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Introduction to Geographic Information Systems

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What is a Geographic Information System?

- A Geographic Information System (GIS)
  - software, hardware, geographic information, spatially explicit data
- Software can be used to store, query, manage, analyze and display spatial data.
- A GIS links cartographic, statistical, and data-basing technologies.

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Historical GIS concepts

London Cholera Epidemic 1854

http://www.ph.ucla.edu/epi/snow/snowmap1_1854.html

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Notable GIS software

Commercial:

- ArcGIS, including ArcMap (Esri)
- IDRISI (Clark Labs)
- ERDAS IMAGINE (ERDAS Inc.)

Open source:

- **Quantum GIS**
- GRASS GIS
- MANIS tool
- GPSvisualizer
- Biogeomancer

Free (but not open source):

- DIVA GIS

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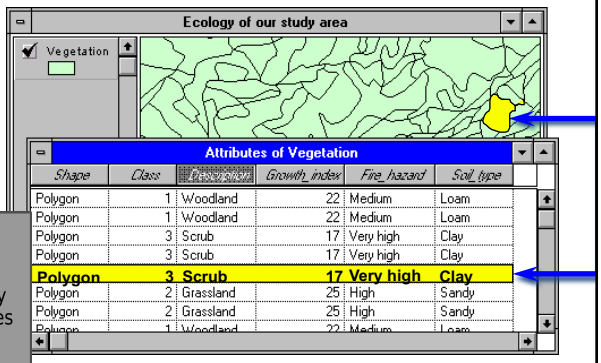
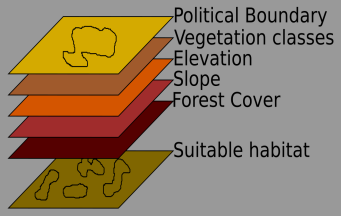
Geography and Databases

- information stored as a collection of thematic layers that can be linked together by geography



Gap analysis



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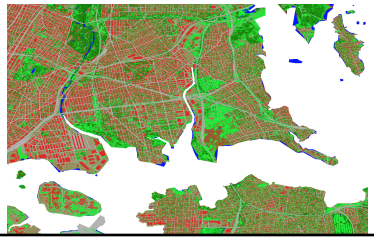
Two methods of GIS representations

- Vector
  - A series of x,y coordinates
  - For discrete data represented as points, lines, polygons
- Raster
  - Grid and cells
  - For continuous data such as elevation, slope, surfaces



New York City landcover classified at 3 foot resolution

Coyote occurrence records (as vector layer)

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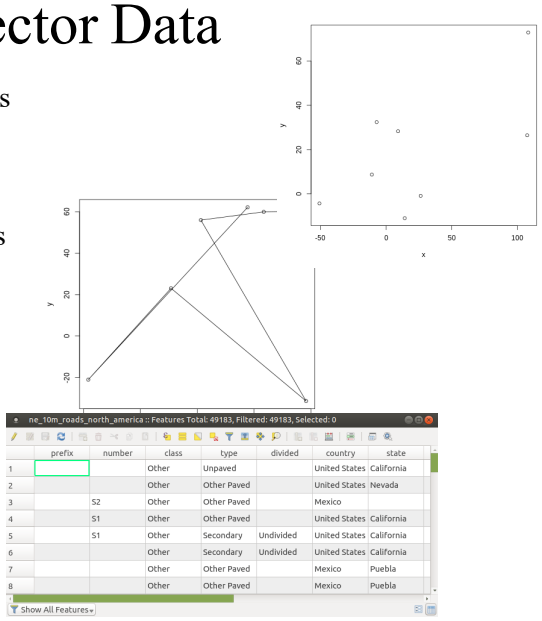
Vector Data

- Vector data represents features as *points*, *lines*, and *polygons*.
- It is best applied to discrete objects with defined shapes and boundaries.
- It is tied with tabular data



- Examples include:
  - GPS points
  - Roads
  - Protected areas

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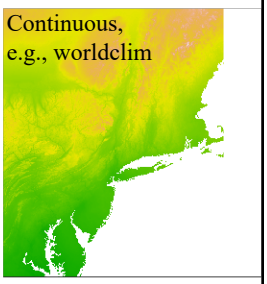
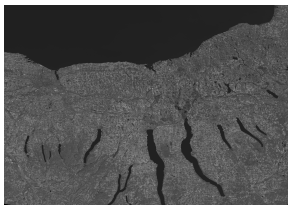
Raster Data

