Welcome to GIS!

Michael F. Nelson

Today's agenda

- Introductions and course structure
- Syllabus key points
- What is GIS?
- Course Overview
- Software
- Big Concepts in GIS
- GIS Applications

About The Course

The Basics

Introductions: About Me

- I’m a lecturer in the Department of Environmental Conservation
- Research and teaching interests include:
  - Invasion ecology
  - Spatial statistics, modeling, and GIS
- I learned GIS on my own, so you don’t have to!
- Other courses I teach:
  - Intro to Quantitative Ecology
  - Analysis of Environmental Data
  - Spatial Data Analysis in R

Course Structure

- This is a hybrid synchronous/asynchronous course. It consists of lectures and optional lab sessions.
- Real-time lectures are held on Zoom Tuesdays and Thursdays 9:45AM – 11:00AM
  - Recordings of the lectures are posted to the course ECHO360 page.
  - Enrolled students will find links to the Zoom channel and the ECHO360 pages in Moodle (they are not public-facing).
- Labs are held Wednesdays 11:00 – 1:00 and Fridays 9:00 – 11:00

Synchronous Lecture Sessions

- These sessions will include:
  - Content delivery
  - Questions: Please feel free to interrupt me to ask questions at any time.
  - Map Puzzlers: these are meant to be fun exercises about mystery locations. Think Carmen Sandiego!
  - Map Showcase: This is your chance to show off the maps you create in lab!

Course Websites

GitHub

- Most course content is included here:
  - Lecture note pdfs
  - Lab instructions and data
  - Links to video walkthroughs and tutorials

Moodle

- There will be minimal content on Moodle. We'll primarily use it for:
  - Assignment submission
  - Midterm
  - Material that is for enrolled students only.
  - Non-public discussion forums

Lectures and Lecture Notes

- PDFs of the slides are posted to GitHub
- Slide PDFs will be updated as needed to account for questions that arise in class.
- Slide PDFs will be updated as needed to focus material on your interests.
- Slide PDFs will be updated as needed when errors are found!
- The most up-to-date slide PDFs can always be found on the course GitHub page.

Course Software

- GIS is software intensive… Lab 1 contains software instructions.
- Windows Virtual Desktop: this takes a couple of days to set up after your request.
  - Sign up for access here ASAP
- Expect to spend time troubleshooting! It's part of the joy of GIS.
  - Don't be afraid to ask for help when you get stuck (Dr. Google, me, your TA)
- Since this is a compressed summer schedule, you'll need to get started on software setup ASAP! Expect to have to do troubleshooting. The course software often runs smoothly, but if you run into problems, it's best to get them fixed early!

Lab Sessions and Office Hours

There are 2 optional lab sections per week.

I strongly encourage you to attend all or part of any lab session you can. They great for questions, collaboration, and troubleshooting

Office hours are held Thursdays after class 11:00AM – 1:00PM

Labs and Lab Due Dates

Labs are designed to:

1. Give you a chance to practice the concepts from lecture
2. Build your general and GIS problem solving skills
3. Build technical proficiency in Arc GIS software

Lab due dates are meant to keep your progress up to date and facilitate timely grading/feedback.

- Life happens. If you need more time, be in touch!
- You can find a list of assignment dates in the syllabus, or by examining the calendar feature in Moodle.
- Labs submitted after the due date will receive a 10% late penalty, unless we've made prior arrangements.

Midterm

- This exam is meant to:
  - Assess and reinforce your understanding of the lecture content.
  - Exercise your problem-solving skills.
  - Exercise and reinforce the technical skills you learned in labs 1 – 5
- The exam is open-book/open-notes, but...
- You may ask questions of your classmates; however, all questions should be posted in the publicly-accessible Midterm Forum on Moodle.
- We cannot answer technical questions on the midterm questions.

Final Projects and Posters

- You’ll get a chance to apply your GIS knowledge and problem-skills to a real-life problem!
- We have a list of potential projects and data sources.
- You may select your own, custom project.
- This is a chance to be creative
- Poster session
- More info to come!

Syllabus Highlights

Full syllabus is on GitHub

- You are responsible for knowing the contents!

Important points:

- Ask us for help
- Don’t get behind on labs
- Ask us for help

What can I expect of this course?

- What do you want to get out of it?
- How much effort will you put into it?

- Warning: you may feel overwhelmed at times, especially in the beginning. GIS isn't easy, but it is a lot of fun.

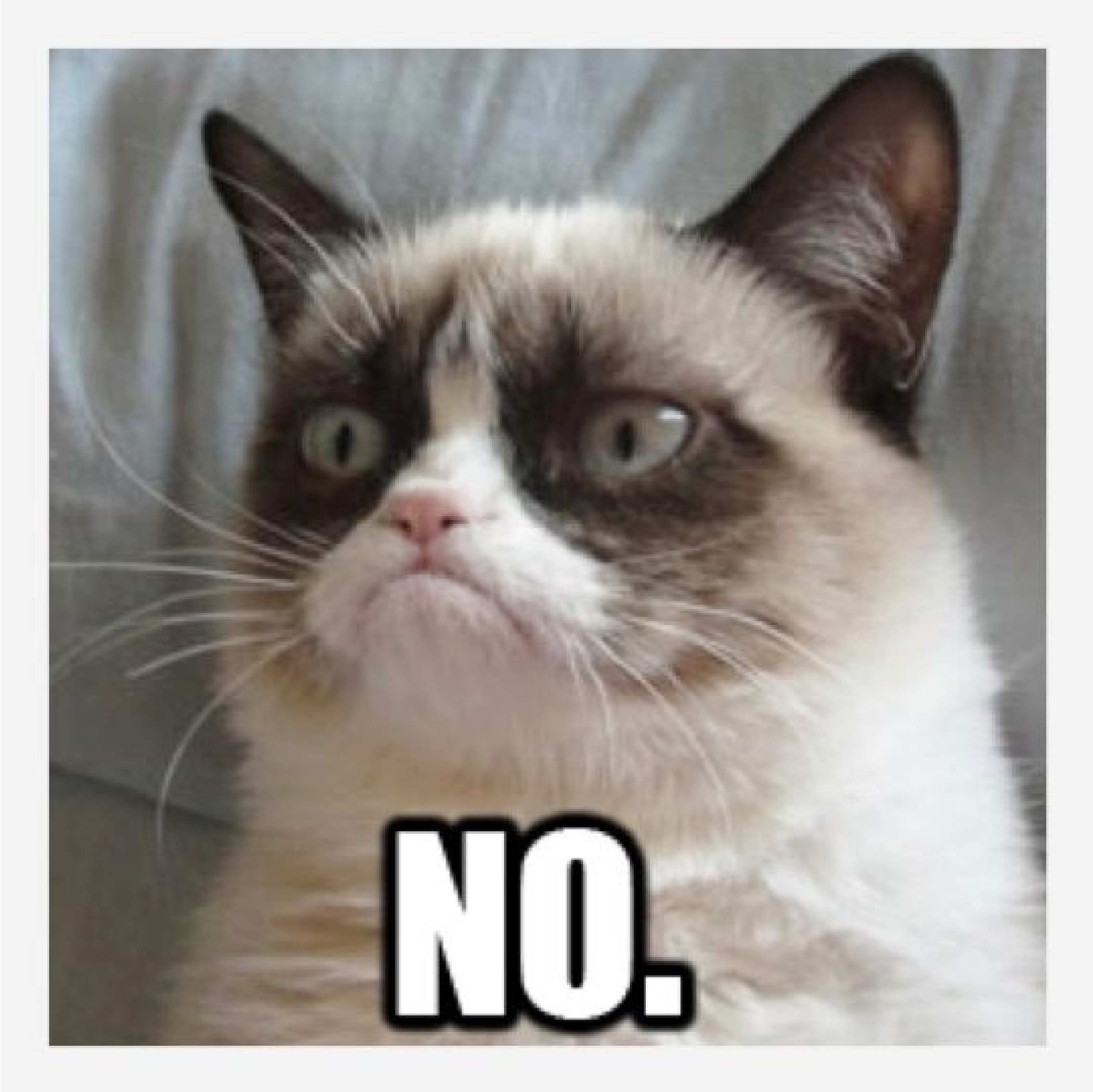
You Will be Overwhelmed

"Piled Higher and Deeper" (PhD) is the comic strip about life (or the lack thereof) in academia by Jorge Cham.

Intro GIS Myths and Misconceptions...

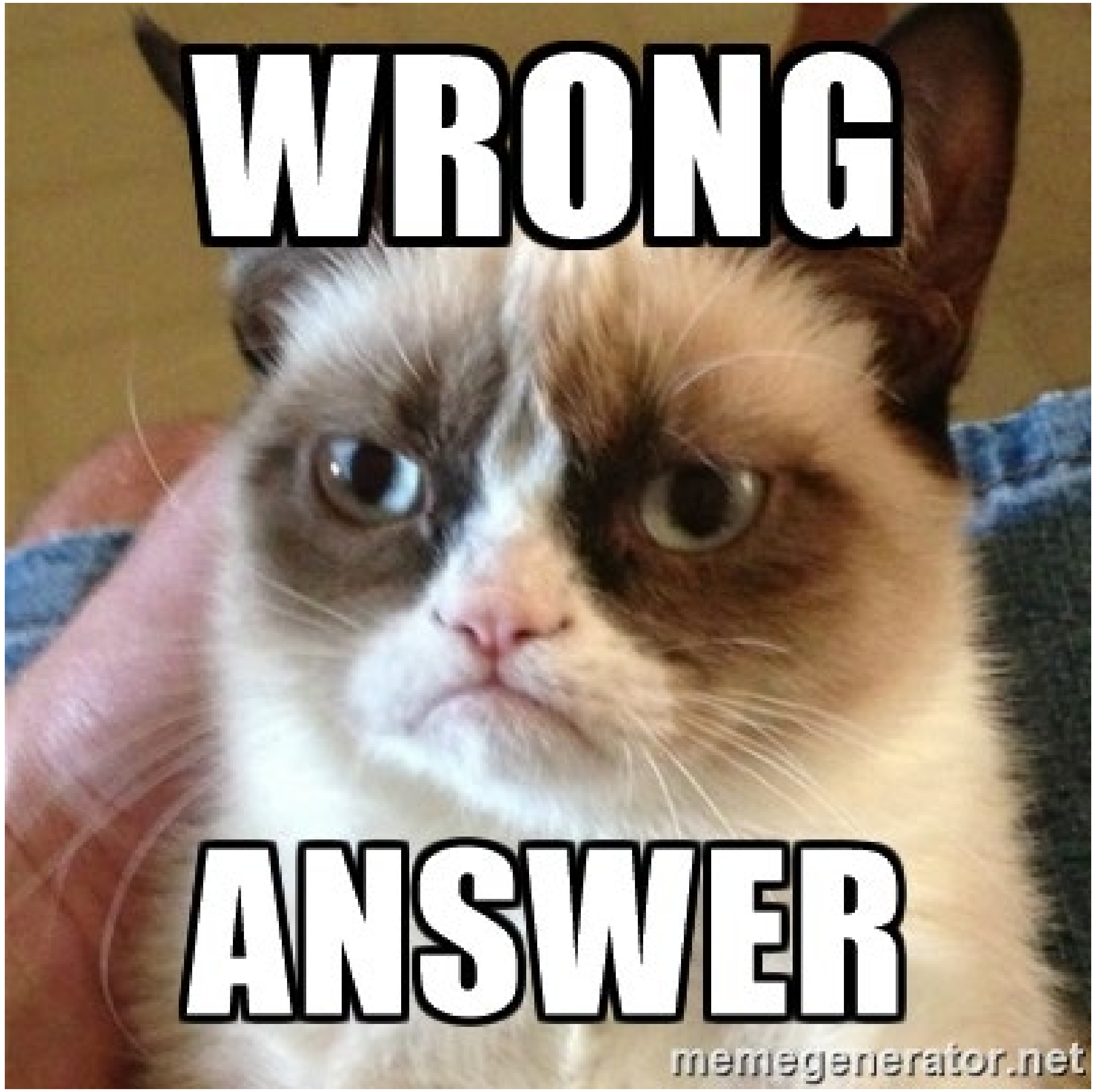
Intro to GIS Myths

MYTH: ‘This course is titled ‘**Introduction** to GIS’, it’s going to be easy!”



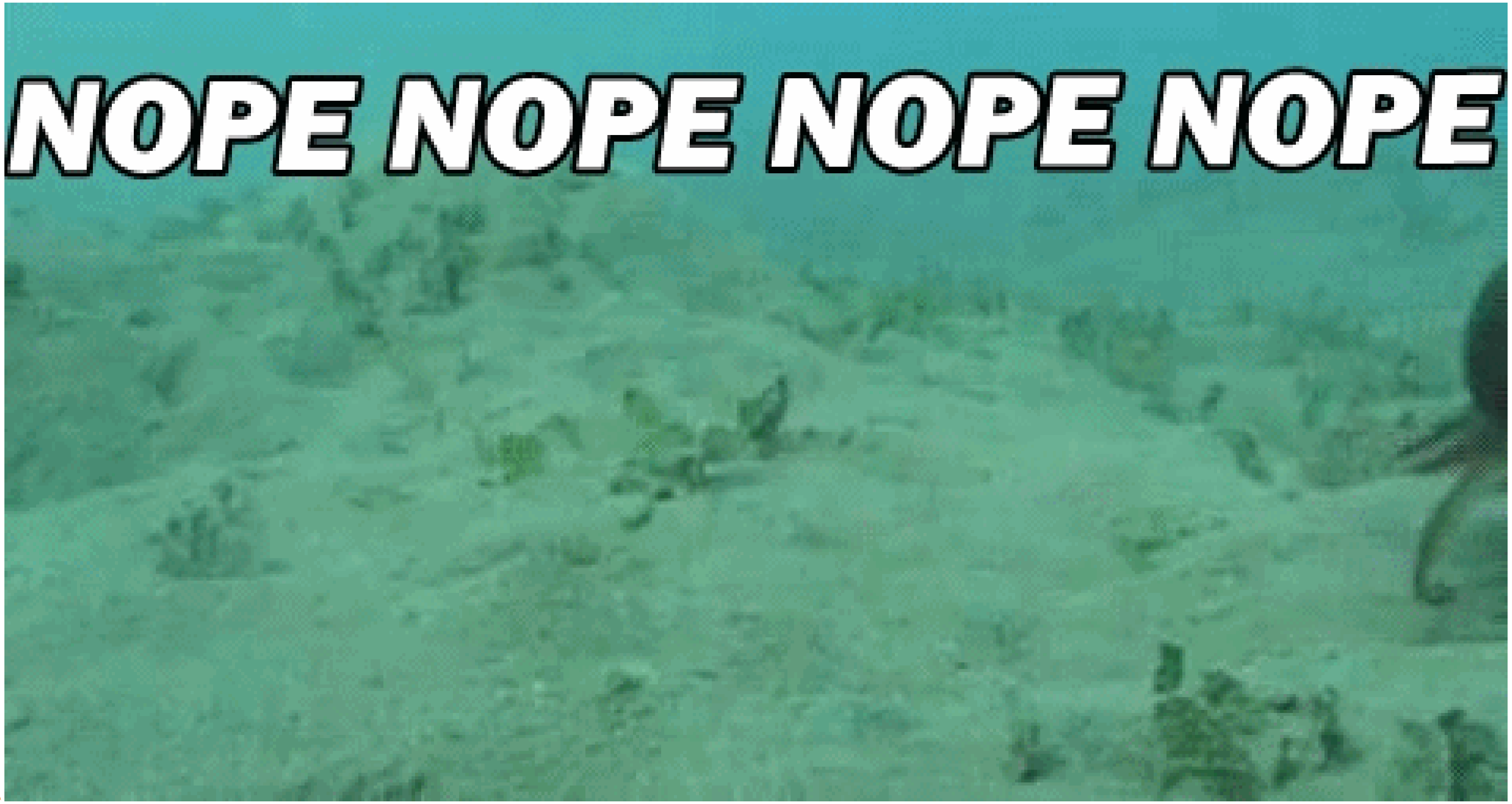
Intro to GIS Myths

MYTH: 'We have three hours in lab each week, **I'll never have to work on GIS on my own!**'



Intro to GIS Myths

MYTH: ‘This class is just about learning a software package; **I’ll always be told exactly what to do’**



Good news!

Even though this is not an easy course, it *is* a lot of fun!

Software and concepts can be challenging, but maps are awesome!

What you need to succeed (with GIS)

Be organized!

It's likely that you'll create a lot of similar file names

You will not remember anything about 'temp1' the day after you create it. Keep notes, use intuitive file names.

Keep a log of useful tools – ArcGIS naming conventions are not always intuitive

What you need to succeed (with GIS)

Be organized!

Try not to get frustrated

What you need to succeed (with GIS)

Be organized!

Try not to get frustrated

Get started early

Save your work often

Use Google in addition to ArcGIS help

Ask someone if you can't solve it yourself

What you need to succeed (with GIS)

A moderately-sophisticated understanding of how your computer sees the world.

Resourcefulness, patience, creativity, and problem-solving skills.

Computers Poll!

Moderate Level of Computer Sophisitication…

Don’t worry if you didn’t know all the terms in the Zoom poll.

We will learn more about all of them during the course.

What is (a) GIS?

