Spatial Data Science

Sankofa Curriculum - Summer 2025

Lesson 02: Foundations of GIS

Rob Hendrickson
Instructor
robwhendrickson@proton.me

Review: Spatial is Special

Definition: **Food System**

The term **food system** describes the interconnected systems and processes that influence nutrition, food, health, community development, and agriculture.

A **food system** includes all processes and infrastructure involved in feeding a population:

Growing, harvesting, processing,

Packaging, transporting, marketing,

Consumption, distribution, and disposal

of food and food-related items.

From Wikipedia (June 2025)

Remember Place

Space

Space is a three-dimensional continuum containing positions and directions.

(Britannica Dictionary, 4/2008)

+

Meaning

A quality that gives something real value and importance

(Britannica Dictionary, 6/2025)

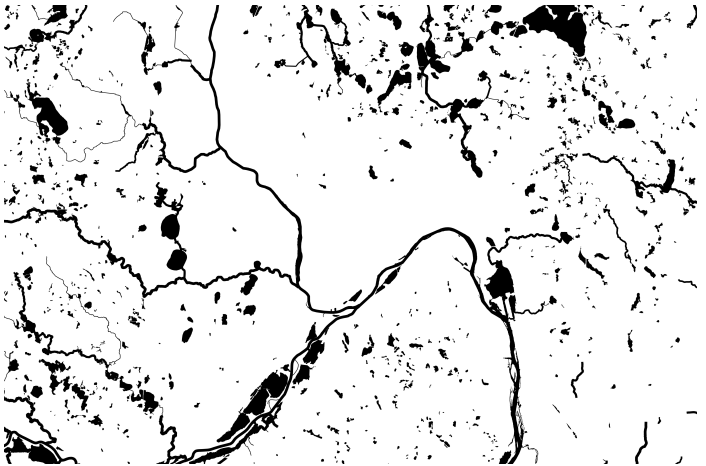
=

Place

Place … is a part of the terrestrial surface that is not equivalent to any other,

that cannot be exchanged with any other without everything changing

(Franco Farinelli - Source)

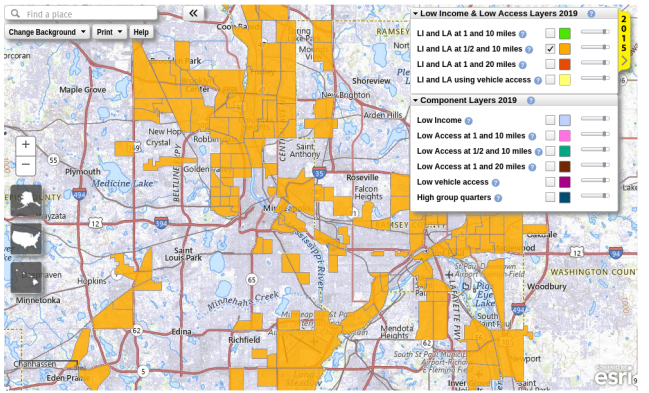


Icebreaker Activity

- Draw or describe something you learned about Minneapolis from the last lab
  - Take 2 minutes to complete #1 on the activity sheet
  - Reintroduce yourself to a neighbor and share your meal

NATIONAL GEOGRAPHIC | MAPMAKER

USDA
U.S. DEPARTMENT OF AGRICULTURE



Agenda

I. **What is GIS?**

II. **How to Make a Map**

~~~ BREAK ~~~

III. **GIS Fundamentals**

IV. **Lab**
~~~

What is GIS?

