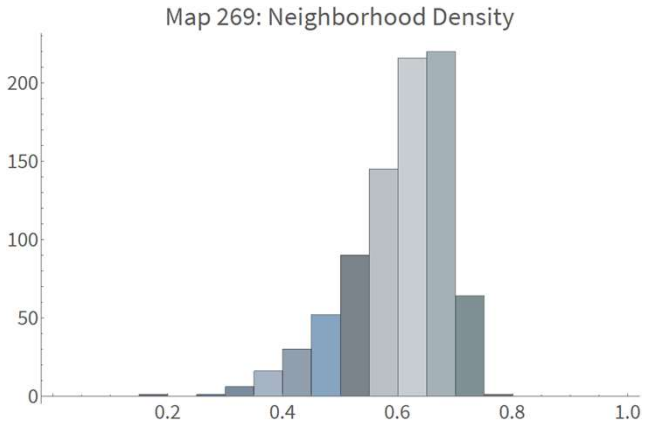
Neighborhood Density

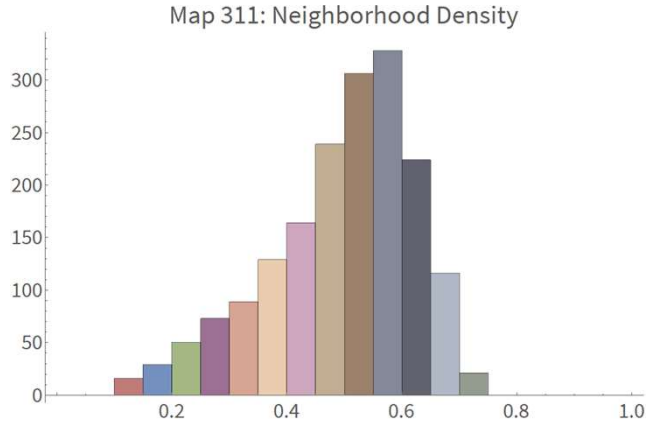




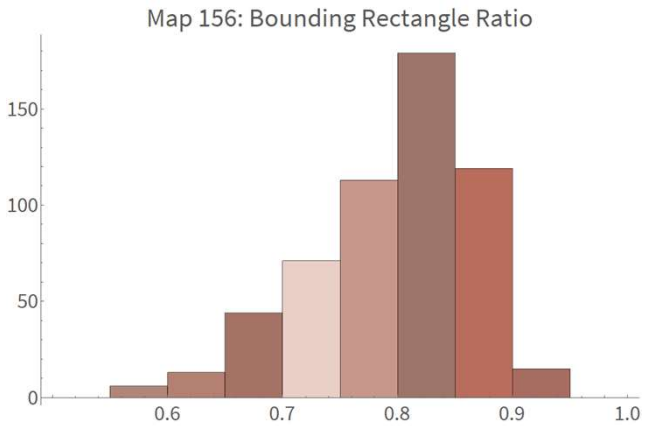


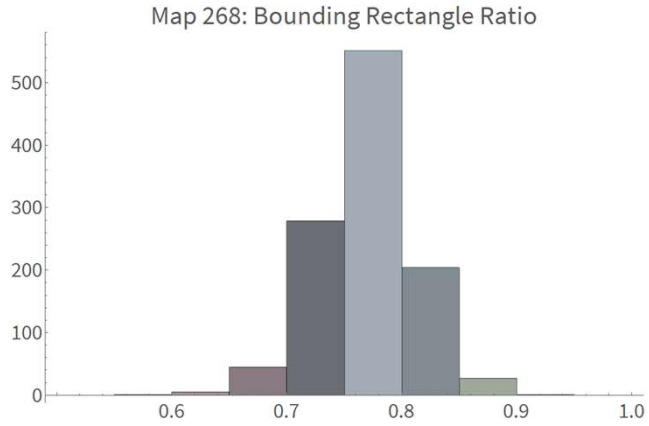


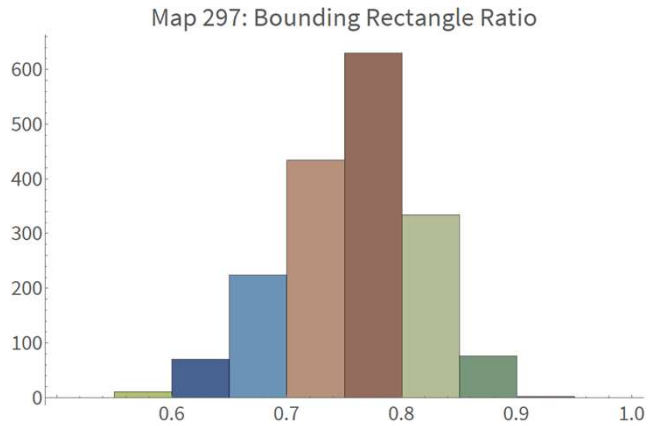


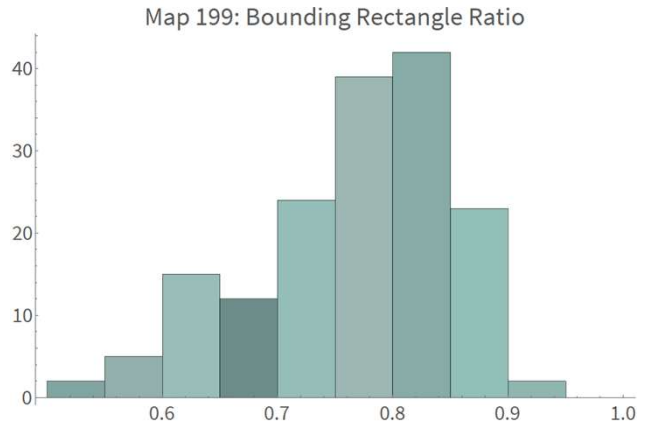


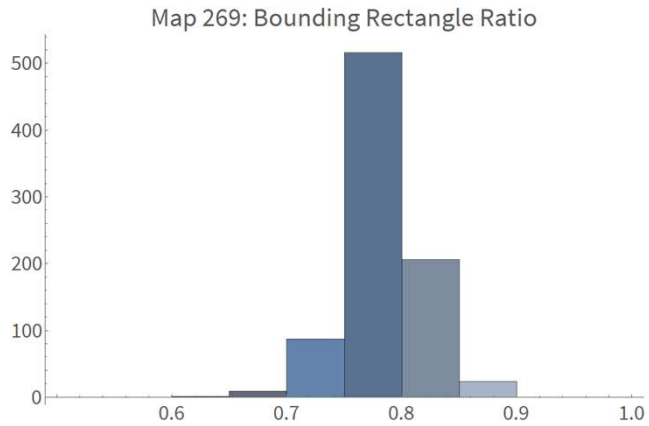
Block Rectangularity

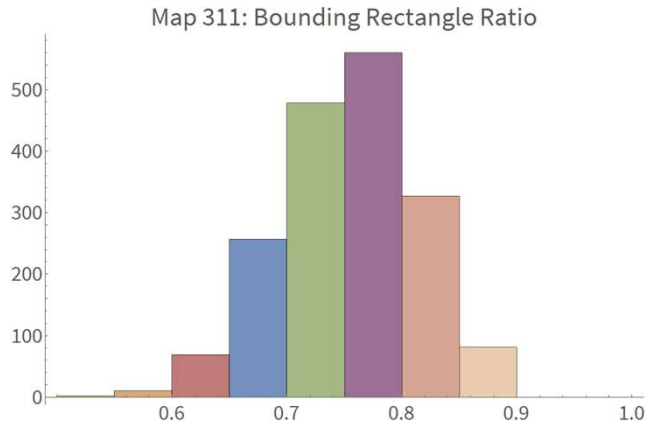






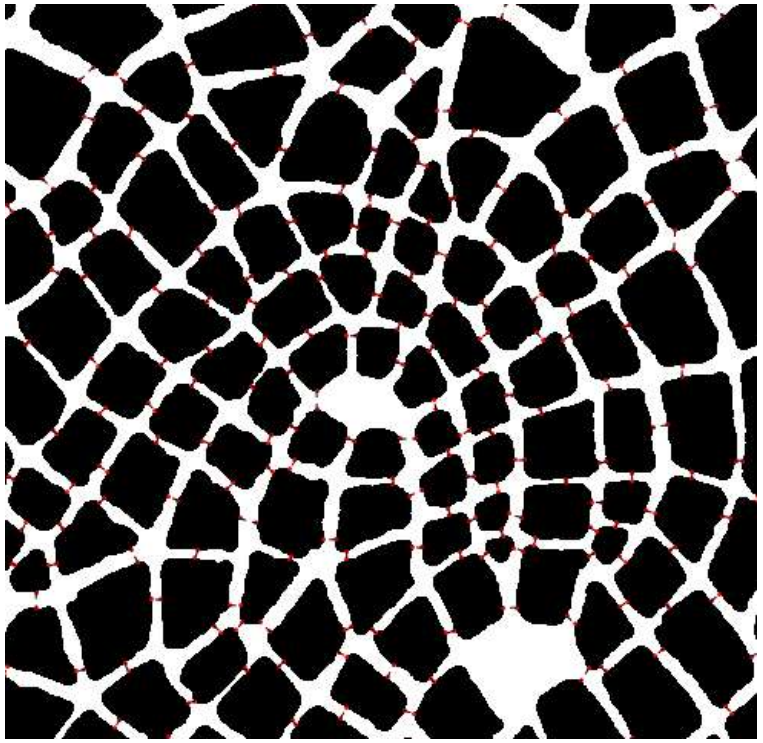




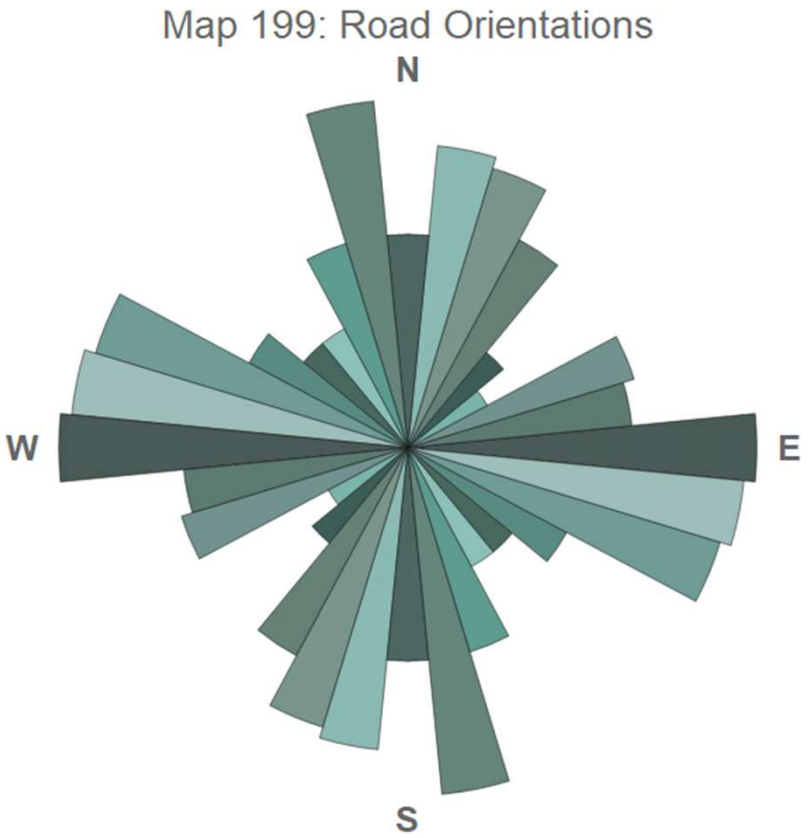


Road analysis

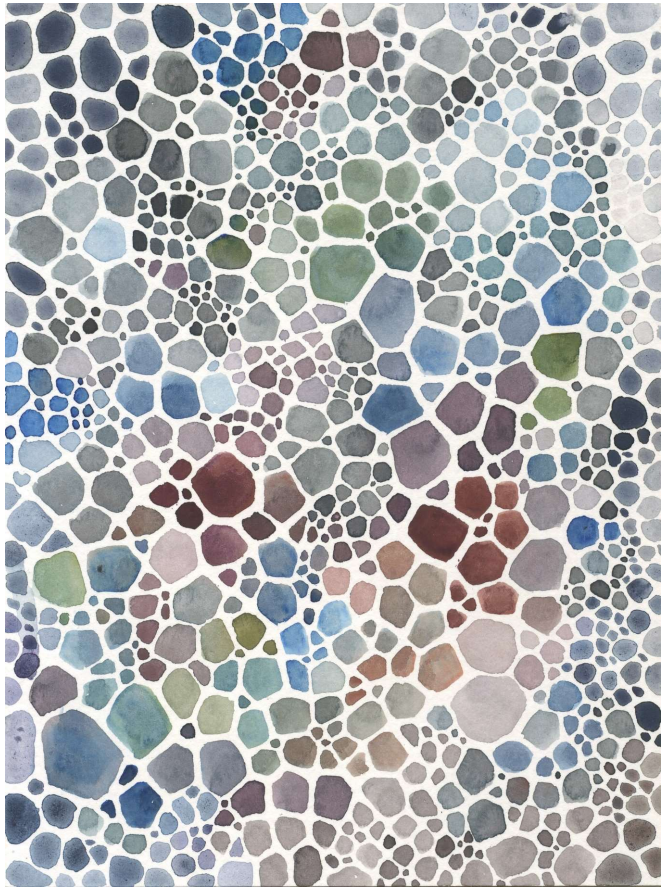
- Width – Skinniest part of road
- Length – Distance between intersections
- Orientation – Street Direction