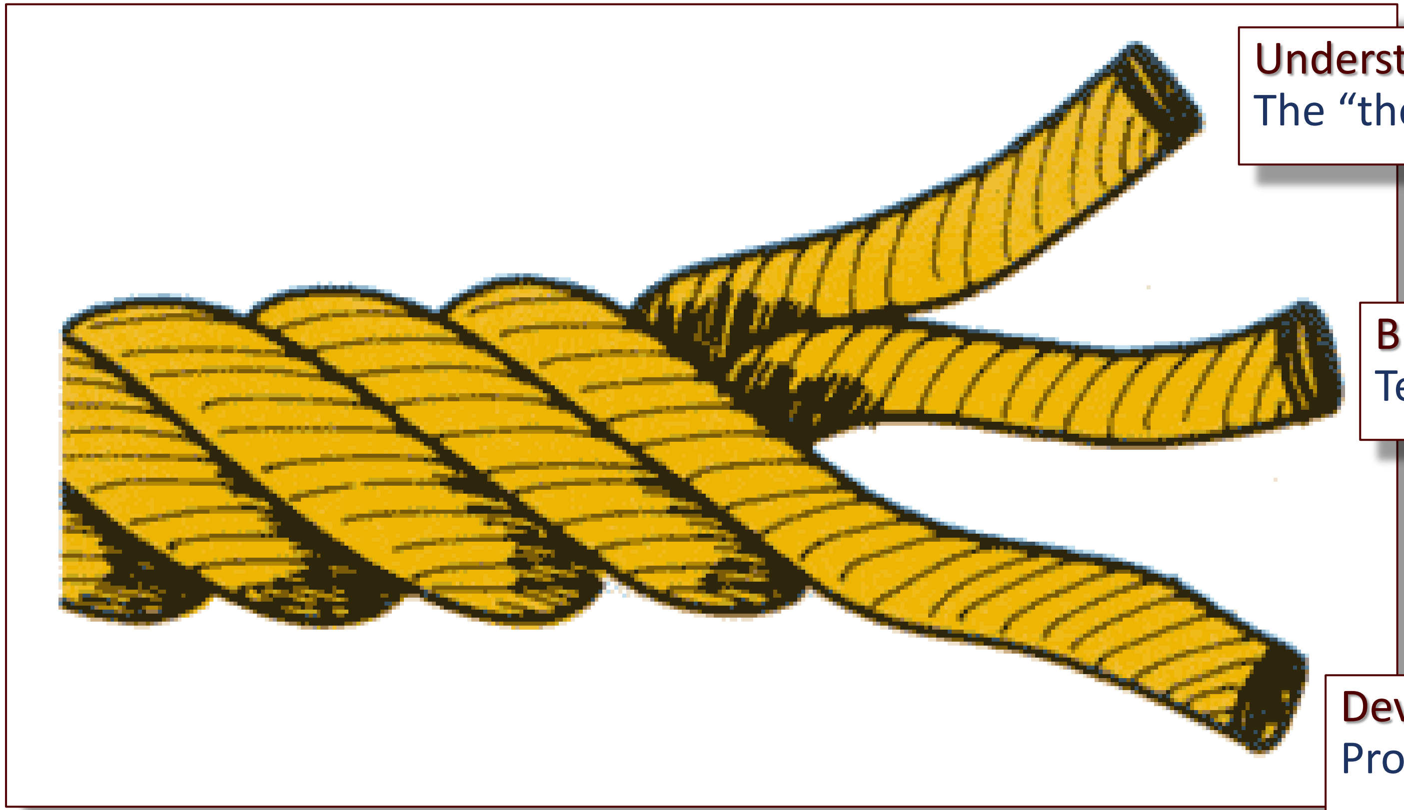
What is a GIS?

“A GIS is a computer-based system to aid in the collection, maintenance, storage, analysis, output, and distribution of spatial data”

With GIS, we can ask (and answer) the question of ‘where’, not just ‘what’

People learn GIS for lots of reasons: academics, research, professional, agency work, and others!

Three Big Themes



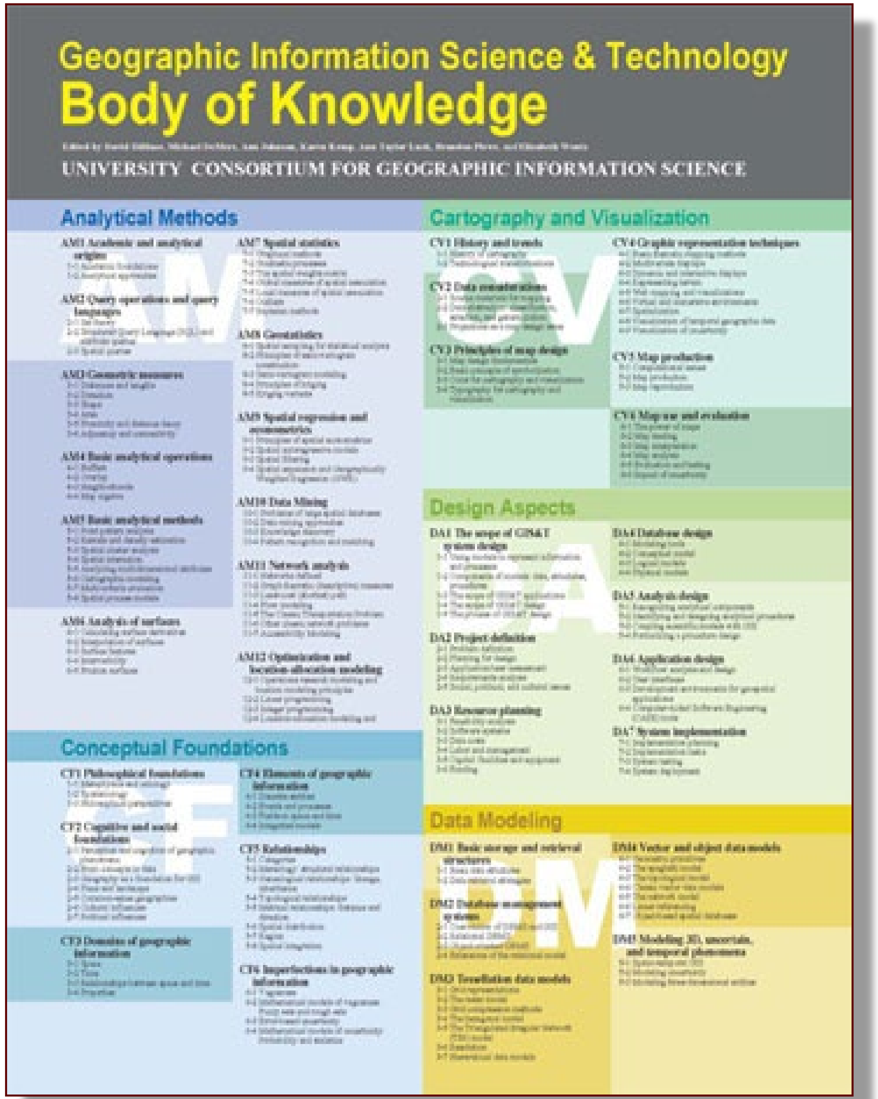
Understanding
The "theory" behind GIS

Building
Technical Competency in GIS

Developing
Professionalism

Source: https://docs.google.com/document/preview?hgd=1&id=1xARwR8xqjNiaN7hFYubwgSXjSxsasUmTxLOmFFWUk1A

Learning Objectives I

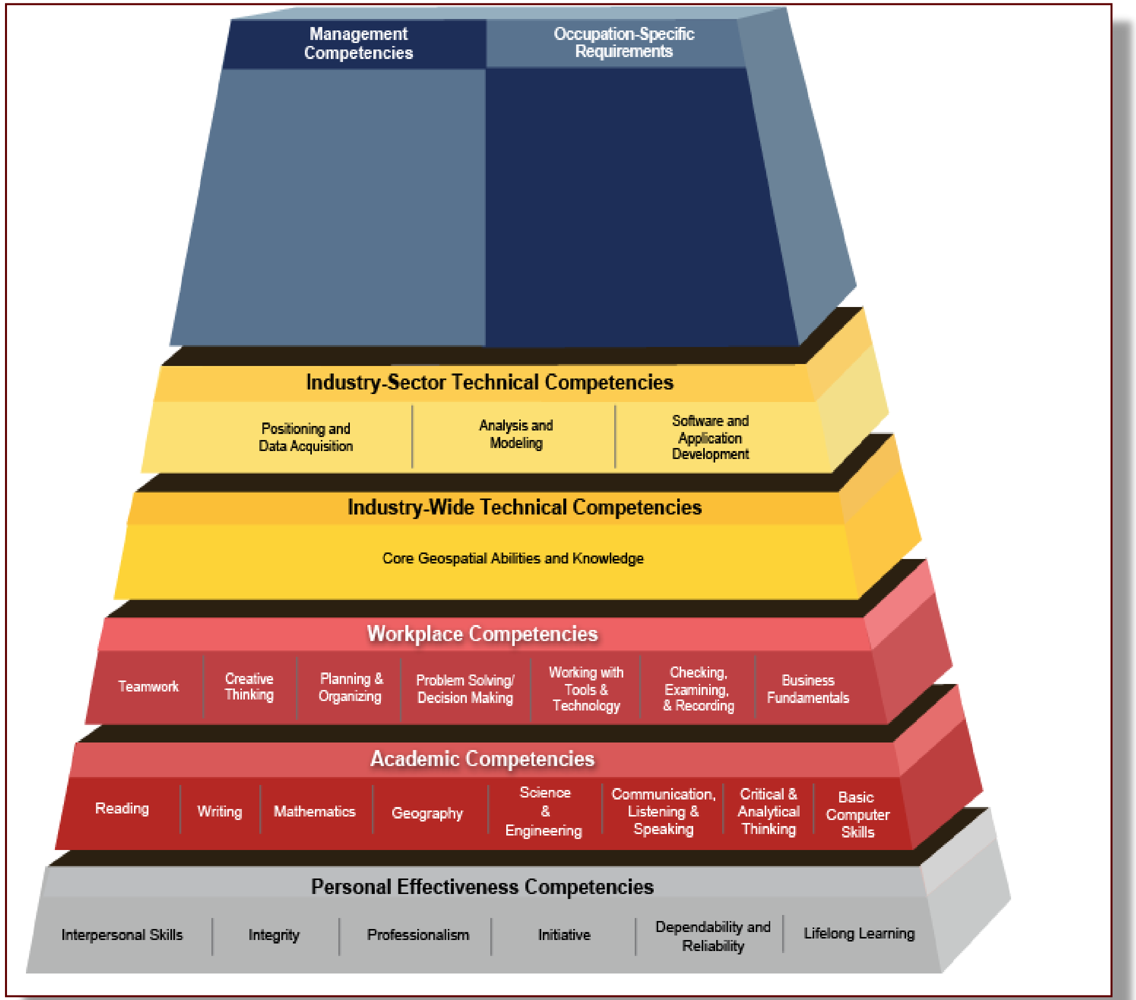


The course is aligned with the Learning Objectives set forth in the

Geographic Information Science & Technology Body of Knowledge

Which *"specifies what aspiring geospatial professionals need to know and be able to do."*

Learning Objectives II



This course will help provide you with some of the core competencies expected of a Geospatial Professional as specified in the

Geospatial Technology Competency Model (GTCM)

- We'll just scratch the surface
- I encourage you to check out the GTCM on your own

https://www.careeronestop.org/competencymodel/competency-models/geospatial-technology.aspx

What is GI Science?

It's complicated…

But we're going to learn!

- GI Science blends concepts from many other disciplines. It includes elements of:
  - information science, 'big data', and computer science
  - Geography and cartography
  - Ecology, conservation, and policy
  - Probability and statistics
  - And others

Communicating with your Peers

- For now, I will set up Moodle Forums.
- I encourage students to self-organize into groups to collaborate on labs.
- I also encourage students to communicate outside of class, or in forums that your instructor isn't part of.   It's helpful to have a space where you can express your ideas without your instructor present!
    - I'll leave it up to you to decide what format this may take.
    - Slack? Discord?

Semester Overview

Semester in Twenty Minutes (ish)

A run through of our semester ahead.

Focus on big topics and important dates.

Should feel overwhelming (it is!)

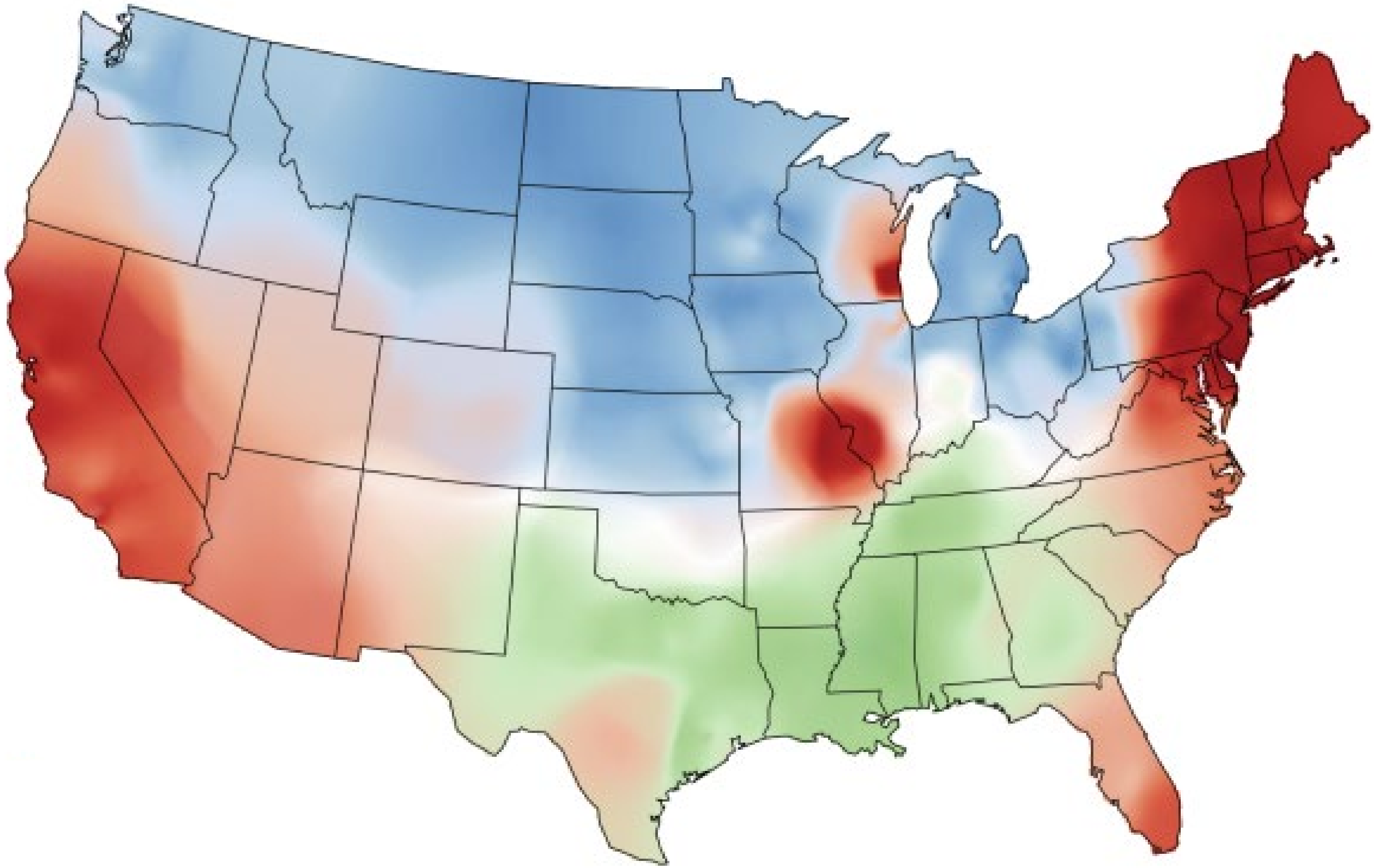
Semester in Twenty Minutes (ish)

Software

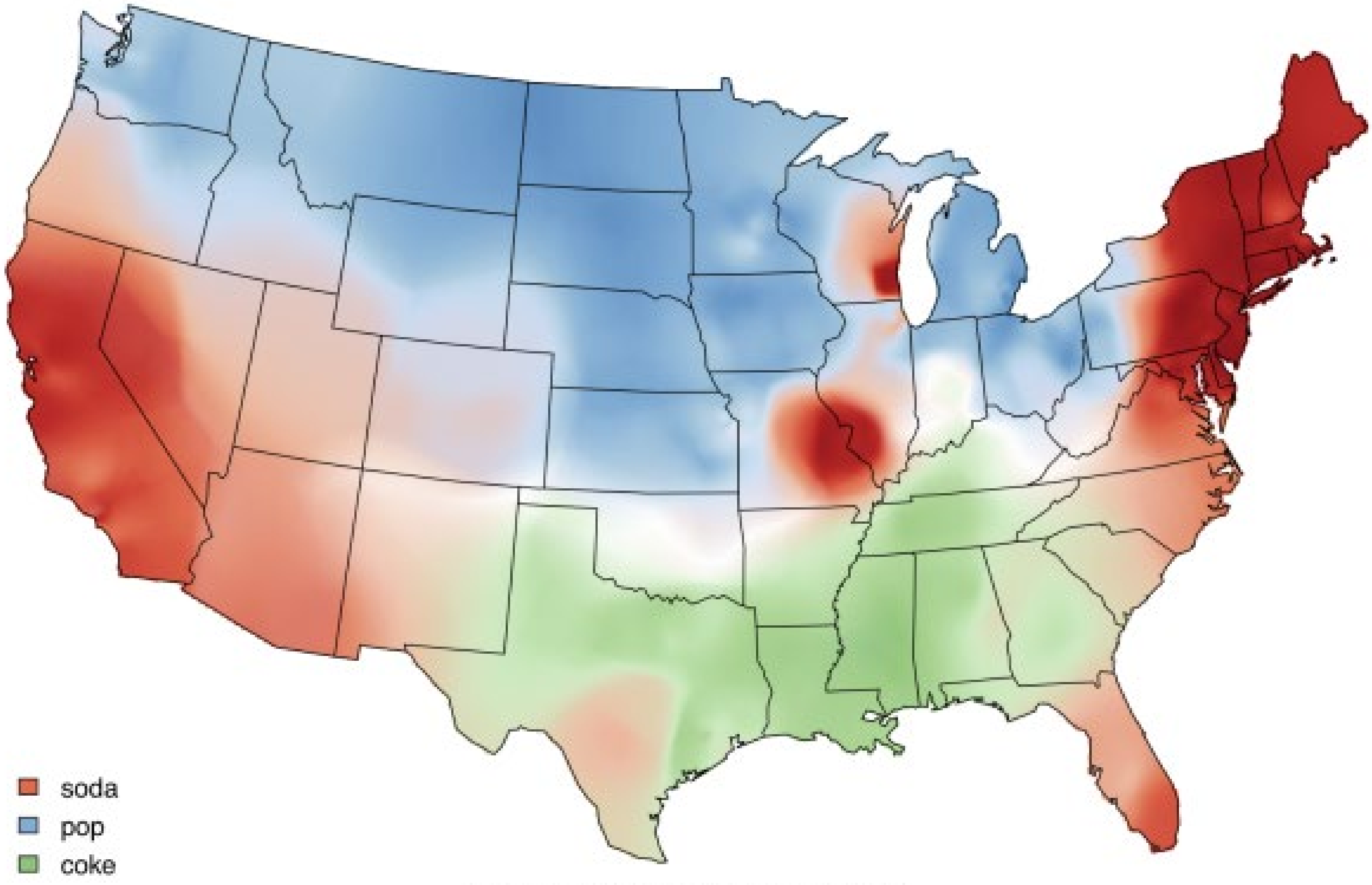
Big concepts

Labs

But first… A map puzzler!



