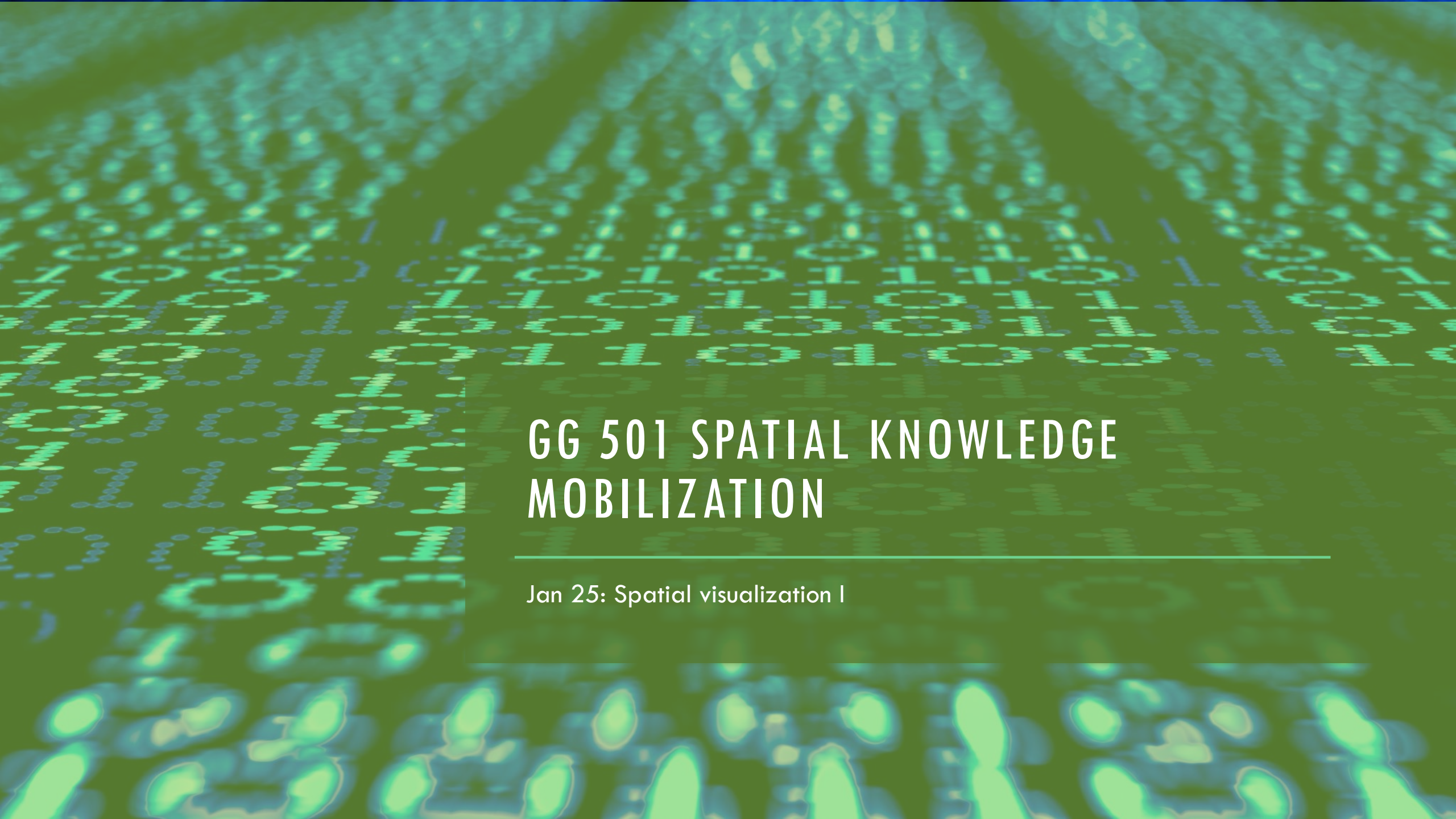


GG 501 SPATIAL KNOWLEDGE MOBILIZATION

Jan 25: Spatial visualization I

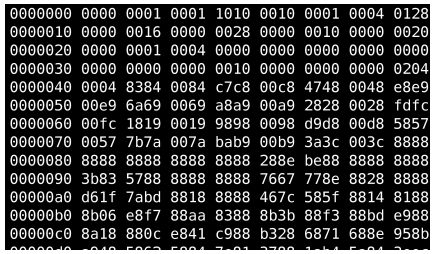
REVIEW

- File and project management in R-Studio
- Understanding r files
  - .r files, .rdata files, .rproj files, .rmd files

How do we put this into GIS?

```
0000000 0000 0001 0001 1010 0010 0001 0004 0128
0000010 0000 0016 0000 0028 0000 0010 0000 0020
0000020 0000 0001 0004 0000 0000 0000 0000 0000
0000030 0000 0000 0000 0010 0000 0000 0000 0204
0000040 0004 8384 0084 c7c8 00c8 4748 0048 e8e9
0000050 00e9 6a69 0069 a8a9 00a9 2828 0028 fdfc
0000060 00fc 1819 0019 9898 0098 d9d8 00d8 5857
0000070 0057 7b7a 007a bab9 00b9 3a3c 003c 8888
0000080 8888 8888 8888 8888 288e be88 8888 8888
0000090 3b83 5788 8888 8888 7667 778e 8828 8888
00000a0 d61f 7abd 8818 8888 467c 585f 8814 8188
00000b0 8b06 e8f7 88aa 8388 8b3b 88f3 88bd e988
00000c0 8a18 880c e841 c988 b328 6871 688e 958b
```

