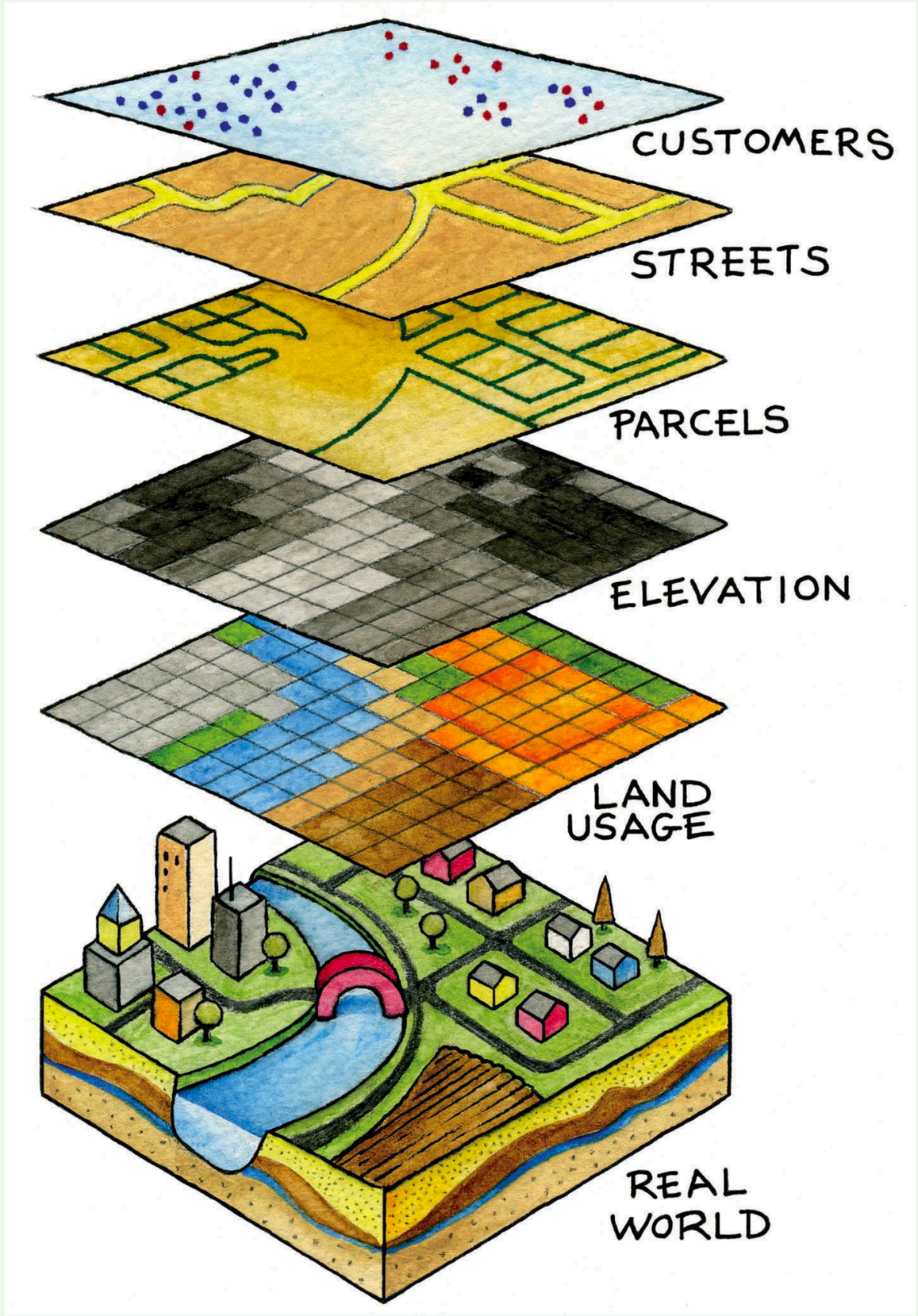
GEOG 358: Introduction to Geographic Information Systems

GIS Data Models



GIS Data Models

Topics

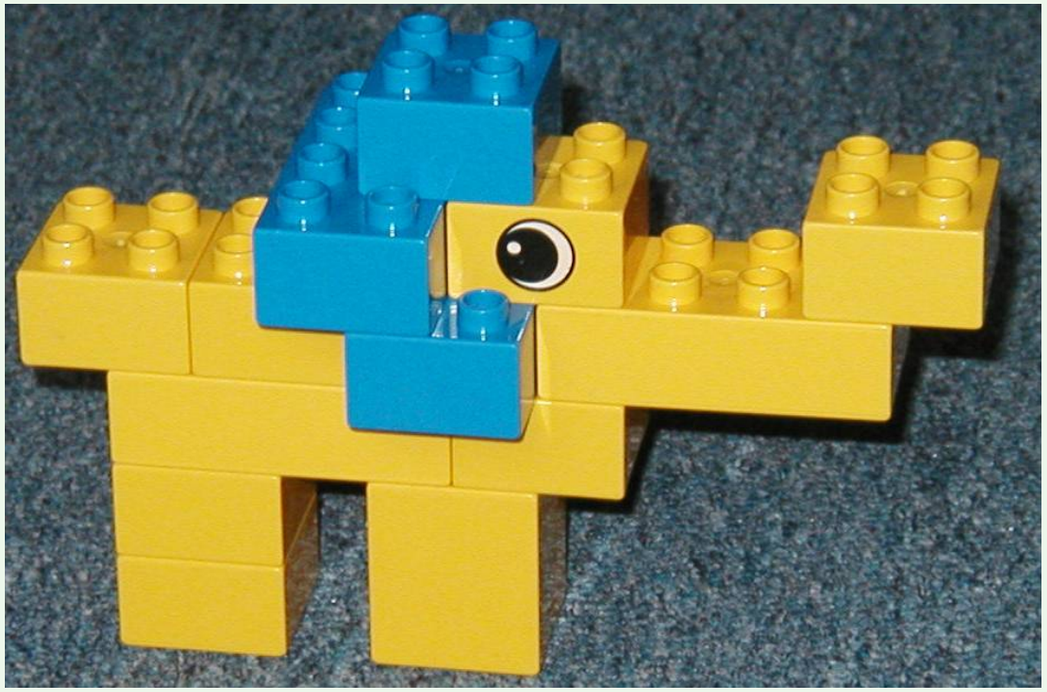
- What is a model?
- Three meanings of a GIS data model:
  - data building blocks
  - database templates
  - populated GIS databases

Representing geographic features & phenomena

- Objects & phenomena on Earth must be represented in a computer
- To do this we create abstractions
    - simplifications of reality
- Analyses are based on these abstractions
    - what is the focus of the analysis?

What are models?

How do we know the toy is an elephant?



A model is a **simplified representation of reality** which represents certain **significant characteristics** of reality.

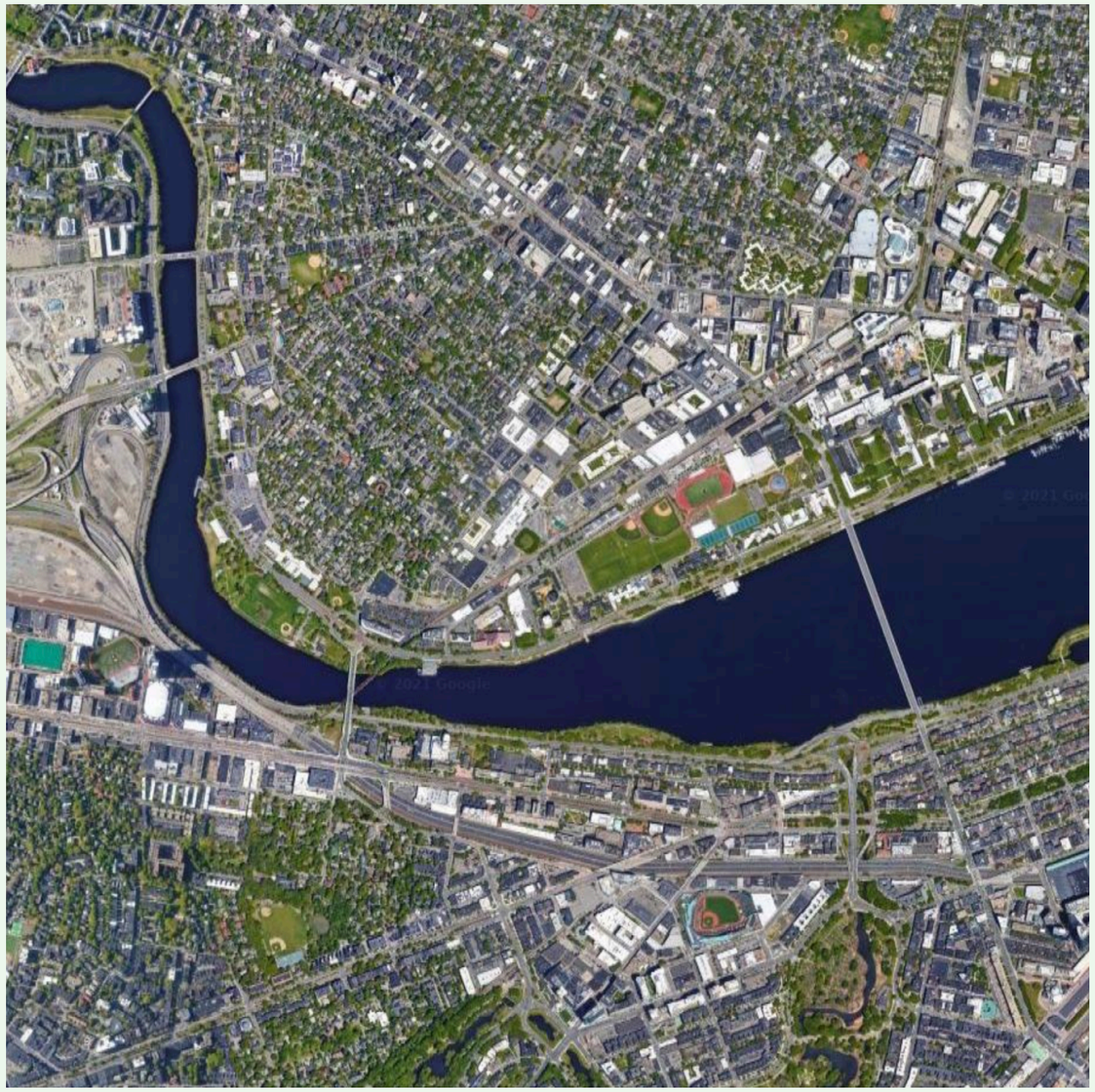
Characteristics of models

- Models are inherently **subjective** because they are created by humans
- Models are **selective** because they only maintain certain aspects of reality
  - what is fundamental and relevant?
- Models are **approximate** because they do not reflect all the complexity of reality

Types of models
(scientific)