What is your generic term for a sweetened, carbonated beverage?



Map by Joshua Katz, Department of Statistics, NC State University

Based on survey data from Bert Vaux, Department of Linguistics, University of Cambridge

GIS is not just ESRI

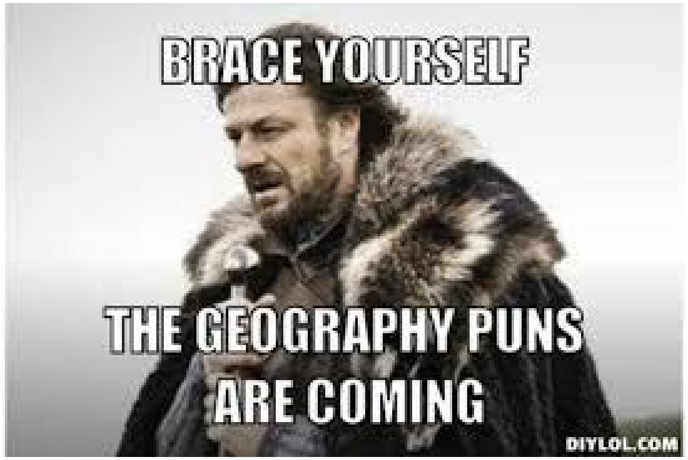
Concepts vs implementation!

GIS Software

GIS Software

- GRASS GIS
- Qgis
- R
- Python
- Lots of niche tools
- **The ESRI universe**
  - **We'll use ArcGIS Pro**

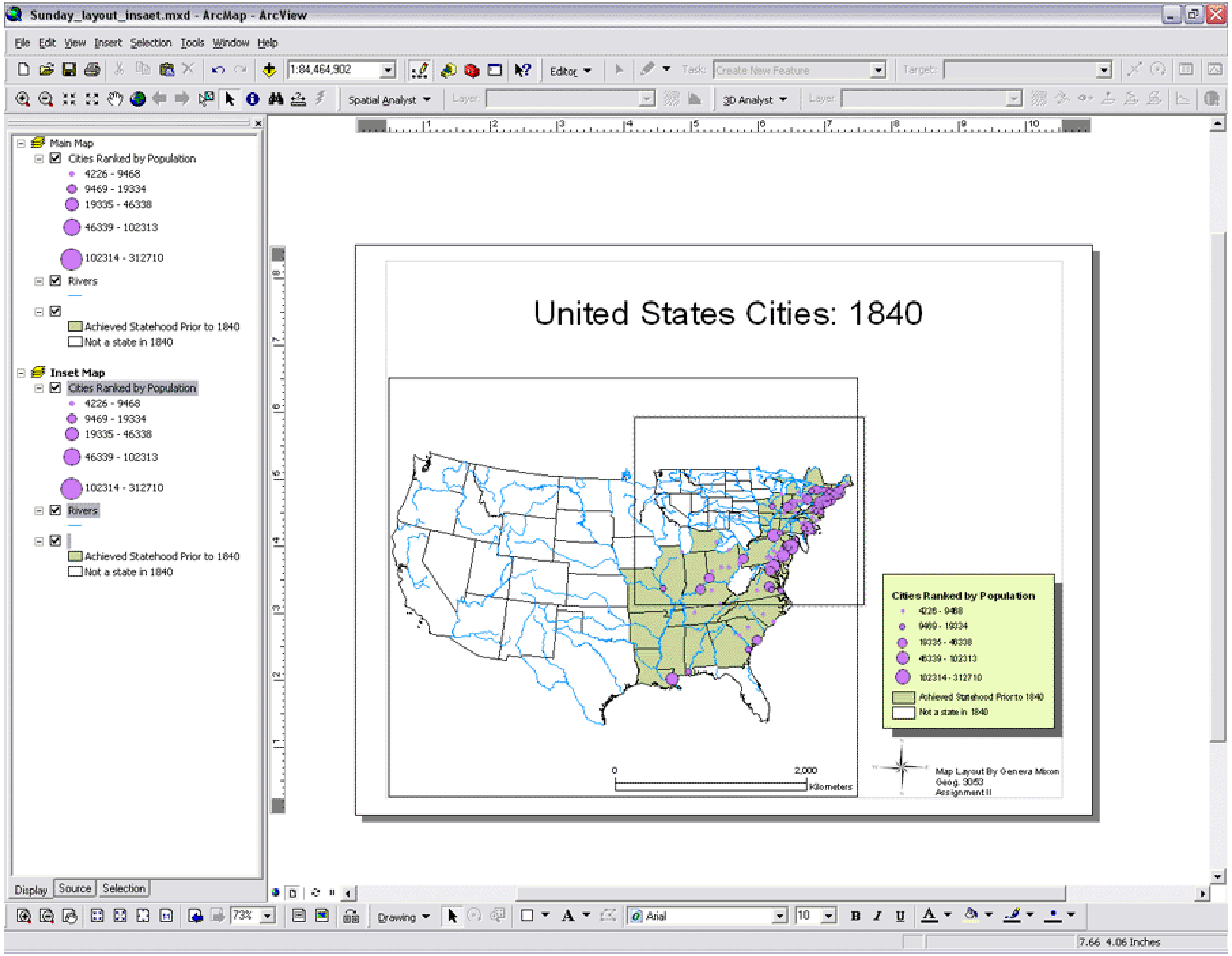
We'll be using ArcGIS Pro



Arc History

- The current iteration of the main ESRI software is called ArcGIS Pro.
- Pro is meant to replace the earlier ArcGIS Desktop. The component most people are familiar with is ArcMap.
- Lots of people still use ArcMap – You'll find lots of help online for both Desktop and Pro. Unfortunately, ArcMap help entries are usually not directly applicable to Pro.
- ESRI software runs on Windows only☹
    - Don't despair – we have workarounds for you.

ArcMap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Layer:
3D Analyst
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9469 - 19334
19335 - 46338
46339 - 102313
102314 - 312710
Rivers
Achieved Statehood Prior to 1840
Not a state in 1840
Inset Map
Cities Ranked by Population
4226 - 9468
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Rivers
Achieved Statehood Prior to 1840
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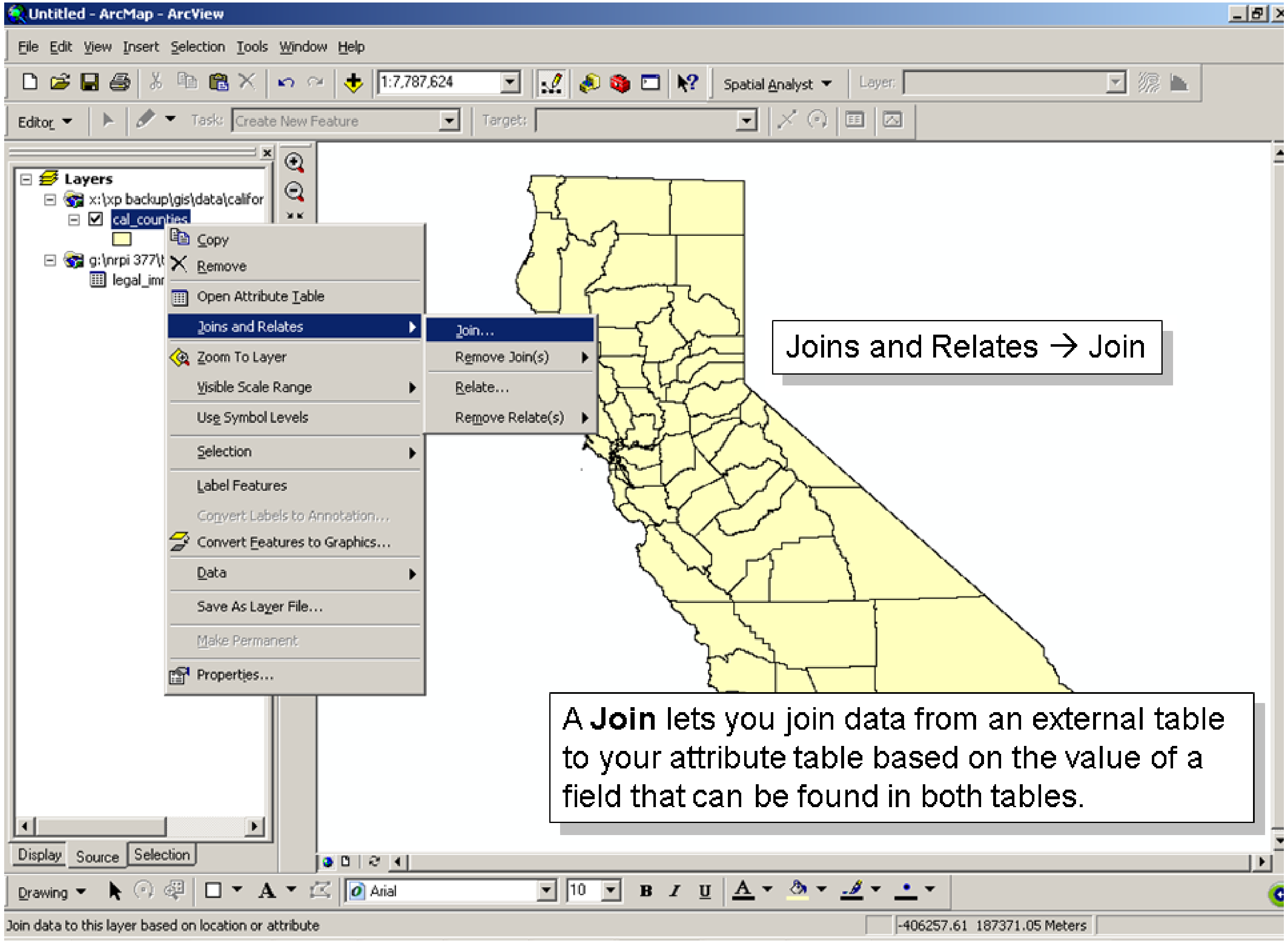
ArcMap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Visible Scale Range
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Selection
Label Features
Convert Labels to Annotation...
Convert Features to Graphics...
Data
Save As Layer File...
Make Permanent
Properties...
Join...
Remove Join(s)
Relate...
Remove Relate(s)
Joins and Relates → Join
A Join lets you join data from an external table to your attribute table based on the value of a field that can be found in both tables.
Display Source Selection
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Join data to this layer based on location or attribute
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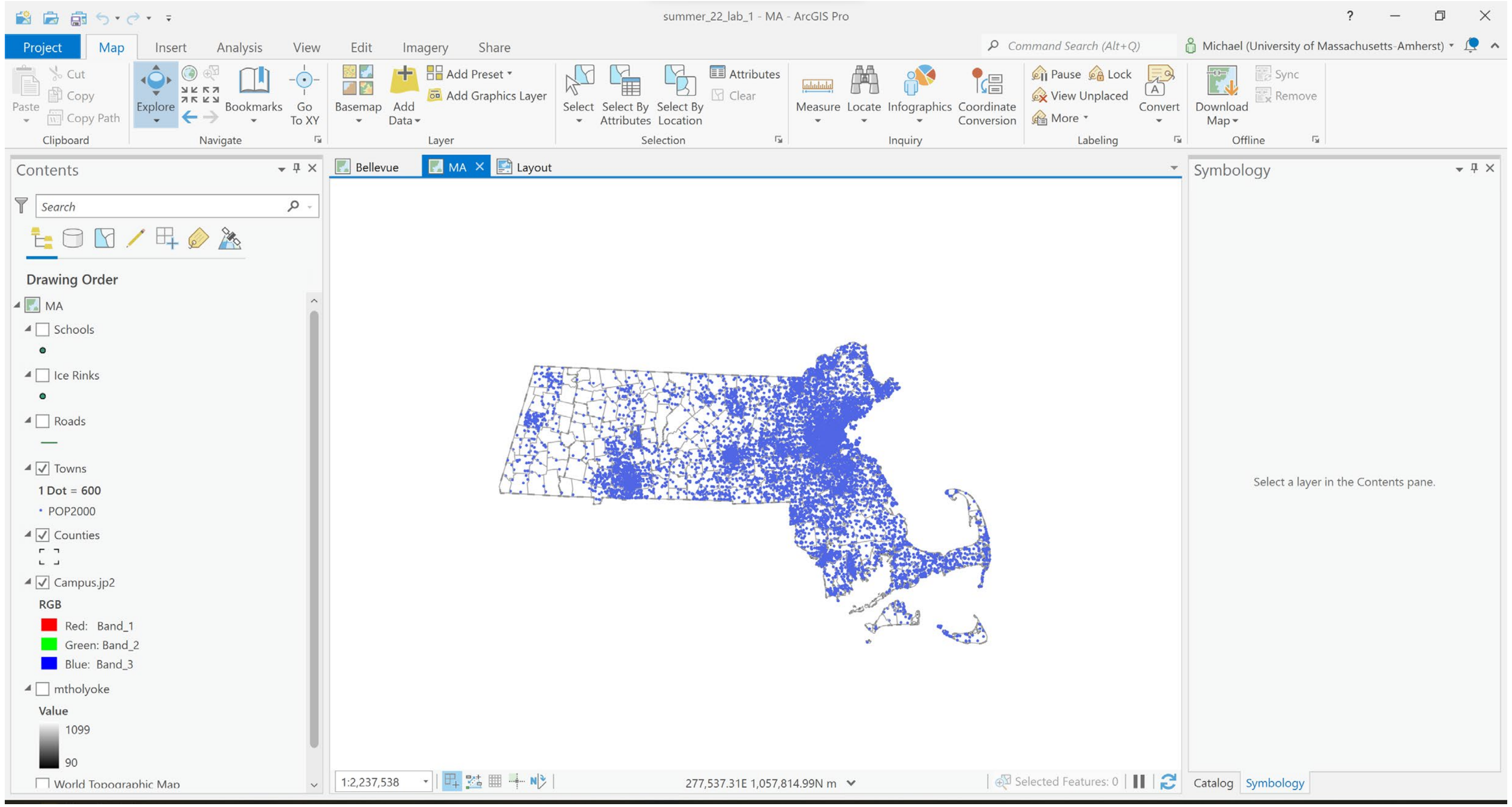
Arc Pro



summer_22_lab_1 - MA - ArcGIS Pro
Project
Map
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Michael (University of Massachusetts Amherst)
Paste
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Copy
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Clipboard
Explore
Bookmarks
Go To XY
Navigate
Basemap
Add Data
Add Preset
Add Graphics Layer
Layer
Select
Select By Attributes
Select By Location
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Clear
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Symbology

Big Concepts in GIS

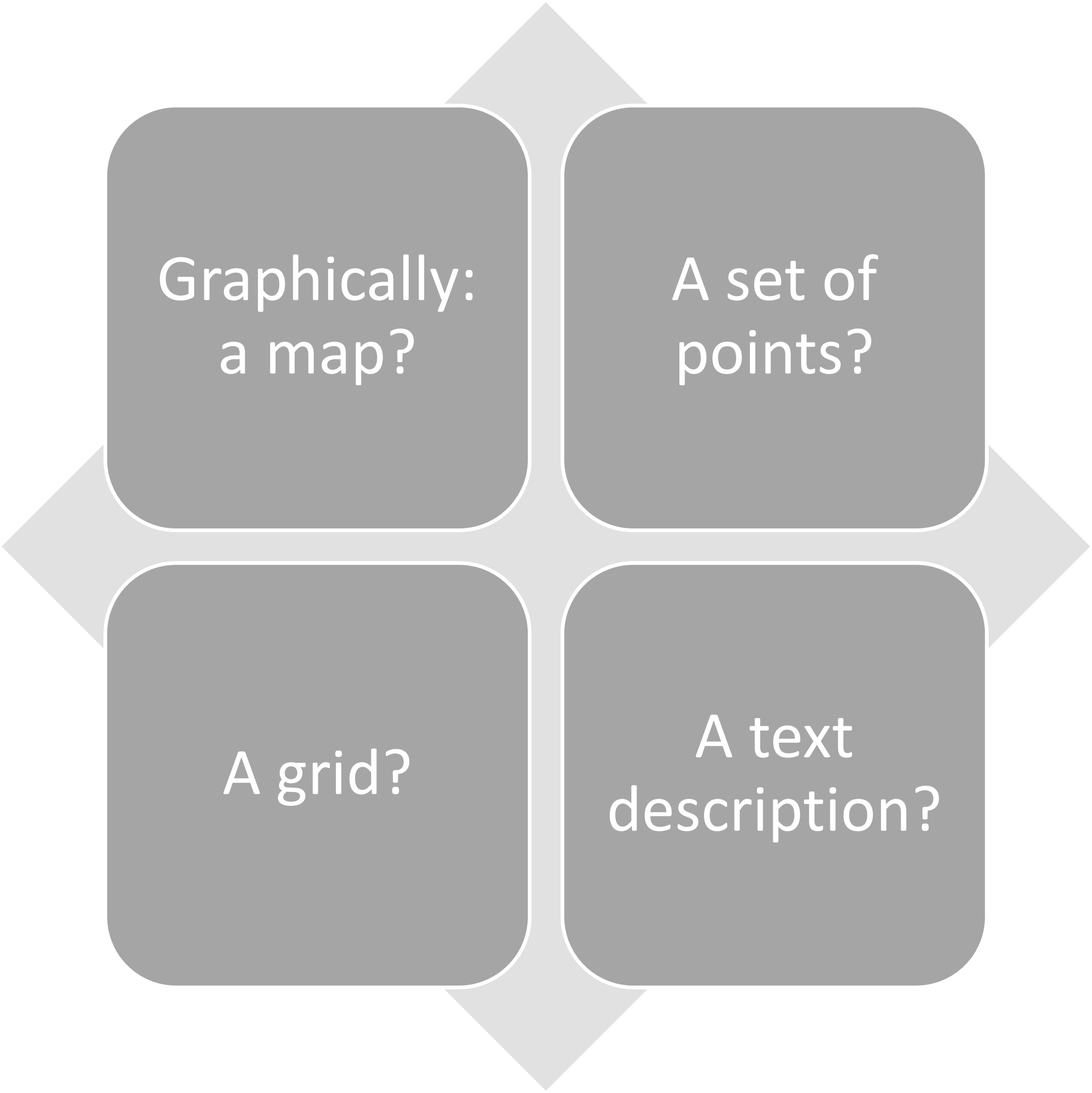
Spatial Data Representation

What’s the best way to represent space?