ABSTRACTION IN GIS



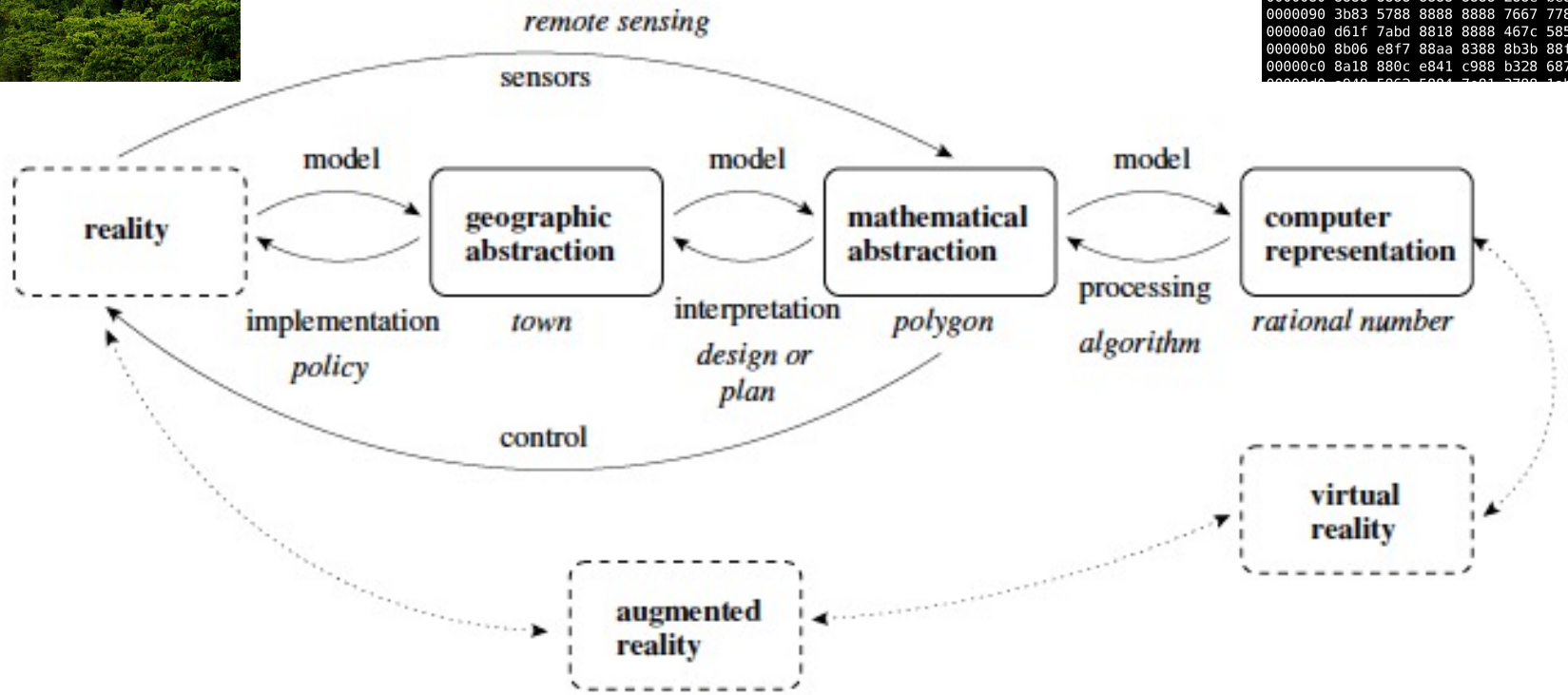
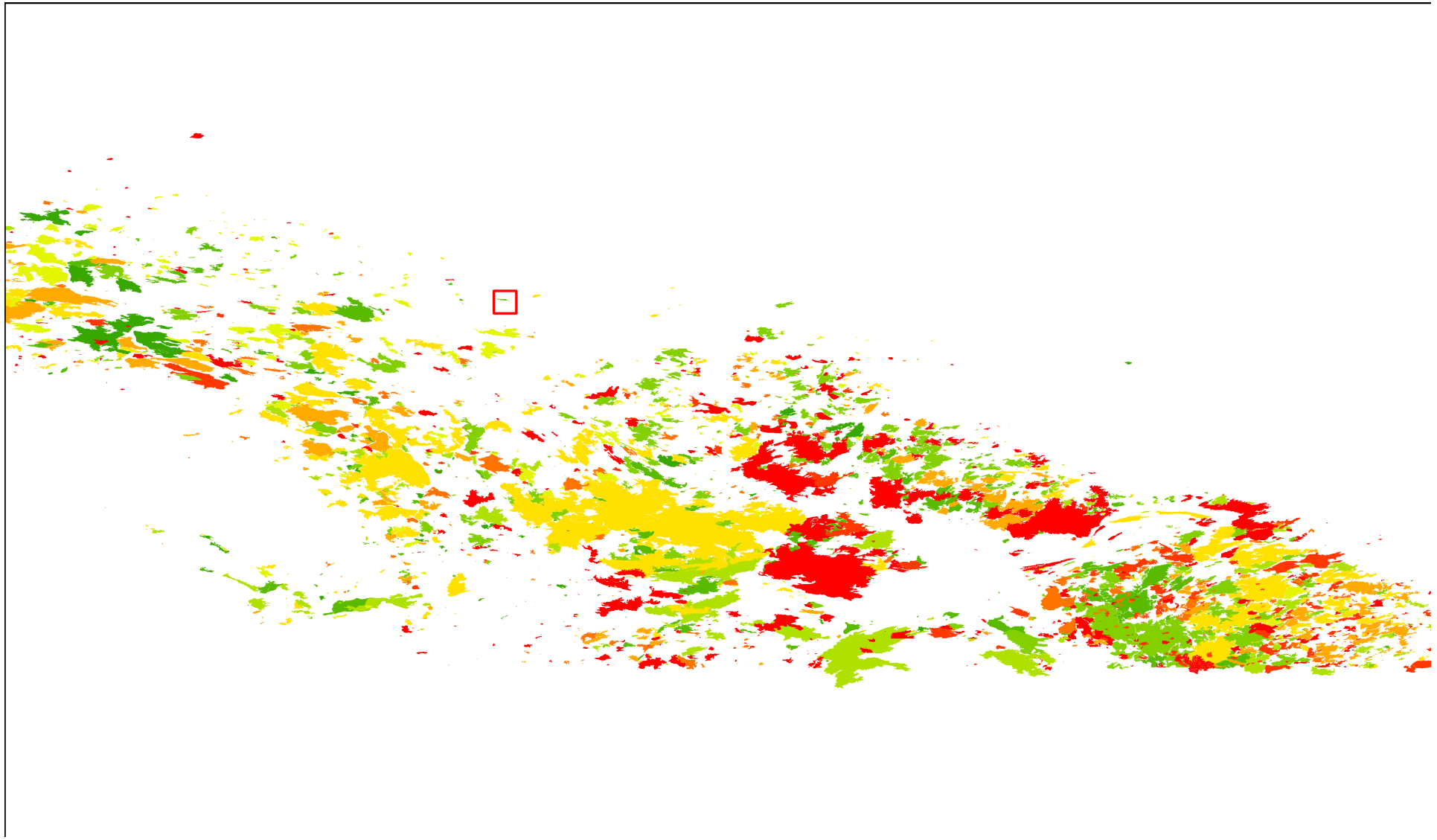
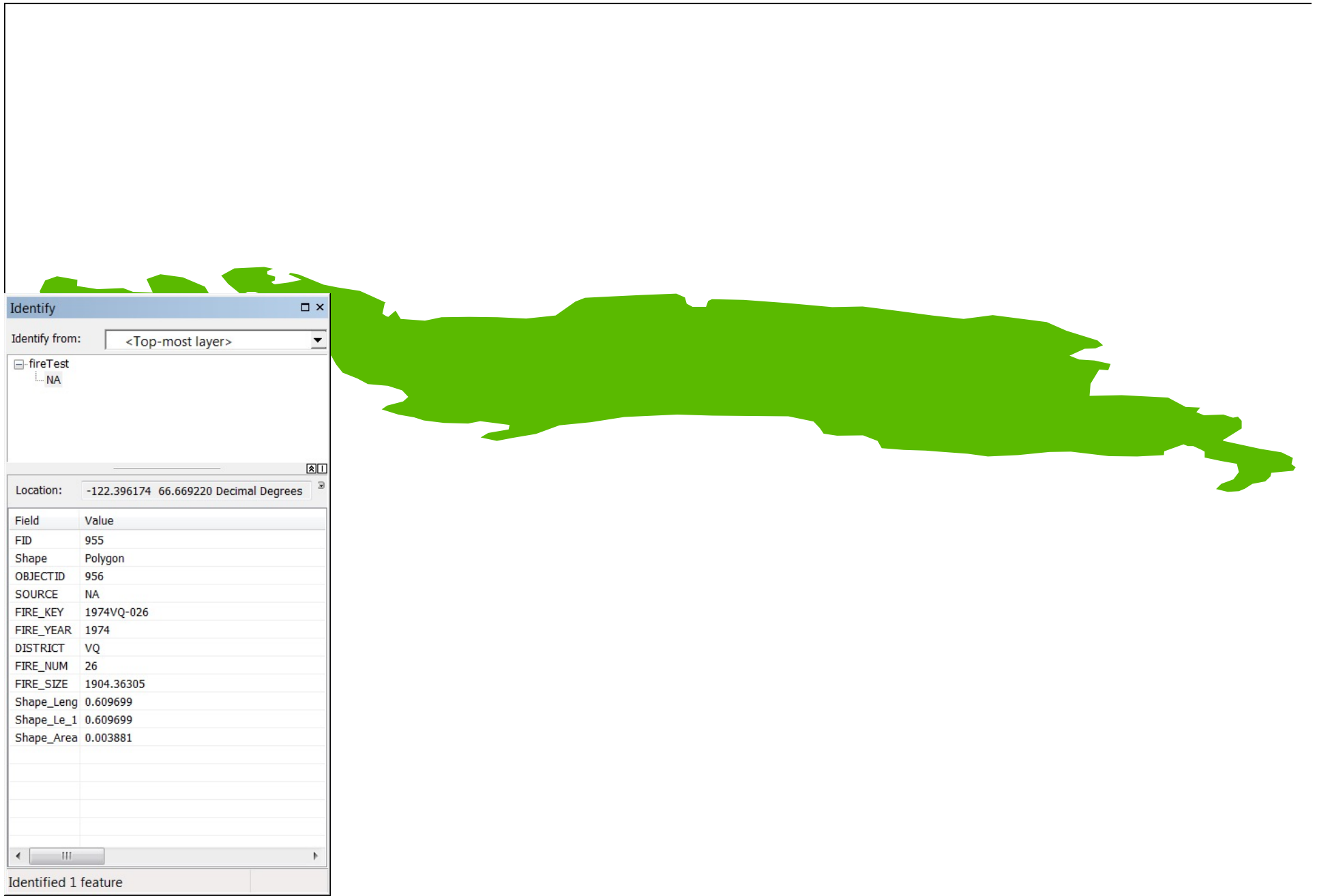