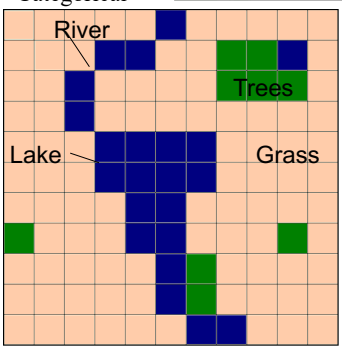
A raster model represents the world as a surface that is divided into a regular grid of cells, each of which are assigned a value.



Raster data includes images and grids. aerial photograph, a satellite image, or a scanned map, are often used for generating raster datasets.



Categorical



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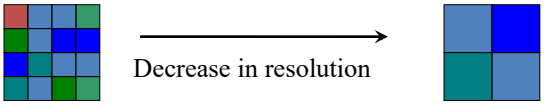
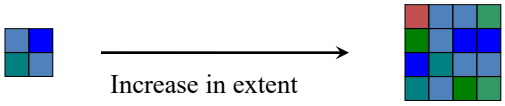
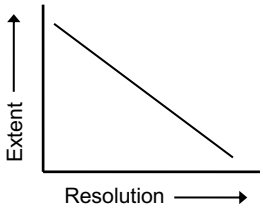
General data issues: spatial scale

Spatial scale has two elements: **resolution** and **extent**





Resolution and extent tend to be inversely related



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Vector data

- Advantage
  - precise representation of points, boundaries, and linear features
    - defining spatial relationship (connectivity and adjacency) between coverage features
    - network analysis (for example to find an optimal path between two nodes in a complex transport network)
- Disadvantage
  - boundaries of the resulting map polygons are discrete/enclosed by well-defined boundary lines. In reality the map polygons may represent continuous gradation or gradual change, as in soil maps

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Raster data

- Advantage
  - represent indistinct boundaries
    - thematic information on soil types, soil moisture, vegetation, ground temperatures
  - reconnaissance satellites and aerial surveys use raster-based scanners
    - scanned images can be directly incorporated into GIS
- Potential disadvantage
  - the higher the grid resolution, the larger the data file is going to be

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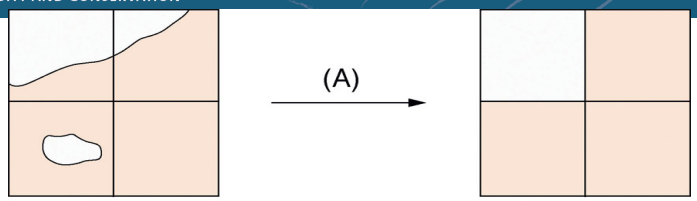
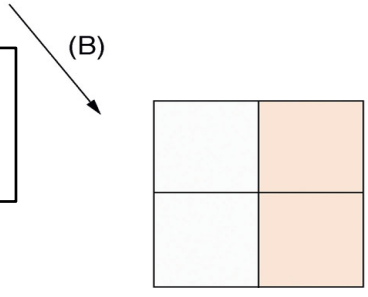
Conversion from vector to raster data





A) the largest share rule

(B) the central point rule

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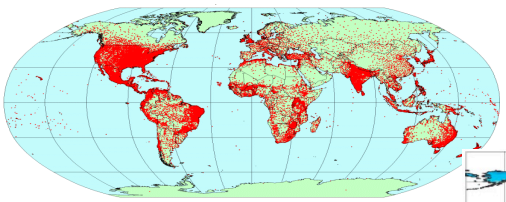
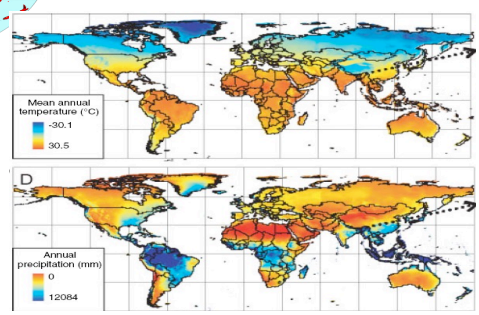
Conversion from vector to raster data