- Graphically: a map?
- A set of points?
- A grid?
- A text description?

It's time for a poll: Spatial Data!

Each of these are valid models of spatial phenomena!

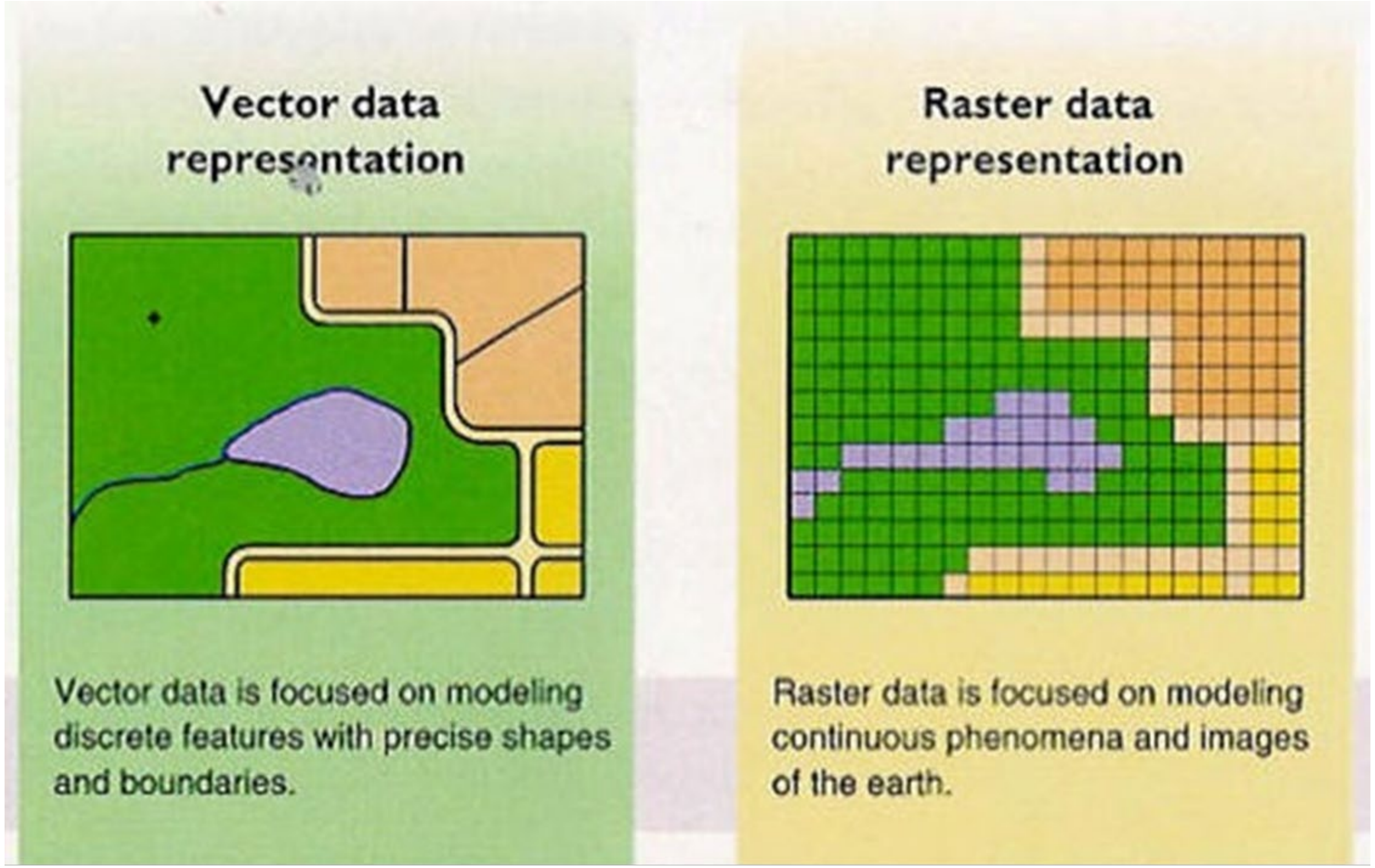


How we represent spatial data depends on:

The nature of the spatial entity: is it a mountain? A tree? A river?

Our focus: do we care about shapes? Relative positions? Distances?

We'll learn all about vector and raster data models!



http://map.sdsu.edu/geog104/lecture/unit-2.htm

Big Concepts in GIS

Map Projections

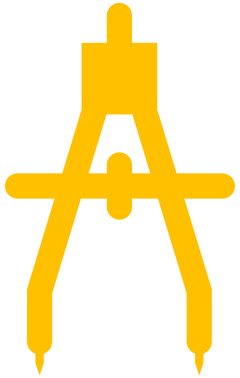
Maps are flat, but the Earth is not!

What's the best way to represent a curved and lumpy shape on a 2-dimensional surface?

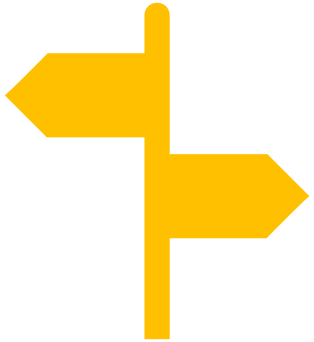
Projections and Coordinate Systems

- Oh, projections….
- Which is bigger, USA or Brasil?
- Let’s check out some areas.

What is a projection?

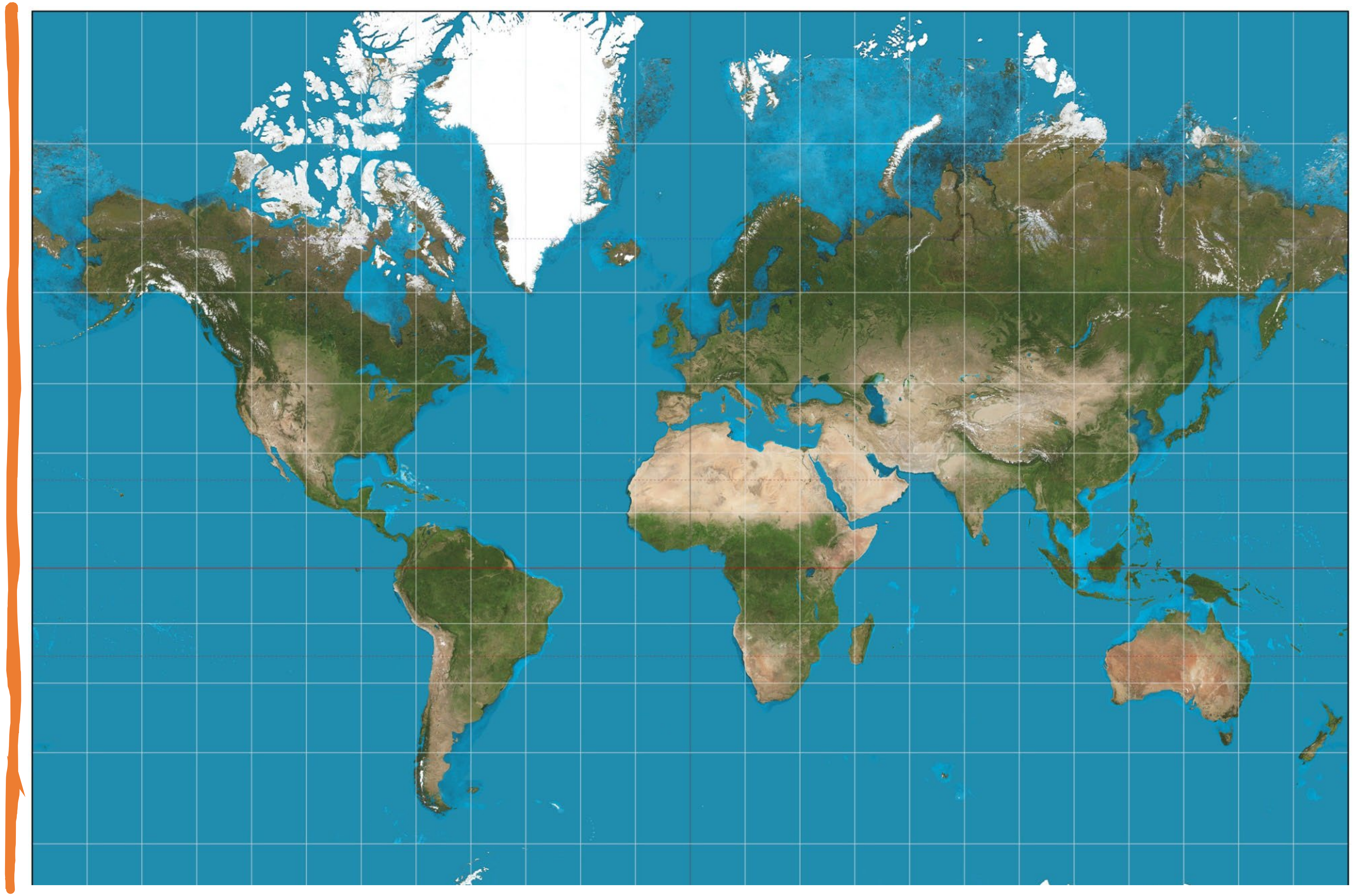


A projection is a mathematical transformation from a curved surface to a flat one.

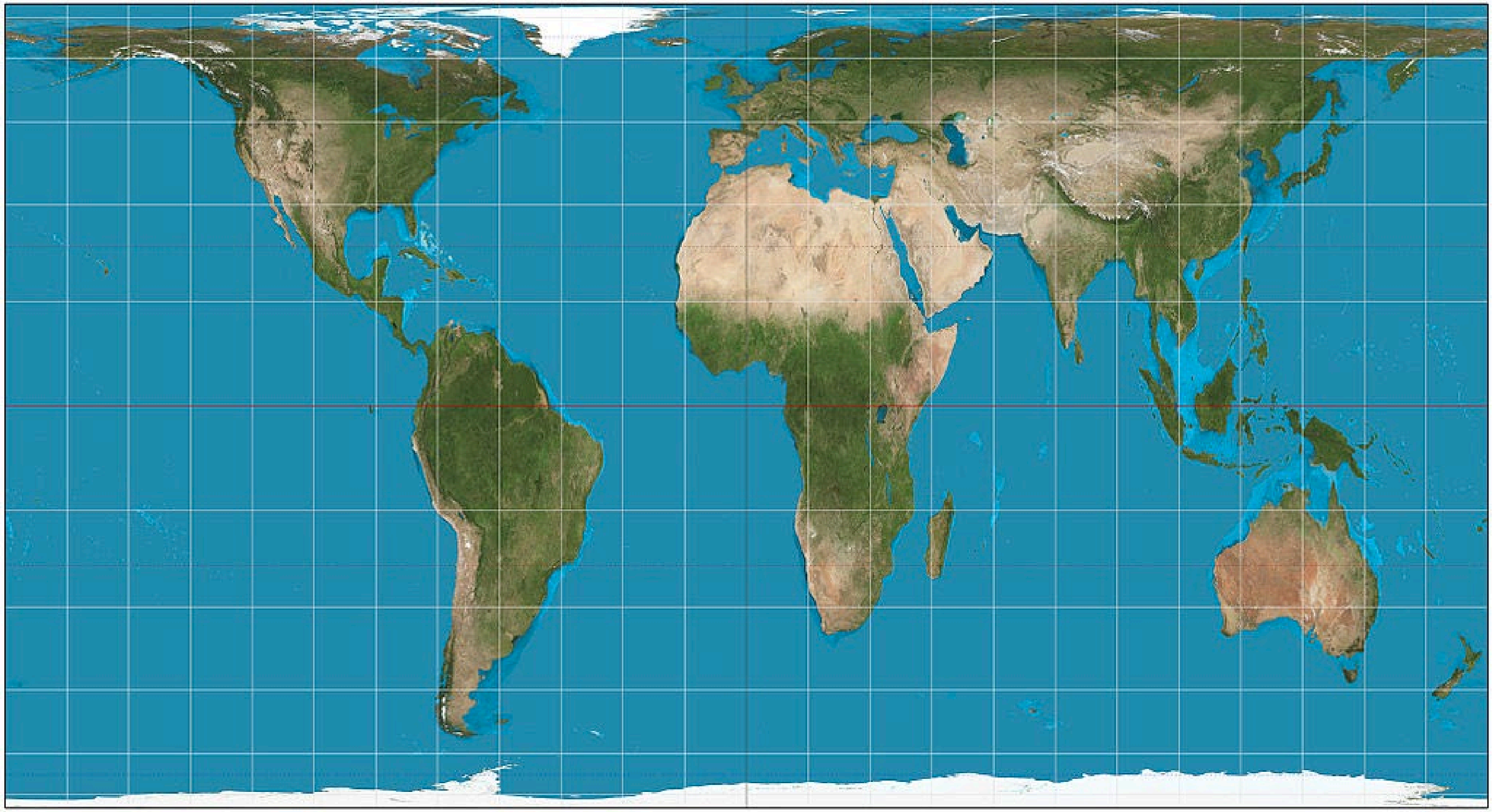


Projections are all about compromise.

World with Mercator Projection

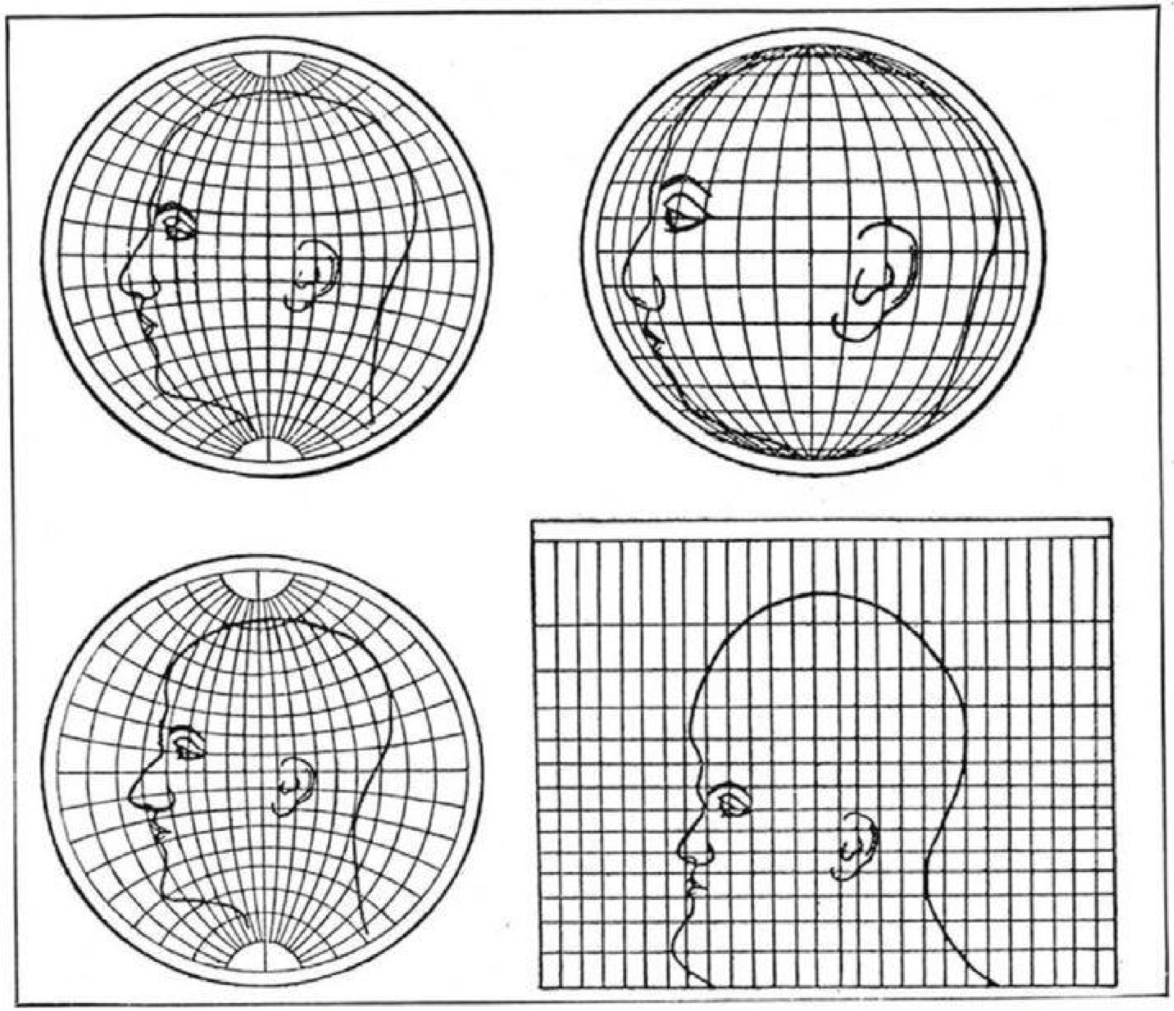


Equal Area Projection – Is this better?