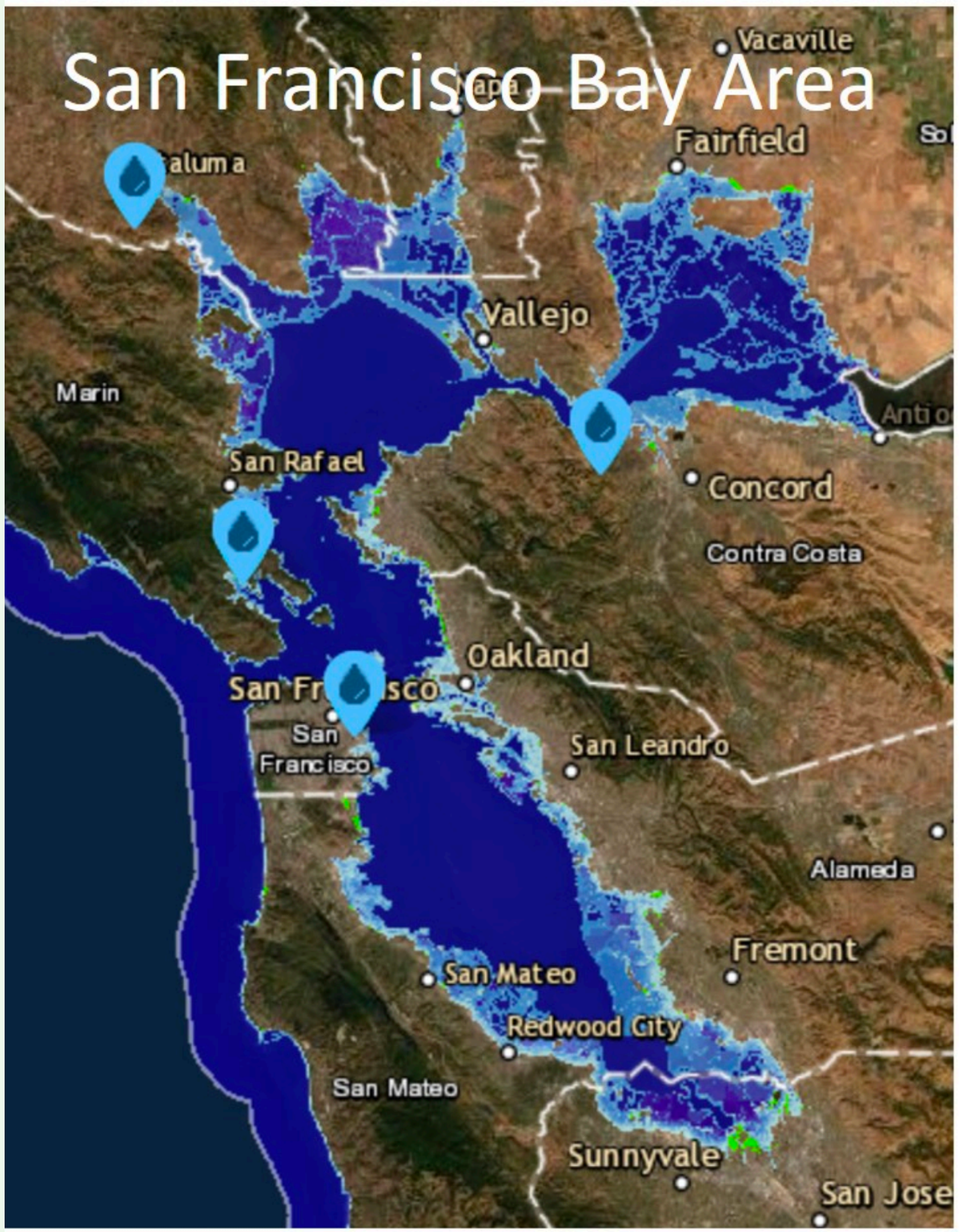
- Physical
- Mathematical
- Computational
- Geographical

Geographical models



Why use models?

- Preserve & communicate knowledge
- Experiment
- Ex: What are the consequences of 2m of sea level rise?
  - Which areas are affected?
  - What populations?

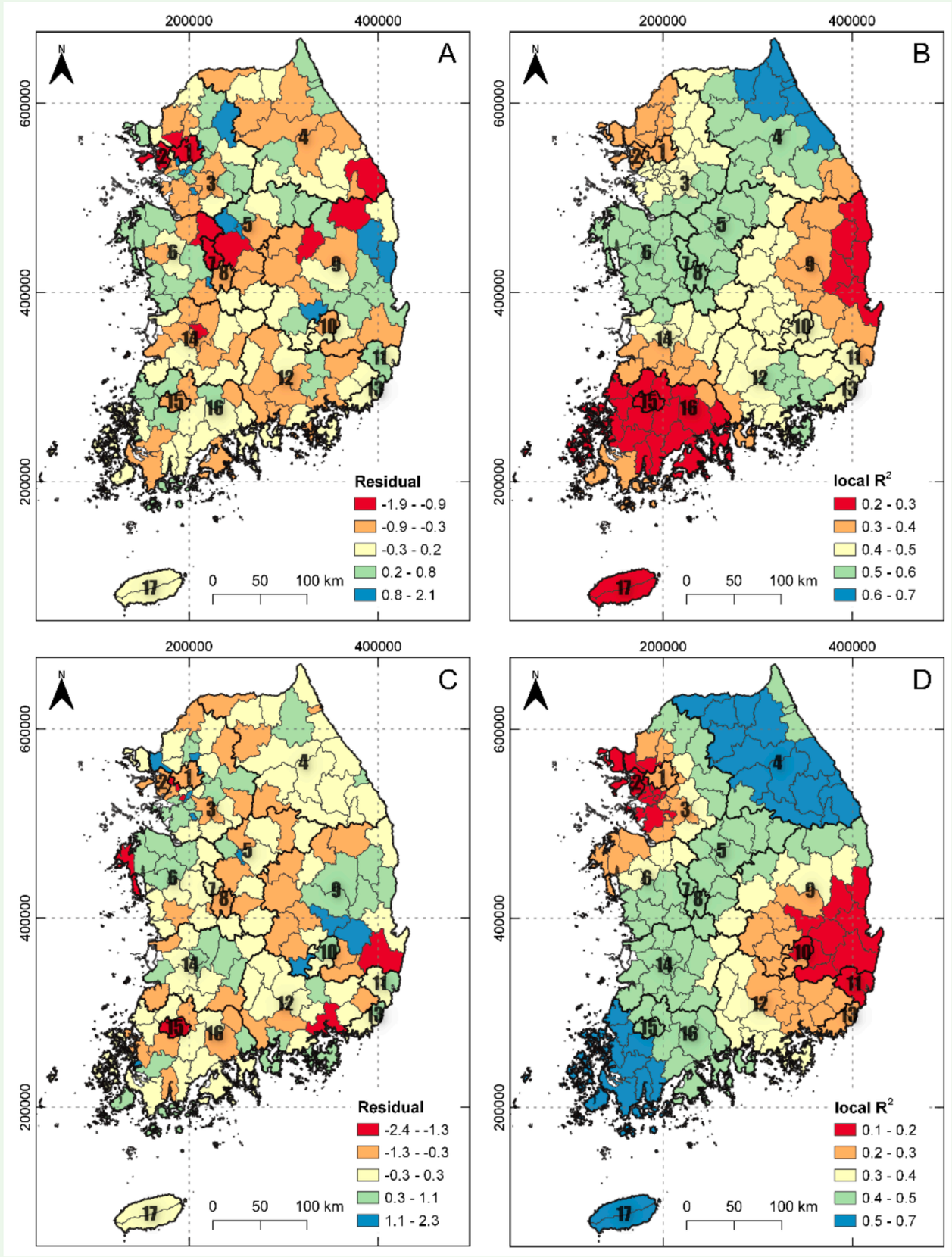


2m (± 1m) sea level rise probable by 2100

Map from NOAA Sea Level Rise Viewer 2019

We model everything!

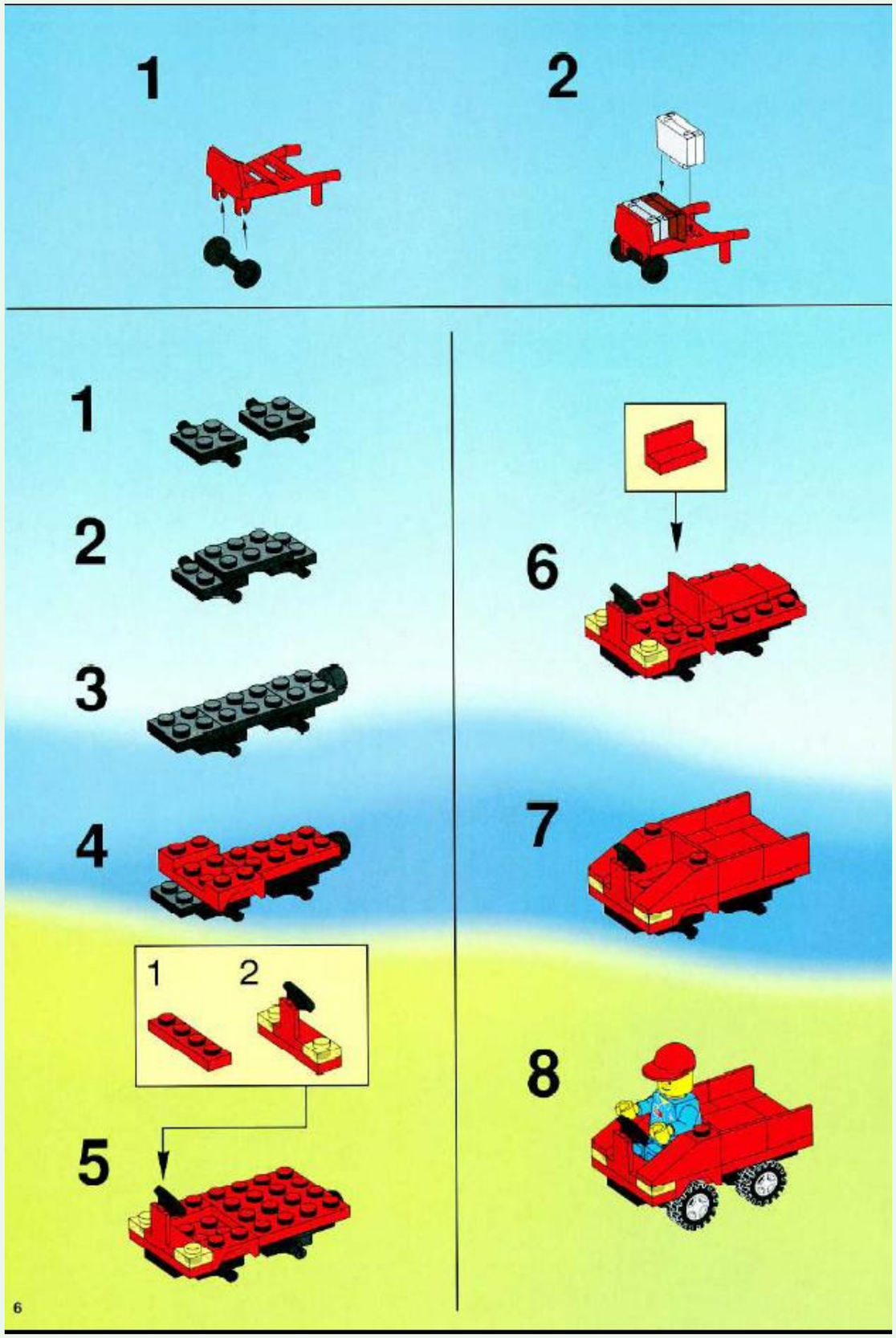
- From atomic structure to the structure of the universe our understanding is based on models
- In GIS we are primarily concerned with the near Earth environment
  - distributions & relationships