Weather station records
(vector point data;
Hijmans et al. 2005)



Interpolated raster climate surfaces (WorldClim)

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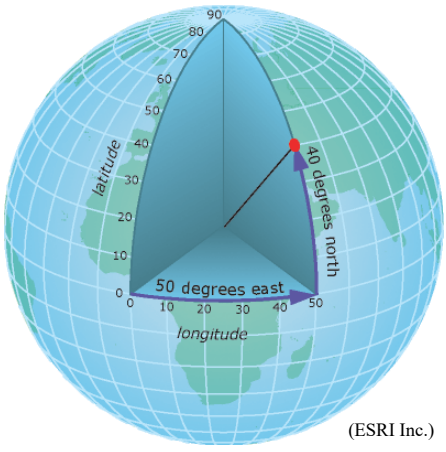
GIS fundamentals: Geographic coordinate systems (GCS)

•A point is referenced by its *longitude* and *latitude*, which are angles measured from the Earth's center to a point on its surface.

•Latitude and longitude are measured either in decimal degrees or in degrees, minutes and seconds.



(ESRI Inc.)

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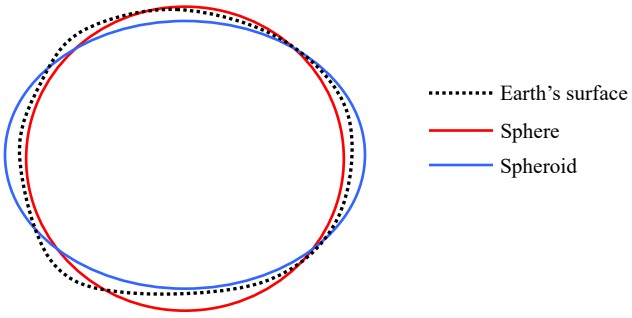
GIS fundamentals: Geographic coordinate systems (GCS)

- The shape and size of a GCS's surface is defined by a sphere or a spheroid
- In fact, the Earth is neither a perfect sphere nor spheroid (the South Pole is closer to the equator than the North pole!)
- A *datum* defines the origin and orientation of latitude and longitude lines.
- Changing a GCS's spheroid or datum changes all values!
- The standard global system is called World Geodetic System 1984 (WGS1984)



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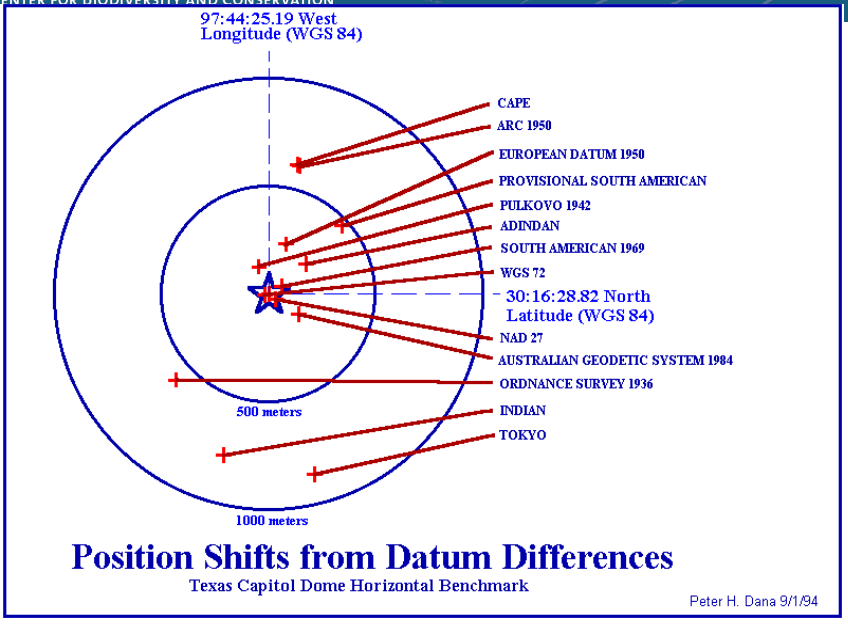