Projections make us think about representation

Projecting always introduces distortion.



Upper left: Globular. *Upper right:* Orthographic. *Lower left:* Stereographic. *Lower right:* Mercator

What four commonly used projections do, as shown on a human head

What is the shape of the Earth?

Hint: It's not a sphere!

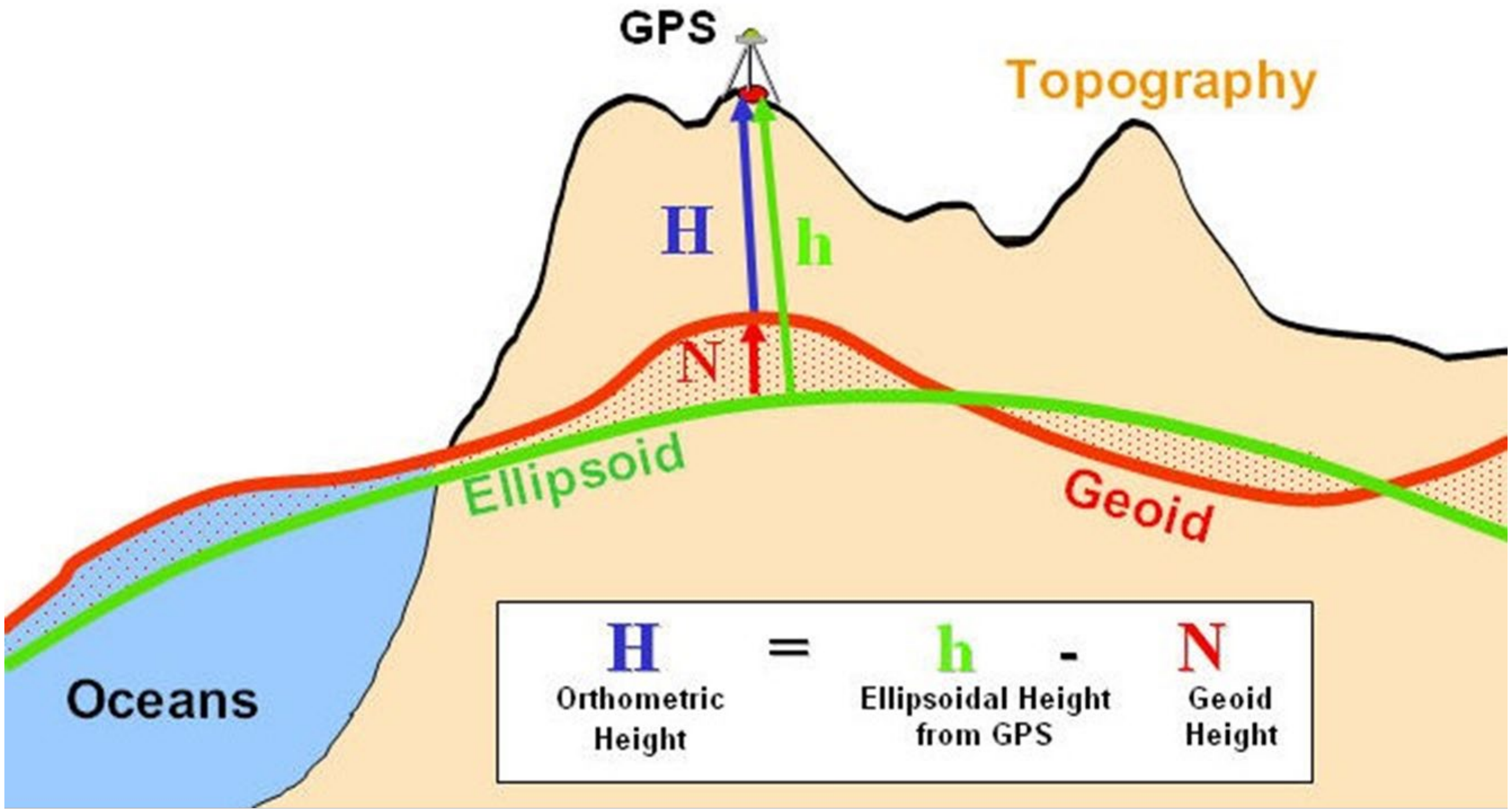


Image via University of Oklahoma at http://principles.ou.edu/earth_figure_gravity/geoid/

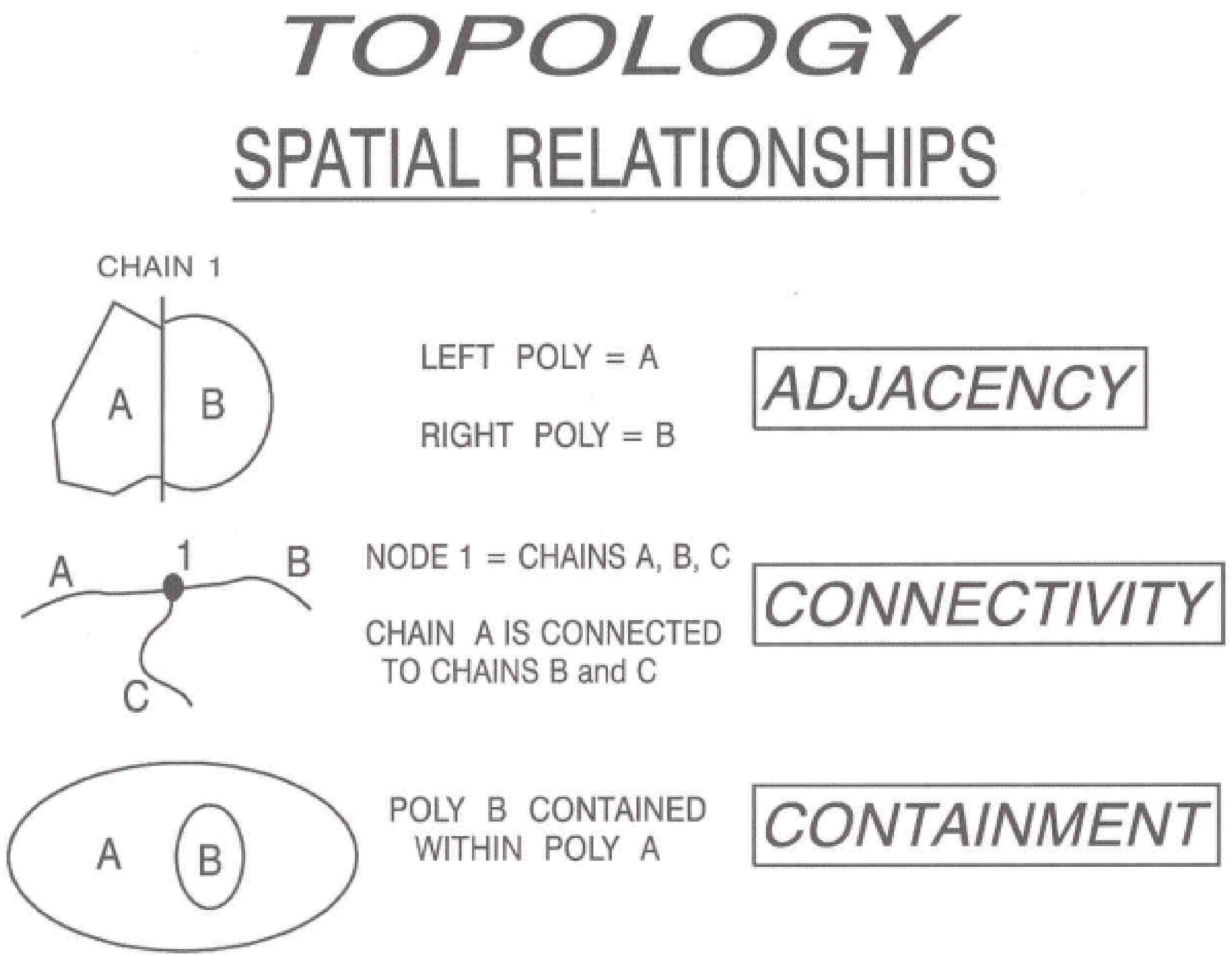
What is the right projection?

We'll save that question for later…

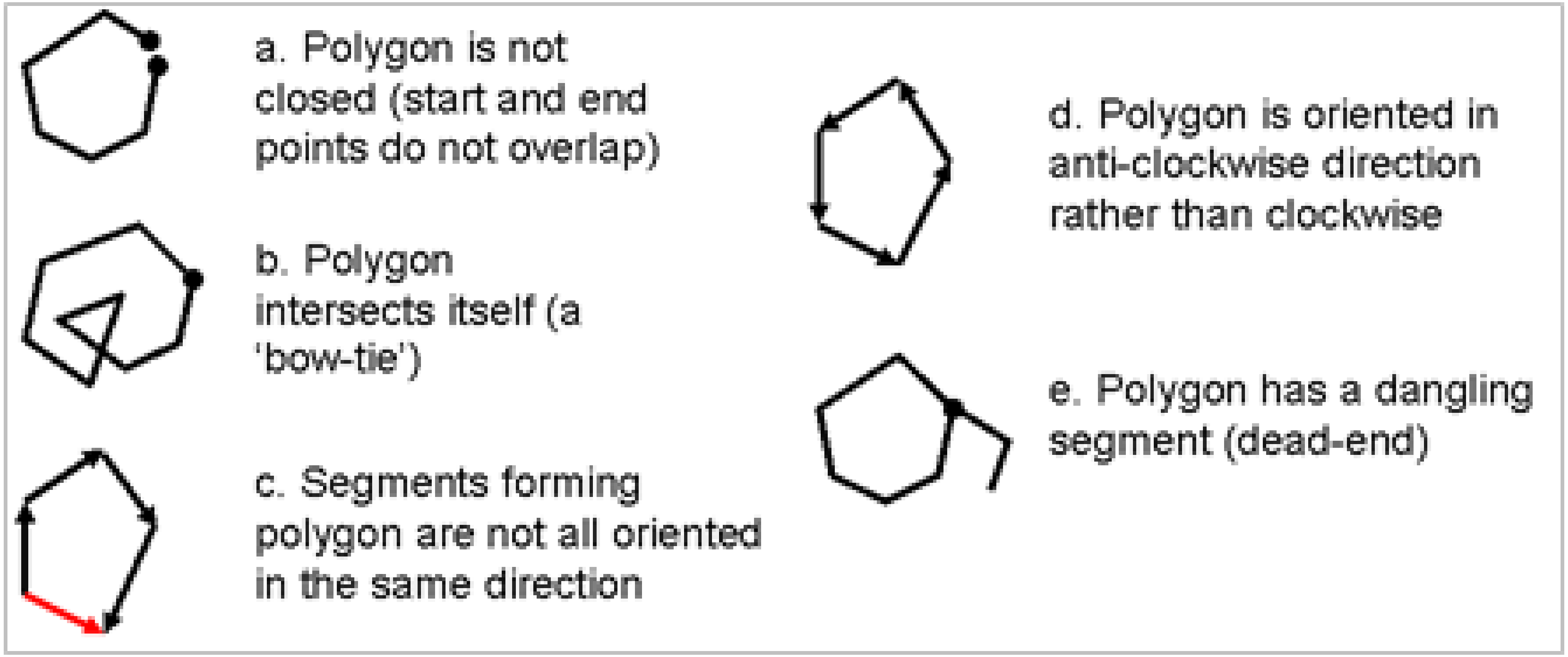
Big Concepts in GIS

Spatial Relationships and Operations

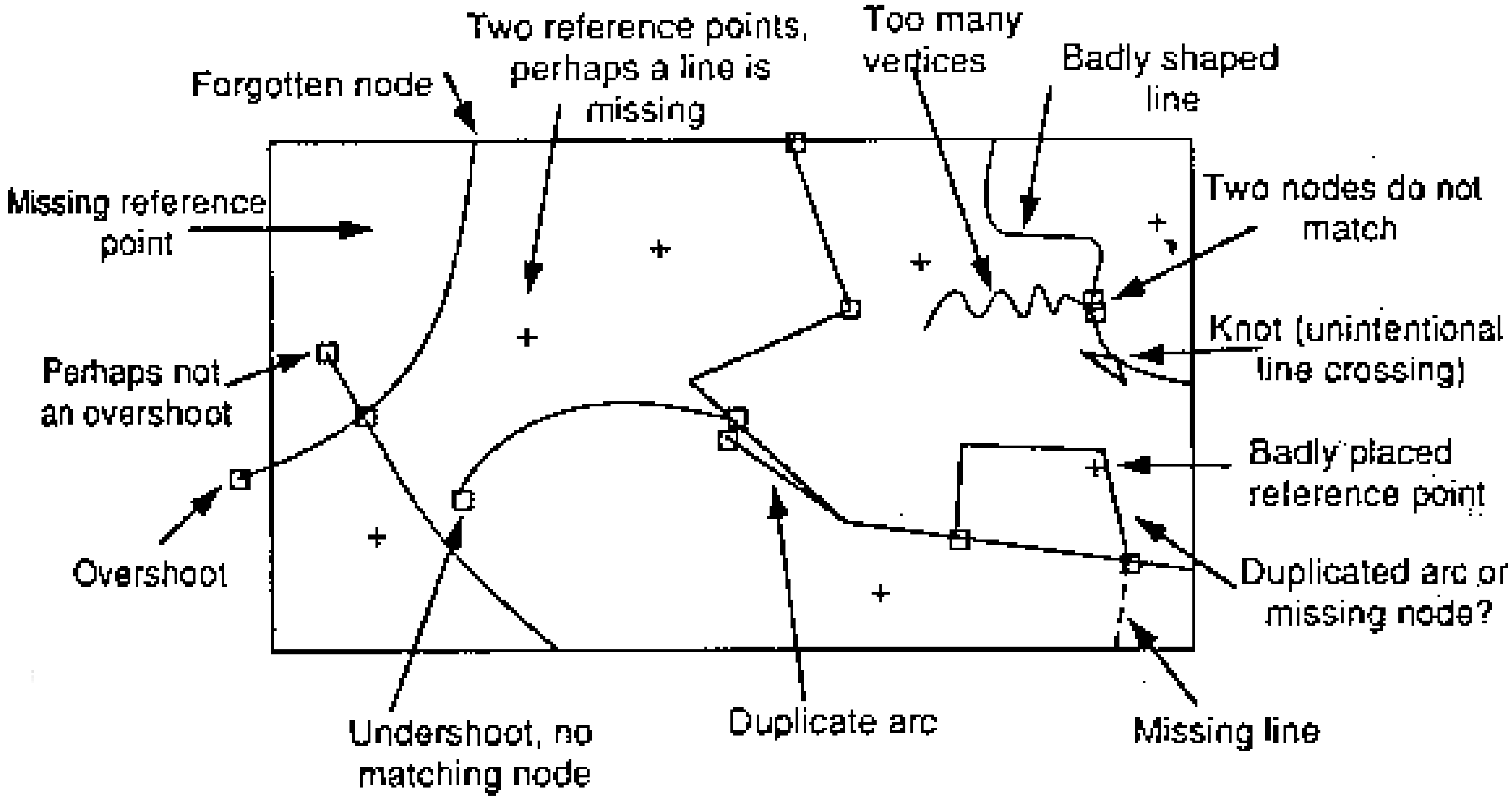
Arrangement of spatial features



Polygon Construction and Editing



Spatial Data Troubleshooting



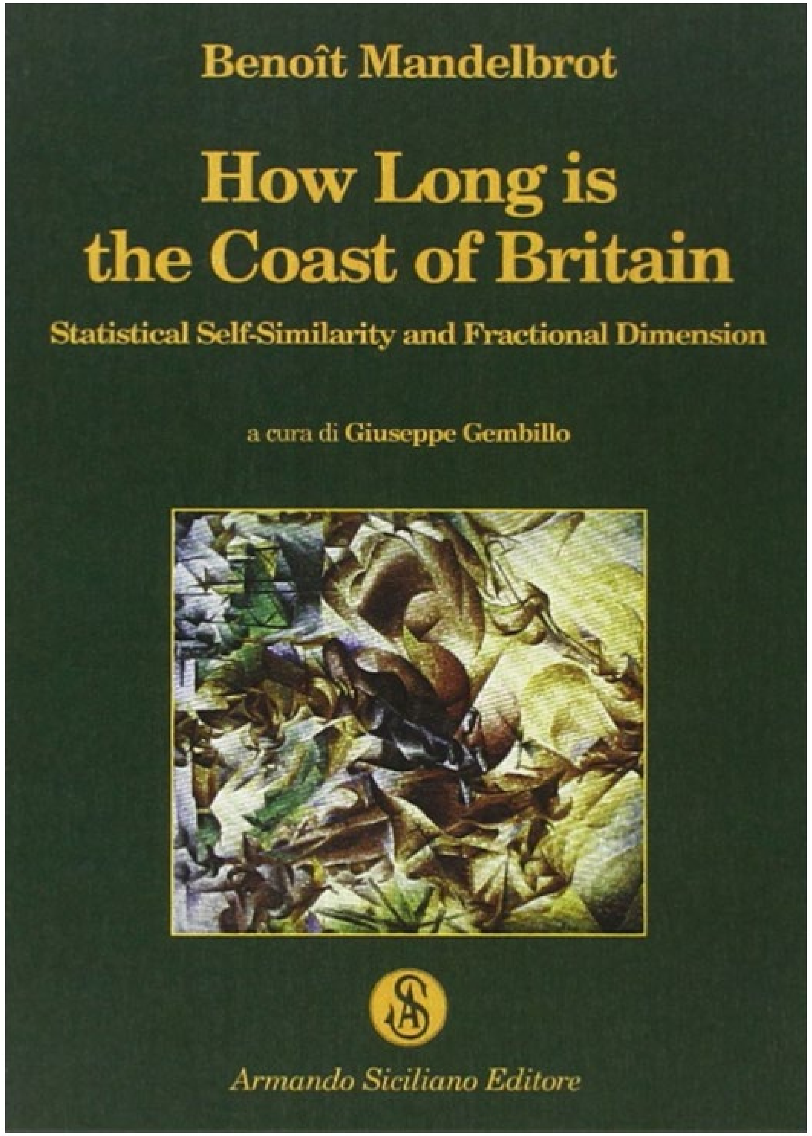
Logical Operations

TABLE 1-1 Basic Identities of Boolean Algebra

(1) $x + 0 = x$	(2) $x \cdot 0 = 0$
(3) $x + 1 = 1$	(4) $x \cdot 1 = x$
(5) $x + x = x$	(6) $x \cdot x = x$
(7) $x + x' = 1$	(8) $x \cdot x' = 0$
(9) $x + y = y + x$	(10) $xy = yx$
(11) $x + (y + z) = (x + y) + z$	(12) $x(yz) = (xy)z$
(13) $x(y + z) = xy + xz$	(14) $x + yx = (x + y)(x + z)$
(15) $(x + y)' = x'y'$	(16) $(xy)' = x' + y'$
(17) $(x')' = x$	