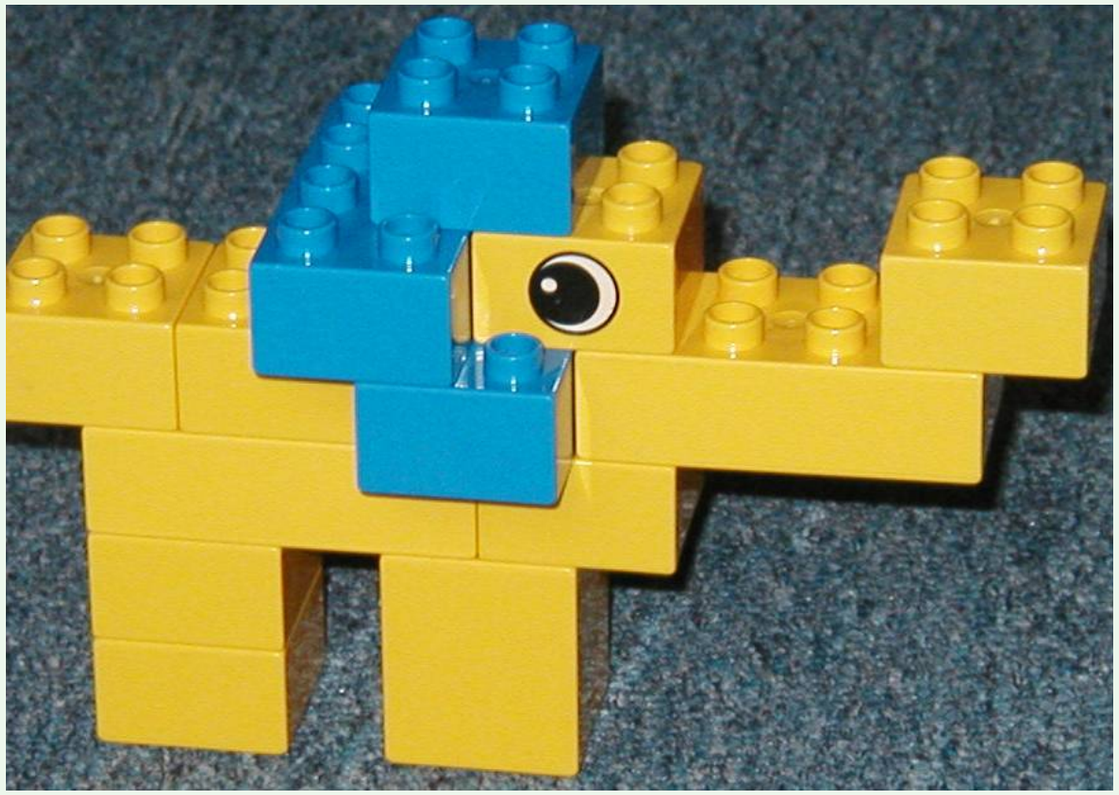


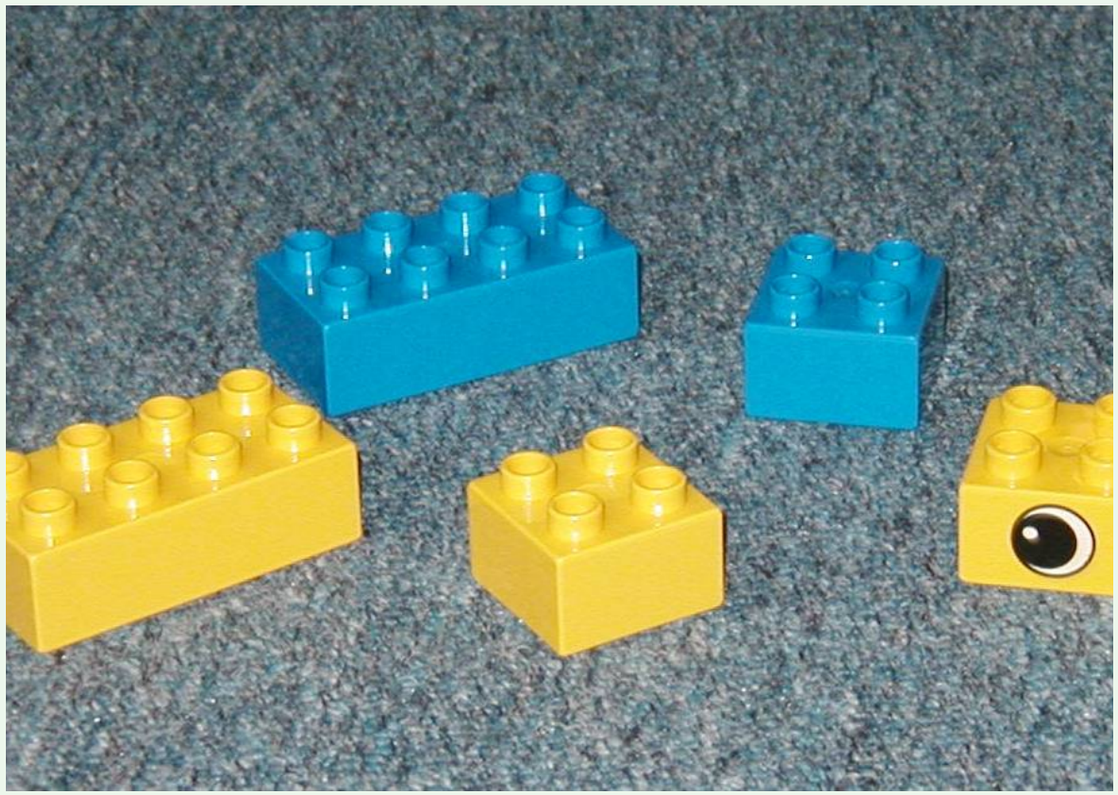
https://www.mdpi.com/2223-7747/10/7/1377/htm#

Geospatial data are models

- Simplified representations of reality which represent certain significant characteristics of reality
- Reality
  - geographic entities or phenomena on or near Earth's surface
  - area of interest and purpose of the model
- Characteristics
  - location (coordinates)
  - attributes (significant properties)
  - structures & relationships both spatial and non-spatial


1
2
1
2
3
4
1
2
5
6
7
8
6

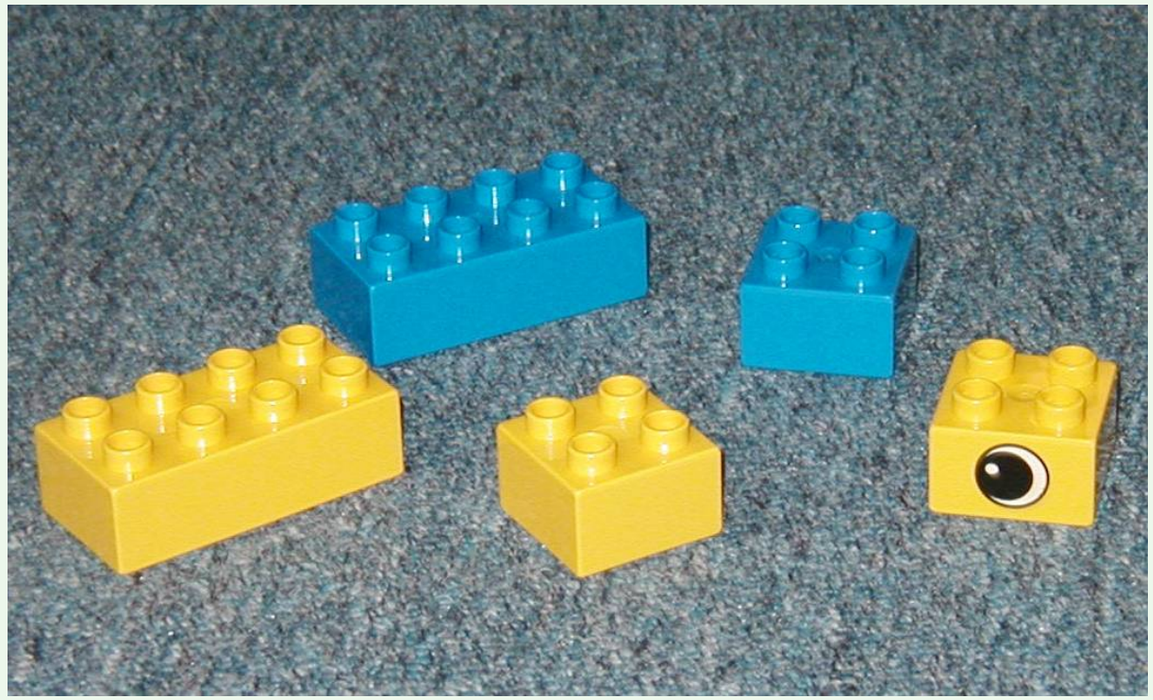


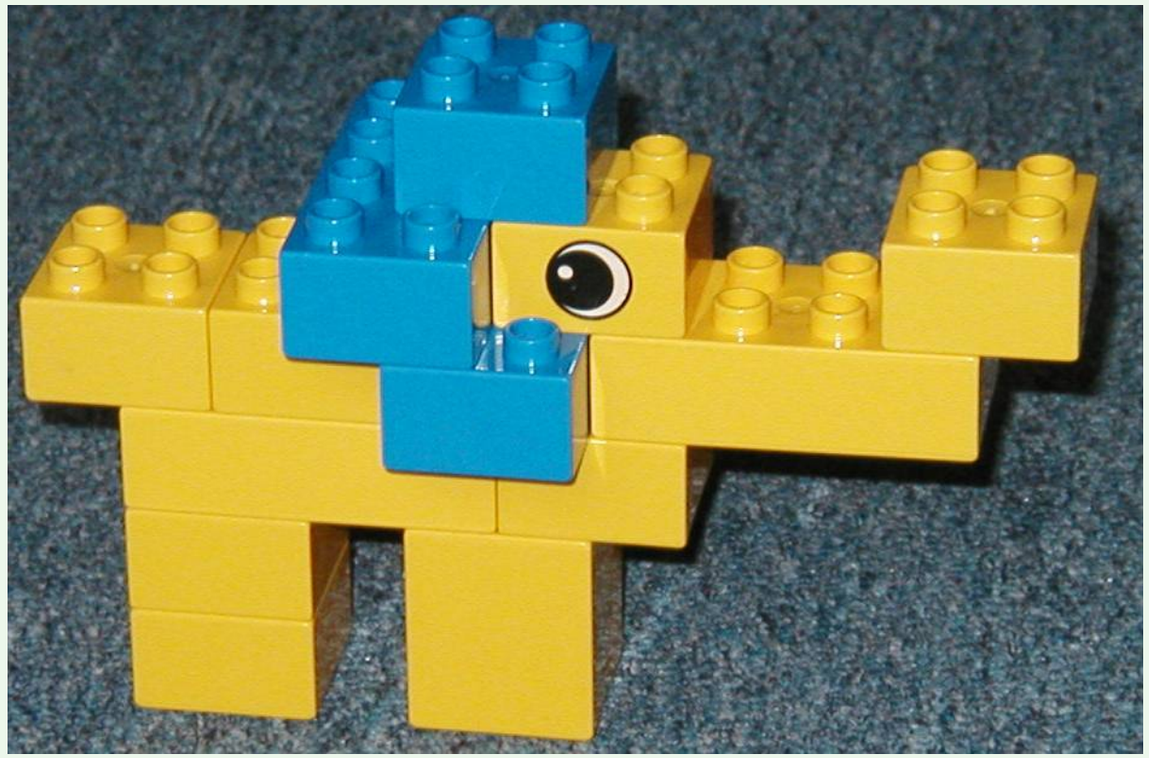


Building blocks of geographic data

- The representative power of a GIS depends on the modelling elements it provides

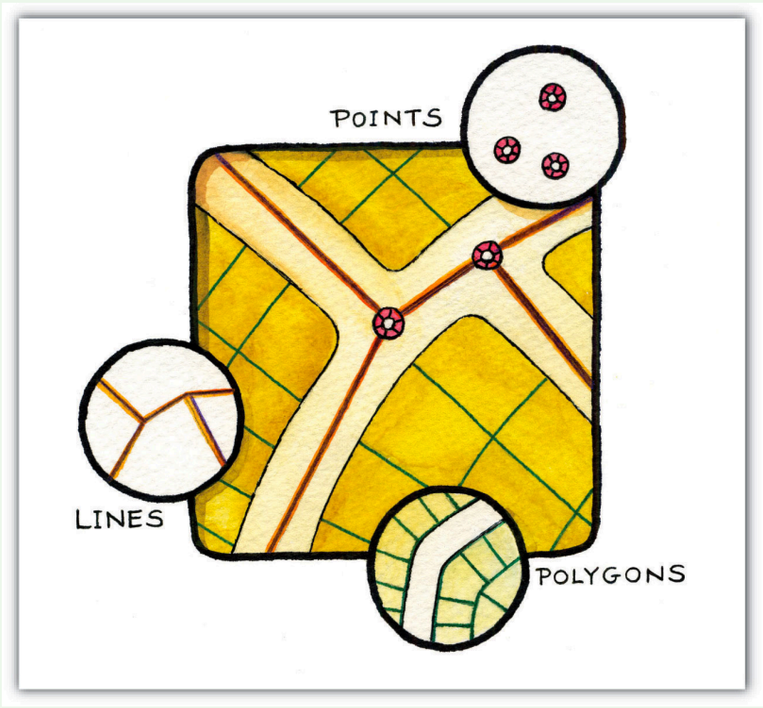
- What elements are needed to represent geographic phenomena?