Figure 2: Levels of abstraction in GIS

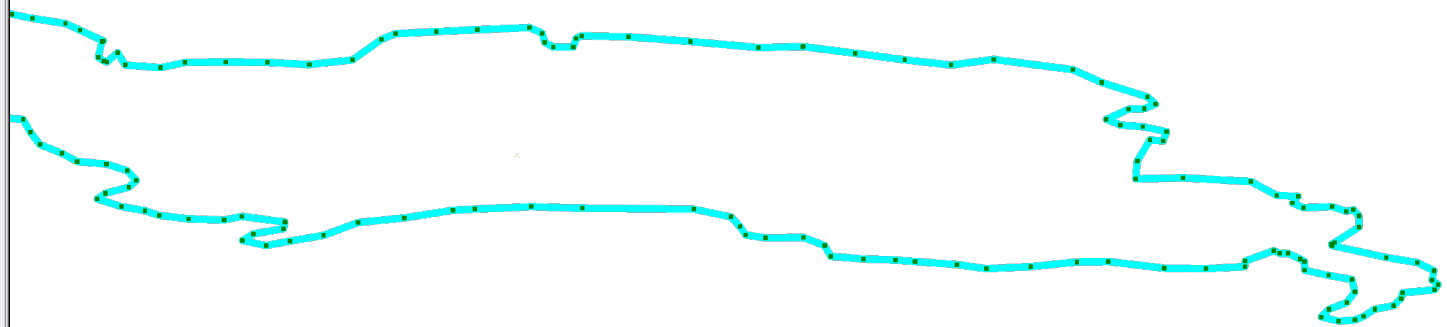


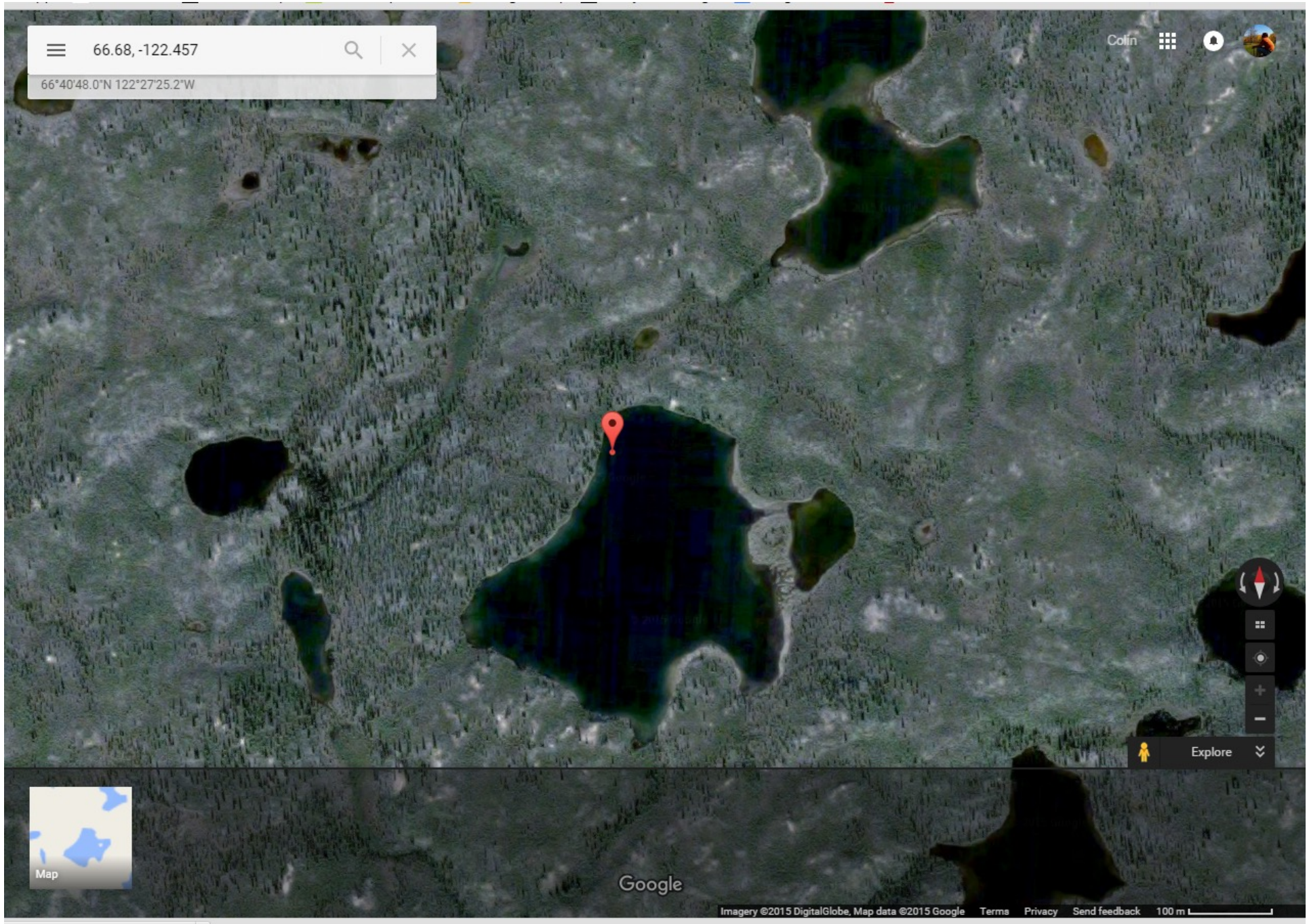

Identify
Identify from:
<Top-most layer>
fireTest
NA
Location:
-122.396174 66.669220 Decimal Degrees
Field
Value
FID
955
Shape
Polygon
OBJECTID
956
SOURCE
NA
FIRE_KEY
1974VQ-026
FIRE_YEAR
1974
DISTRICT
VQ
FIRE_NUM
26
FIRE_SIZE
1904.36305
Shape_Leng
0.609699
Shape_Le_1
0.609699
Shape_Area
0.003881
Identified 1 feature