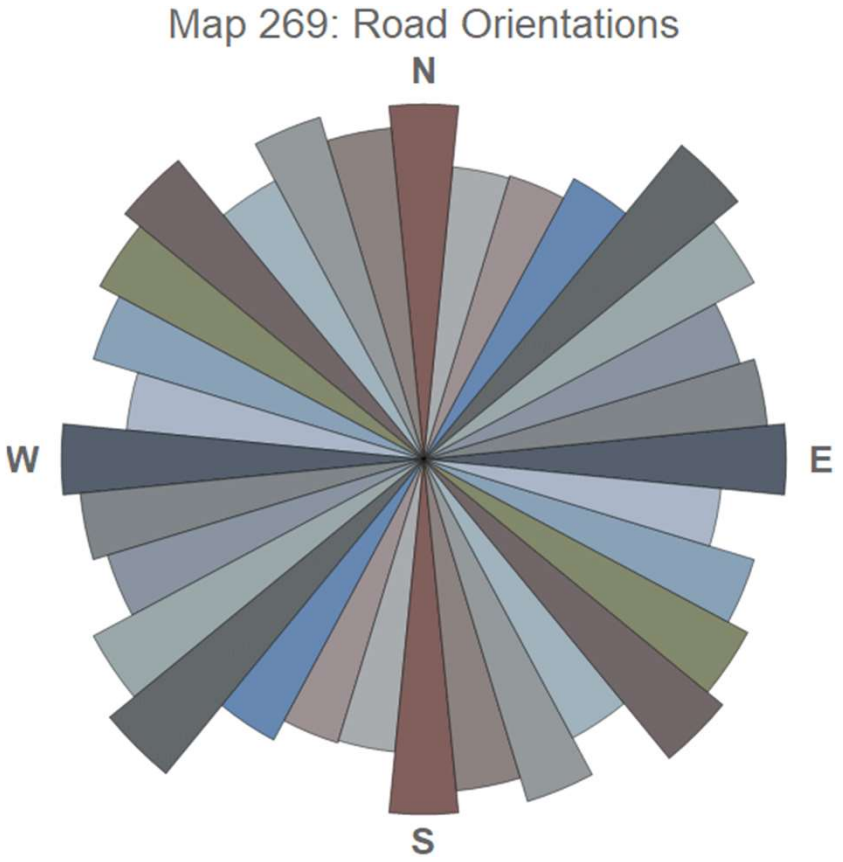


Road Orientation

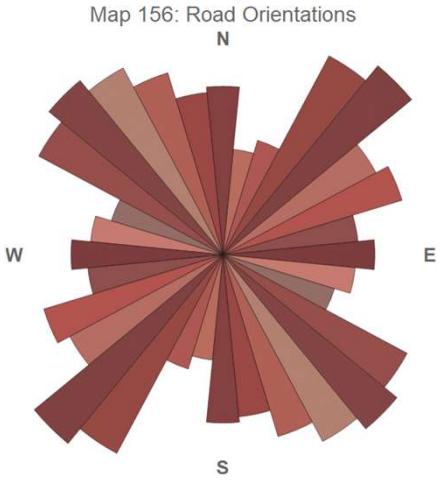


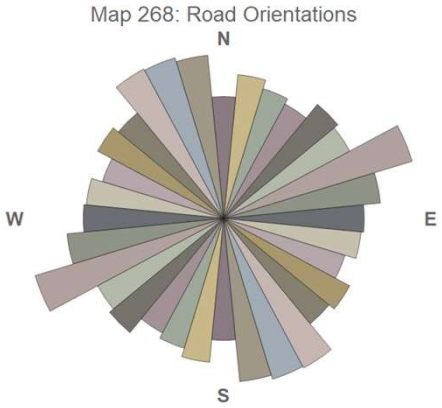
Road Orientation

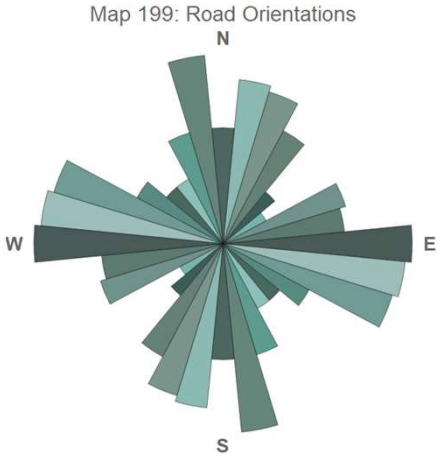


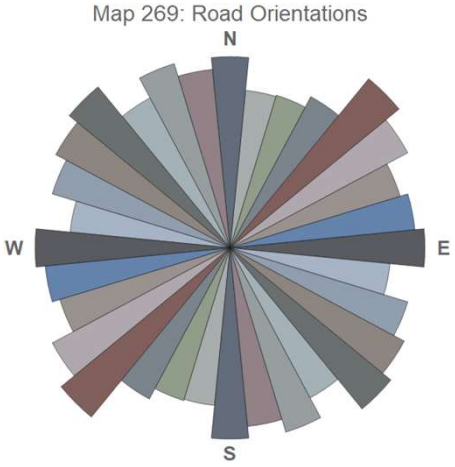


Road Orientation

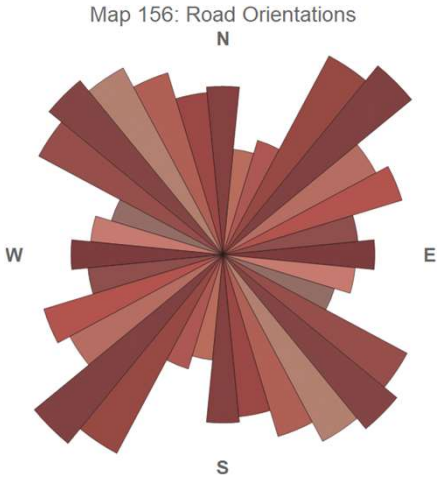


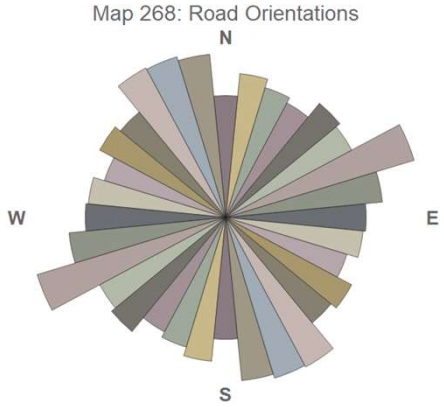




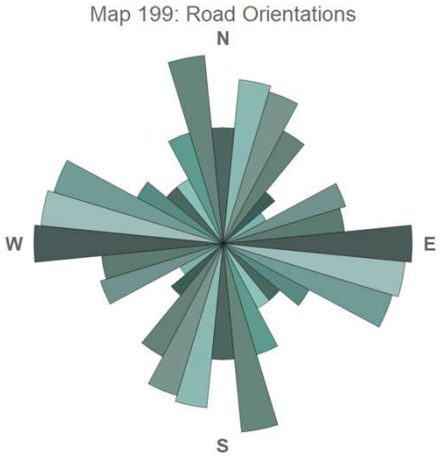


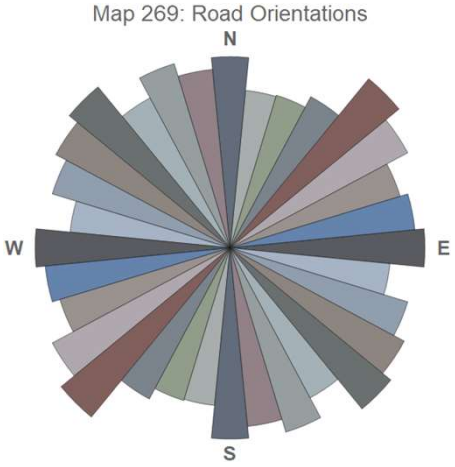
Road Orientation

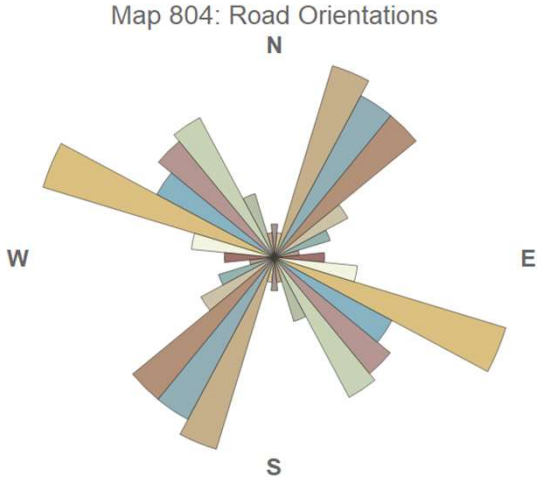




Davis Square – Emily Garfield



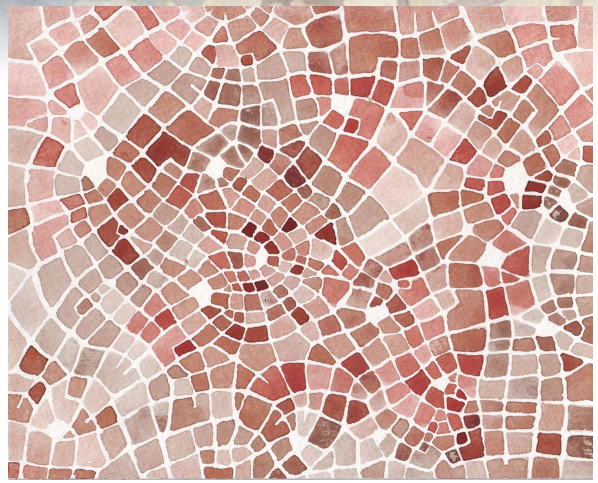


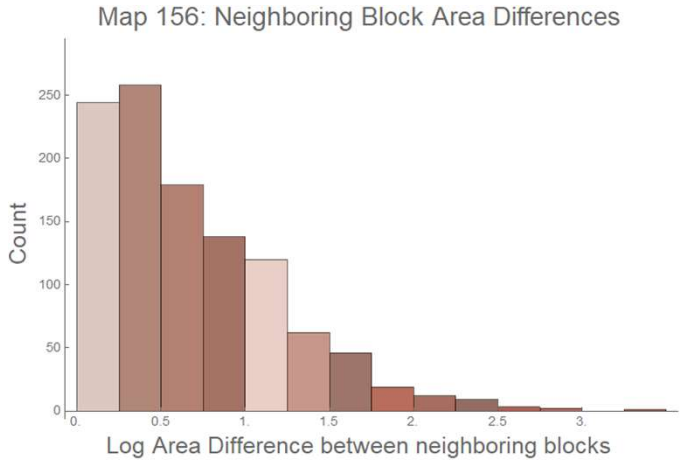


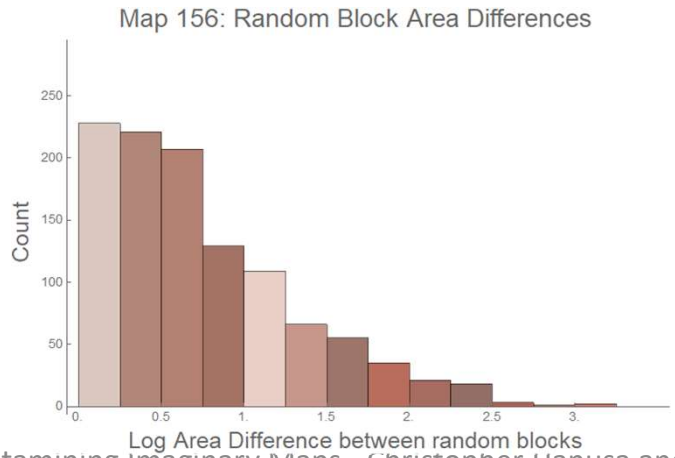
Neighbor analysis

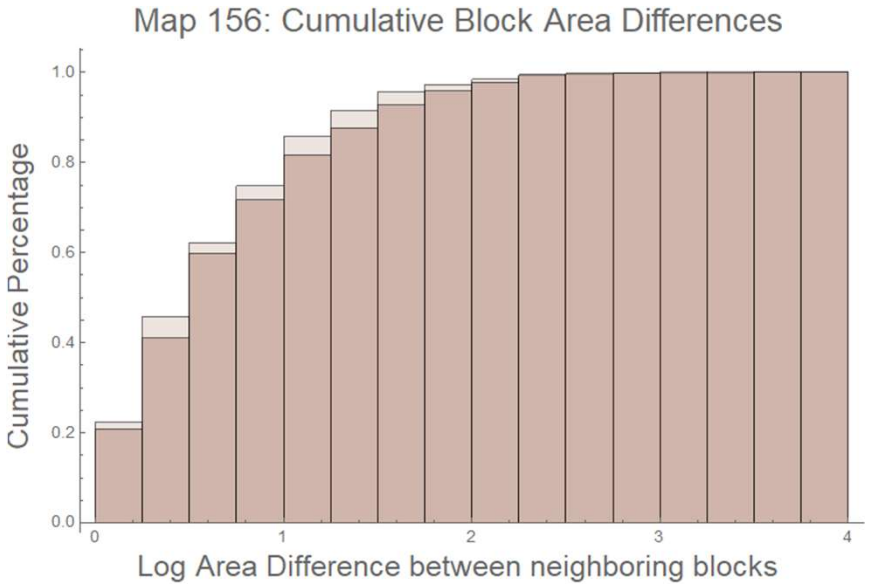
- Number of neighbors
- Neighbor Size Ratio (Difference in Log Area)
- Neighbor Color Difference

How close in size are neighbors?

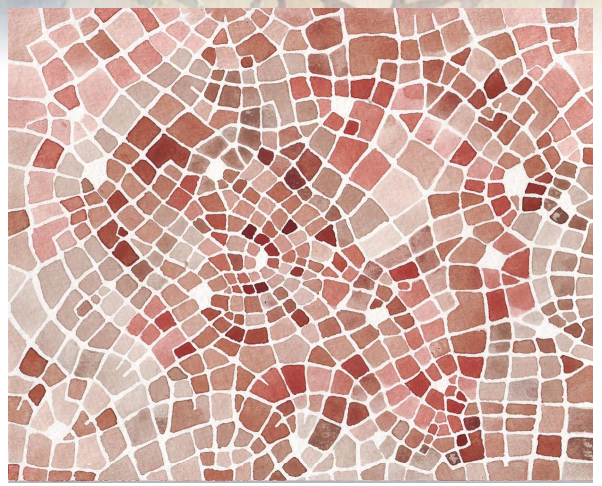


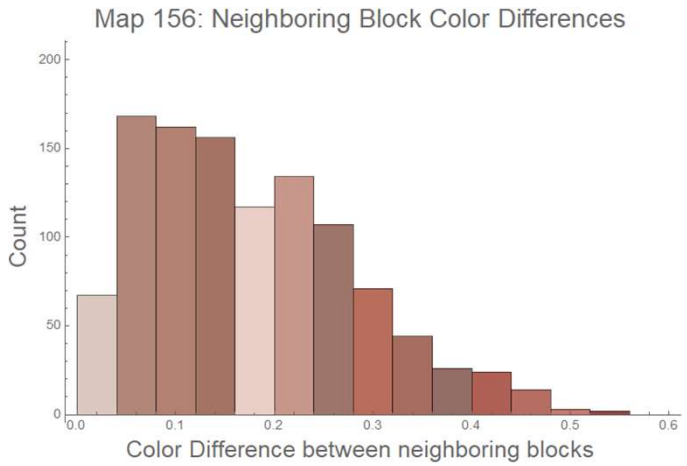


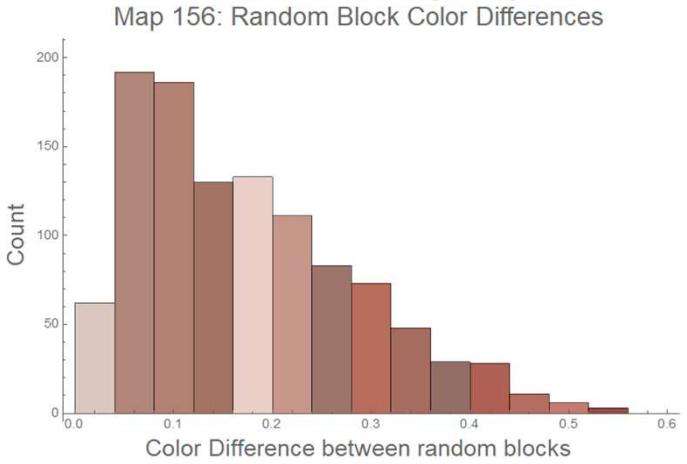


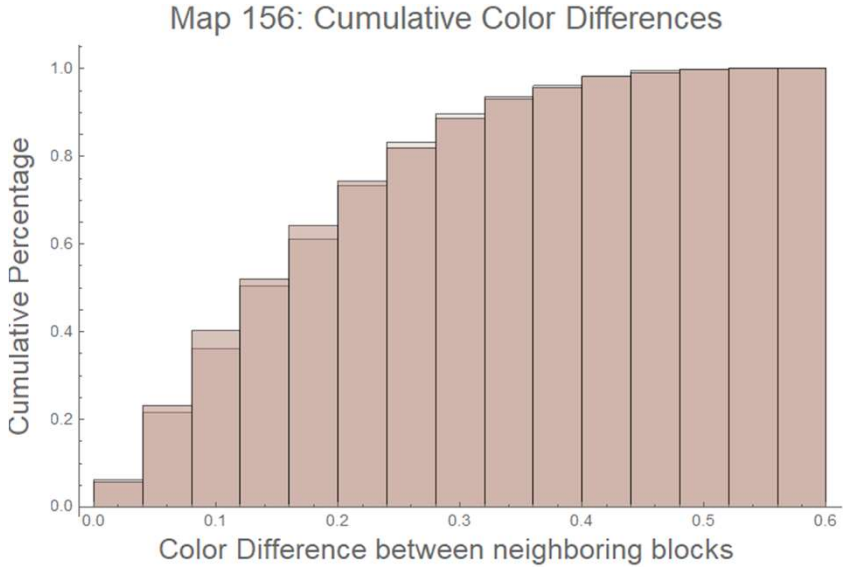


How close in COLOR are neighbors?

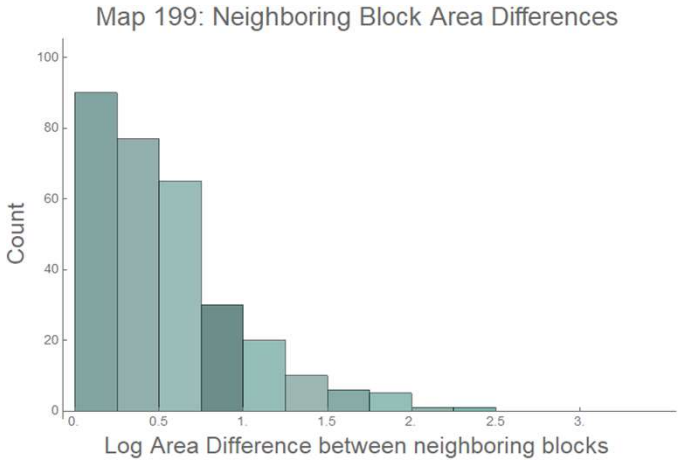


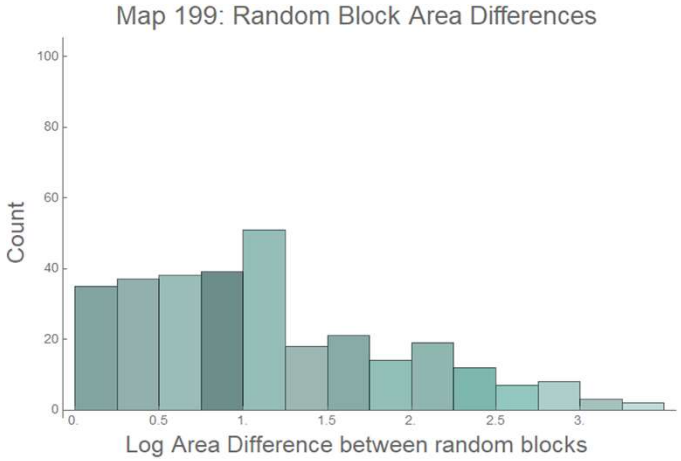


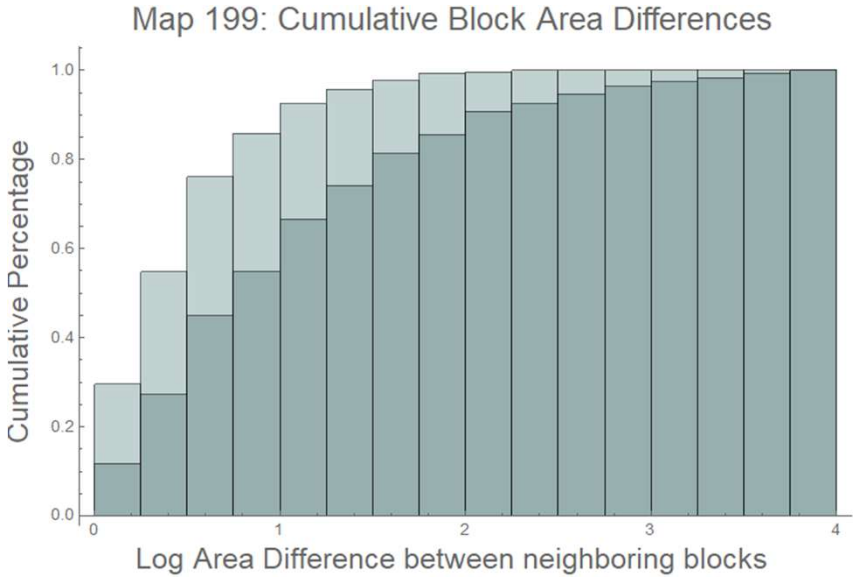




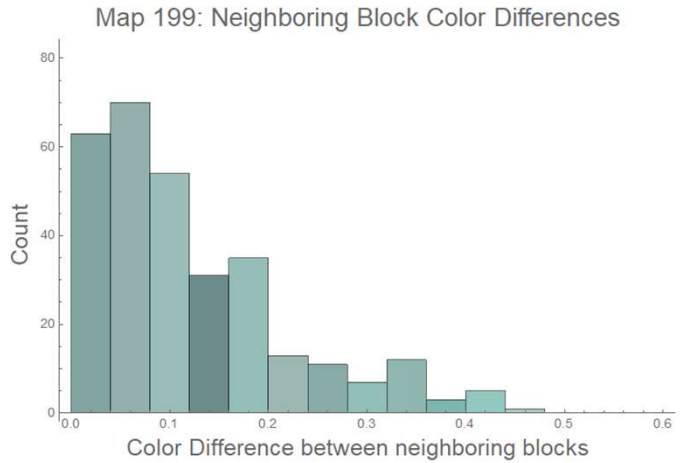
How close in size are neighbors?