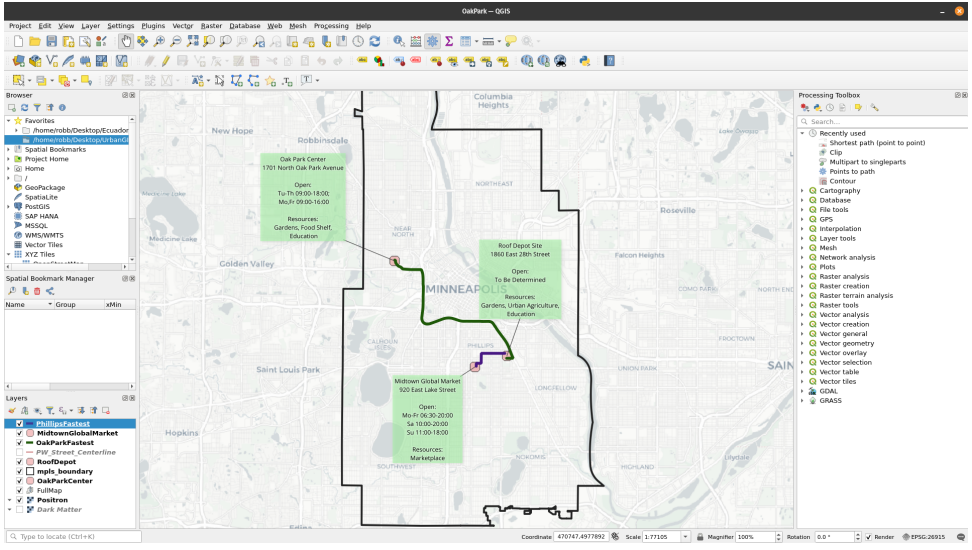
Definition: **GIS**

A Geographic Information System (**GIS)** is a computer-based system to aid in the

<u>collection</u>, <u>maintenance</u>, <u>storage</u>,

<u>analysis</u>, <u>output</u>, and <u>distribution</u>

of spatial data and information



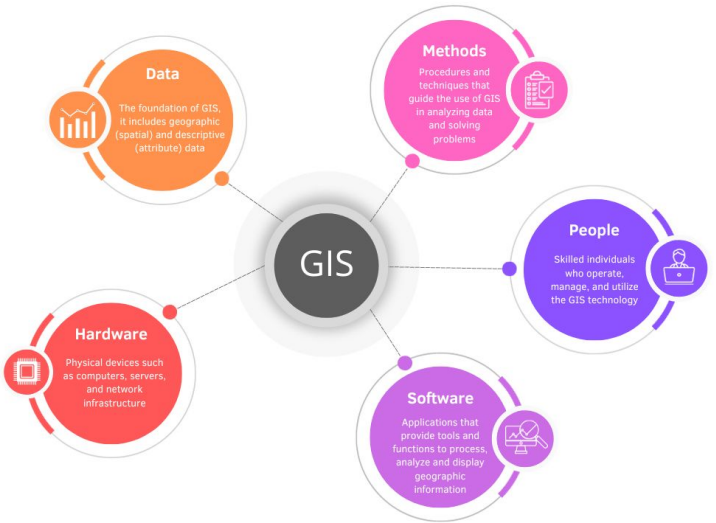
QGIS

esri™

From Bolstad (6th Edition)

A GIS consists of:

- **Digital Data**
  - The geographical information that you will view and analyze using computer hardware and software.
- **Computer Hardware**
  - Computers used for storing data, displaying graphics and processing data.
- **Computer Software**
  - Computer programs that run on the computer hardware and allow you to work with digital data. A software program that forms part of the GIS is called a GIS Application.

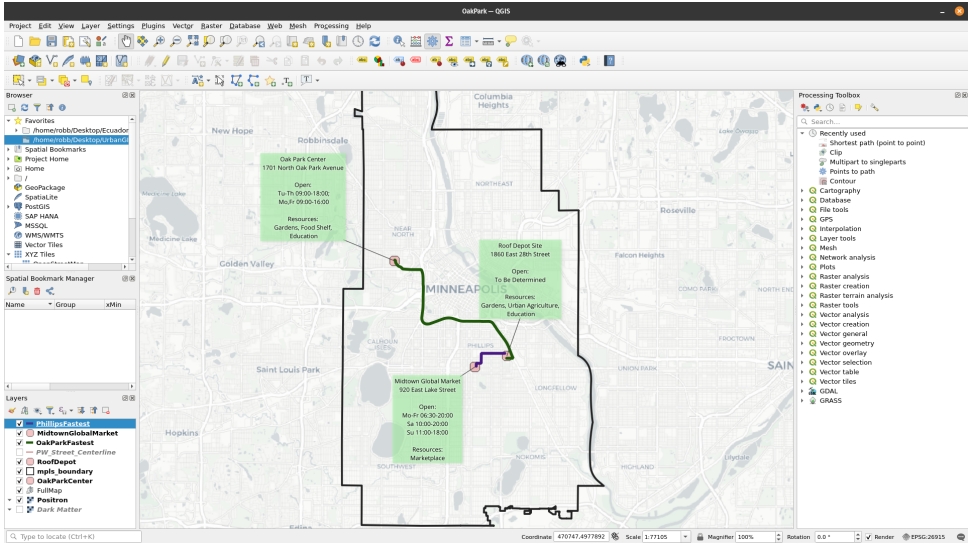


Source: https://www.swyvl.io/blog/what-is-gis-geographical-information-systems-mapping-explained-with-examples

From https://docs.qgis.org/3.40/en/docs/gentle_gis_introduction/introducing_gis.html

Activity – Why SankofaPOWER?