http://www.cs.science.cmu.ac.th/person/chumphol/204231/Basic%20Identities%20of%20Boolean%20Algebra.jpg

How do you measure the distance of a complicated curve?



Big Concepts in GIS

Probability and Statistics, Modeling, and Computational Thinking

Spatial Autocorrelation

An application of a statistical concept (correlation coefficient) to spatial phenomena

http://pro.arcgis.com/en/pro-app/tool-reference/spatial-statistics/h-how-spatial-autocorrelation-moran-s-i-spatial-st.htm

The Moran's I statistic for spatial autocorrelation is given as:

$$I = \frac{n}{S_0} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j} z_i z_j}{\sum_{i=1}^{n} z_i^2} \quad (1)$$

where z_i is the deviation of an attribute for feature i from its mean $(x_i - \bar{X})$, $w_{i,j}$ is the spatial weight between feature i and j, n is equal to the total number of features, and S_0 is the aggregate of all the spatial weights:

$$S_0 = \sum_{i=1}^{n} \sum_{j=1}^{n} w_{i,j} \quad (2)$$

The z_I-score for the statistic is computed as:

$$z_I = \frac{I - \mathrm{E}[I]}{\sqrt{\mathrm{V}[I]}} \quad (3)$$

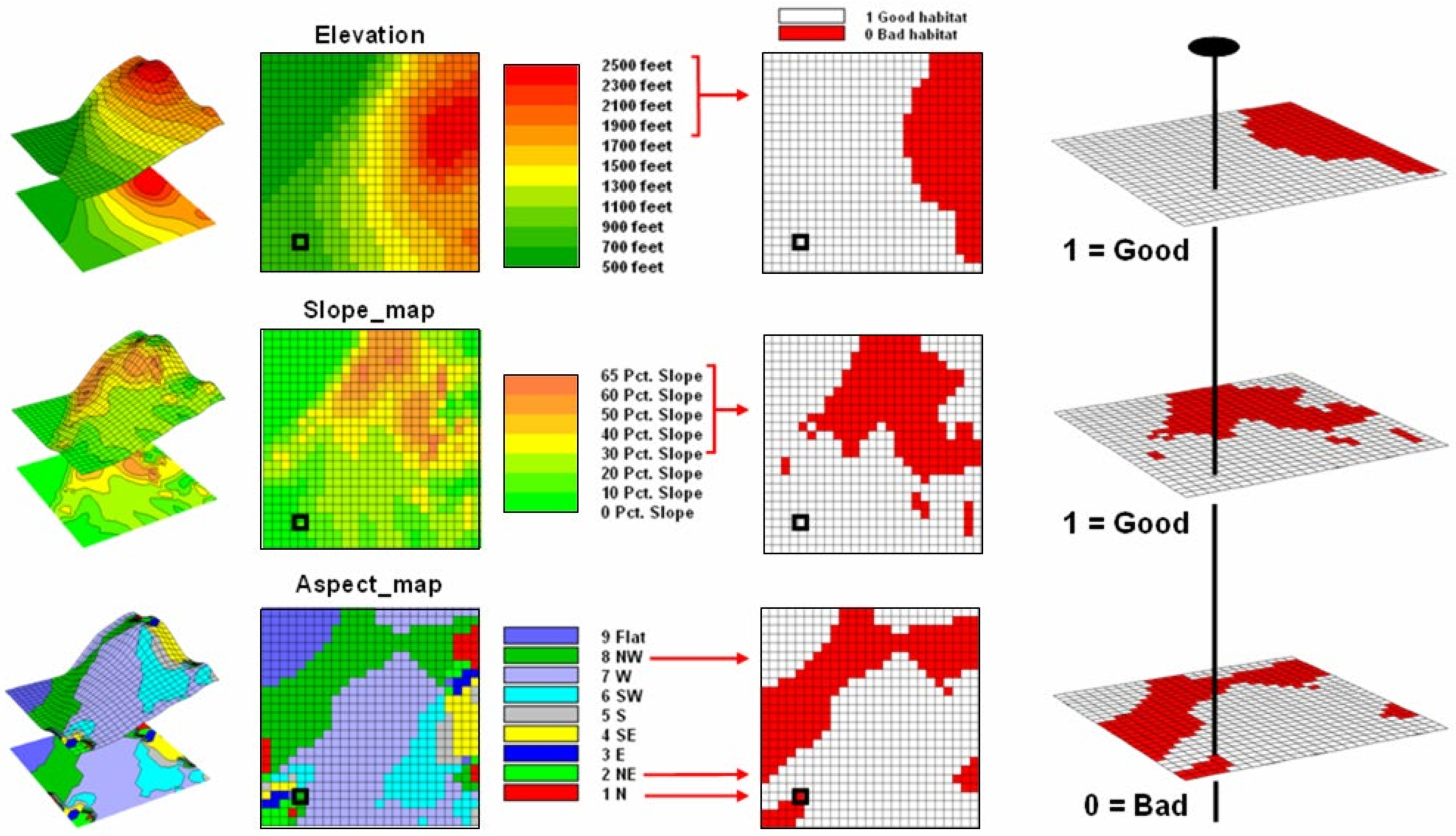
where:

$$\mathrm{E}[I] = -1/(n-1) \quad (4)$$

$$\mathrm{V}[I] = \mathrm{E}[I^2] - \mathrm{E}[I]^2 \quad (5)$$

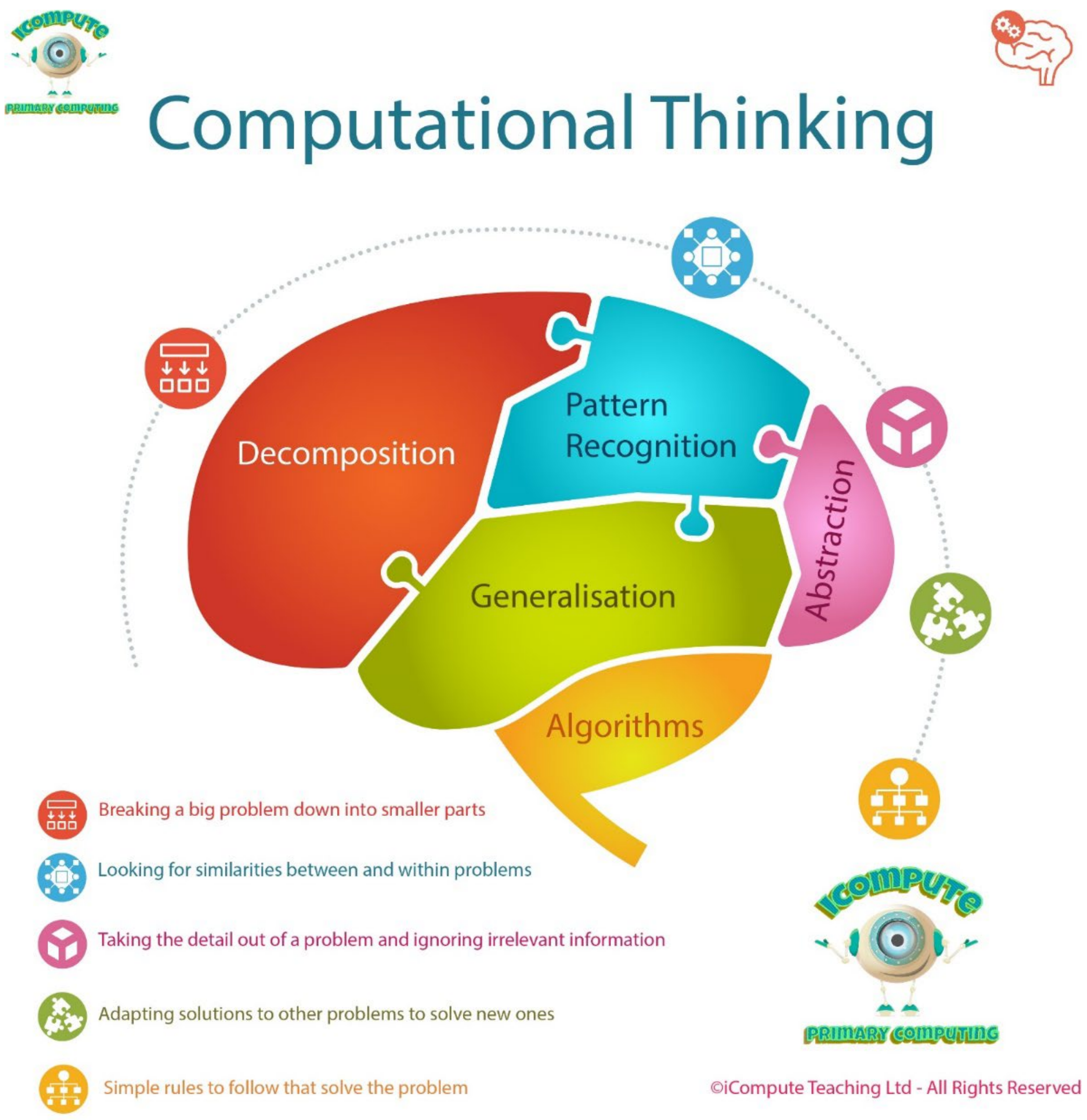
How do we model terrain?

What can we use our model for?

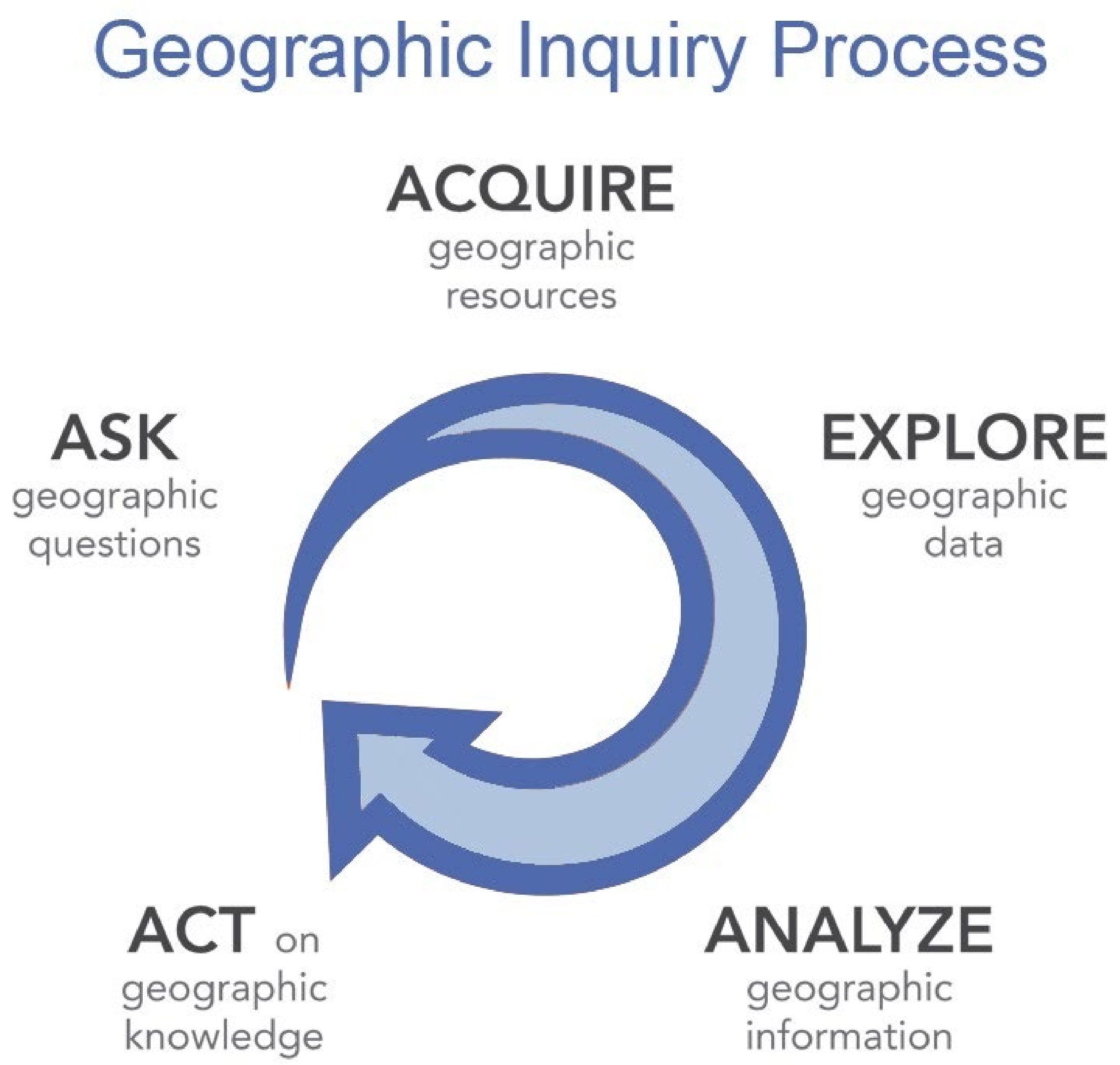


Via: http://www.innovativegis.com/basis/Papers/Other/ASPRSchapter/

Computational Thinking is Model Thinking



A GIS modeling process



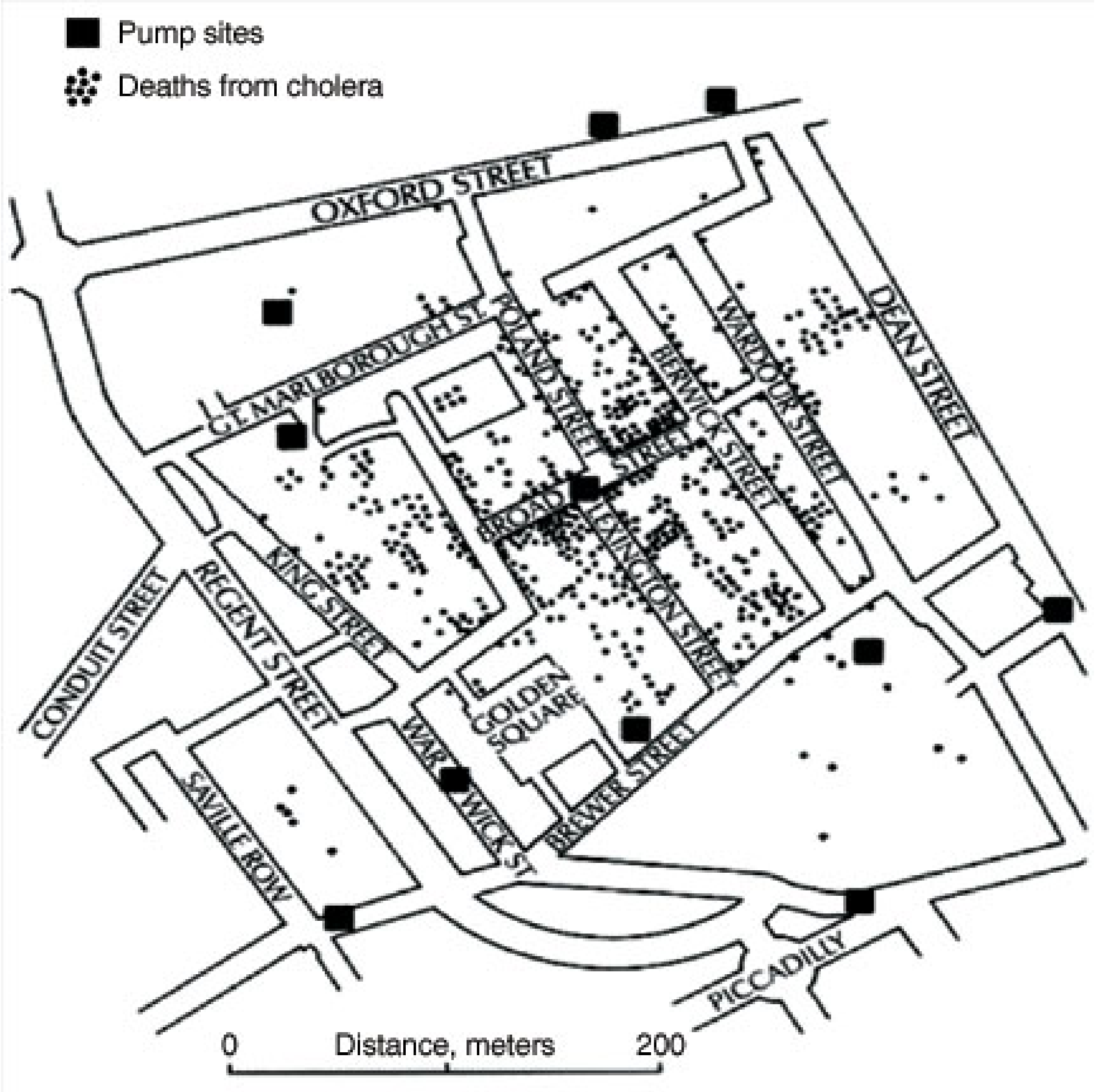
http://www.esri.com/Industries/k-12/education/~/media/Files/Pdfs/industries/k-12/pdfs/geoginquiry.pdf