Edit Sketch Properties

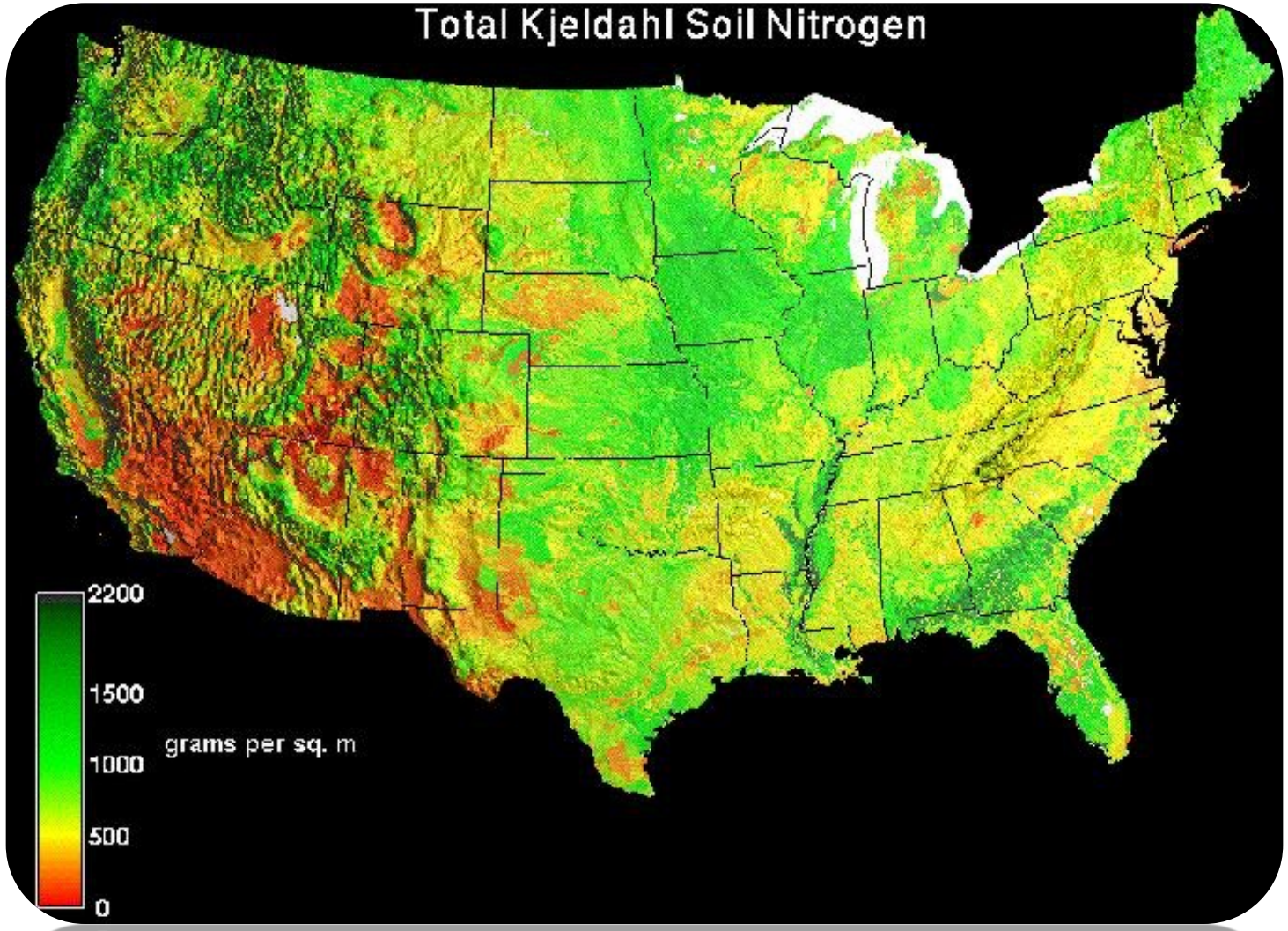
Finish Sketch

#	X	Y
0	-122.457	66.680
1	-122.457	66.680
2	-122.459	66.682
3	-122.461	66.683
4	-122.458	66.685
5	-122.453	66.685
6	-122.451	66.685
7	-122.452	66.684
8	-122.452	66.684
9	-122.451	66.683
10	-122.451	66.683
11	-122.451	66.682
12	-122.451	66.682
13	-122.451	66.682
14	-122.448	66.682
15	-122.446	66.683
16	-122.448	66.684
17	-122.448	66.684
18	-122.446	66.684
19	-122.442	66.682
20	-122.439	66.681
21	-122.435	66.681
22	-122.433	66.680
23	-122.430	66.678
24	-122.430	66.678
25	-122.431	66.676
26	-122.430	66.676
27	-122.430	66.676
28	-122.428	66.677
29	-122.427	66.675
30	-122.423	66.675
31	-122.420	66.676
32	-122.414	66.676

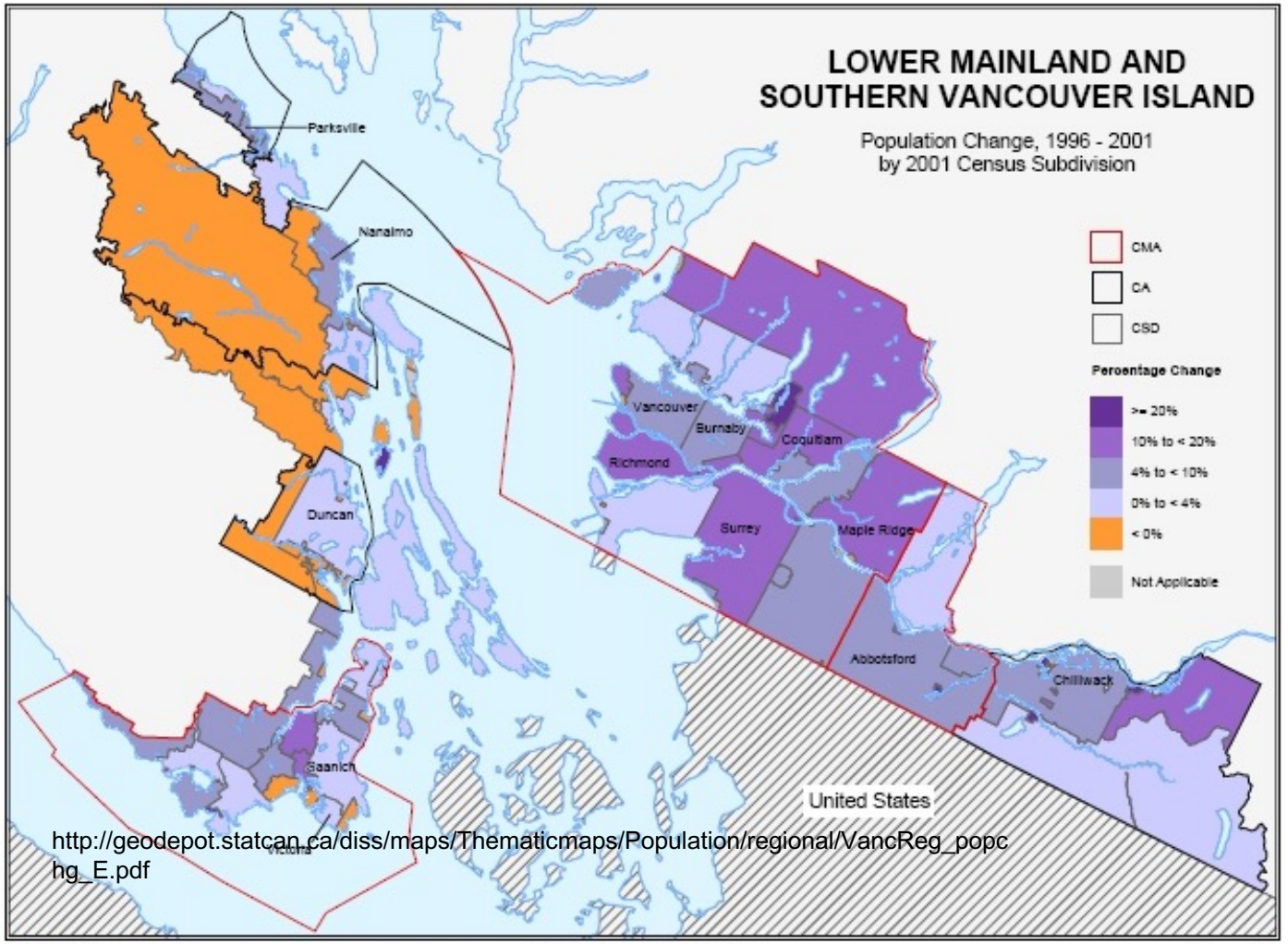



66.68, -122.457
66°40'48.0"N 122°27'25.2"W
Colin
Explore
Map
Google
Imagery ©2015 DigitalGlobe, Map data ©2015 Google
Terms
Privacy
Send feedback
100 m

The amount of nitrogen in soil at a specific location



Census data – population change in census areas



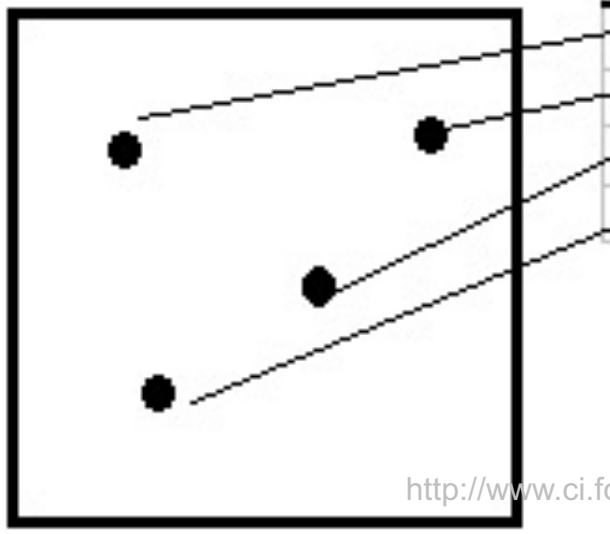
http://geodepot.statcan.ca/diss/maps/Thematicmaps/Population/regional/VancReg_popchg_E.pdf

The location of trees

Components of Spatial Data

1) Location – describes where a "thing" is

2) Attribute – provides information about the "thing"



ID	School Name	School Type
1	Tavelli	Elementary
2	Fort Collins	High School
3	Lincoln	Jr. High School
4	Cache La Poudre	Jr. High School

http://www.ci.fort-collins.co.us/gis/what-is.php

COMPONENTS OF SPATIAL DATA

Tree

- **Location:**
  - A single tree
- **Attributes:**
  - Tree height
  - Tree species
  - Tree health