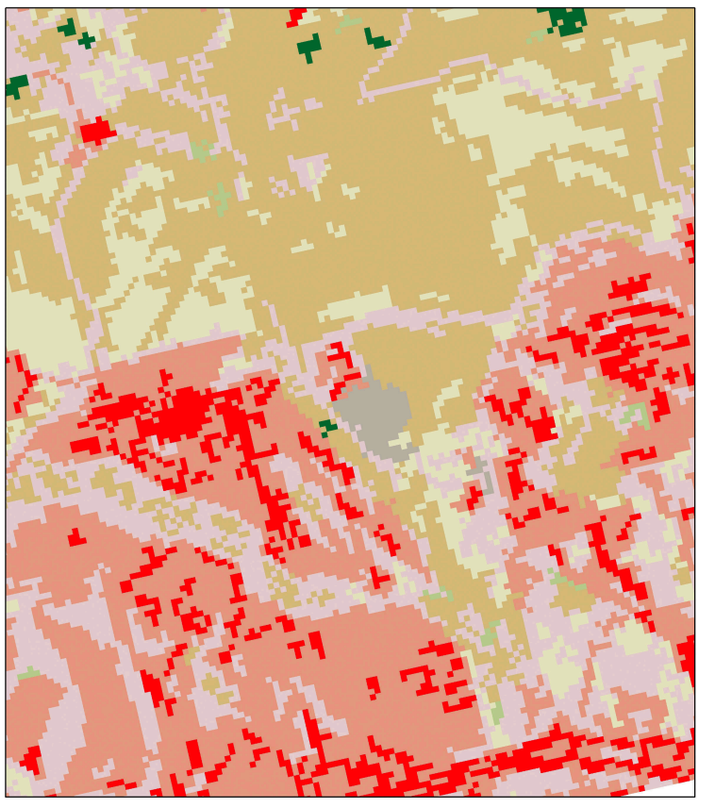




Types of geographic phenomena

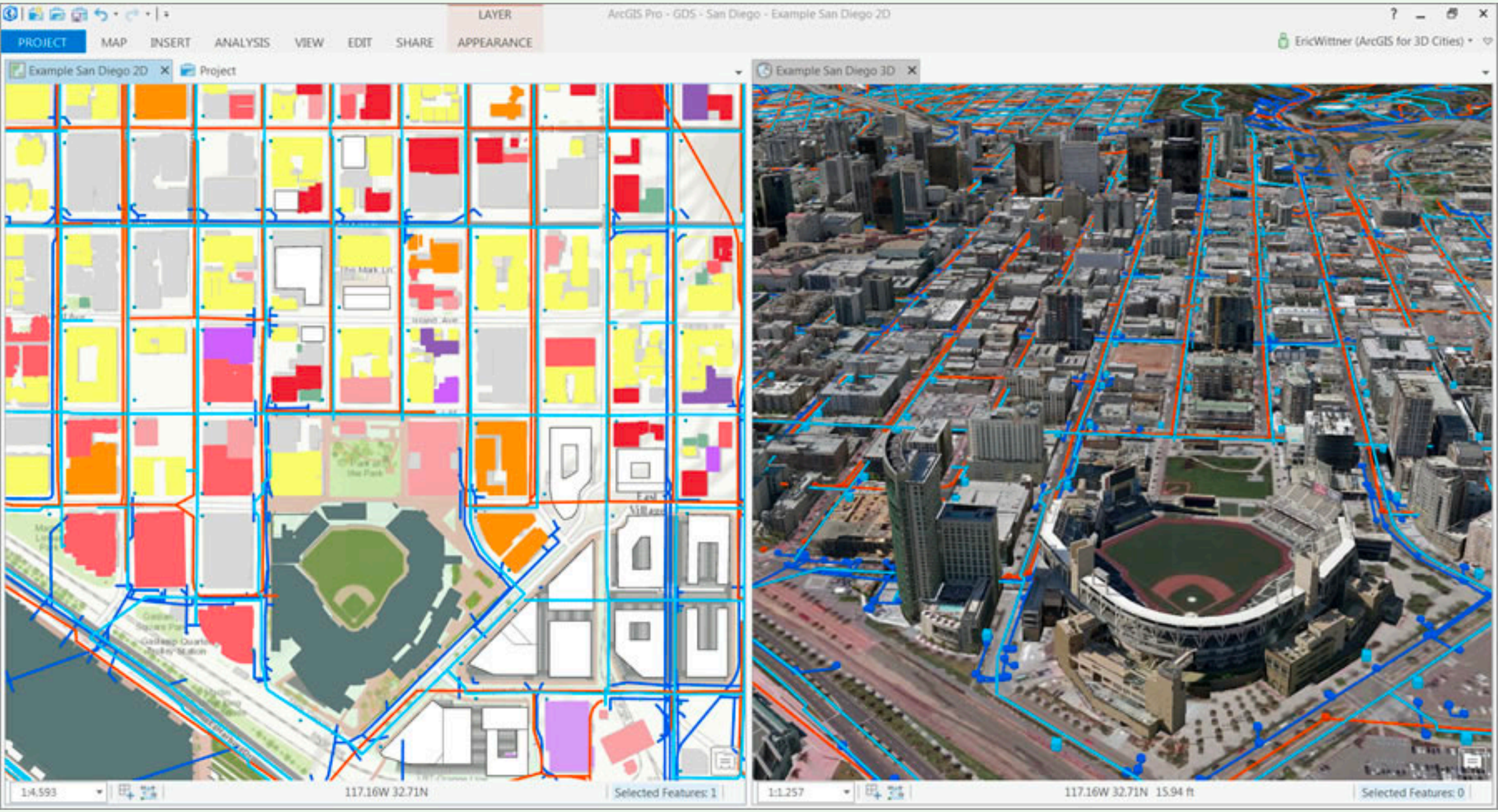
- Discrete objects in space
  - easy to identify boundaries
- Continuous surfaces in space
  - gradients