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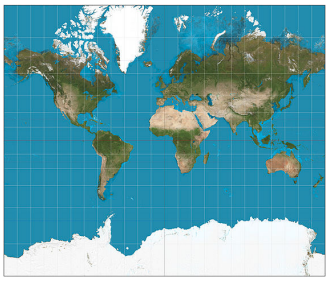
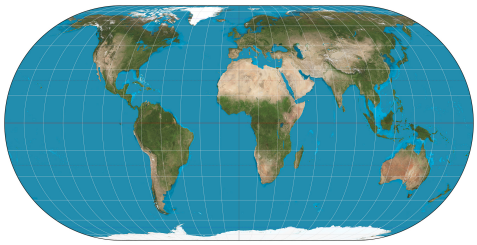
GIS fundamentals: Projected coordinate systems (PCS)

- Representing the earth's surface in two dimensions causes distortion in the shape, area, distance, or direction of the data.
  - Impossible to show spherical object in 2 dimensions without distortion
- A map projection uses mathematical formulas to relate spherical coordinates on the globe to flat, planar coordinates.
- Different projections are designed to minimize different distortions.



Mercator: maintains direction



Eckert IV: maintains area

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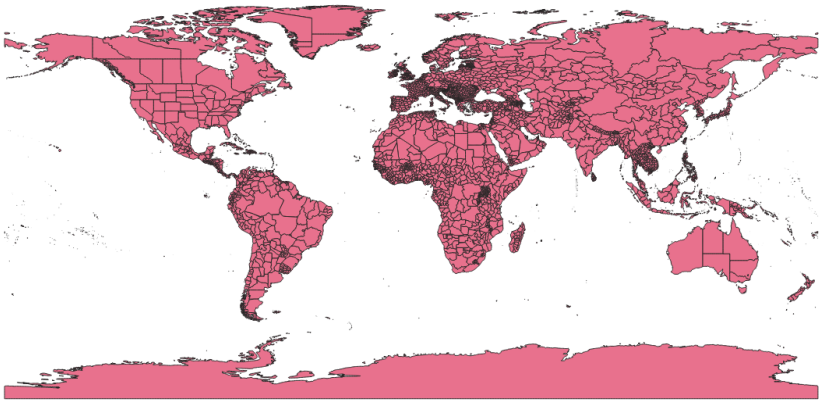
GIS fundamentals: Geographic coordinate systems (GCS)

WGS84 – Unprojected: Distortion near extents of map



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GIS fundamentals: Geographic coordinate systems (GCS)

- WGS84
  - Default Datum for GPS units
  - Pretty good for global measurements
  - Small changes in landmass movements can be significant at global scale
    - Melting glaciers cause rising elevation
    - Tectonic movements
  - Local datums are better for local maps (e.g., North American Datum; NAD83) and reduce significance of landmass movements.

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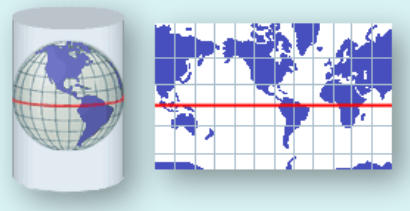
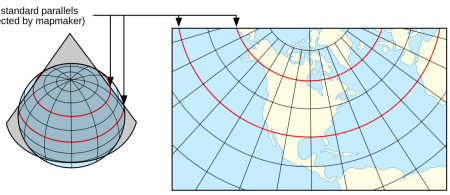
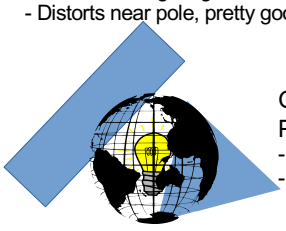
GIS fundamentals: Projected coordinate systems (PCS)



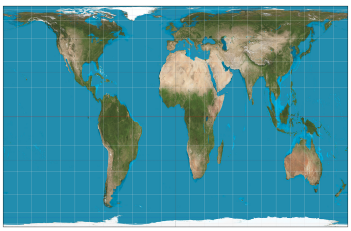
Mercator Projection
- Maintains direction
- Good for navigating
- Distorts near pole, pretty good near equator



Conic Projection
- Maintains area near center
- Distortion near edges
- Good for east/west because distortion constant