- How might the spatial information we collect with SankofaPOWER be useful?
  - Take 2 minutes to complete #2 on the activity sheet
  - Share with your neighbor



How to Make a Map

The QGIS project for this demonstration can be downloaded at:
https://rwhendrickson.github.io/Portfolio/pages/resources#free--open-source-software

Types of Maps

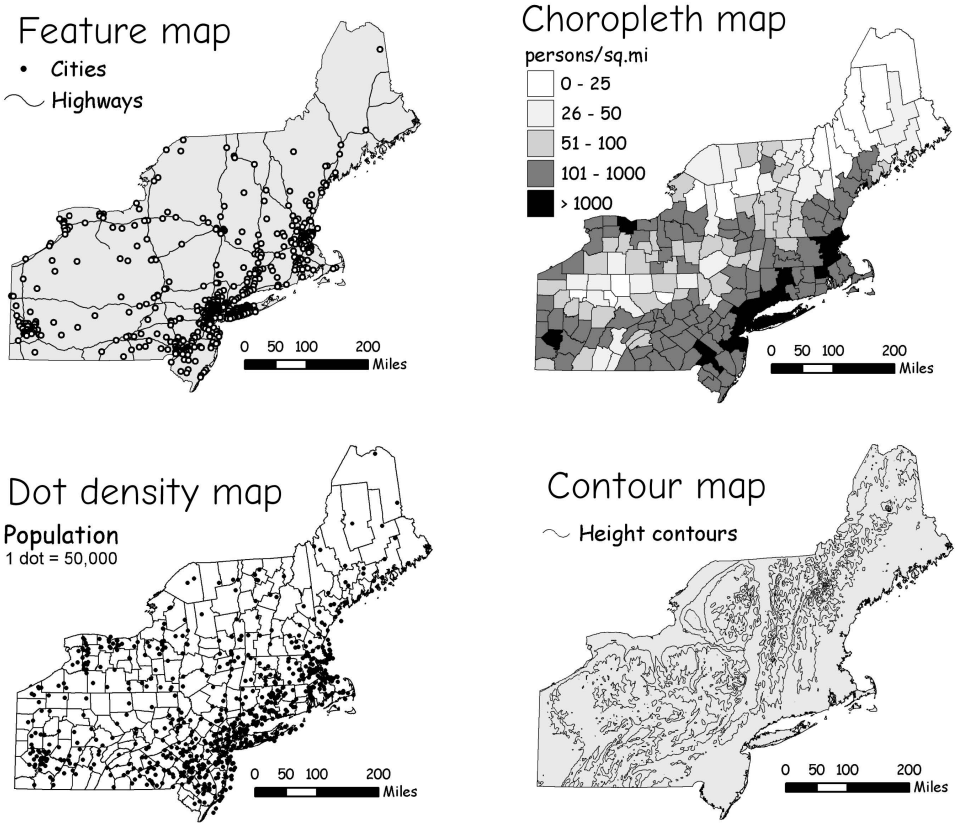


Figure 4.5 from Bolstad (6th Edition)

Activity – Download QGIS!

Let’s head over to QGIS and download our first GIS application!

https://qgis.org/download/

BREAK!

(Please be back in 10 minutes)

GIS Fundamentals

What is a Dataset?

- A **dataset** is a collection of data (measurable info) consisting of the following:
  - **Observations** – Elements of the study | rows in a table
  - **Variables** – Properties of observations | columns in a table
  - **Data Values** – Measurements of the variables for each observation