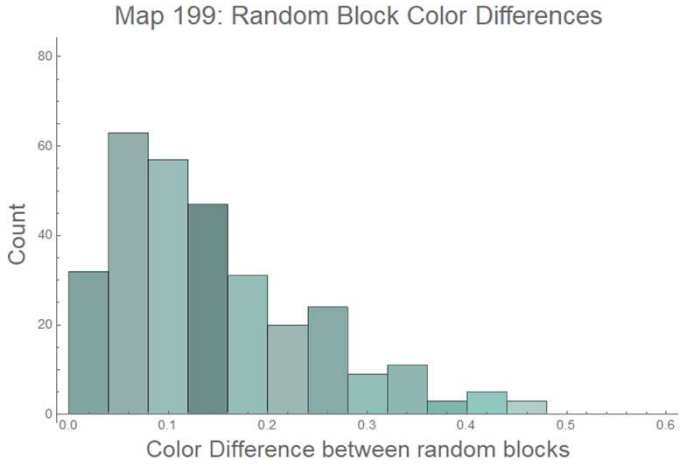


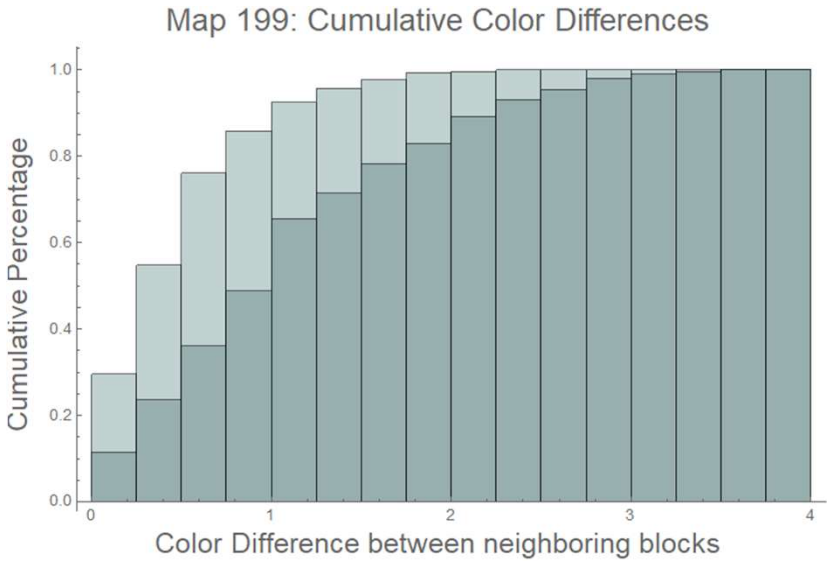




How close in COLOR are neighbors?







Fractal Analysis

Sub-images ≈ Whole image ?

Neighborhoods of small blocks ≈ Neighborhoods of large blocks ?

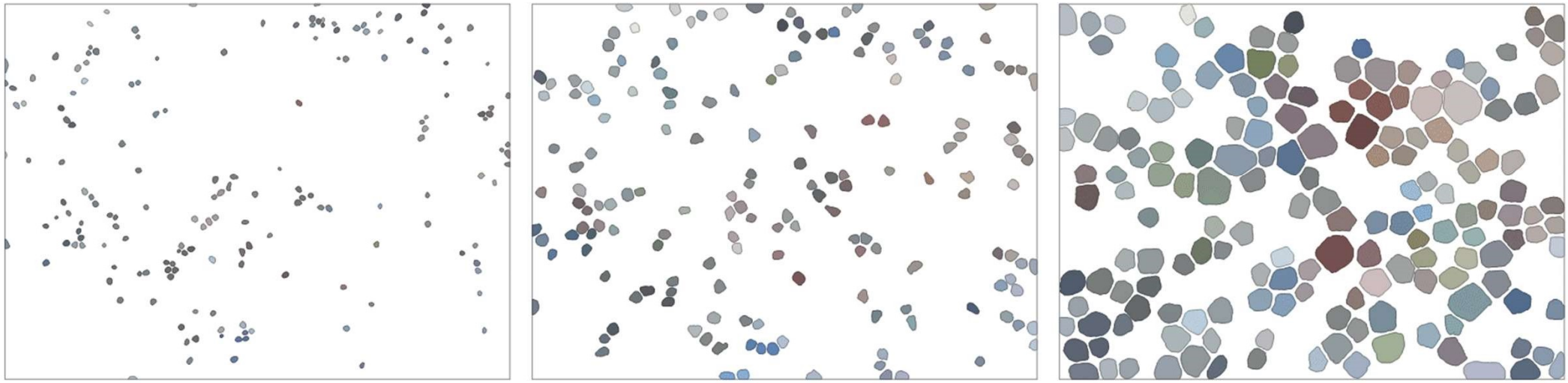
Fractal Analysis

Sub-images ≈ Whole image ?

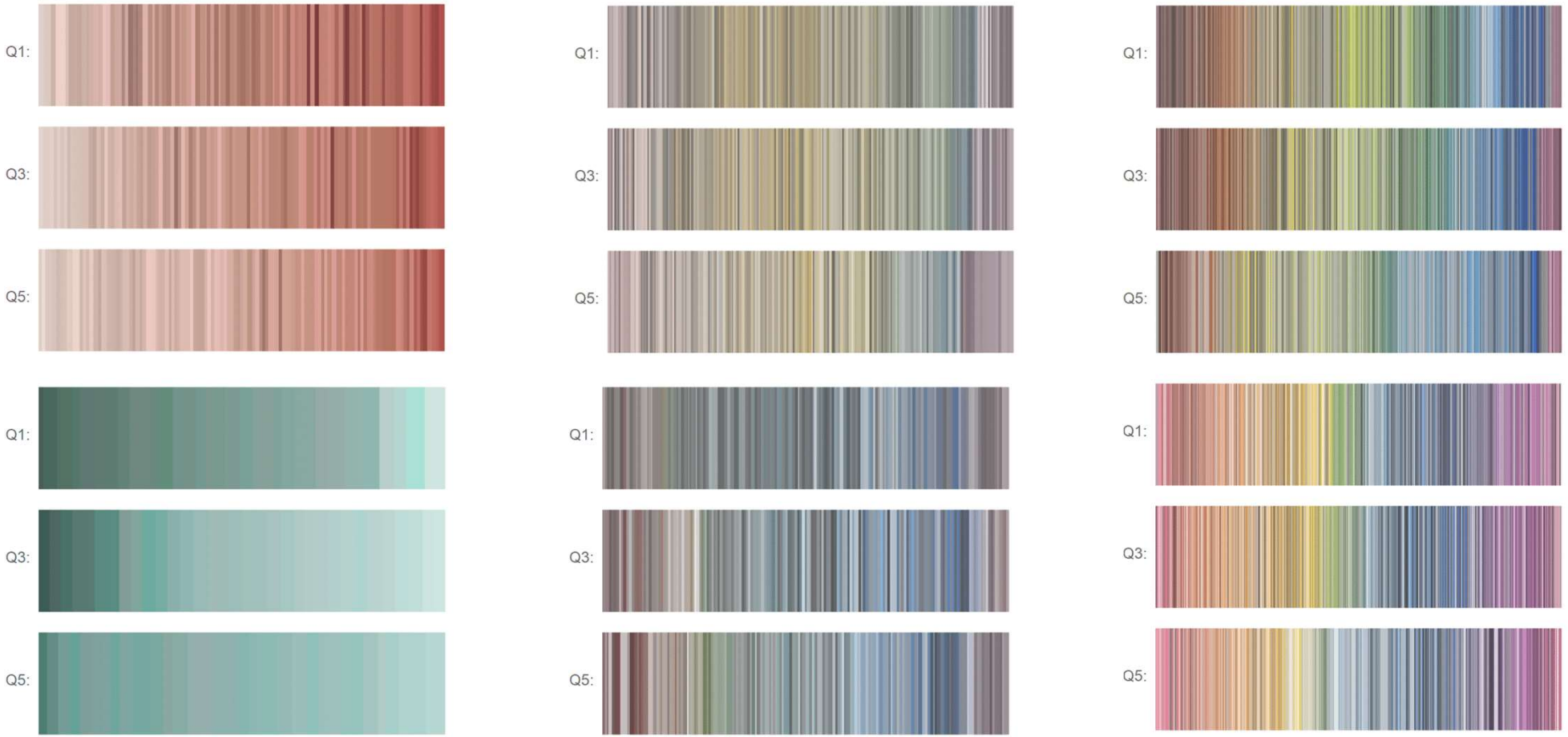
Neighborhoods of small blocks ≈ Neighborhoods of large blocks ?

Partition blocks based on size ⇝ Compare Quintiles 1, 3, and 5:

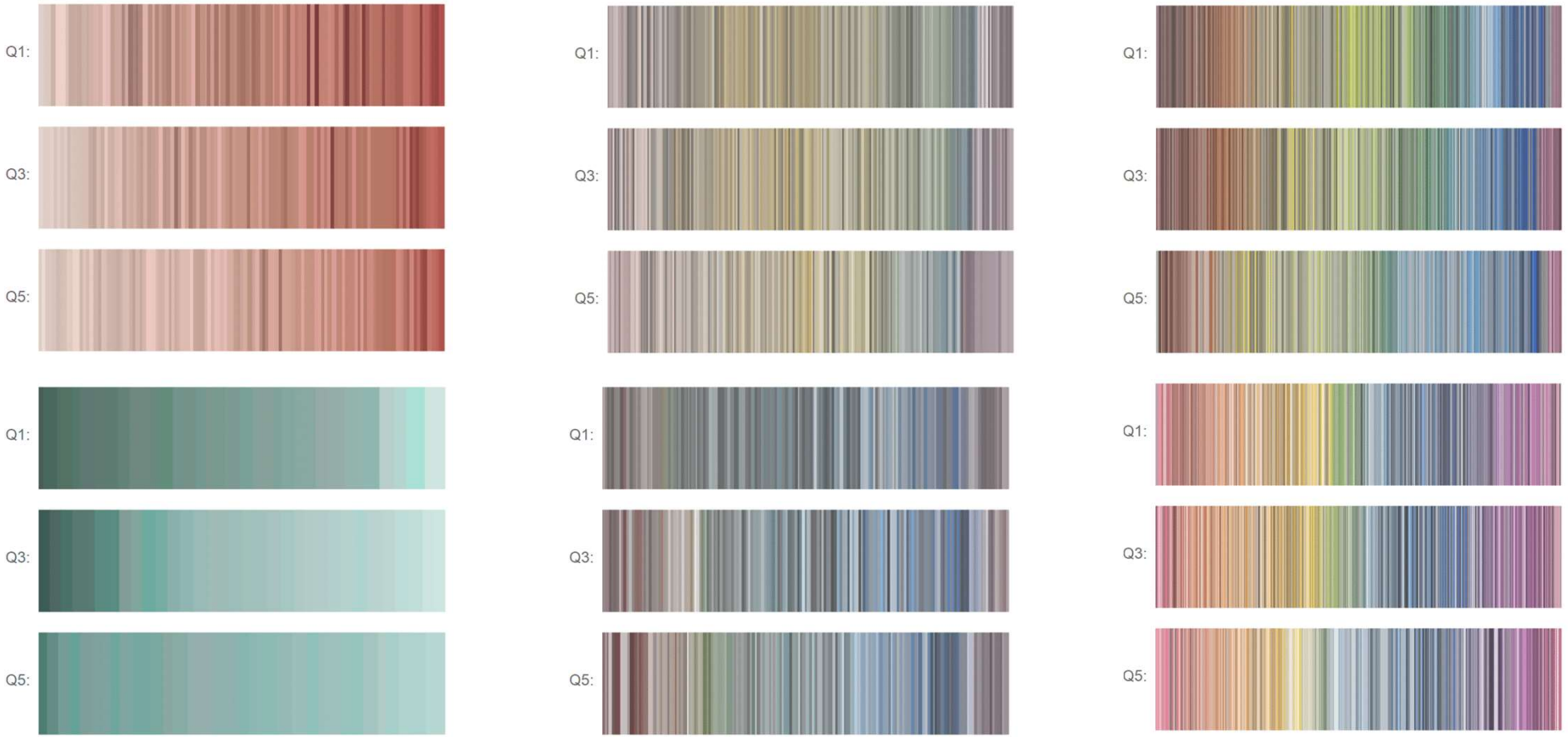
Map 269: Blocks in Size Quintiles 1, 3, 5



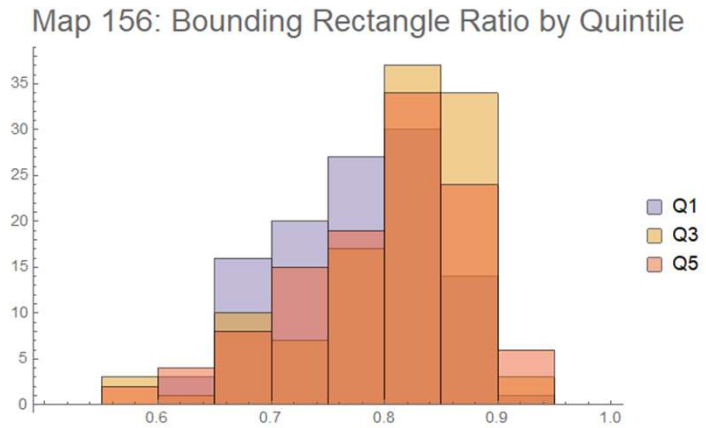
Color Distributions are Independent of Block Size