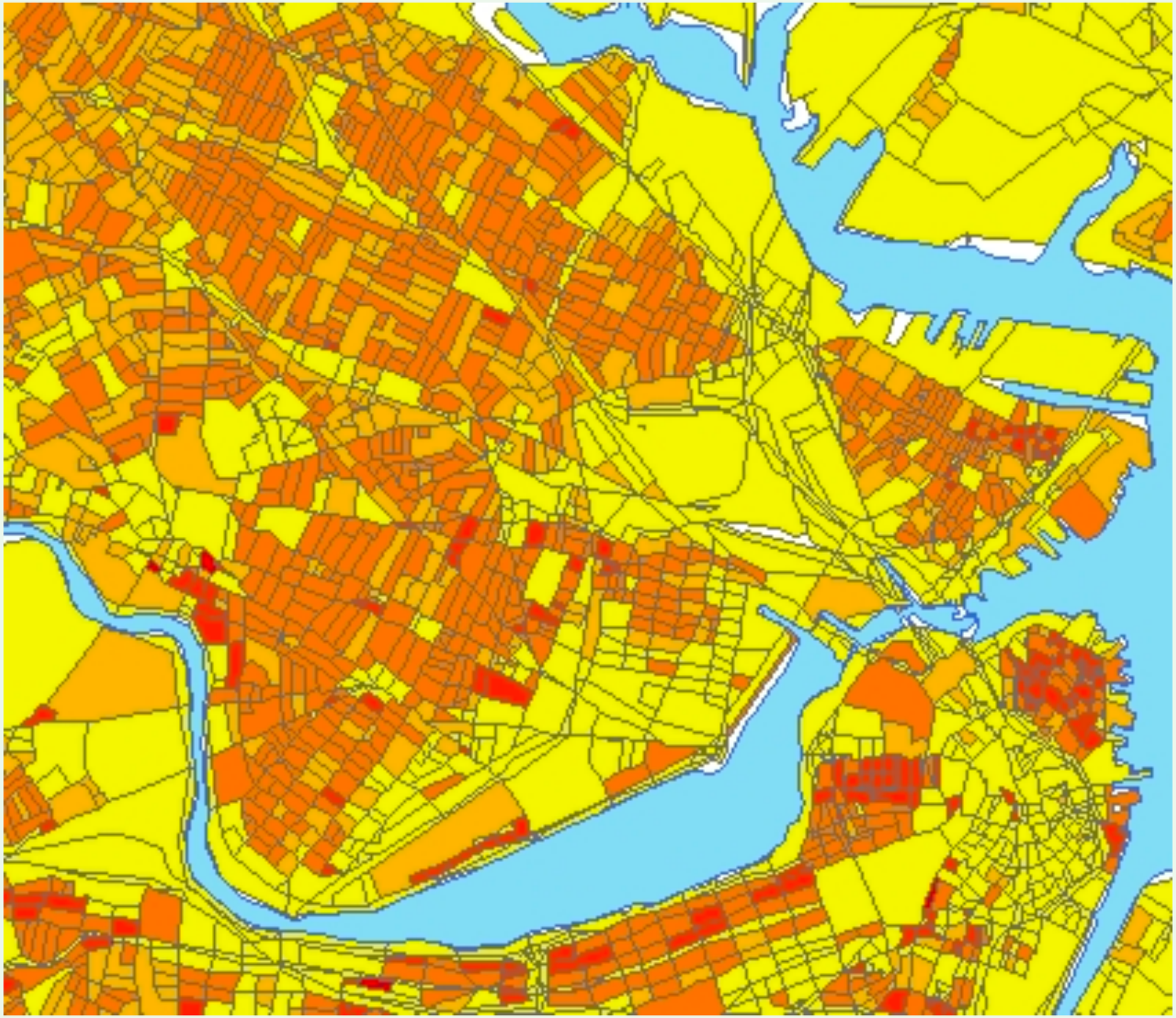


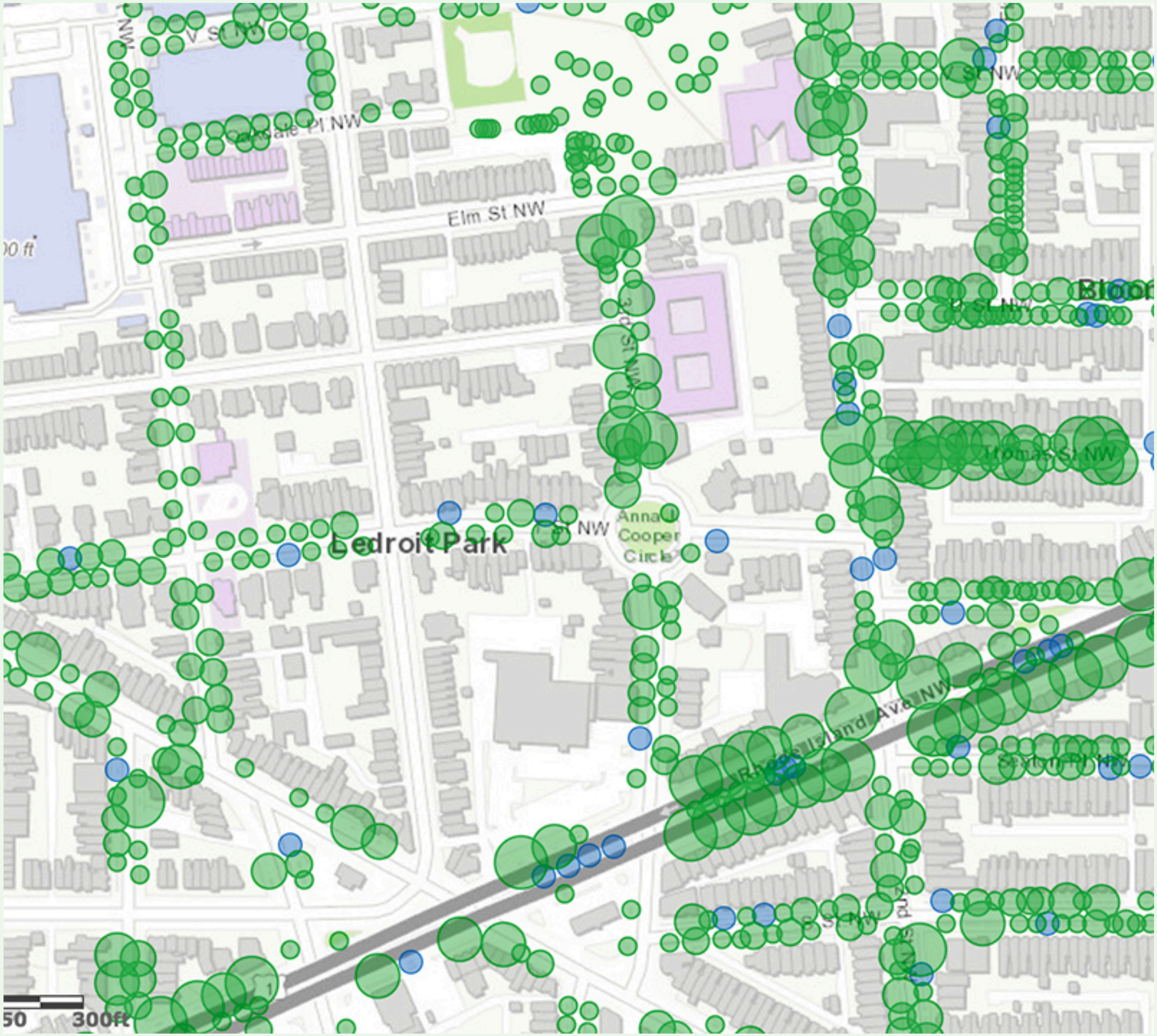


Discrete objects

- Geographical features that usually have well-defined identities and boundaries in space
- Objects have dimensionality, shapes, and can be counted
- Objects have attributes
- Objects may be composed of other objects and have specific relationships with other objects


LAYER
ArcGIS Pro - GDS - San Diego - Example San Diego 2D
PROJECT
MAP
INSERT
ANALYSIS
VIEW
EDIT
SHARE
APPEARANCE
EricWittner (ArcGIS for 3D Cities)
Example San Diego 2D
Project
Example San Diego 3D
1:4,593
117.16W 32.71N
Selected Features: 1
1:1,257
117.16W 32.71N 15.94 ft
Selected Features: 0




V St NW
Delaware Pl NW
Elm St NW
Ledroit Park
Annex Cooper Circle
Florida Ave NW
300ft

Vector data in GIS

Points, lines, & polygons

- Three types of geometric elements are used represent discrete geographic entities/features: **points, lines, and polygons**

- Points define geographic features too small to be depicted as lines or polygons (hydrants, wells, telephone poles, buildings, cities).

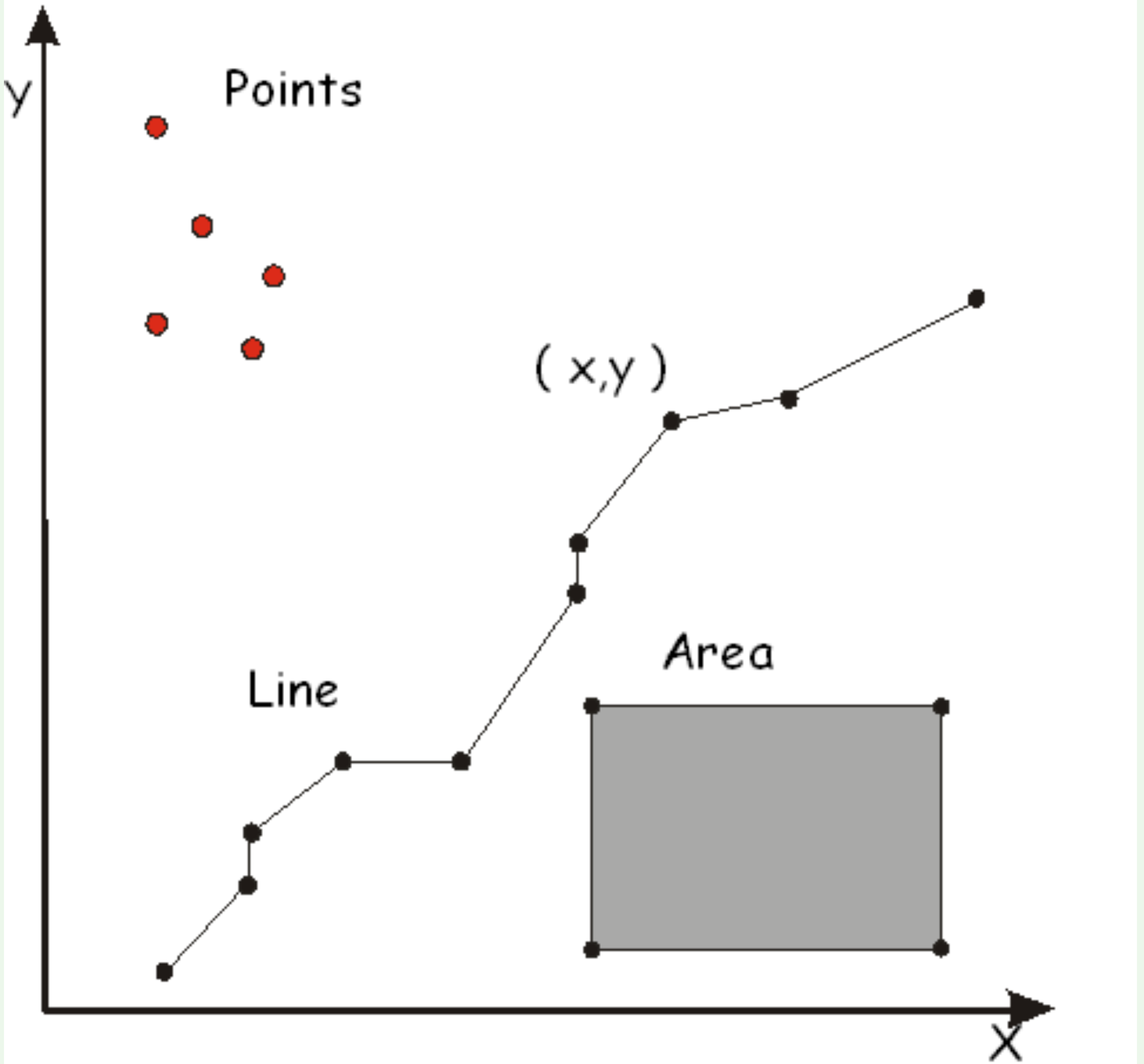
- Lines represent geographic features too narrow to be depicted as polygons (streets, streams, electrical lines).

- Polygons represent geographic features span certain area in space (cities, states, counties, parcels, land use zones).

- Geometric types are decided by needs of the analysis

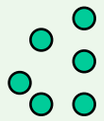
    - Are cities points or polygons?

Vector

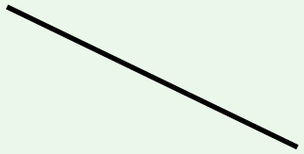


Complex Points, Lines and Polygons

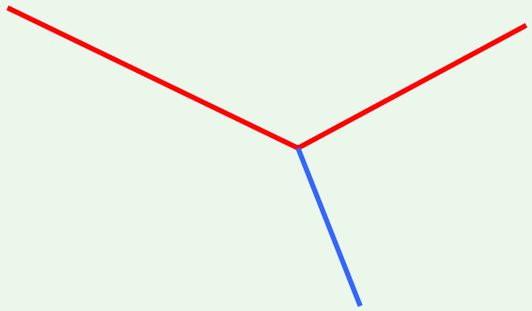
point



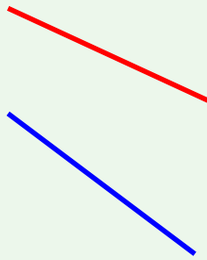
multipoint -- a set of point with a common set of attributes