	STATION	NAME	LATITUDE	LONGITUDE	ELEVATION	DATE	TAVG	TMAX	TMIN
0	USW00003951	LONGVIEW 11 SE, TX US	32.3466	-94.6533	124.1	2021-02-01	NaN	65.0	29.0
1	USW00003951	LONGVIEW 11 SE, TX US	32.3466	-94.6533	124.1	2021-02-02	NaN	65.0	29.0
2	USW00003951	LONGVIEW 11 SE, TX US	32.3466	-94.6533	124.1	2021-02-03	NaN	56.0	34.0
3	USW00003951	LONGVIEW 11 SE, TX US	32.3466	-94.6533	124.1	2021-02-04	NaN	65.0	44.0
4	USW00003951	LONGVIEW 11 SE, TX US	32.3466	-94.6533	124.1	2021-02-05	NaN	73.0	38.0

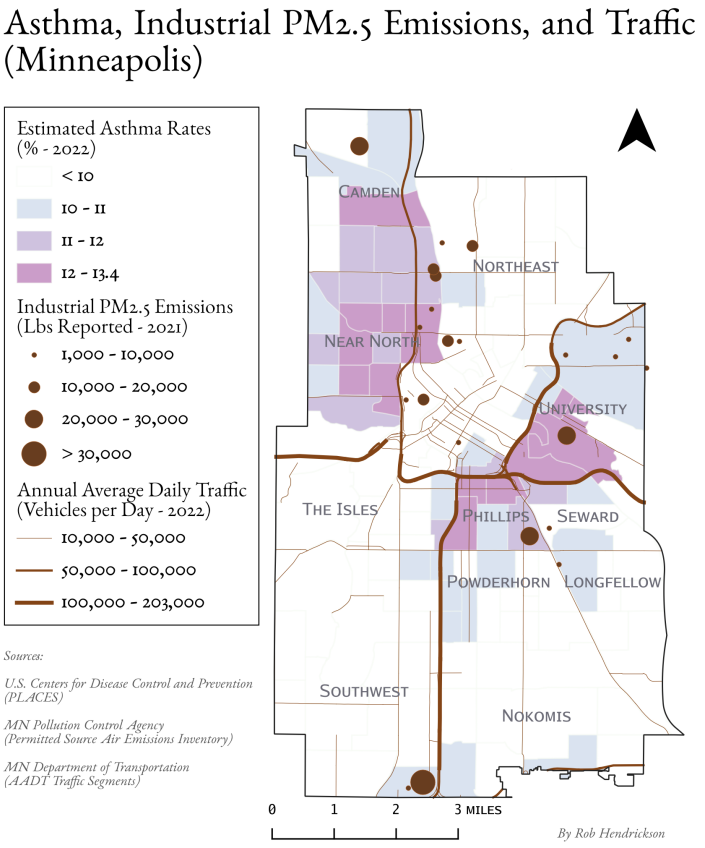
Spatial Representations

How do we

represent the real world

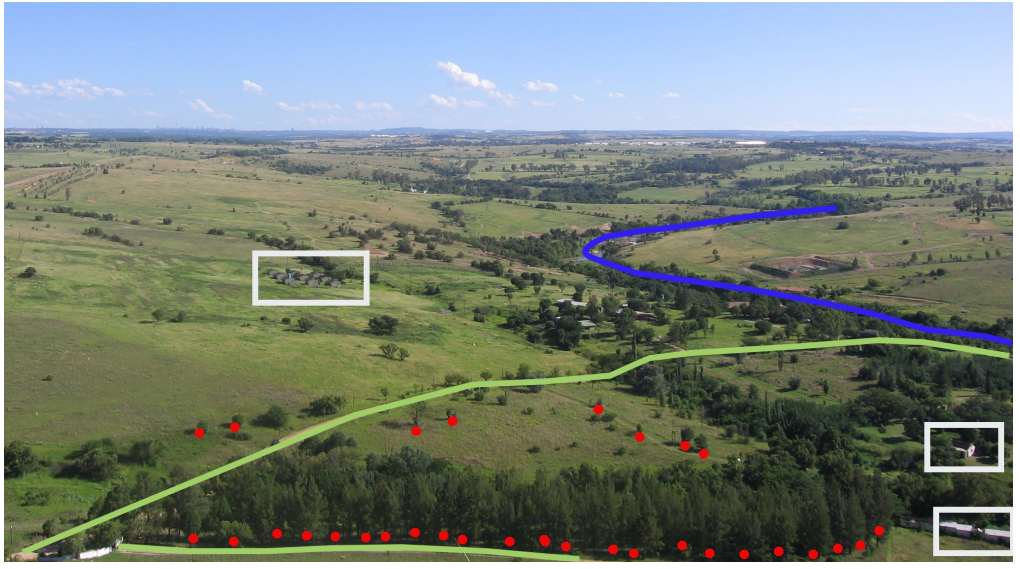
in a way our

computers can understand?