Gall-Peters Projection
- Maintains relative areas
- High distortion



https://thetruesize.com/

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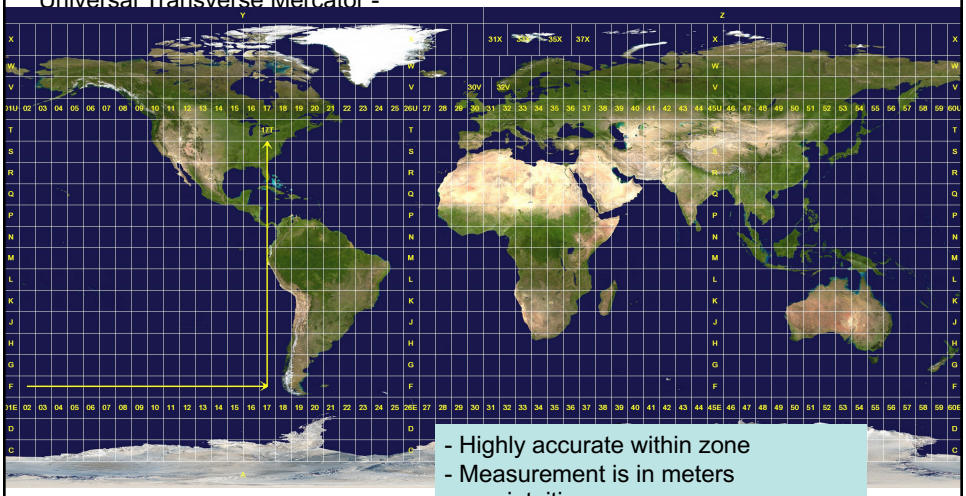
GIS fundamentals: Projected coordinate systems (PCS)

Universal Transverse Mercator -



- Highly accurate within zone
- Measurement is in meters
  - intuitive
- Not great for large areas (across zones)

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GIS fundamentals: Geographic and Projected coordinate systems

•Modern GIS make dealing with coordinate systems relatively straightforward; however:

IT IS ESSENTIAL TO KNOW THE COORDINATE SYSTEM OF ANY DATA WITH WHICH YOU ARE WORKING!

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Species' distribution data: possible sources

- Personal collection during field surveys (e.g., using a GPS receiver or smartphone)
- Extracting data from large surveys (e.g., North American Breeding Bird Survey)
- Digitizing atlases (e.g. *The new atlas of breeding birds in Britain and Ireland: 1988-1991*)
- Collections in natural history museums
- On-line distributed databases (e.g. GBIF, HerpNET, FishNET, ORNIS)

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Georeferencing

- Woodbury, NY
- Near Woodbury
- 5 miles from Woodbury
- 1 mile east of Woodbury
- 10 minutes along the path leading out of Woodbury

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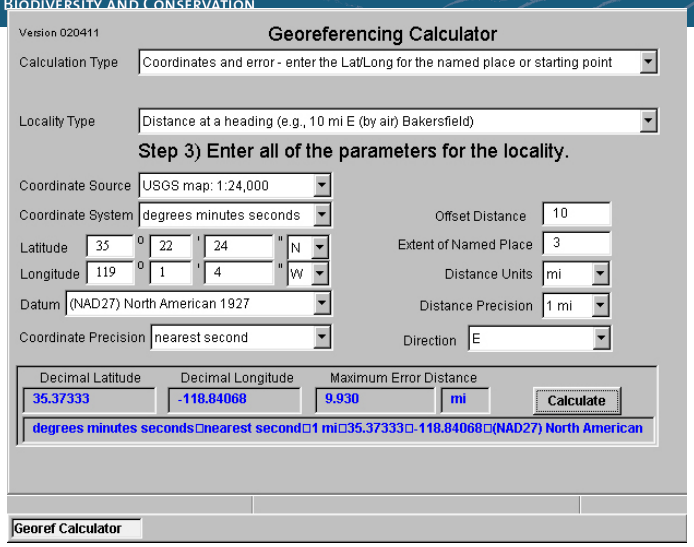

http://manisnet.org/gc.html
John Wieczorek, UC Berkeley

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GBIF: Global Biodiversity Informatics Facility
www.gbif.org

•An international organization that aims to make the world's biodiversity data accessible anywhere in the world

•Potentially, a very useful resource… but a word of caution:

•*Dendroica fusca* is a common neotropical migrant found at higher elevations (900 - 2800 m) in Ecuador. What happened if we searched the GBIF data base for it in 2006?

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