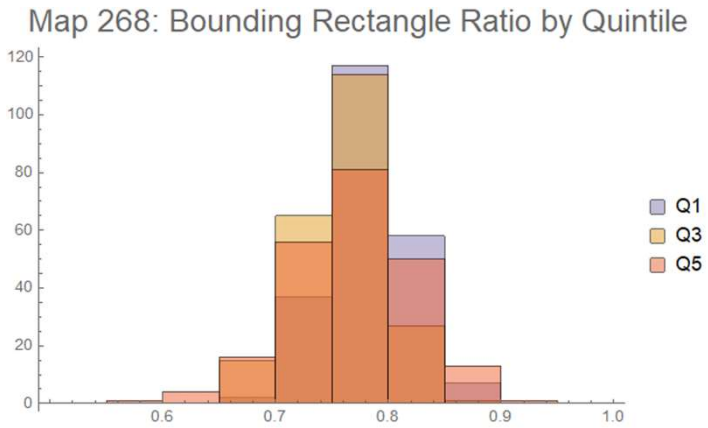


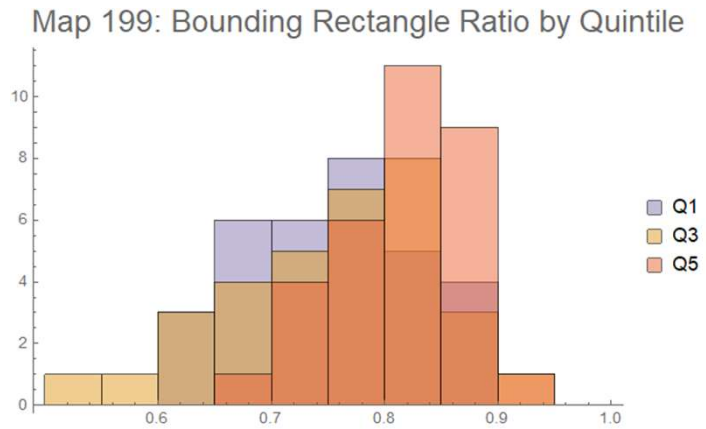
Color Distributions are MOSTLY Independent of Block Size