GIS Applications

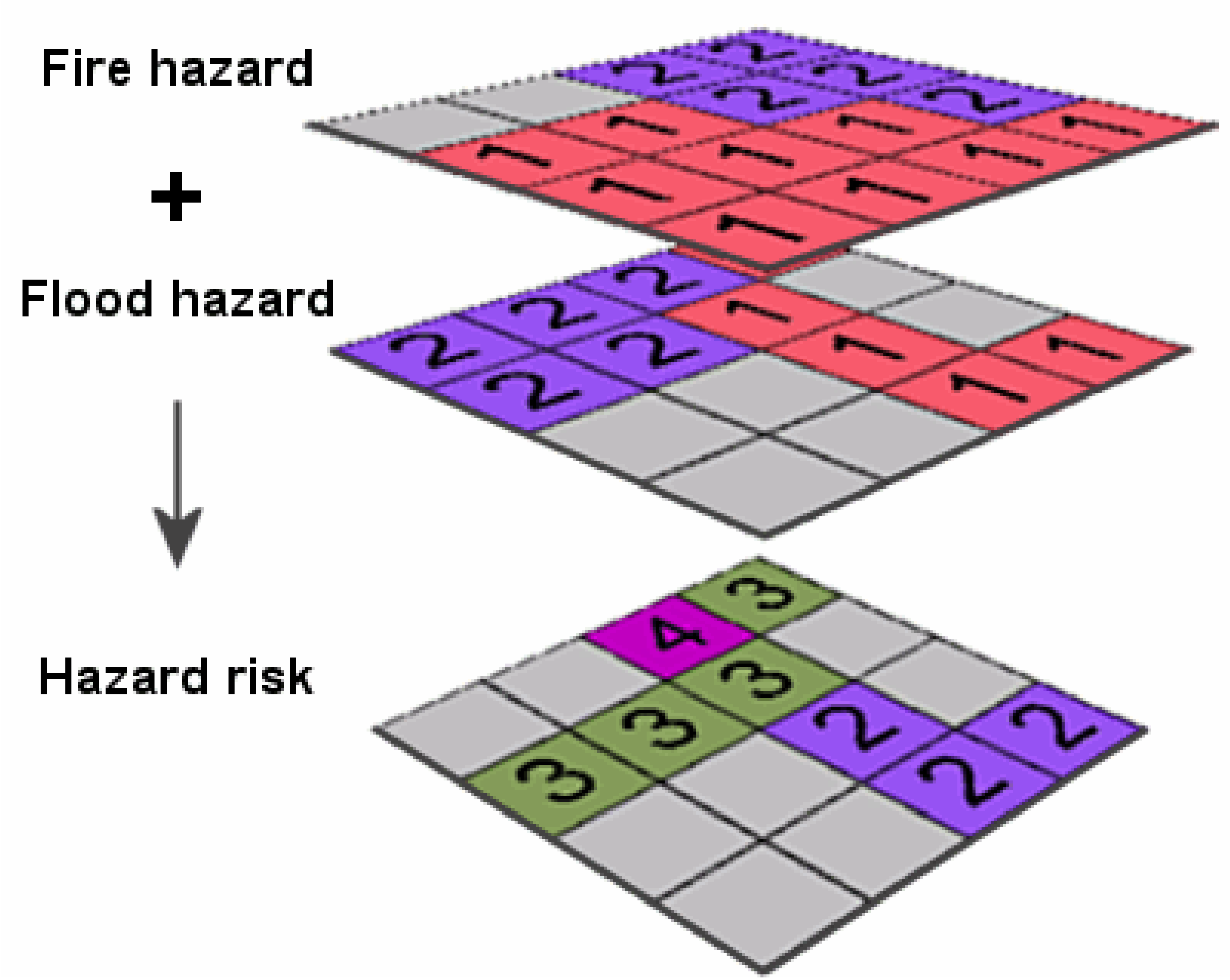
Early application in epidemiology:

Dr. John Snow's map of cholera outbreaks in London, 1854.

Deathswere concentrated near Broad Street Pump, which was adjacent to a cesspit.



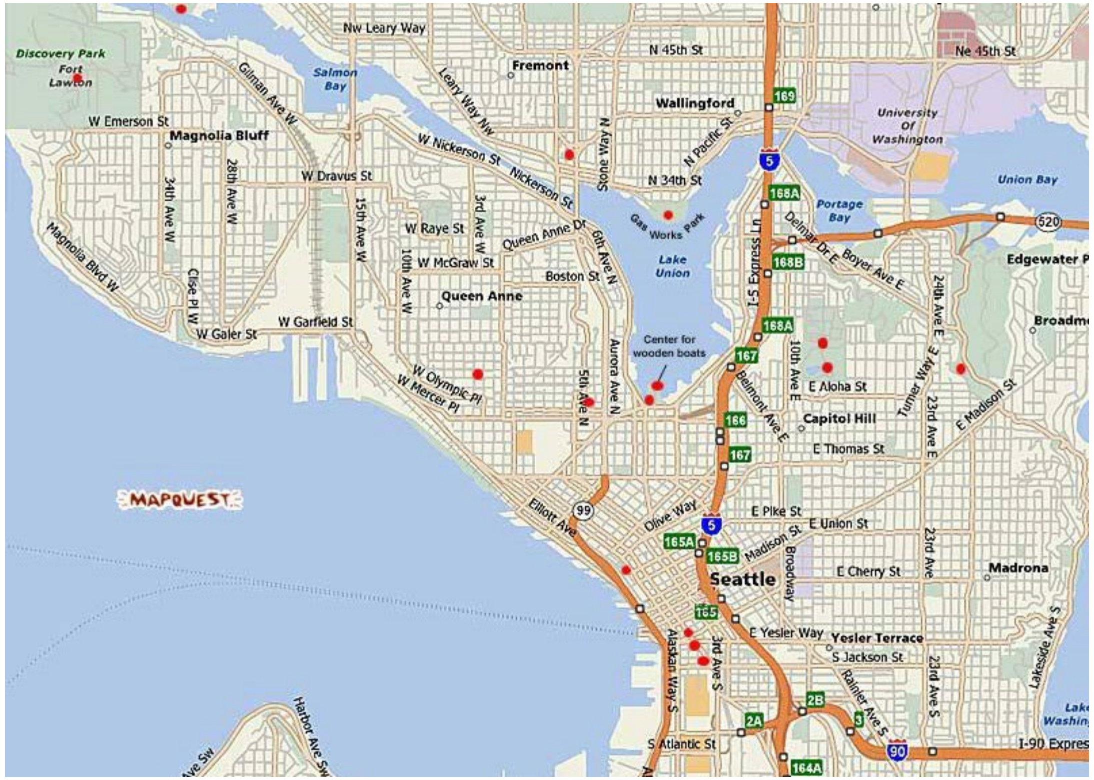
Risk Analysis



http://www.geography.hunter.cuny.edu/~jochen/GTECH361/lectures/lecture11/concepts/Working%20with%20NoData.htm

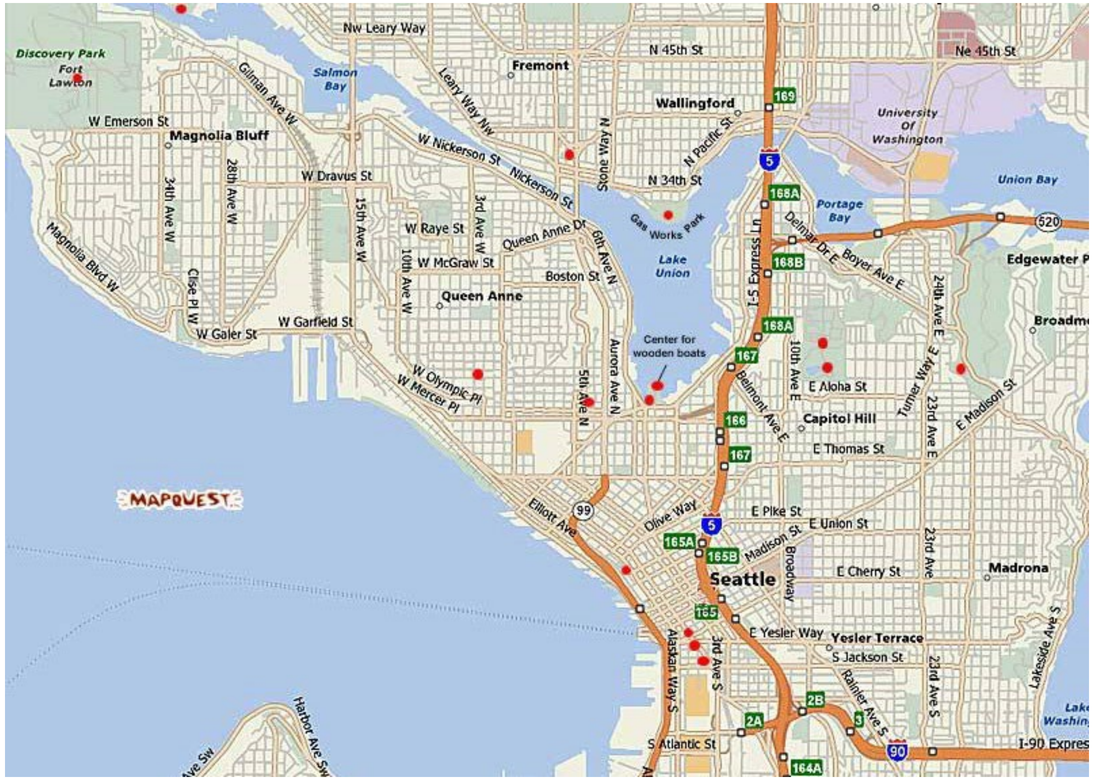
Suitability analysis example:
Where's the best location for a new doggie daycare in Seattle?

Nap time

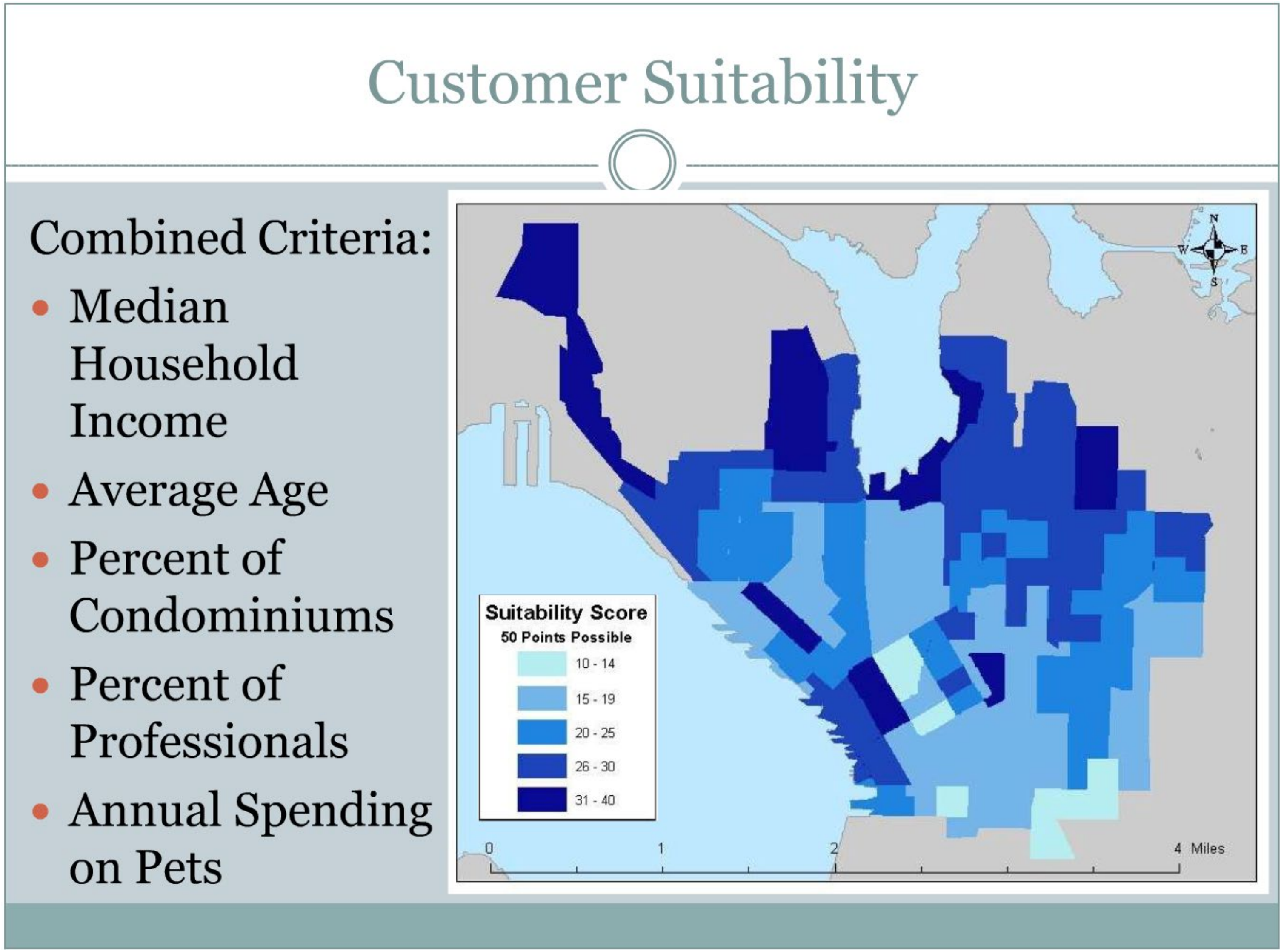


Where's the best location for a new doggie daycare in Seattle? What factors might be important?