Representations (Vector)

- Points, Lines, and Polygons
- Represents a discrete number of objects (features) grouped into a layer
- Think of choropleths, rivers, roads, trees, buildings, etc.



Source: https://docs.qgis.org/3.34/en/docs/gentle_gis_introduction/vector_data.html

Representations (Raster)

- A matrix (grid/field) of cells (pixels) with an affine transformation
- Represents a surface of continuously changing values
- Think satellite images, weather radar, basemaps, kernel density estimation, land classification, etc.

Source:https://docs.qgis.org/3.34/en/docs/gentle_gis_introduction/raster_data.html

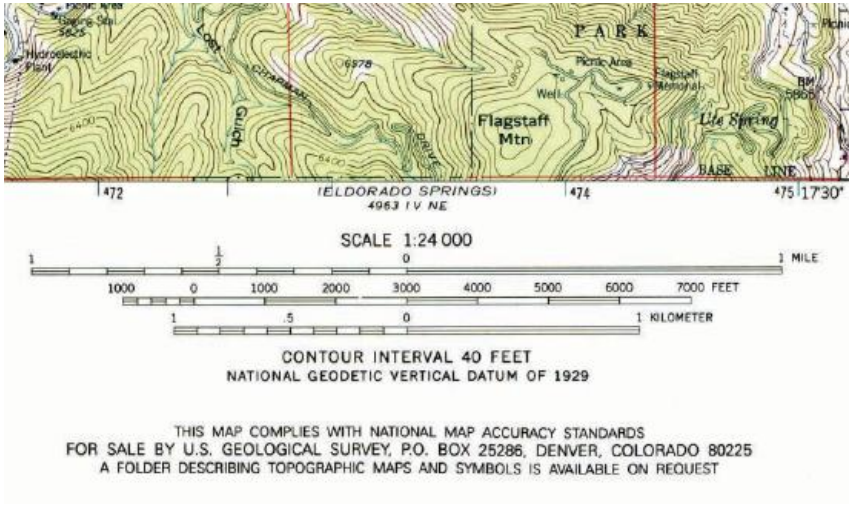
Data Formats

- Vector
  - GeoJSON (.json)
  - Shapefile (many files)
  - Geo Markup (.gml)
  - Well Known Text (WKT)
  - .kml, WKB, GDF, ...
- Raster
  - GeoTIFF (.tif)
  - ASCII Grid (.asc)
  - ERDAS Imagine (.IMG)
  - DEM (.ddf, .dem, .dat)
  - .png, .pdf, .jpg, .rst, ...

Read more here: https://gisgeography.com/gis-formats/ | https://en.wikipedia.org/wiki/GIS_file_format

Scale vs. Scope

- The **scale** of a map is the ratio of distance on the map to the real distance
- Opposite of intuition!
  - Large scale = More detail with less area
  - Small scale = Less detail with more area
- **Scope** = Extent in space



Source: https://geo.libretexts.org/Bookshelves/Geography_(Physical)/Essentials_of_Geographic_Information_Systems_(Campbell_and_Shin)/02%3A_Map_Anatomy/2.02%3A_Map_Scale_Coordinate_Systems_and_Map_Projections

Read more here: https://www.geographyrealm.com/understanding-scale/ | https://geo.libretexts.org/Bookshelves/Geography_(Physical)/Essentials_of_Geographic_Information_Systems_(Campbell_and_Shin)/02%3A_Map_Anatomy/2.02%3A_Map_Scale_Coordinate_Systems_and_Map_Projections