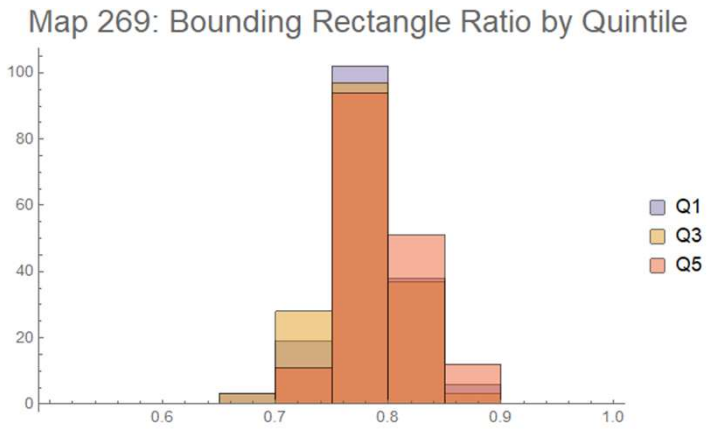


Bounding Rectangle Ratio is Independent



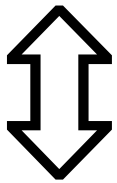




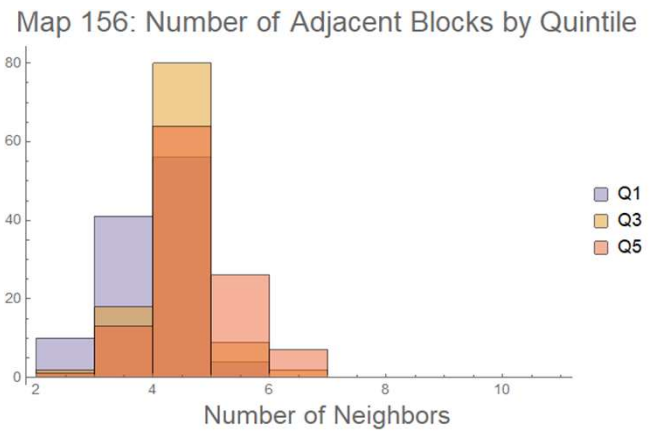


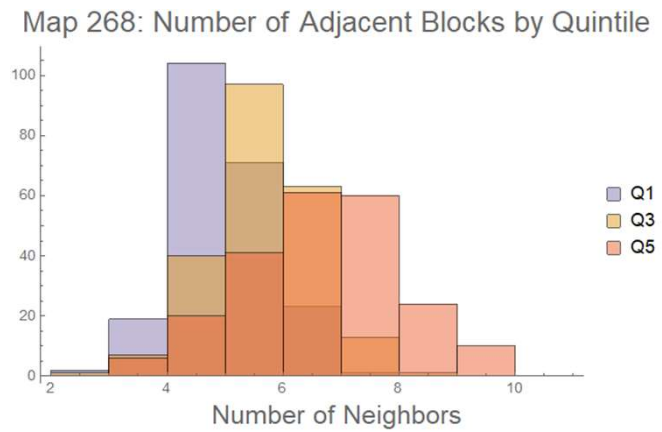
Number of Neighbors is Dependent

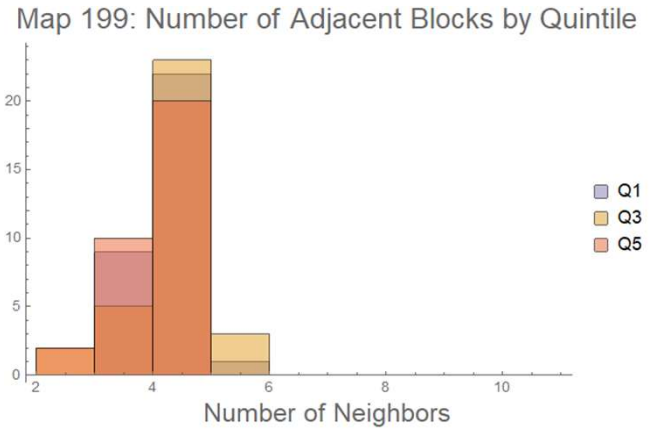
Larger block

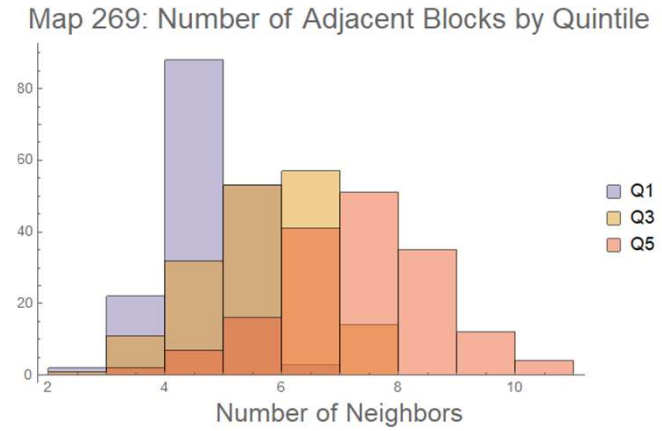


More Neighboring Blocks



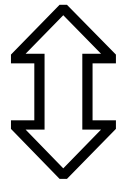




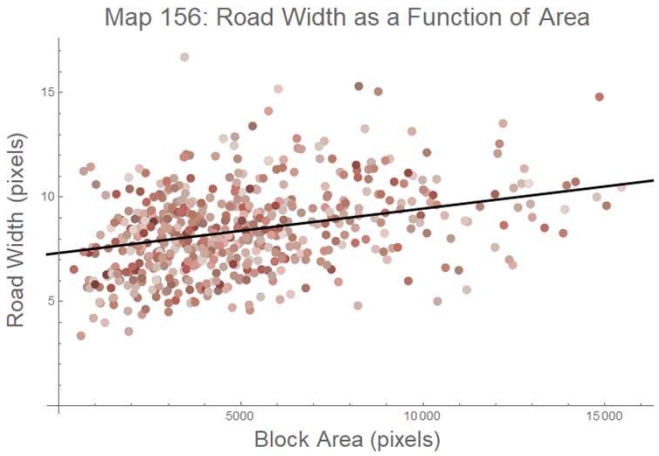


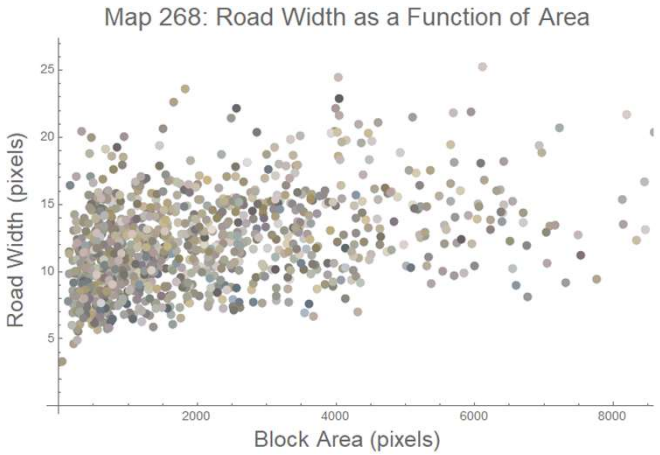
Road Width is Dependent

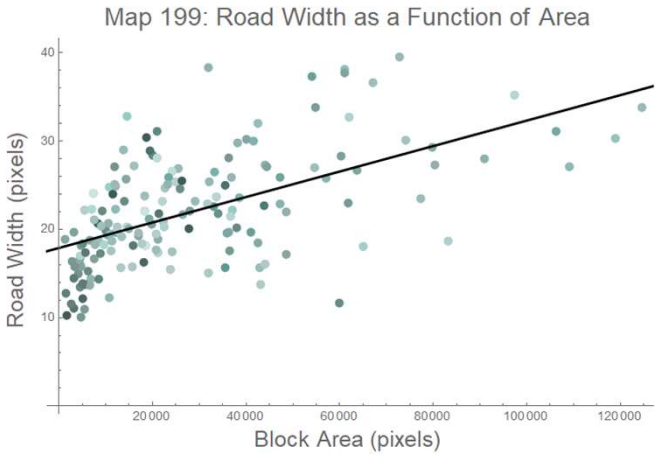
Larger block

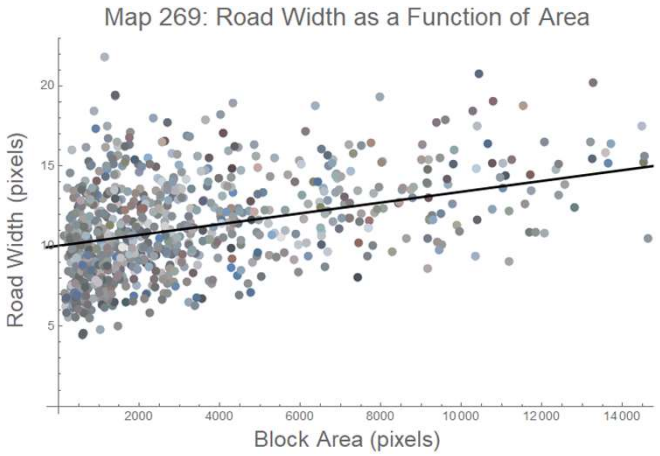


Wider Road



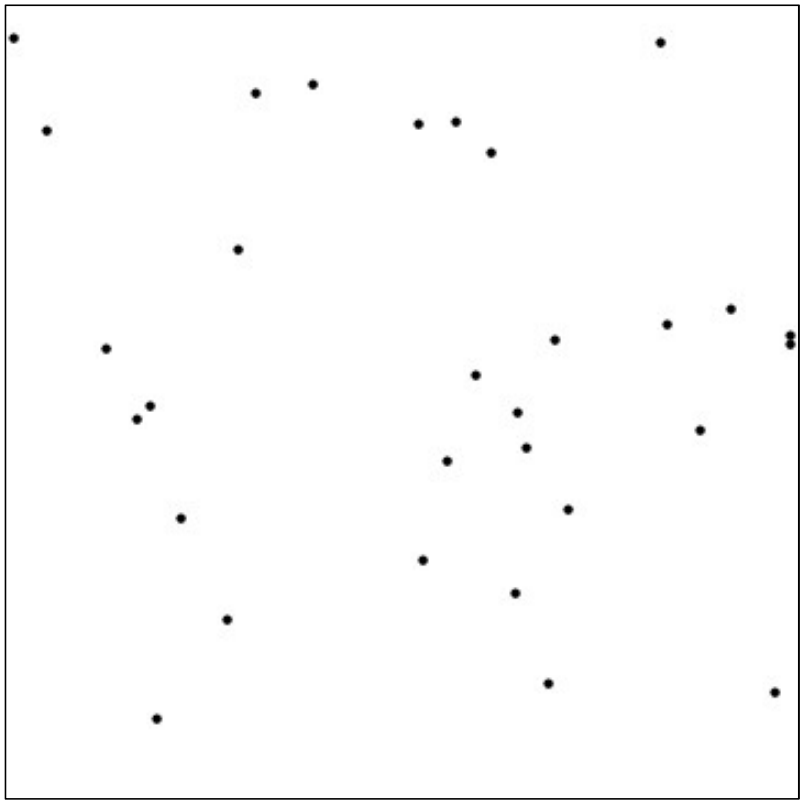






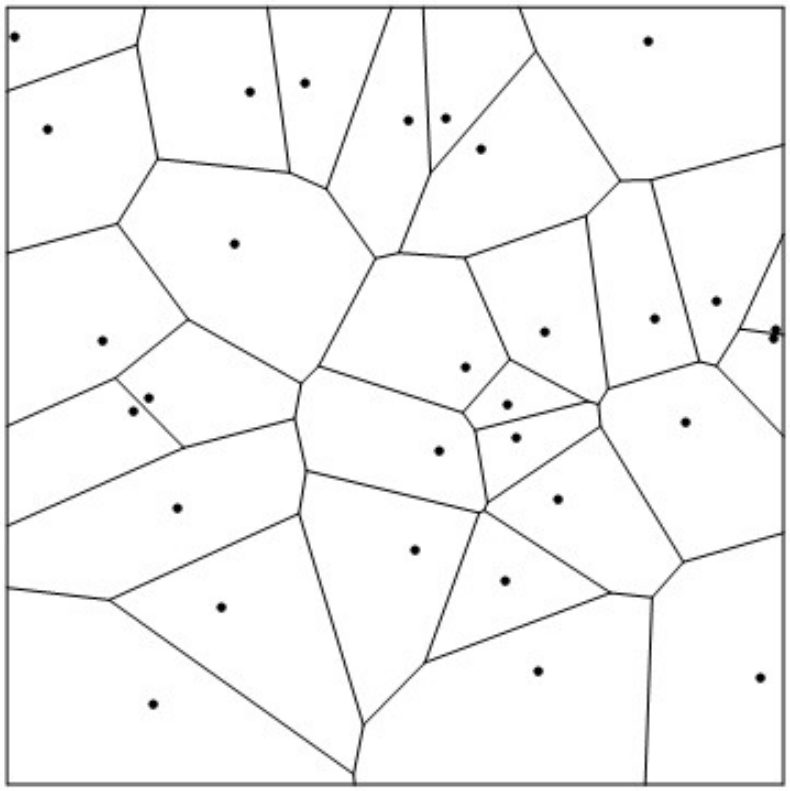
Creating a new map

- Generate block locations
  - Find point sets



Creating a new map

- Generate block locations
  - Find point sets
- Determine block boundaries