Spatial and attribute information are stored separately but related

Geo-relational data

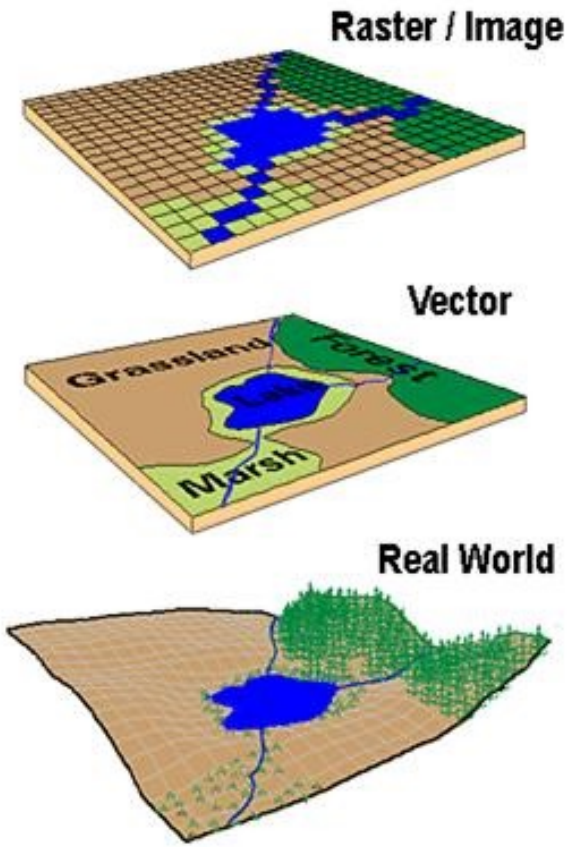
DATA MODELS AND DATA MODELLING

Model: simplified representation of a phenomenon or a system retaining significant features and relationships of reality

Data Model: a description or view of the real world

- E.g. A map

Data Modelling: **process** to formalize a data model at different levels of abstraction



forward

Real world

Conceptual Level

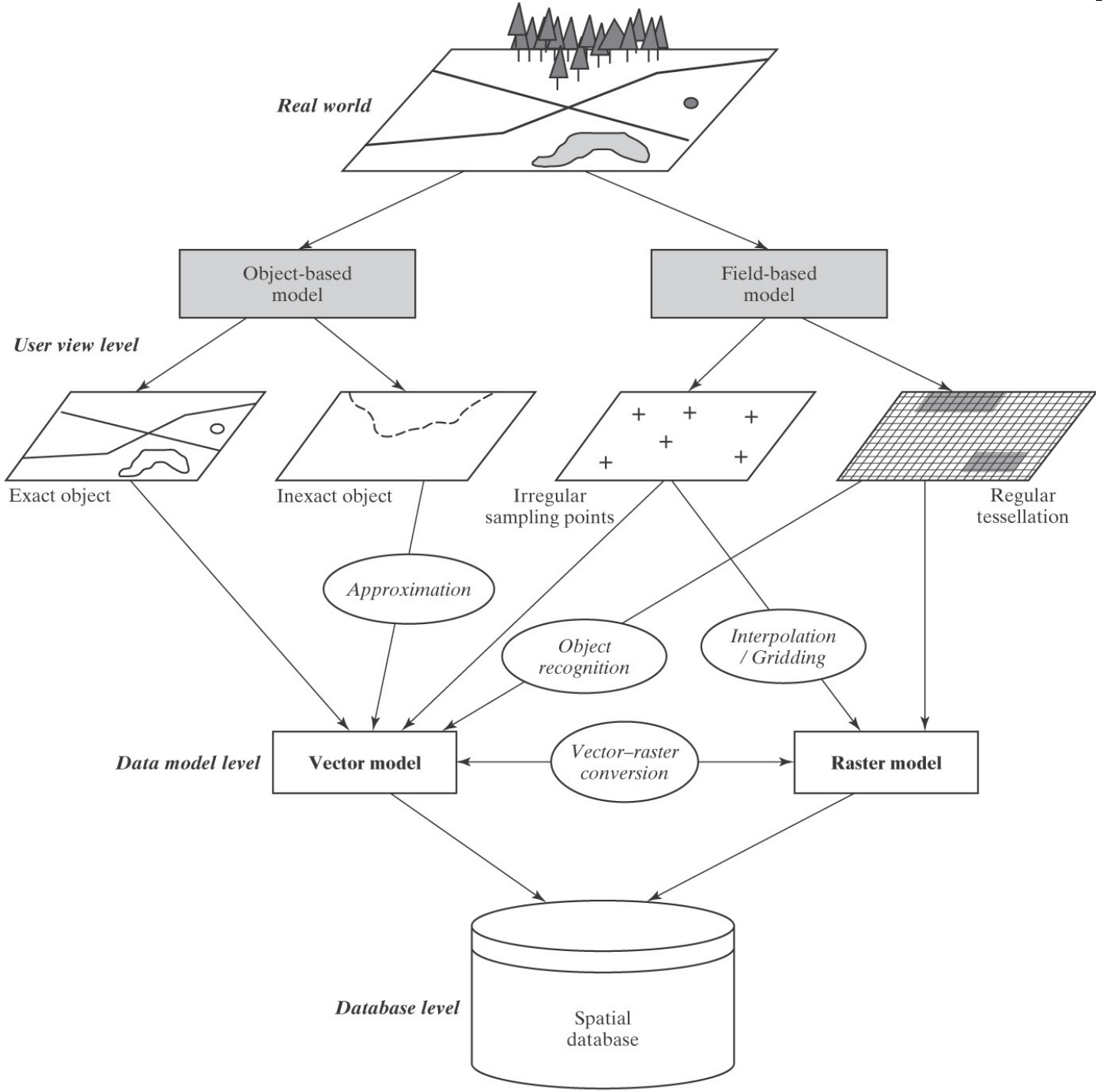
Our understanding of real world features and relationships

Logical Level

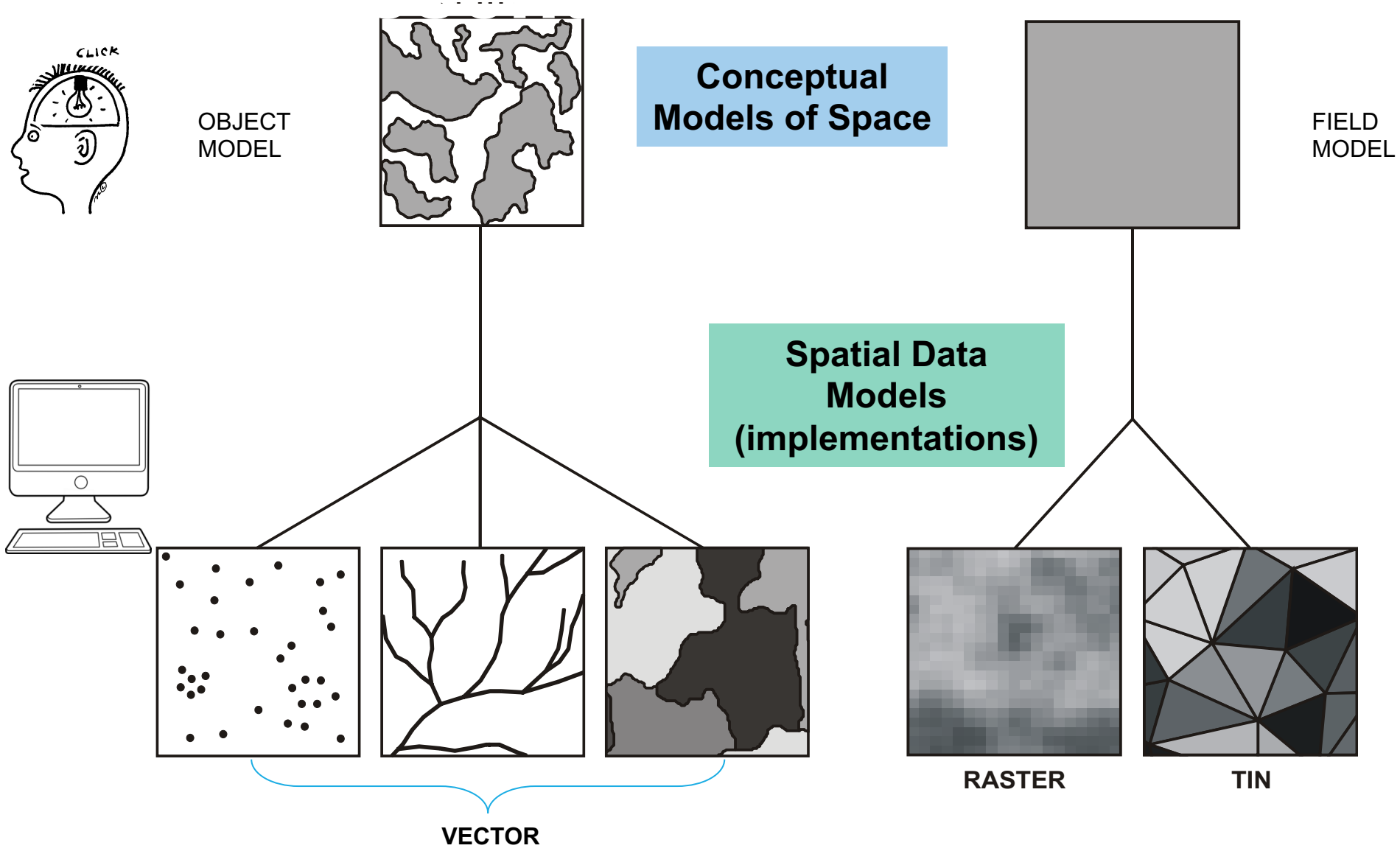
Organization of data within the computer