line with one part



line with multiple connected parts



line with multiple disjoint parts

Multipart polygon

- Different representations of the same objects

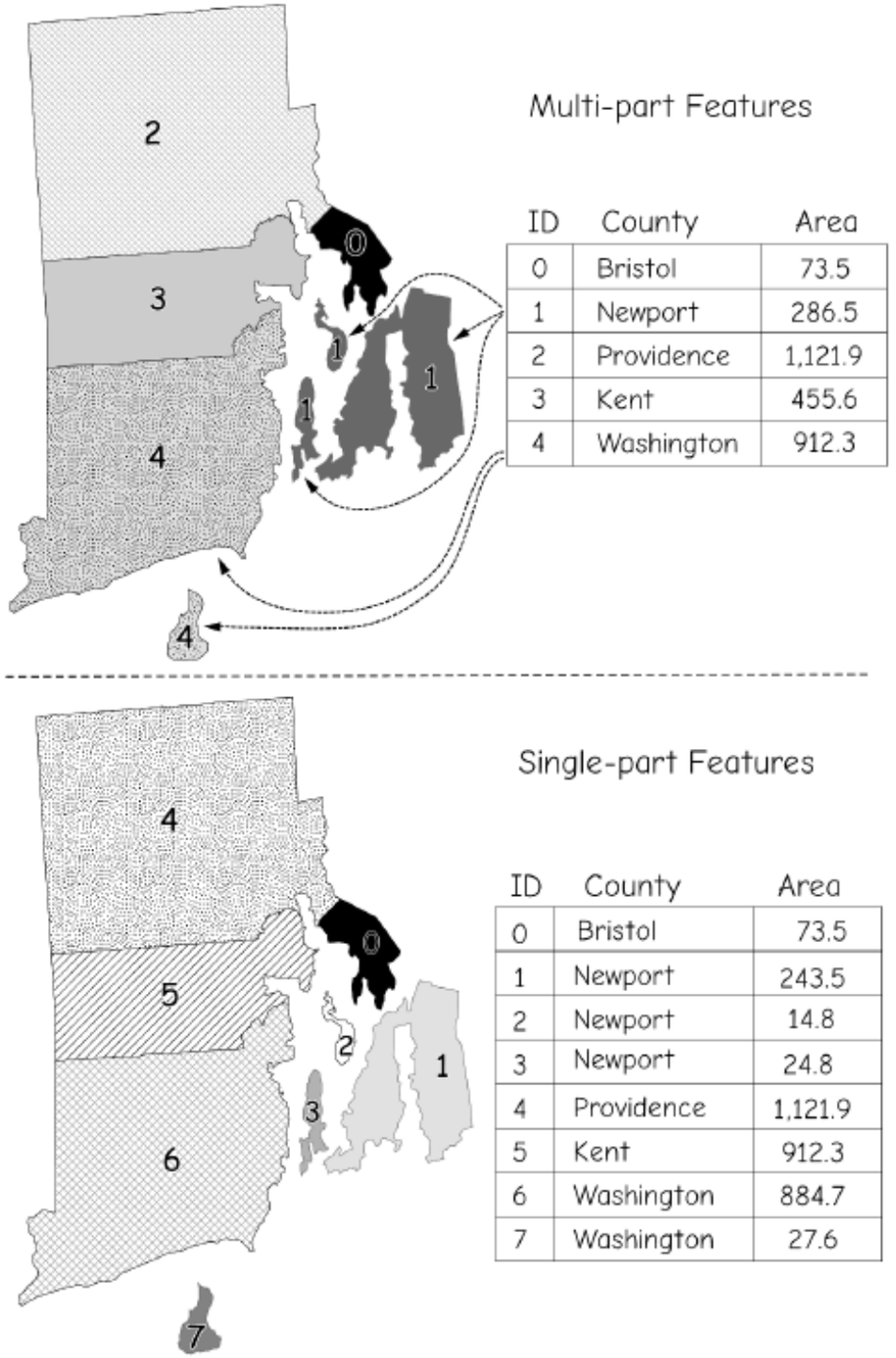


Figure 2-22: Example of multi-part and single-part features. Here, counties for Rhode Island, a state in

Attribute data

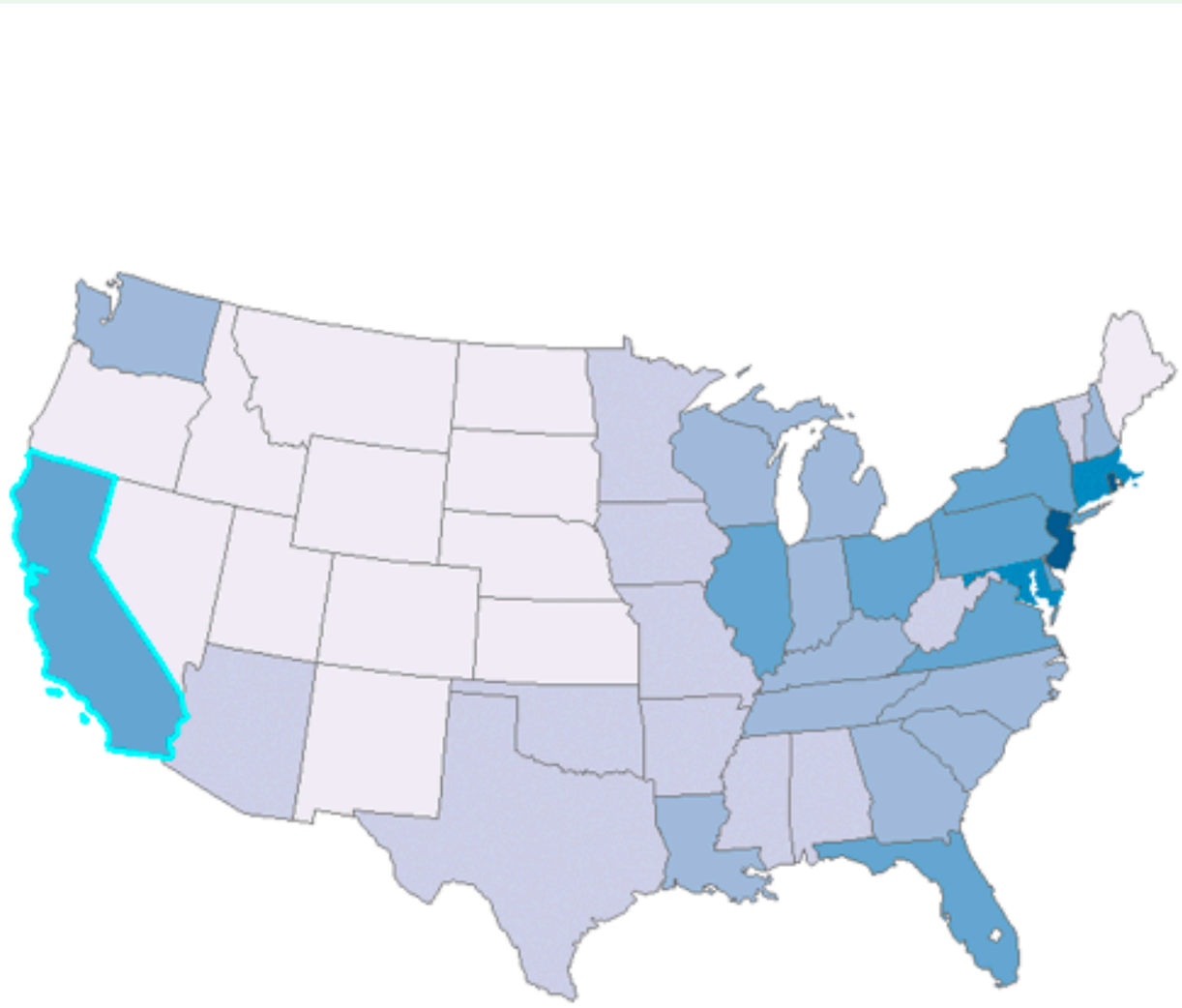
Table

Population Density

FID	Shape	STATE	NAME	FIPS	LON	LAT
0	Polygon	AK	Alaska	02	-152.24099	64.24018
1	Polygon	AL	Alabama	01	-86.82675	32.79353
2	Polygon	AR	Arkansas	05	-92.4392	34.89977
3	Polygon	AZ	Arizona	04	-111.66457	34.29323
4	Polygon	CA	California	06	-119.60818	37.24537
5	Polygon	CO	Colorado	08	-105.54783	38.99855
6	Polygon	CT	Connecticut	09	-72.72623	41.62196
7	Polygon	DC	District of Columbia	11	-77.01464	38.90932
8	Polygon	DE	Delaware	10	-75.50592	38.99559
9	Polygon	FL	Florida	12	-82.50941	28.67437
10	Polygon	GA	Georgia	13	-83.44848	32.65155
11	Polygon	HI	Hawaii	15	-156.34744	20.24924
12	Polygon	IA	Iowa	19	-93.50003	42.07463
13	Polygon	ID	Idaho	16	-114.65933	44.38905
14	Polygon	IL	Illinois	17	-89.19838	40.06501
15	Polygon	IN	Indiana	18	-86.27548	39.90801
16	Polygon	KS	Kansas	20	-98.38019	38.48471

26 (1 out of 55 Selected)