  - Voronoi / Delaunay



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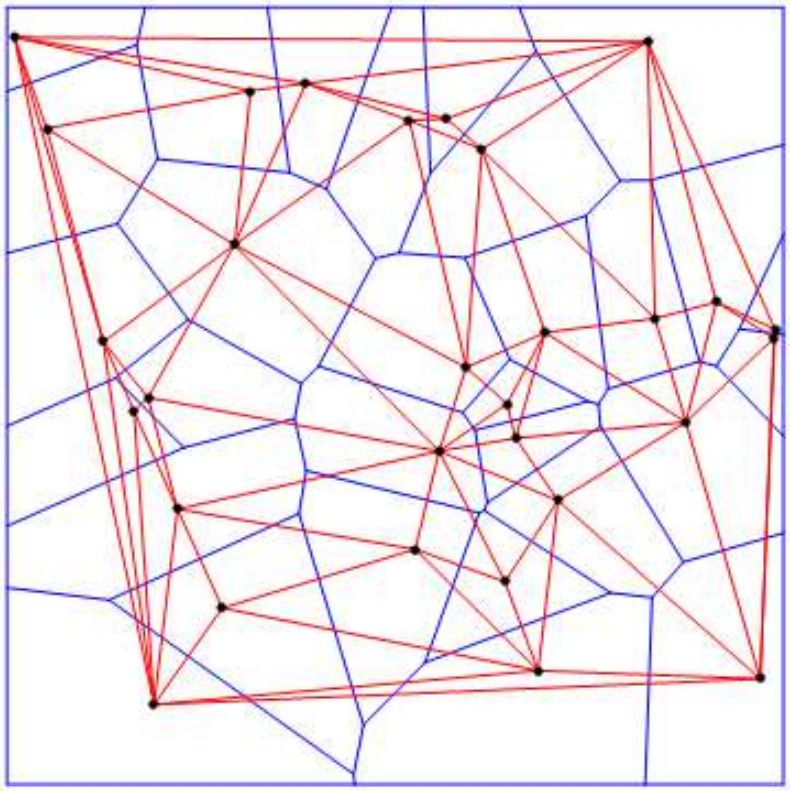
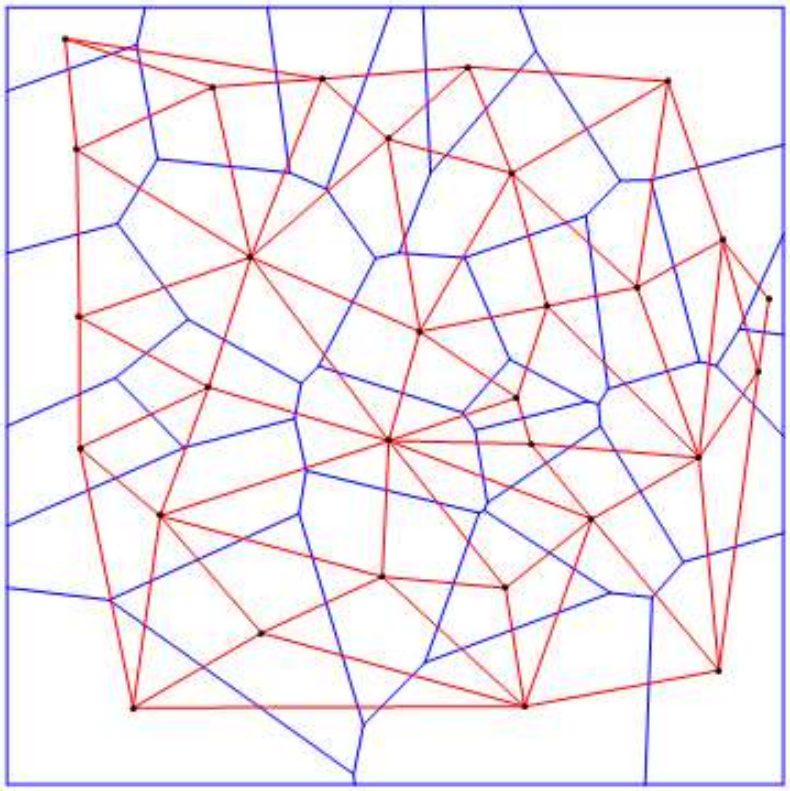


Creating a new map

- Generate block locations
  - Find point sets
- Determine block boundaries
  - Voronoi / Delaunay
  - Use the dual graph



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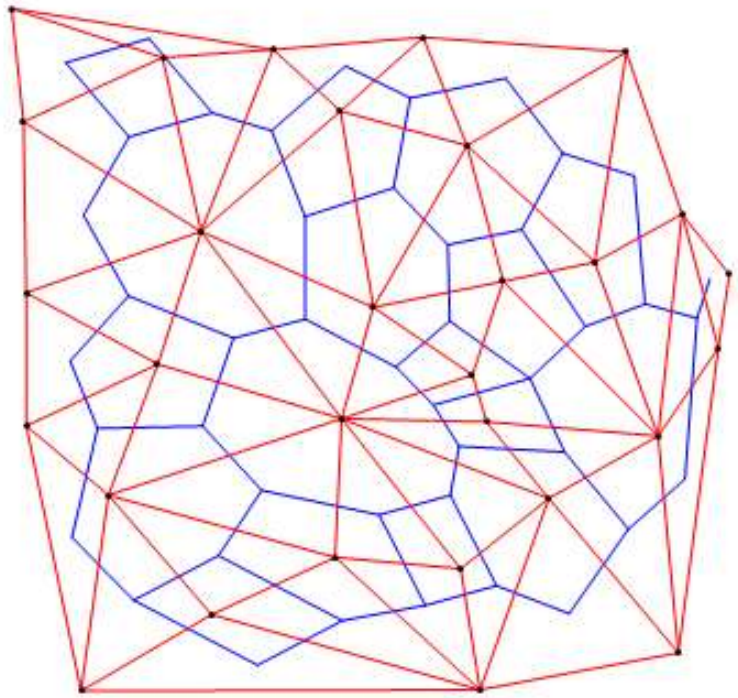

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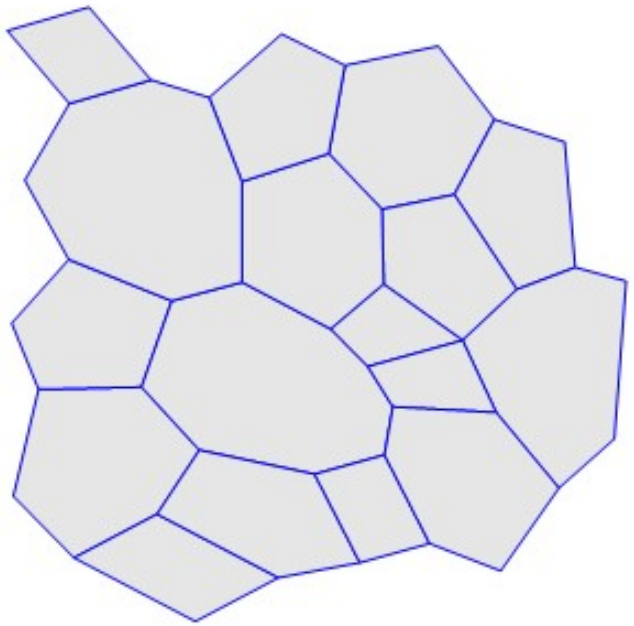

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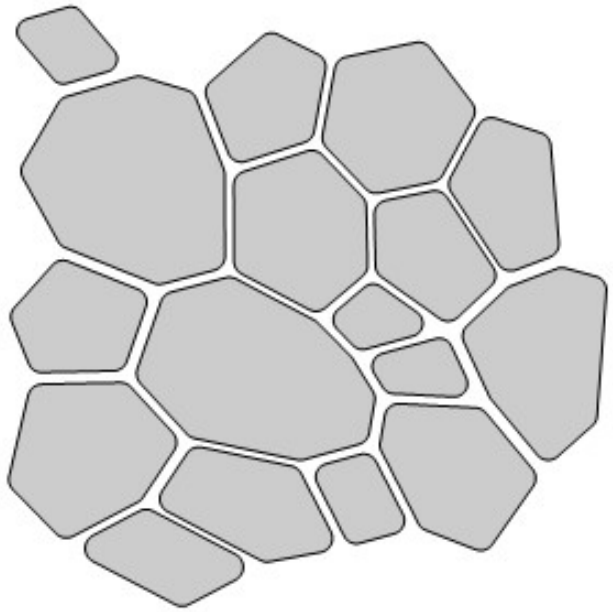
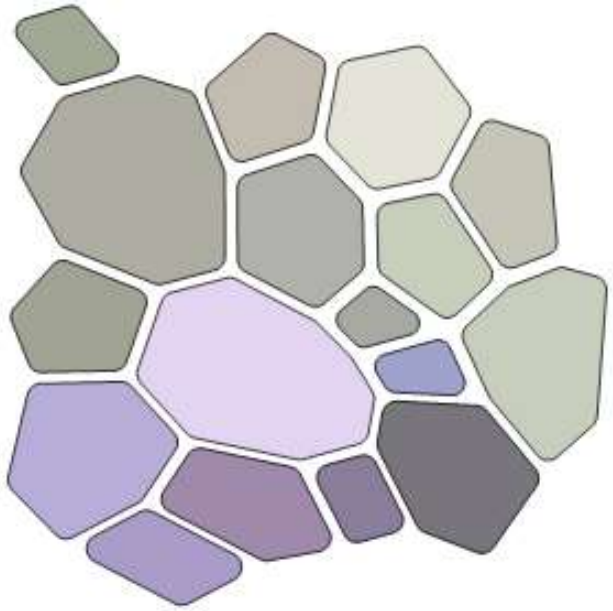


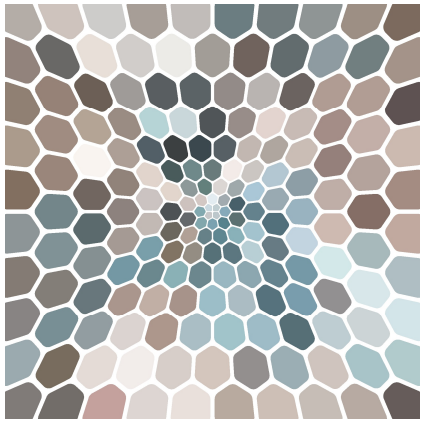
Creating a new map

- Generate block locations
  - Find point sets
- Determine block boundaries
  - Voronoi / Delaunay
  - Use the dual graph
- Color the blocks
  - Generate similar distributions
  - Nearby blocks prioritized