Physical Level

Actual storage technology (hardware specific)



Representing Spatial Data



VECTOR DATA MODEL

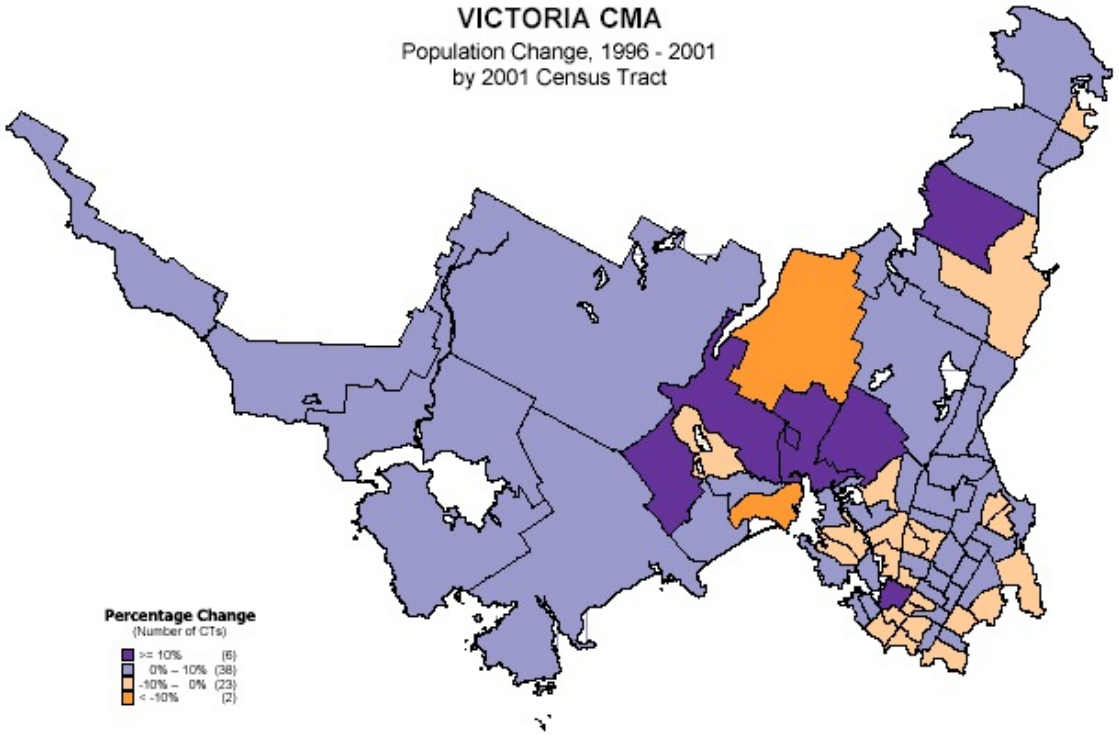
Land parcels in a tax assessment system

Electoral districts

Location of light poles

Forest inventory polygons

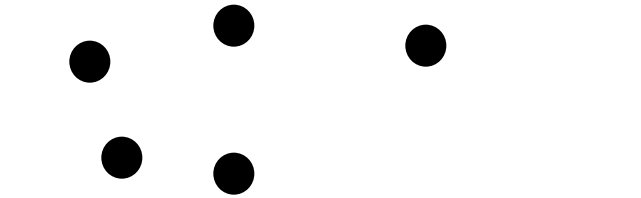
What attributes might be associated with each of these?



POINTS, LINES, AREAS

x and *y* coordinates

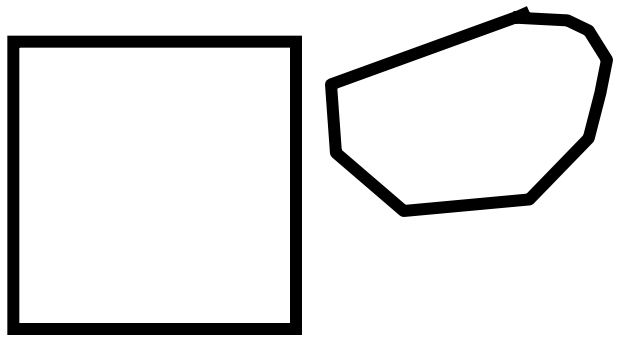
Ordered set of point coordinates



First and last coordinates sometimes called nodes

Lines sometimes called **arcs or polylines**

An ordered set of point coordinates that represent a boundary, with the first and last being identical