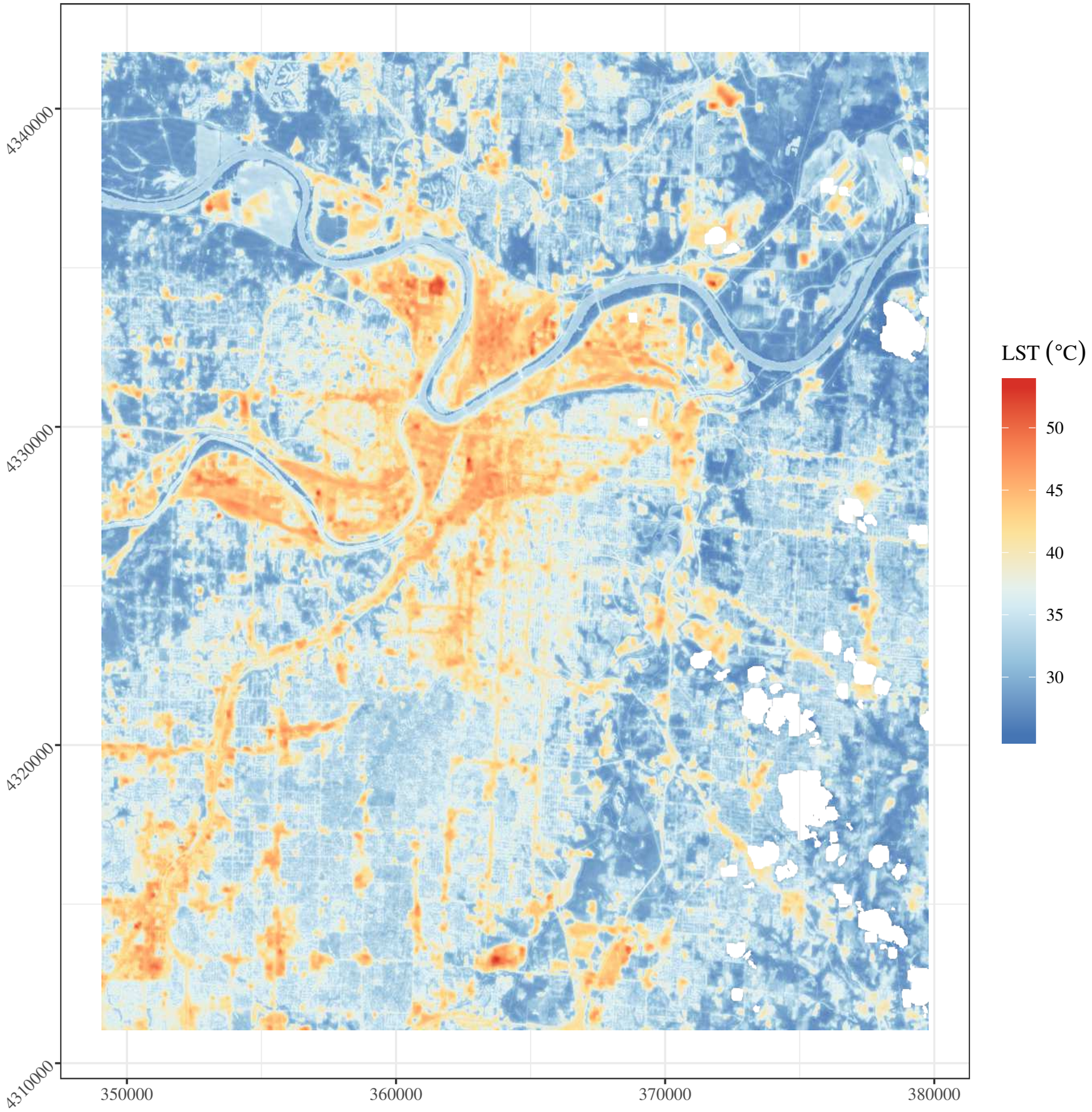
Population Density



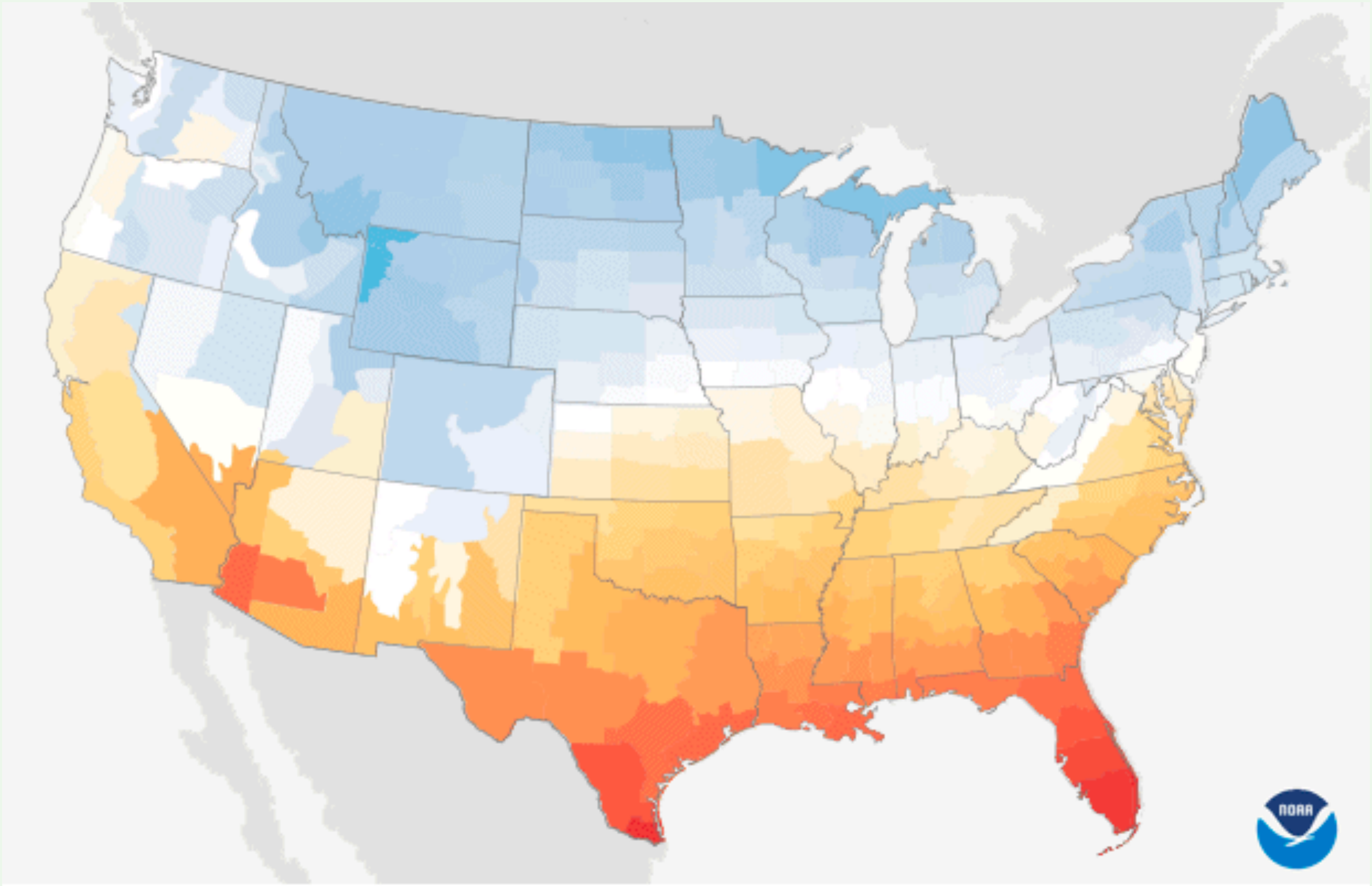
- One row for each object
- One column for each attribute of the object

Continuous fields

- Environmental characteristics that occur continuously across space
- Boundaries cannot easily be defined
- gradients

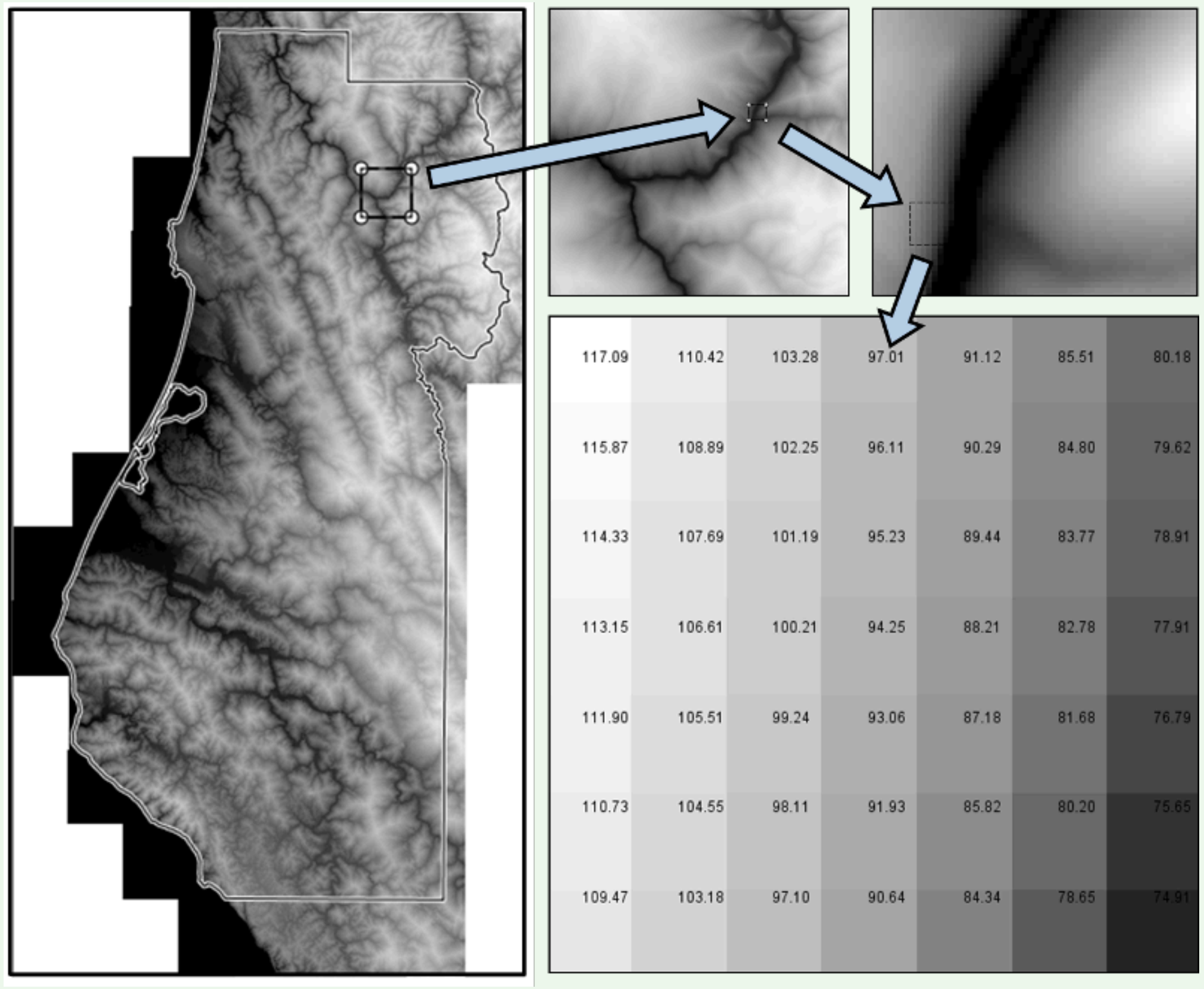


https://www.mdpi.com/2072-4292/11/19/2322


April 2020
Average temperature (°F)
0
50
100
Climate.gov
Data: NCEI

Raster data in GIS

- Space is divided into a two-dimensional array of cells (spatial tessellation)
- An attribute is measured and stored for each cell
  - May be a single measured value or the average value



117.09	110.42	103.28	97.01	91.12	85.51	80.18
115.87	108.89	102.25	96.11	90.29	84.80	79.62
114.33	107.69	101.19	95.23	89.44	83.77	78.91
113.15	106.61	100.21	94.25	88.21	82.78	77.91
111.90	105.51	99.24	93.06	87.18	81.68	76.79
110.73	104.55	98.11	91.93	85.82	80.20	75.65
109.47	103.18	97.10	90.64	84.34	78.65	74.91