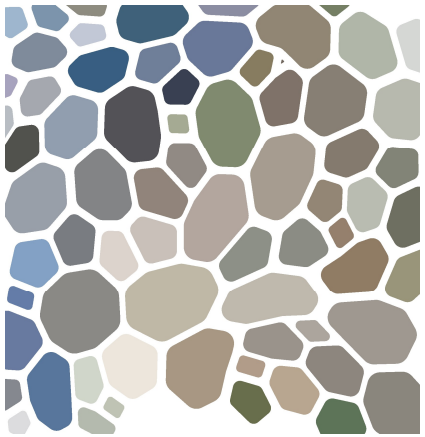


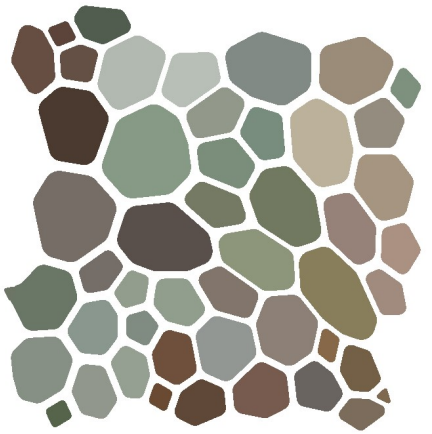
Algorithmically Generated Imaginary Maps

Deliberate Vertices



Random Vertices





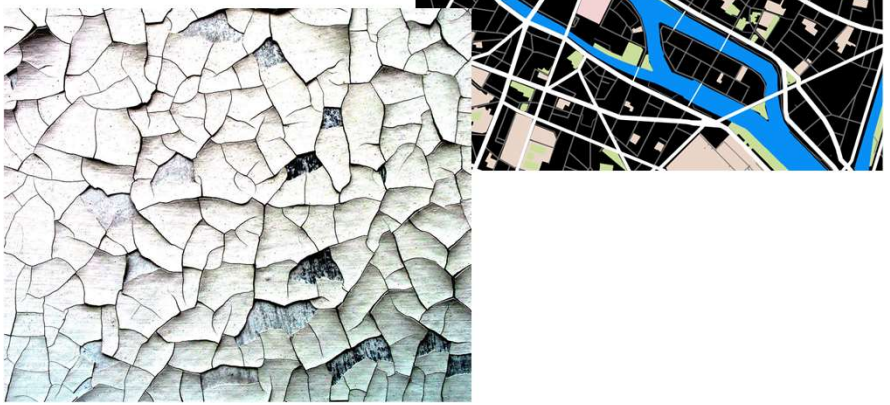
Our Takeaways

- We can quantify Garfield's maps
- Have defining characteristics
- Not "fractal"
- Making new maps is fun
  - Choosing points is hard!
  - ♥ Generative Art
- The power of *Mathematica*
- Statistical analysis of my artwork
- Think differently
- Artworks are more random than expected
- Does quantification take us out of the realm of artwork?

Future Exploration

- Compare to real world cities
- Compare to other cellular networks
- GIS specialist (Geographic Information System)
- Enhance map generation
- What is an intersection?
- What is the scale of an imaginary map?
- What other artworks have this color distribution?
- How do we quantify aesthetics?

Future Exploration



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Thank you!

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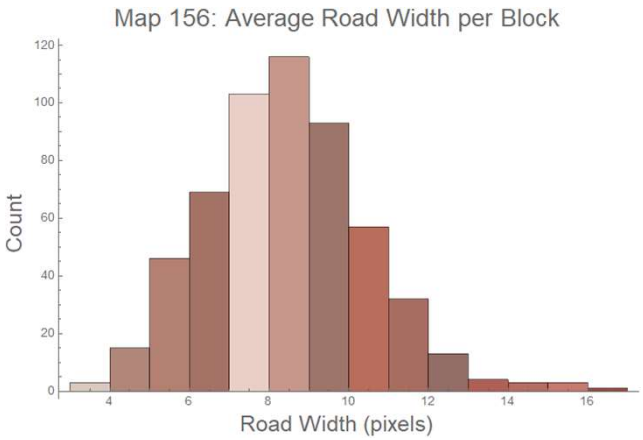
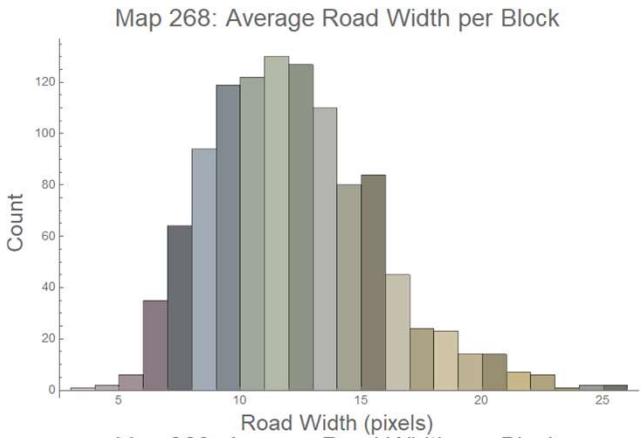
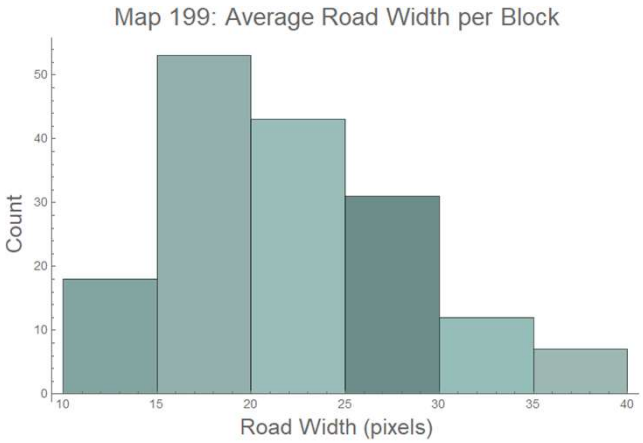
SciArt Initiative

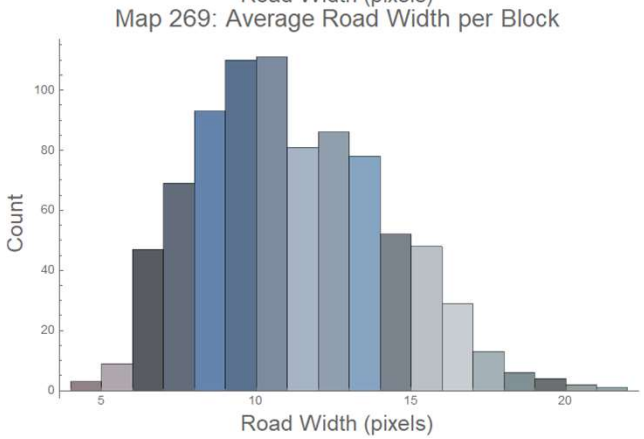
sciartinitiative.org

Road Width (Average around each block)

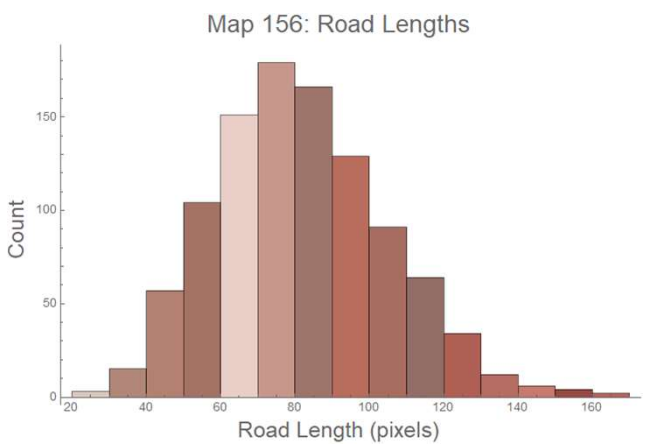


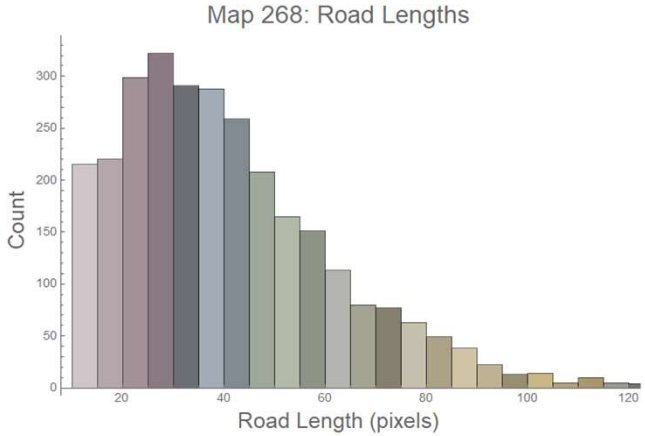


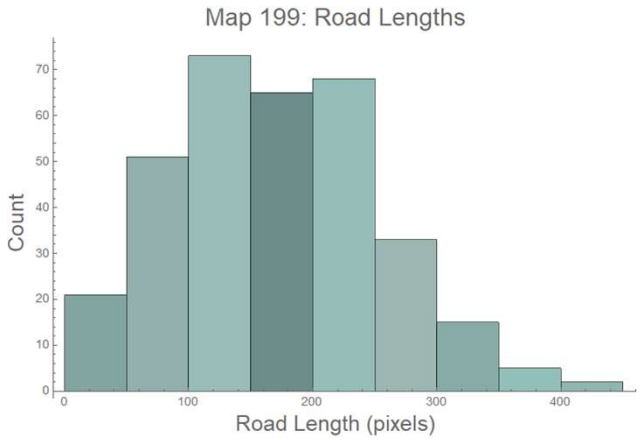


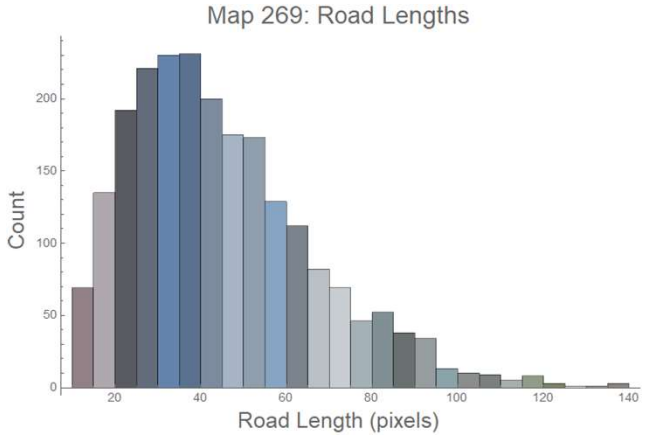


Road Length

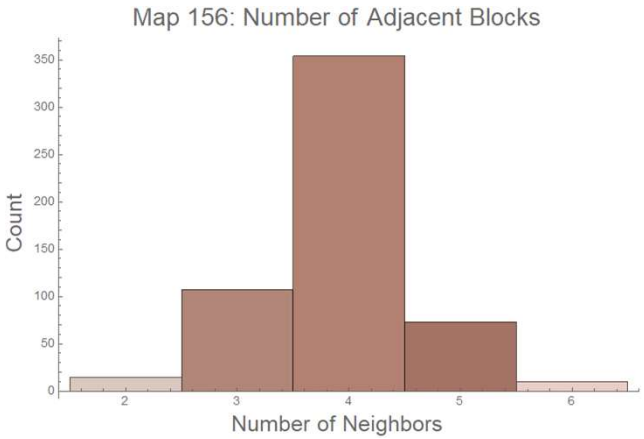

Map 156: Road Lengths
Count
Road Length (pixels)

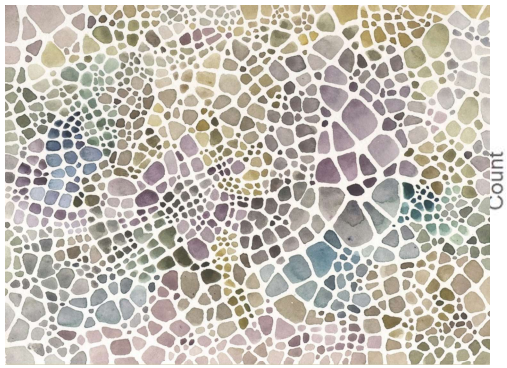

Map 268: Road Lengths
Count
Road Length (pixels)