BASIC GEOMETRY PRIMITIVES

Points

Trees

Houses

People sitting at the fountain

Animals

Lines

- A road
- One segment of a river
- Hiking trail

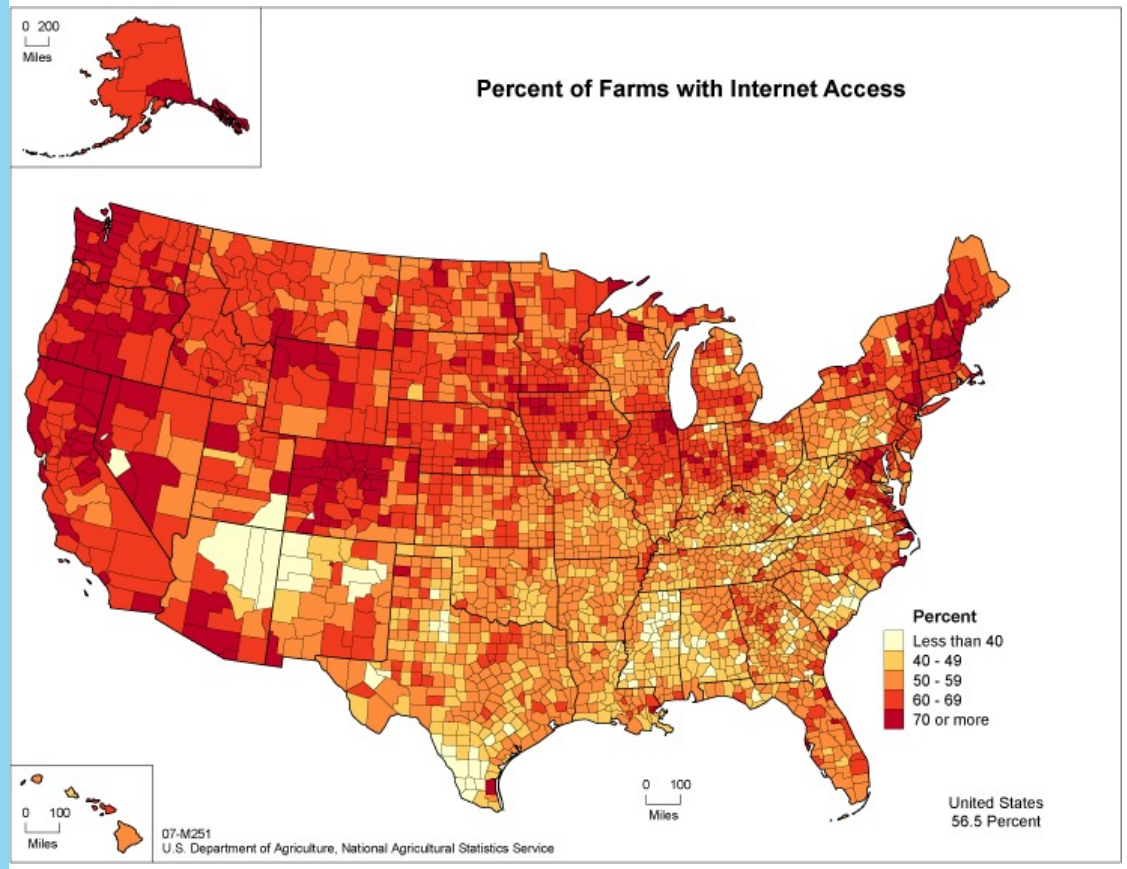
Areas

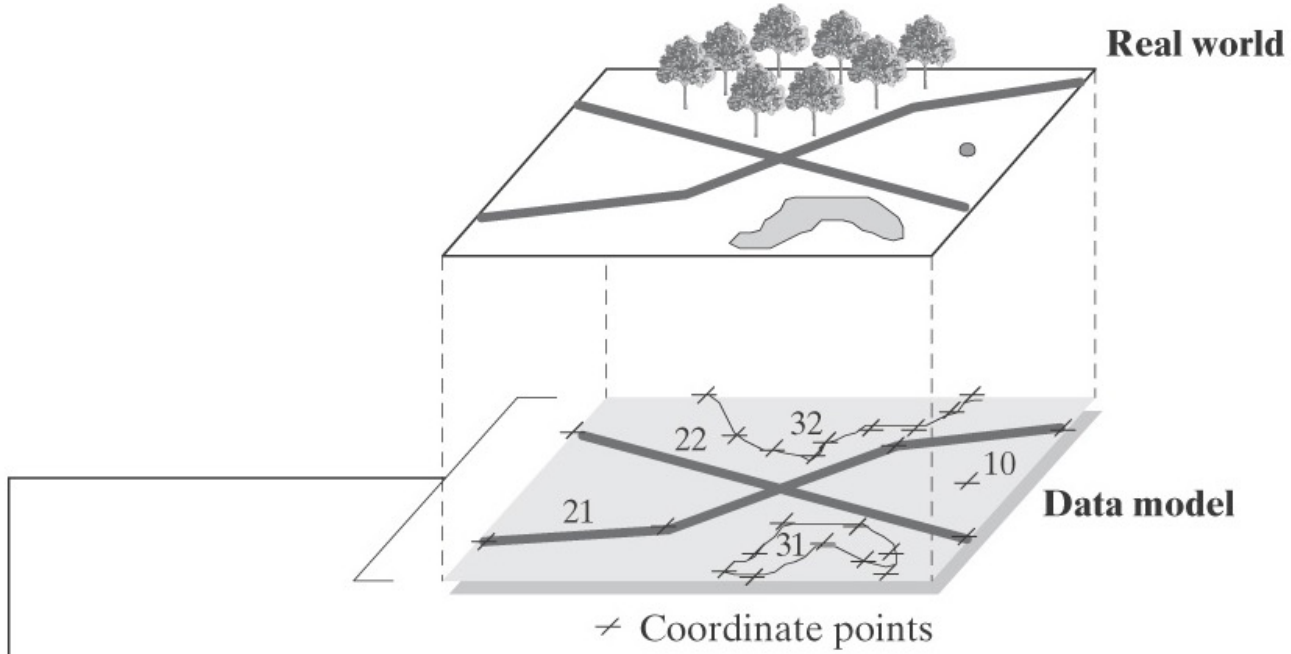
- Forest inventory polygon
- Lakes
- Census districts
- Watersheds

AREAS / POLYGONAL DATA

Can be of two main types

- Lattices
  - Regular: everywhere covered by polygons of the same shape and size
    - quadrats
  - Irregular: everywhere covered by polygons of different shapes and sizes
    - Census tracts, health districts etc.
- Discrete
  - Polygons mapped 2-dimensionsal features
    - Forest fires
    - Hurricanes etc





Stored data

Feature ID	Feature type	Location
10	Point	xy
21	Line	$x_1y_1, x_2y_2, x_3y_3 \ldots x_ny_n$ (string)
22	Line	$x_1y_1, x_2y_2, x_3y_3 \ldots x_ny_n$ (string)
31	Polygon	$x_1y_1, x_2y_2, x_3y_3 \ldots x_1y_1$ (closed loop)
32	Polygon	$x_1y_1, x_2y_2, x_3y_3 \ldots x_1y_1$ (closed loop)

SPATIAL DATA IN R – first generation packages

- `sp` was first R package to establish a uniform vector layer class system around 2003
- Other packages emerged for more sophisticated 'GIS'-like functionality:
  - `rgdal` (2003) – for reading and writing geospatial data
  - `rgeos` (2011-)- for geospatial operations / processing
    - intersect, union, clip. etc.
- `sp` classes were based on a data.frame class and extended to handle geometry/CRS

Class	Geometry type	Attributes
`SpatialPoints`	Points	-
`SpatialPointsDataFrame`	Points	`data.frame`
`SpatialLines`	Lines	-
`SpatialLinesDataFrame`	Lines	`data.frame`
`SpatialPolygons`	Polygons	-
`SpatialPolygonsDataFrame`	Polygons	`data.frame`

- `raster` package was the dominant class for handling and processing raster geospatial data in r

SPATIAL DATA IN R – first generation packages

```
library(sp)
# Make a set of coordinates that represent vertices with longitude and latitude in the familiar degrees
x_coords <- c(-60,-60,-62,-62,-60)
y_coords <- c(20,25,25,20,20)
#use the Polygon function in the sp package to make a polygon from our matrix of vertices
poly1 <- sp::Polygon(cbind(x_coords,y_coords))
#Then we make poly1 into a Polygon class using the Polygons function
firstPoly <- sp::Polygons(list(poly1), ID = "A")
str(firstPoly,1)
#Then we can make firstPoly into a SpatialPolygons
firstSpatialPoly <- sp::SpatialPolygons(list(firstPoly))
df <- data.frame(POLYID=1)
#then we can add our attributes and turn it into a spatialpolygonsdataframe=
spdf <- SpatialPolygonsDataFrame(firstSpatialPoly, df, match.ID = FALSE)
```

- spatial objects are complex objects which has different sub objects stored in ‘slots’ and accessed through ‘@’
- demo from AI surveillance project

SPATIAL DATA IN R – 2nd generation packages

- `sf` is the replacement R package for `sp` and the modern way for handling geospatial data in r
- implements the *simple features standard* (ISO 19125-1:2004) which is common across geospatial software/databases
  - did not exist at time `sp` was written
- A feature is a thing, or an object in the real world, such as a building or a tree
  - can consist of other objects
- Features have *geometry* describing *where* on Earth the feature is located, and they have attributes, which describe other properties

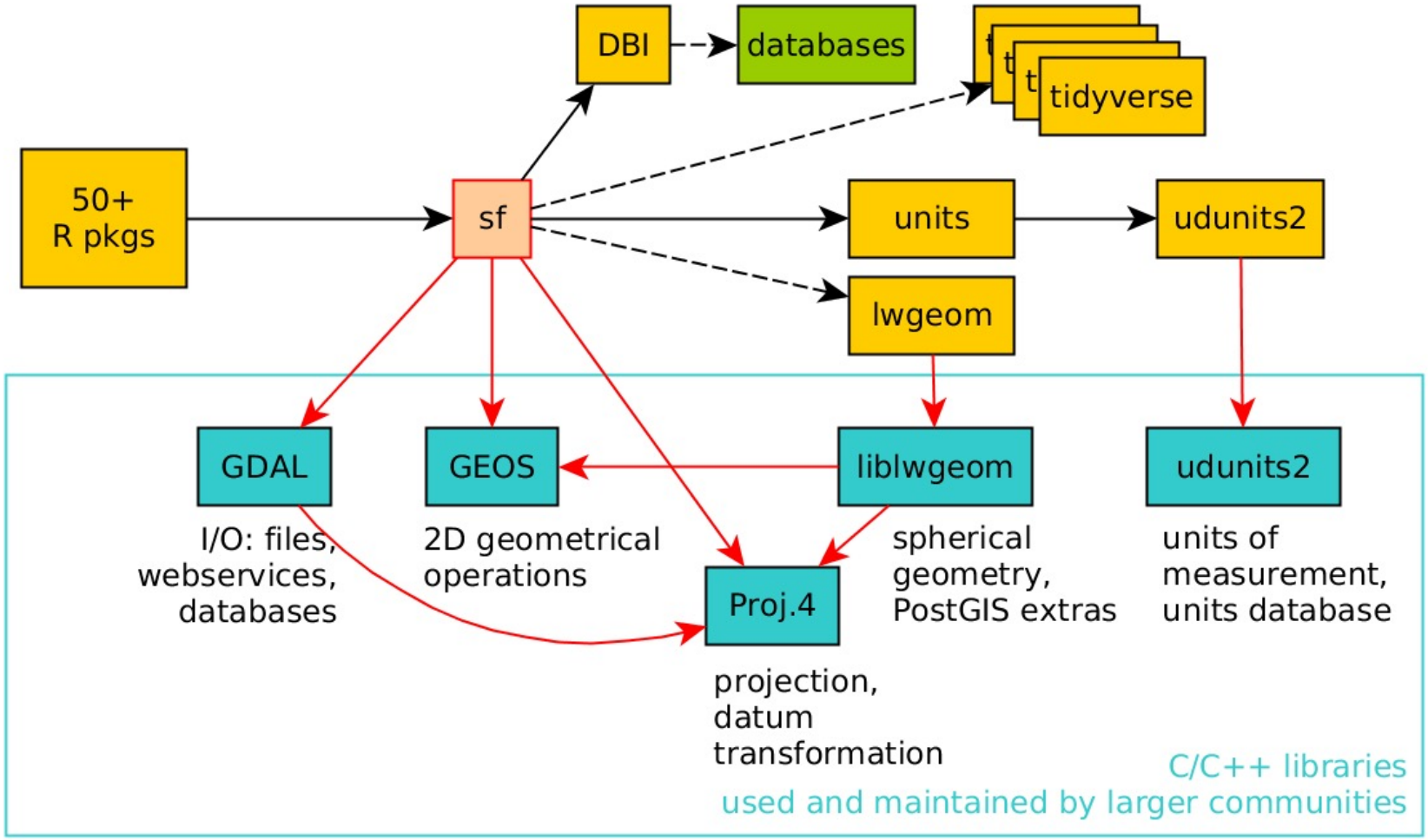
SPATIAL DATA IN R – 2nd generation packages