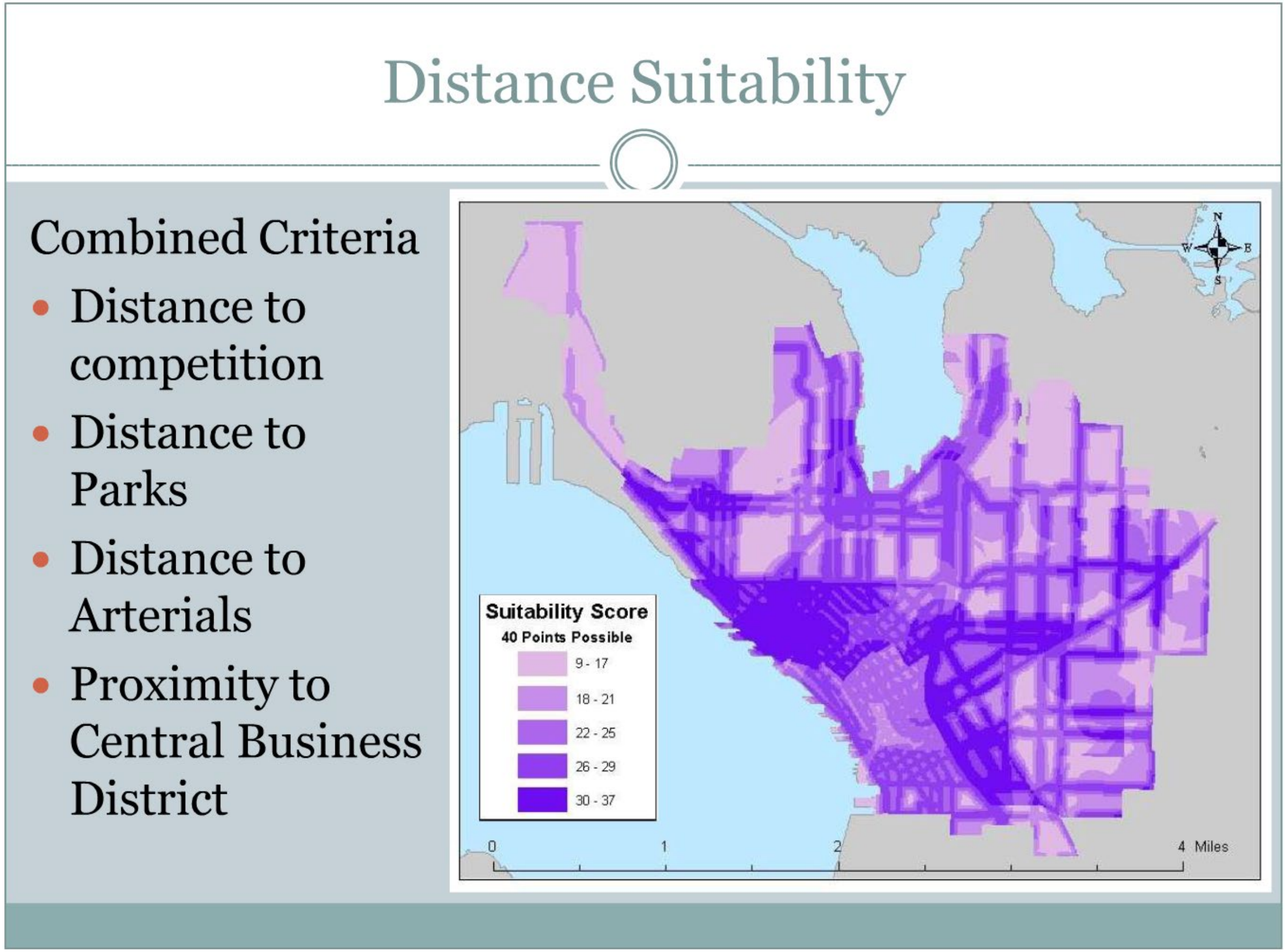
Nap time



Demographic Layer

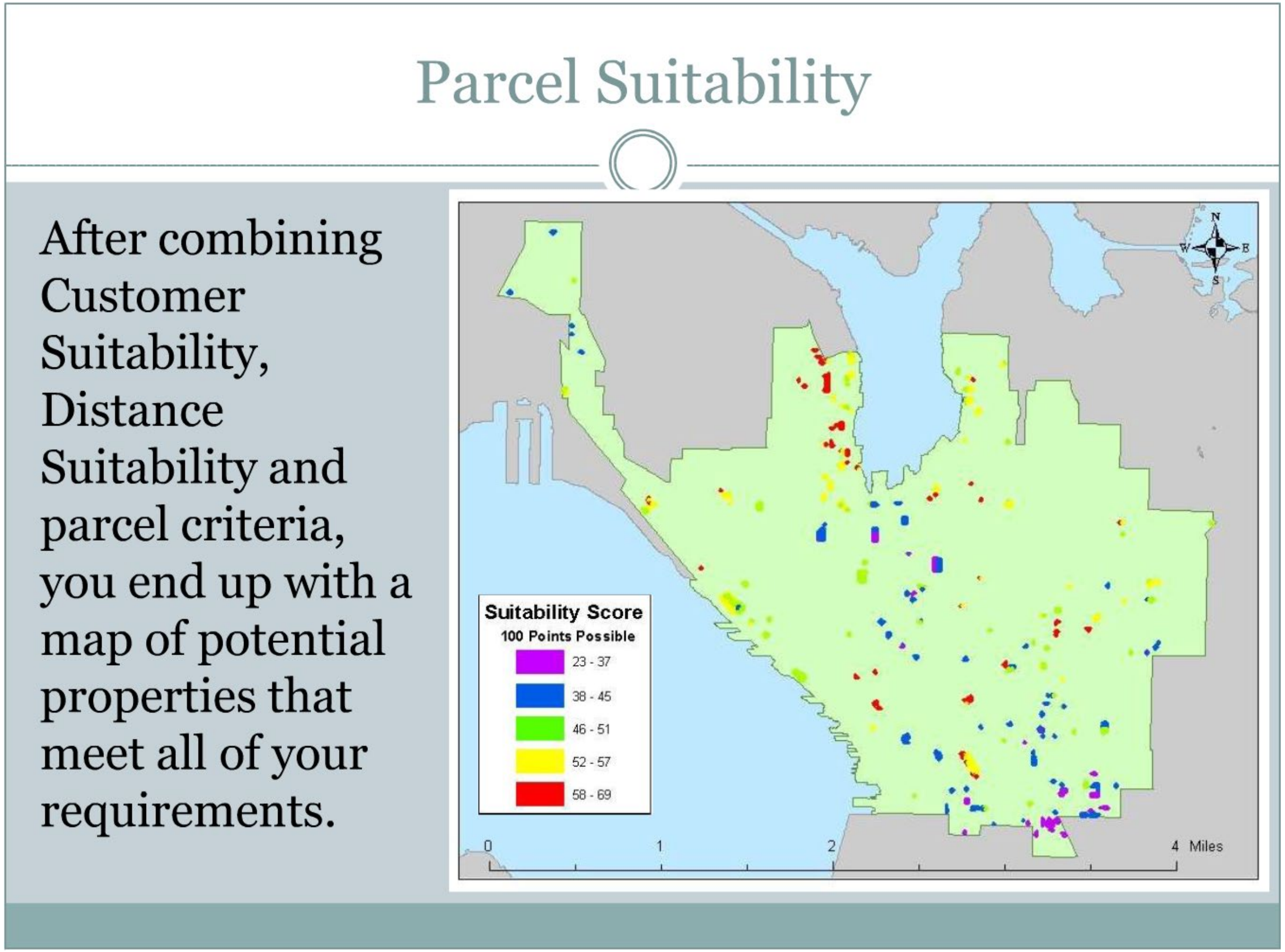


Infrastructure Layers

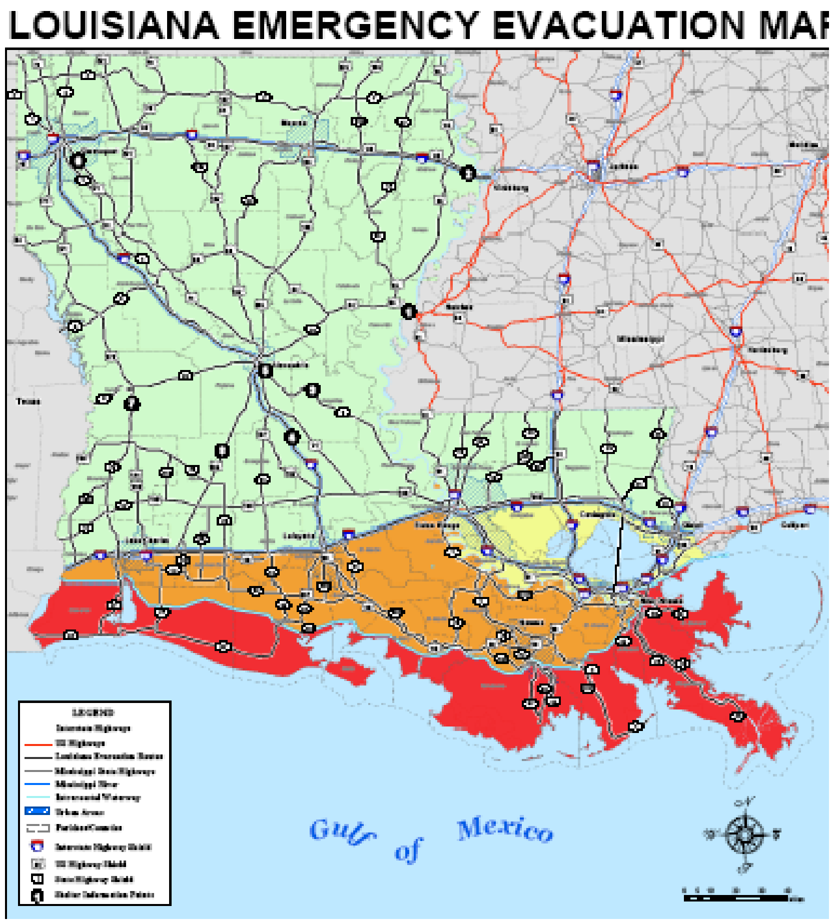


Suitability Model

Overall suitability is a combination of demographic and infrastructure layers.

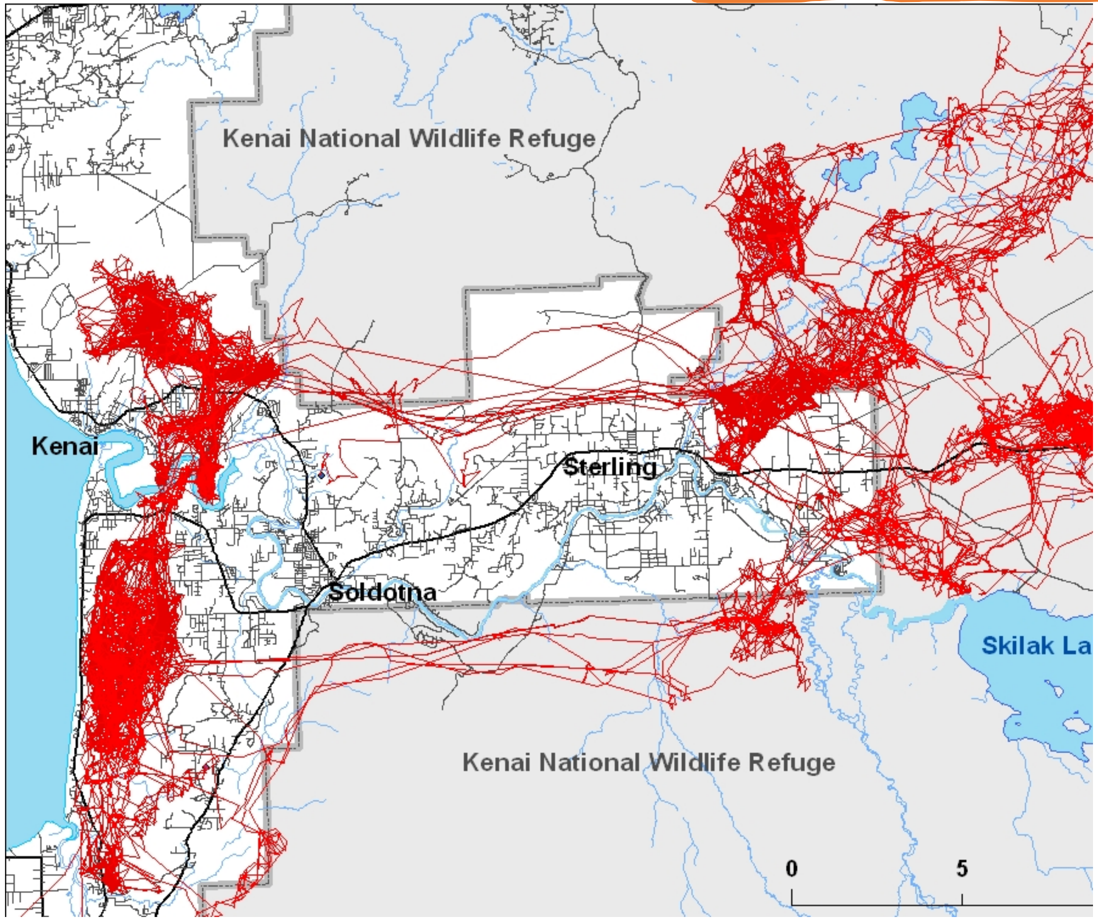


Example: Emergency Planning

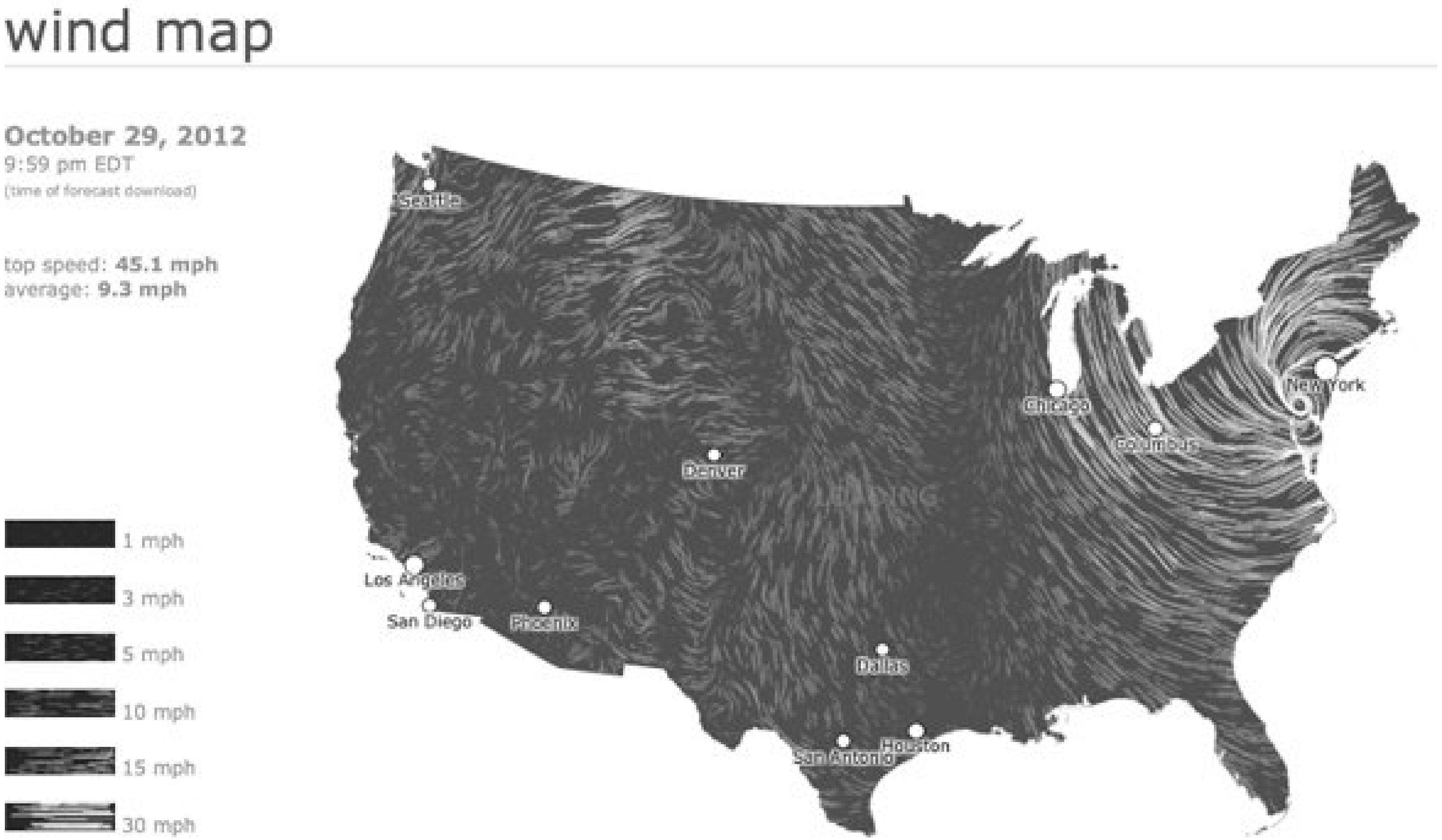


- Priority evacuation sites in Louisiana
- What information could the priority levels be based upon?

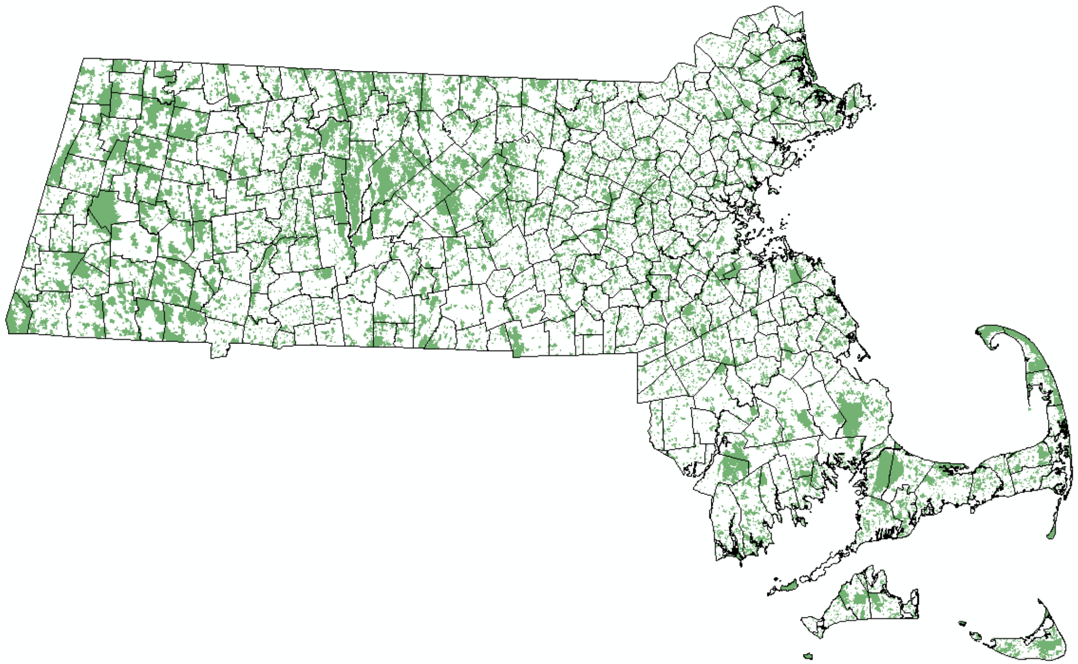
Animal Movement: What applications could this map have?



Map of the day: Visualization



Data exploration (in ArcGIS)



Protected lands in Massachusetts is a spatial dataset that you can download from MassGIS.

You'll get a chance to use this data layer in a lab!

For next session:

- Spatial Data Basics.
- Into To Cartography.
- Intro to Midterm and Final Projects.