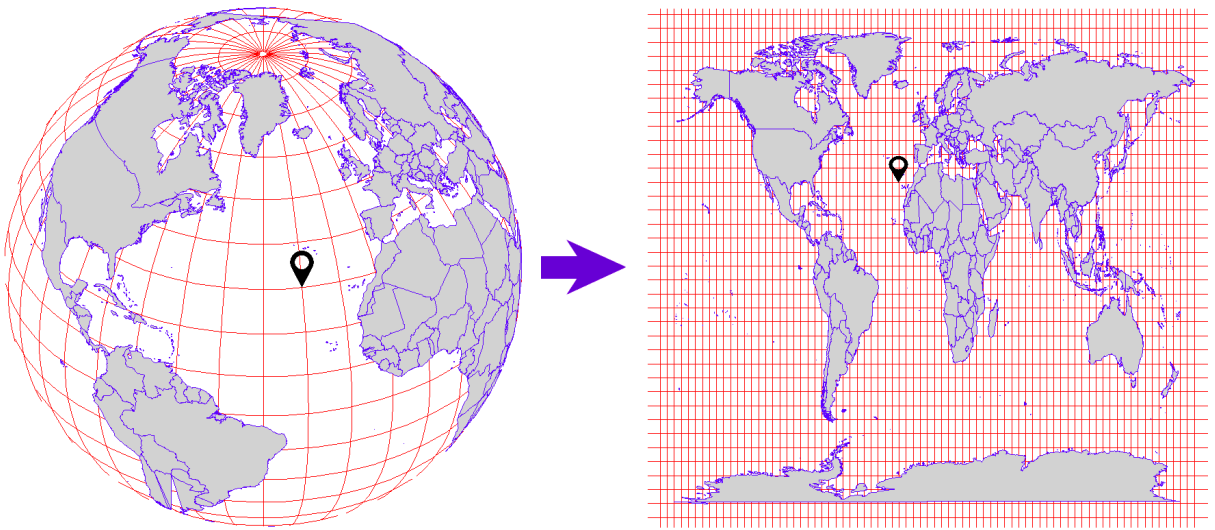
Coordinate Reference Systems (1)

- How do we put the round Earth on a flat piece of paper or computer screen?

1) We must agree on the 3D shape of the globe

  - Geodesy
  - Geographic Coordinate System (eg. WGS84)

2) Then we can project!

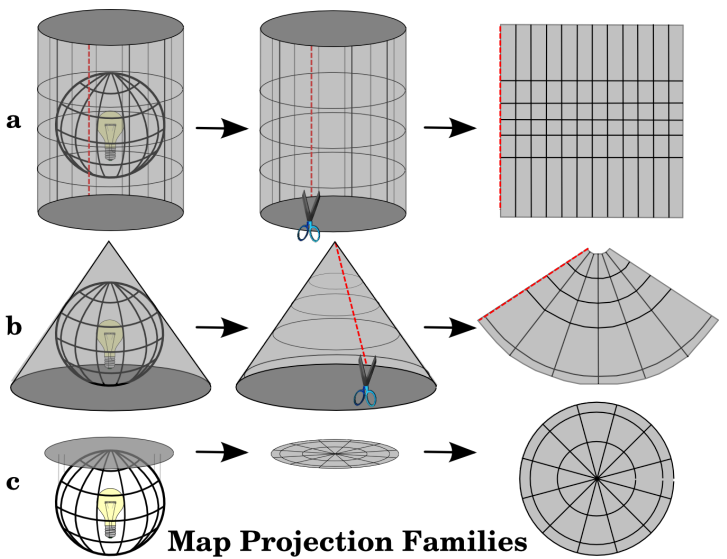


Source: https://raw.githubusercontent.com/ThamesEstuaryPartnership/booklet/main/Figures/pcs.png

Read more here: https://docs.qgis.org/3.34/en/docs/gentle_gis_introduction/coordinate_reference_systems.html | https://bookdown.org/tep/gis/introduction-to-coordinate-reference-system.html

Coordinate Reference Systems (2)

- A **Map Projection** attempts to transform the Earth from 3D to 2D using mathematical principles of geometry and trigonometry
- There are 3 families of projection:
    a) Cylindrical
    b) Conical
    c) Planar
- No projection is perfect!
    - Compromise is key

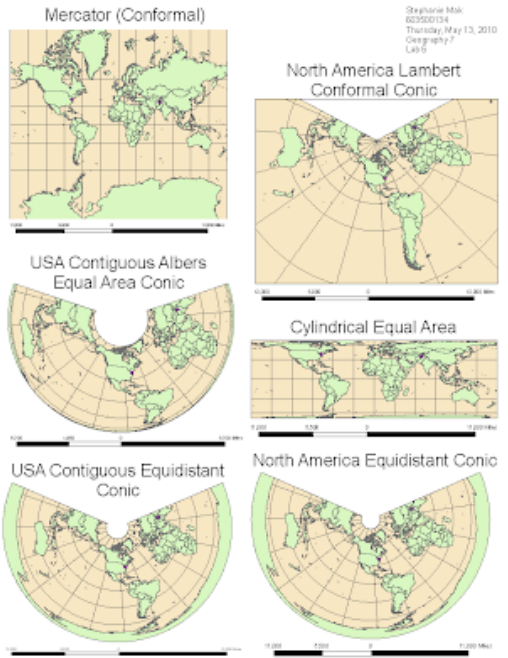


Source: https://docs.qgis.org/3.34/en/docs/gentle_gis_introduction/coordinate_reference_systems.html