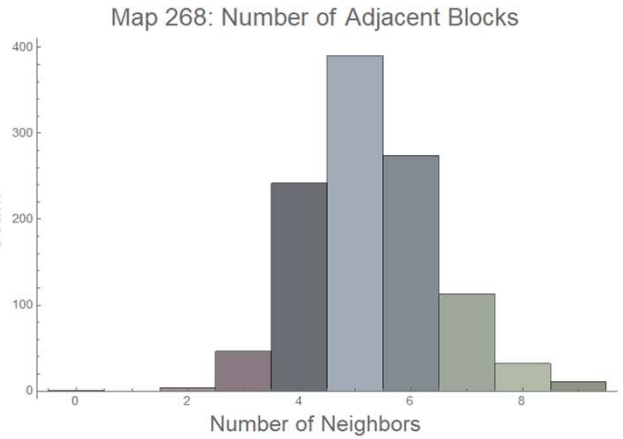

Map 199: Road Lengths
Count
Road Length (pixels)

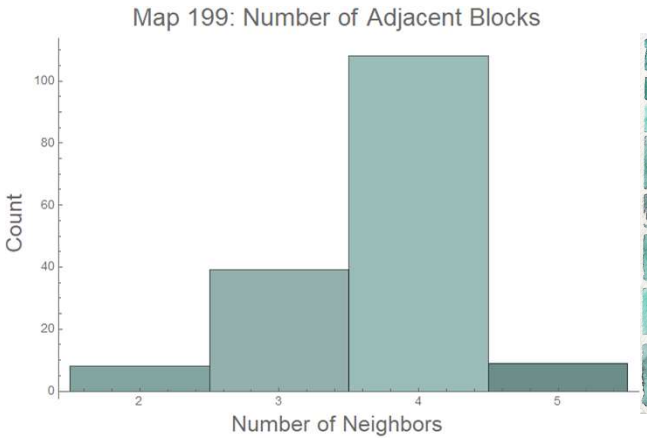

Map 269: Road Lengths
Count
Road Length (pixels)

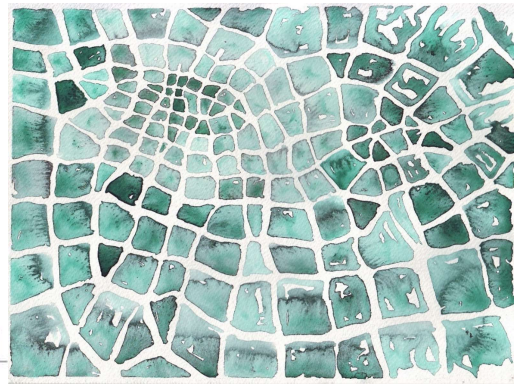
Number of Neighbors

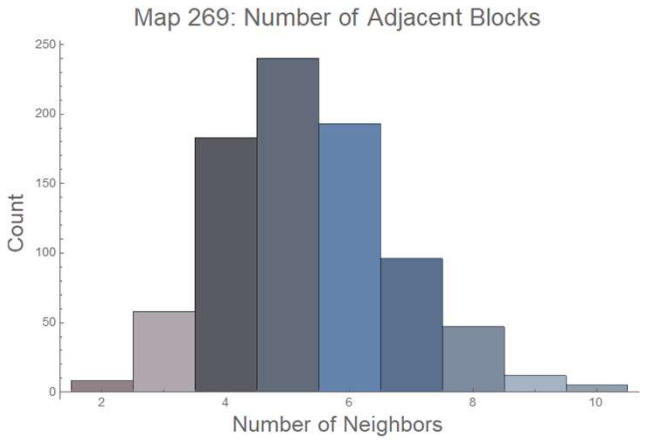




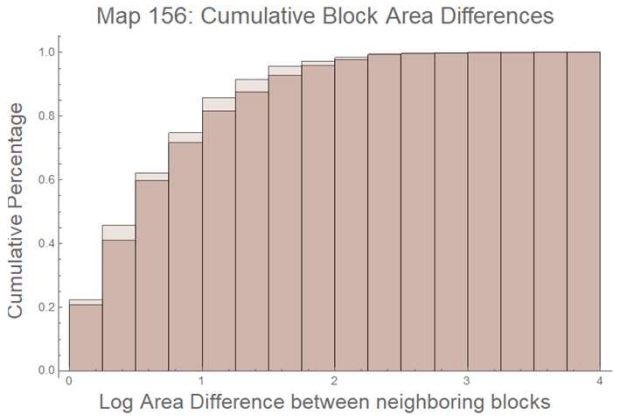


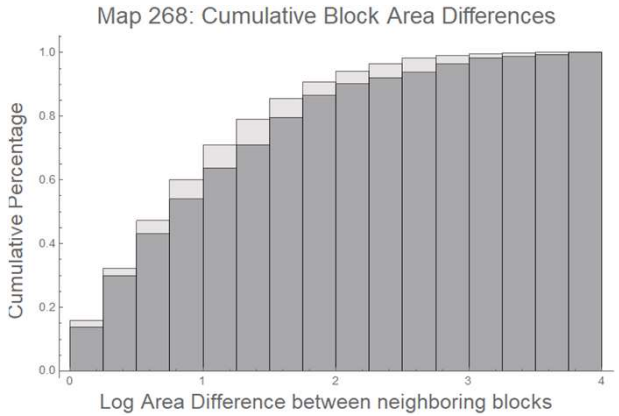


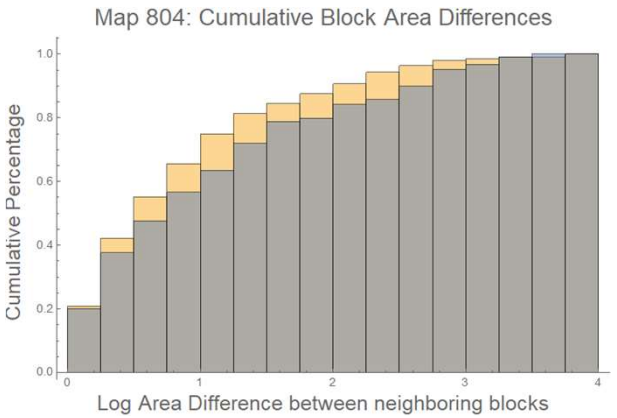


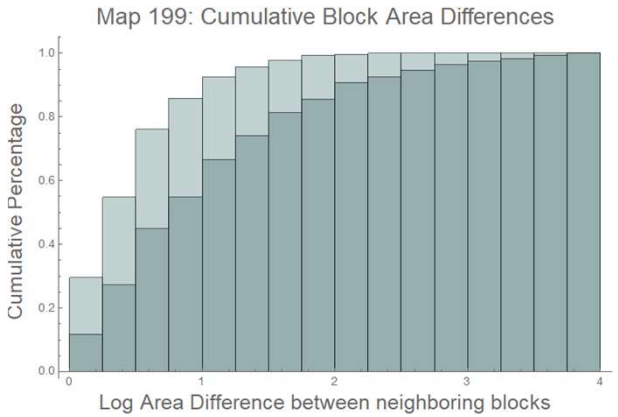


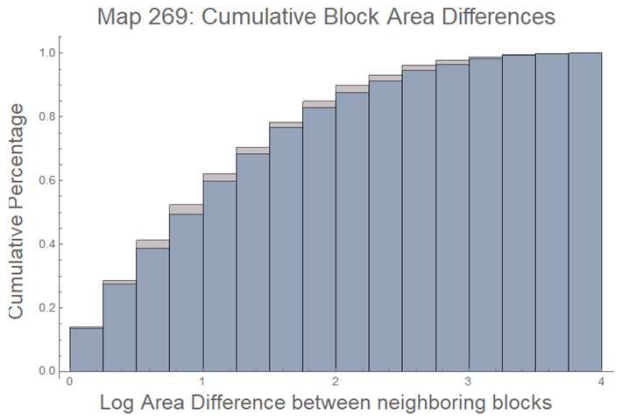
How close in size are neighbors?



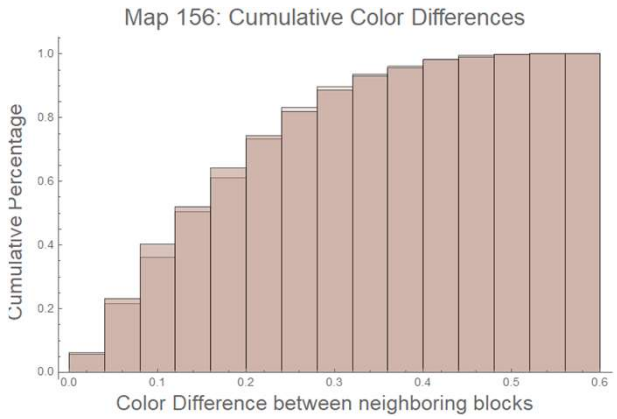


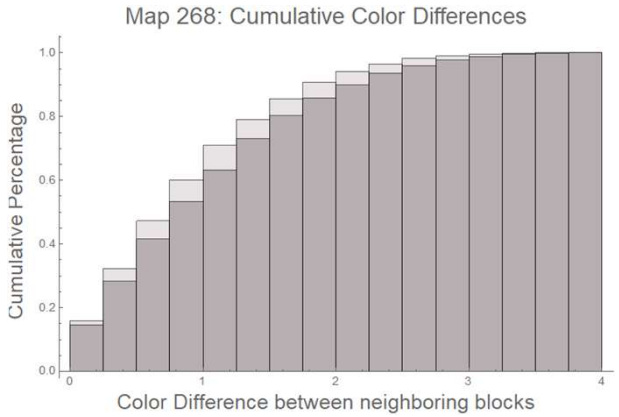


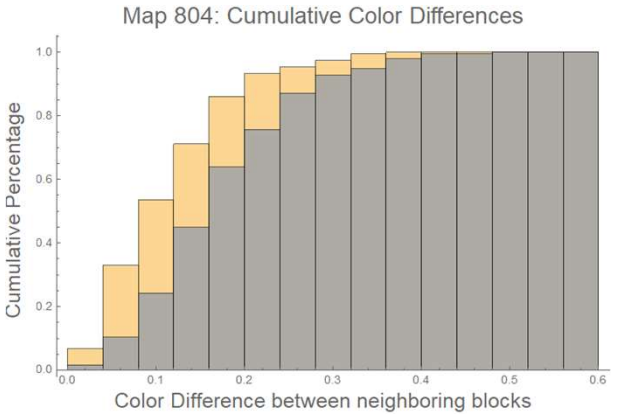


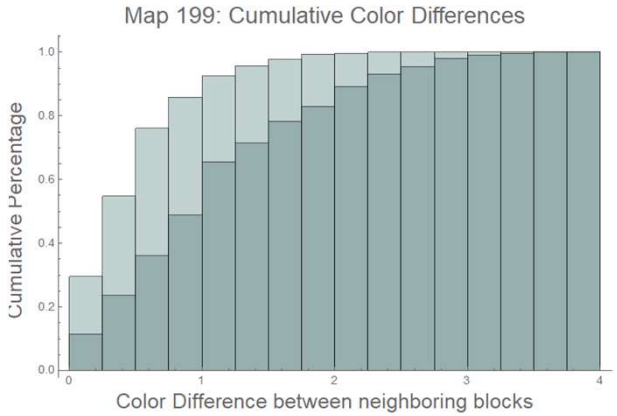


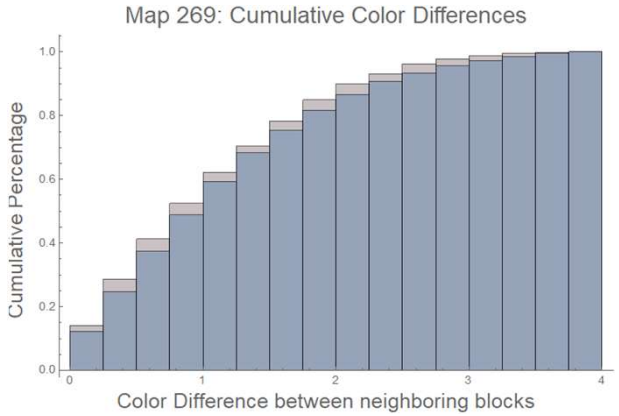
How close in COLOR are neighbors?











Fractal Analysis

Block-size-independent metrics

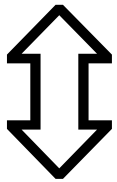
- Color Distribution
- Bounding Rectangles Ratios

Block-size-dependent metrics

- Number of Adjacent Blocks
- Neighborhood Density
- Road Width

Neighborhood Density is Dependent

Larger block



Denser neighborhood