- sf package depends on several external software components (installed along with the R package[30]), most importantly **GDAL, GEOS** and **PROJ**

Class **sfg**—a *single* geometry

Class **sfc**—a geometry column, which is a *set* of sfg geometries + CRS information

Class **sf**—a layer, which is an sfc geometry column inside a data.frame with non-spatial



https://github.com/edzer/rstudio_conf

SPATIAL DATA IN R – 2nd generation packages

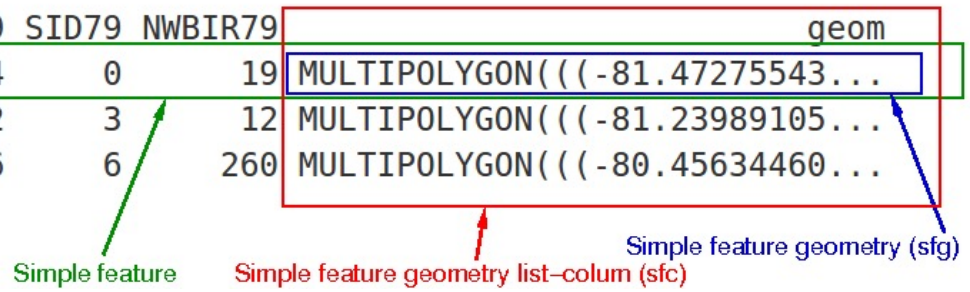
- in addition to adoption of simple features standard within R, sp classes did not work well with tidyverse workflows which have become a dominant paradigm for analytics in r
- remember that a data frame in r is a list of equal length vectors
  - can we store the geometry as a list of coordinates in a single column of a data frame
  - this is the approach taken by sf so that sf objects behave much like regular data frames
    - more consistent with tidy approaches

```
library(sf)
Linking to GEOS 3.8.1, GDAL 3.1.1, PROJ 6.3.1

nc <- st_read(system.file("shape/nc.shp", package="sf"))
Reading layer `nc' from data source
`/Library/Frameworks/R.framework/Versions/4.0/Resources/libr
ary/sf/shape/nc.shp' using driver `ESRI Shapefile'
Simple feature collection with 100 features and 14 fields
geometry type:  MULTIPOLYGON
dimension:      XY
bbox:           xmin: -84.32385 ymin: 33.88199 xmax: -
75.45698 ymax: 36.58965
geographic CRS: NAD27

class(nc)
[1] "sf"         "data.frame"

print(nc[9:15], n = 3)
```

sf PACKAGE

- in green a simple feature: a single record, or data.frame row, consisting of attributes and geometry
- in blue a single simple feature geometry (an object of class sfg)
- in red a simple feature list-column (an object of class sfc, which is a column in the data.frame)
  - that although geometries are native R objects, they are printed as well-known text (part of the standard)

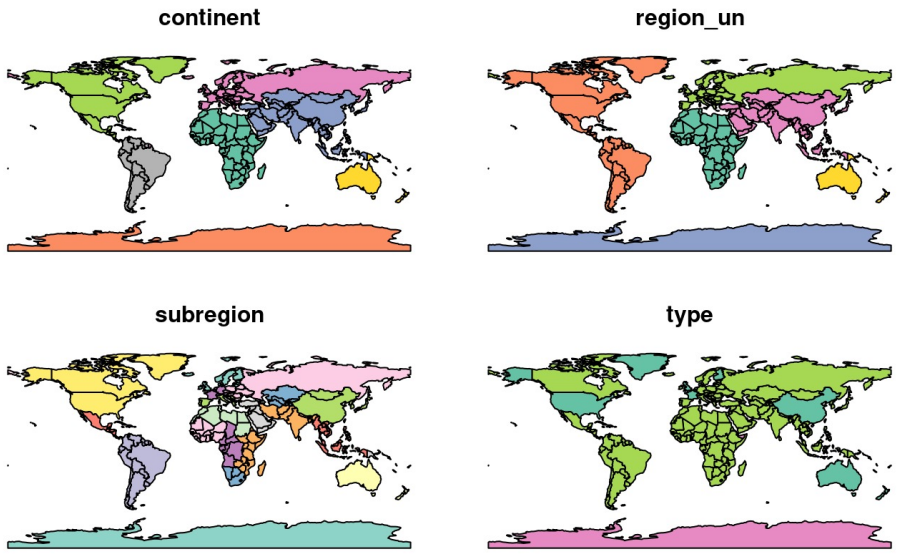
```
## Simple feature collection with 100 features and 6 fields
## geometry type:  MULTIPOLYGON
## dimension:      XY
## bbox:           xmin: -84.32385 ymin: 33.88199 xmax: -75.45698 ymax: 36.58965
## epsg (SRID):    4267
## proj4string:    +proj=longlat +datum=NAD27 +no_defs
## precision:      double (default; no precision model)
## First 3 features:
##   BIR74 SID74 NWBIR74 BIR79 SID79 NWBIR79                       geom
## 1  1091     1      10  1364     0      19 MULTIPOLYGON(((-81.47275543...
## 2   487     0      10   542     3      12 MULTIPOLYGON(((-81.23989105...
## 3  3188     5     208  3616     6     260 MULTIPOLYGON(((-80.45634460...
```

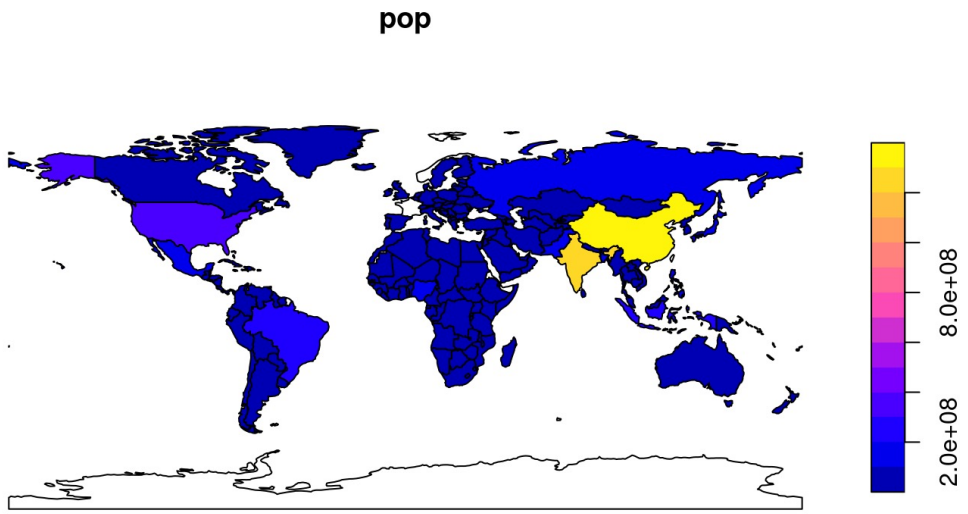


MAPPING `sf` Data

- basic mapping of sf data in r with the `plot` function

```
library(sp)
world_sp = as(world, Class = "Spatial") # from an sf object to sp
# sp functions ...
world_sf = st_as_sf(world_sp)           # from sp to sf
plot(world[3:6])
plot(world["pop"])
```





SPATIAL VISUALIZATION WALKTHRU

https://mhweber.github.io/R-User-Group-Spatial-Workshop-2018/Mapping.html

GG 501 SPATIAL KNOWLEDGE MOBILIZATION

Jan 25: Spatial visualization I