Read more here: https://docs.qgis.org/3.34/en/docs/gentle_gis_introduction/coordinate_reference_systems.html | https://bookdown.org/tep/gis/introduction-to-coordinate-reference-system.html

Coordinate Reference Systems (3)

- We must compromise distortions of **angular conformity**, **distance**, and **area** as well as the **scope of the map/analysis**
- **Conformal** or **Orthomorphic:** Preserve angles, used for navigation
- **Equidistant:** Preserves distance, used for seismology & navigation
- **Equal Area:** Preserves area, used for development

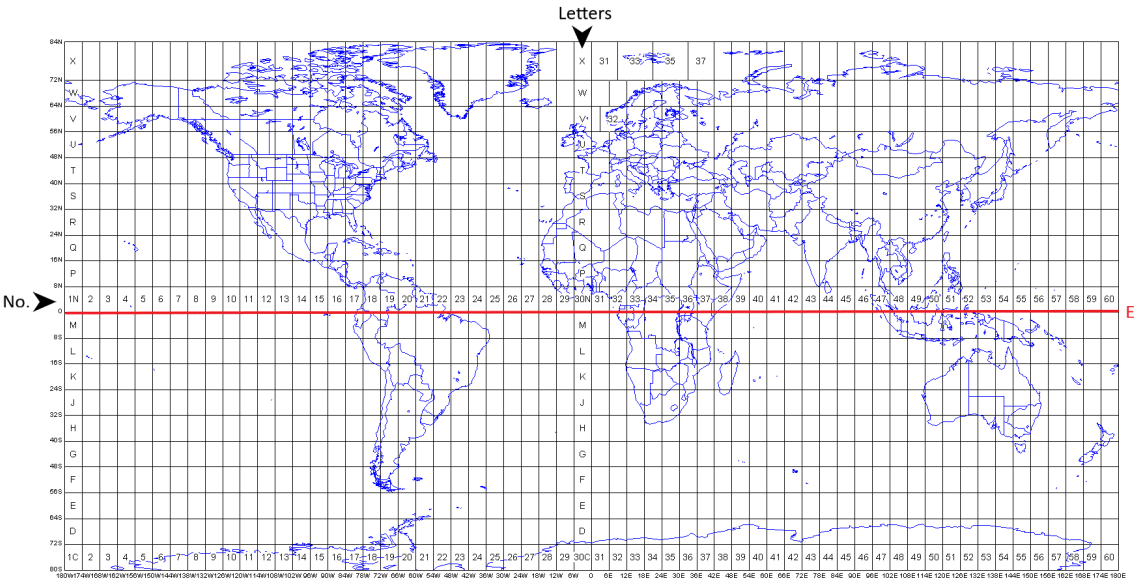


Source: https://smgeog7.blogspot.com/2010/05/lab-6-map-projections.html

Read more here: https://docs.qgis.org/3.34/en/docs/gentle_gis_introduction/coordinate_reference_systems.html | https://bookdown.org/tep/gis/introduction-to-coordinate-reference-system.html

Coordinate Reference Systems (4)

- A **Coordinate Reference System (CRS)** refers to a specific method of Geographic or Projected Coordinate System
- 3 Common CRS
  - WGS84 | EPSG:4326 | (lat/lons)
  - Web Mercator | EPSG:3857 | Google
  - UTM | EPSG:Various | Zones
- Many more localized options



UTM Zones
Source: https://docs.qgis.org/3.34/en/docs/gentle_gis_introduction/coordinate_reference_systems.html

Read more here: https://docs.qgis.org/3.34/en/docs/gentle_gis_introduction/coordinate_reference_systems.html | https://bookdown.org/tep/gis/introduction-to-coordinate-reference-system.html

Lab Time!

Please go to

https://github.com/RwHendrickson/SankofaClass/blob/main/Session02/LabInstructions.pdf

Github.com/RwHendrickson/SankofaClass

Thank you!