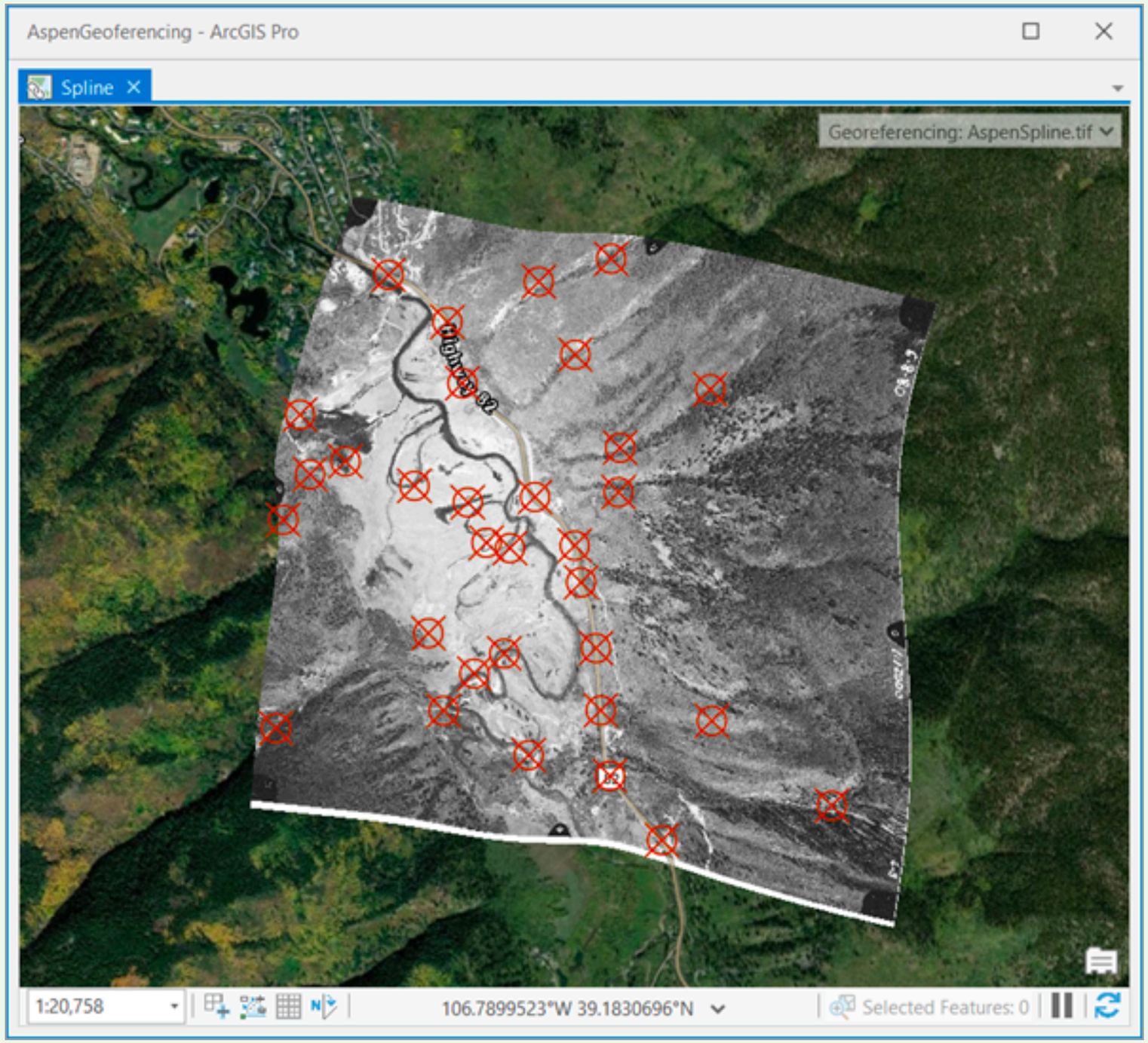
High spatial resolution

Medium spatial resolution

Low spatial resolution

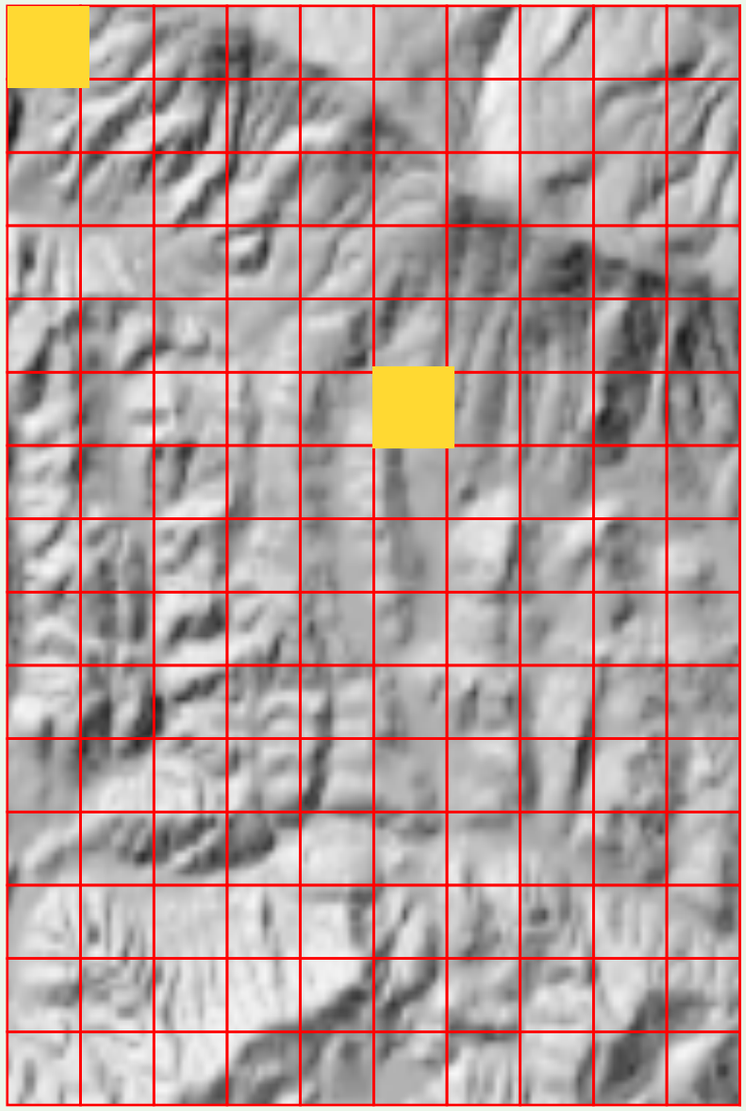
Raster georeferencing

- Locate a raster in a geospatial coordinate system



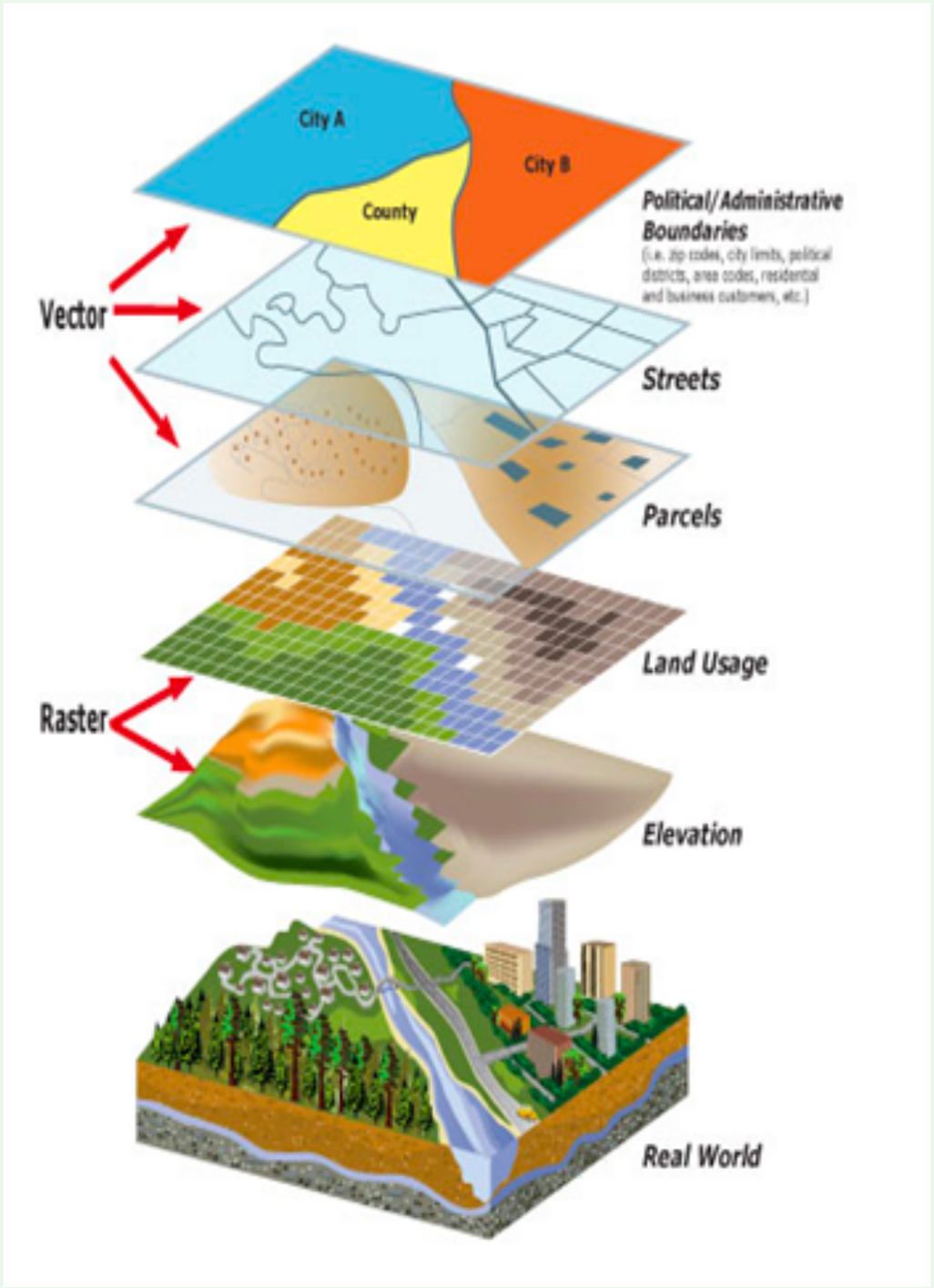
Cell-center coordinates

- Upper left cell center: x = 405,135; y = 4,425,560
- Cell size = 30 m
- What is the (x, y) at the center of the cell at row 6 column 6?
- x = 405,135 + (30 * 5) = 405,285
- y = 4,425,560 - (30 * 5) = 4,425,410

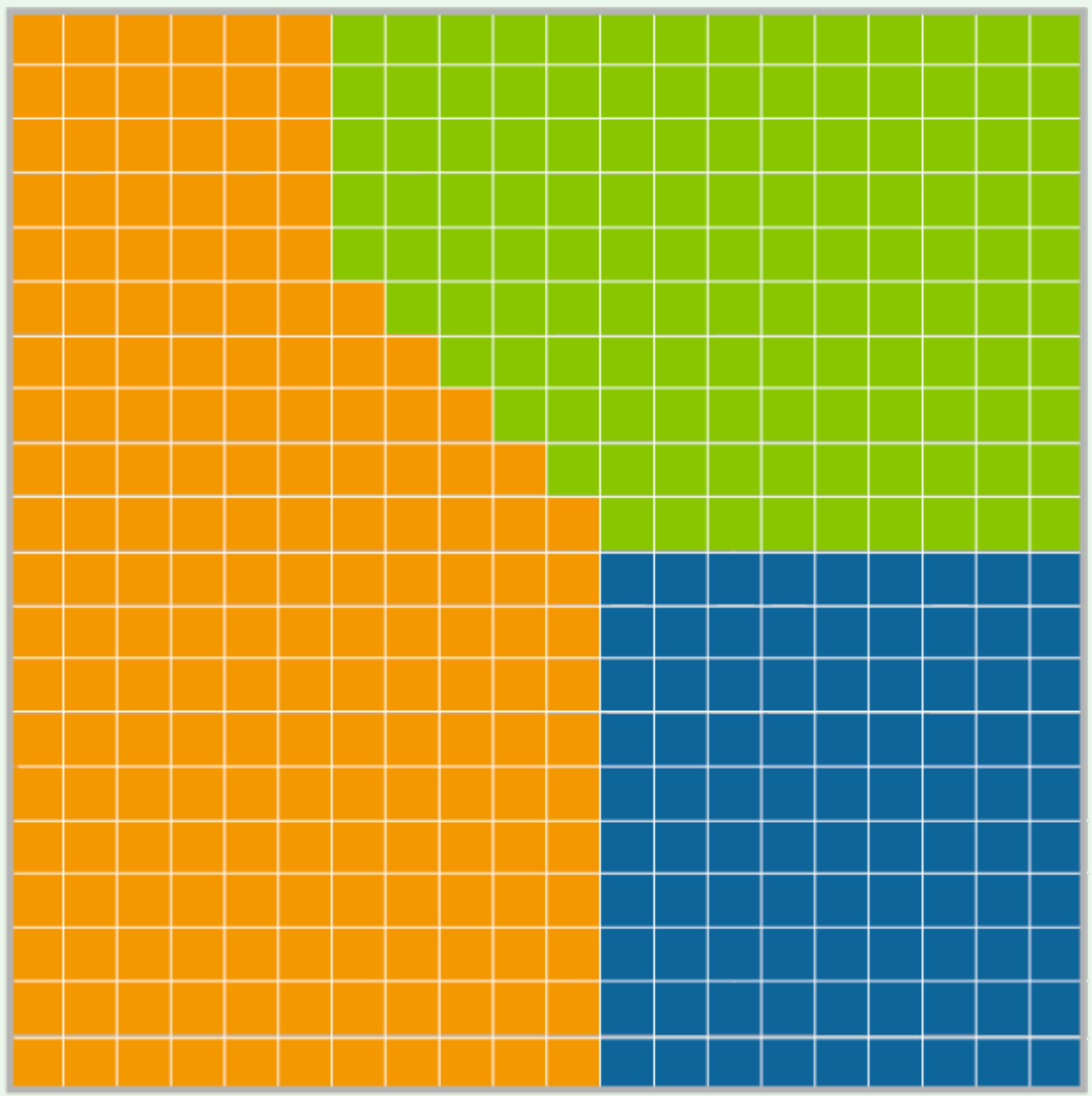


Map layers in GIS databases

- Geographic features and fields are organized as map layers
- A **vector** map layer (feature classes) is a collection of features with the same geometric type and attributes
  - Point layers
  - Line layers
  - Polygon layers
- Continuous surfaces are organized as raster map layers



RASTER MODEL



VECTOR MODEL