Georeferencing II

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Review

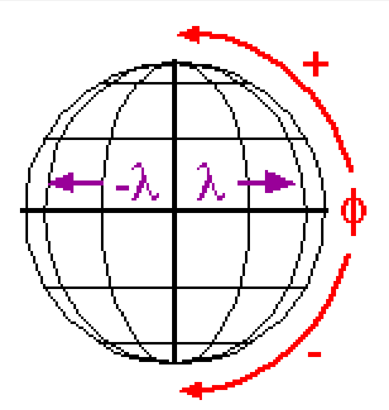
- There are several different systems which we may use to georeference data
- Common referencing systems vary around the world
  - Place-names and points of interest
  - Postal addresses and postal codes
  - Linear referencing systems
  - Cadasters and the US Public Land Survey System
  - Measuring the Earth: latitude and longitude

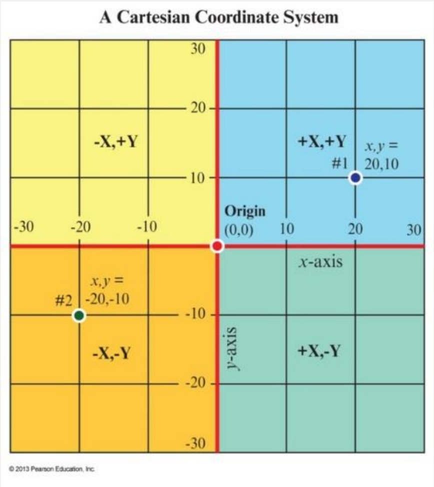
Learning Objectives

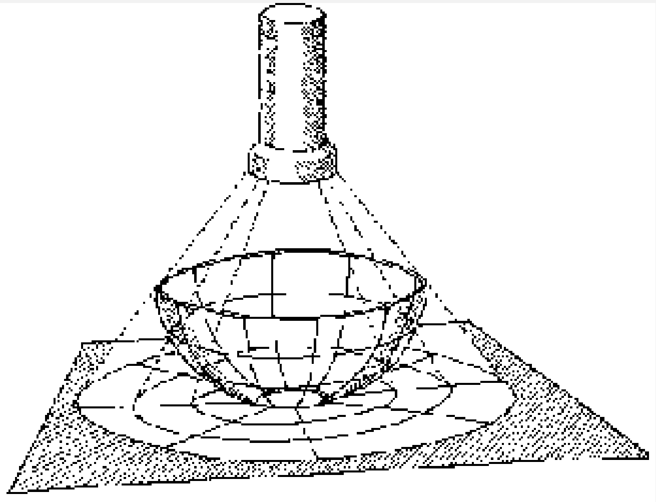
- Know the basic principles of map projections, and the details of some commonly used projections.
- Know about conversion between different systems of georeferencing.

Map Projection

- All of the steps we've discussed still only give us a **3D model of the Earth.**
- Projection: is the systematic transformation of the 3-dimensional Earth into a 2-dimensional flat map.
- uses mathematical formulas to relate spherical coordinates on the globe to flat, planar coordinates.





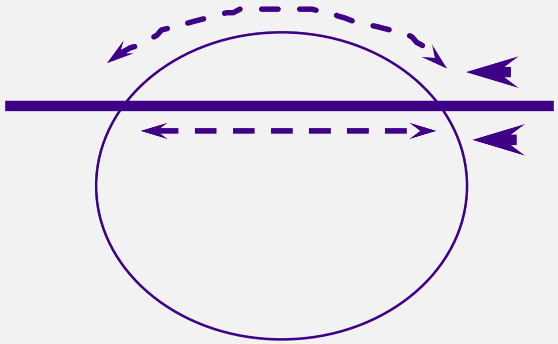


Projections and Coordinates

- There are many reasons to project the Earth's surface onto a plane, rather than dealing with the curved surface
  - The paper used to output GIS maps is flat.
  - Flat maps are scanned and digitized to create GIS databases.
  - Square and rectangular rasters are flat (gaps and overlaps).
  - The Earth has to be projected to see all of it at once.
  - It's much easier to measure distance on a plane.

Distortions

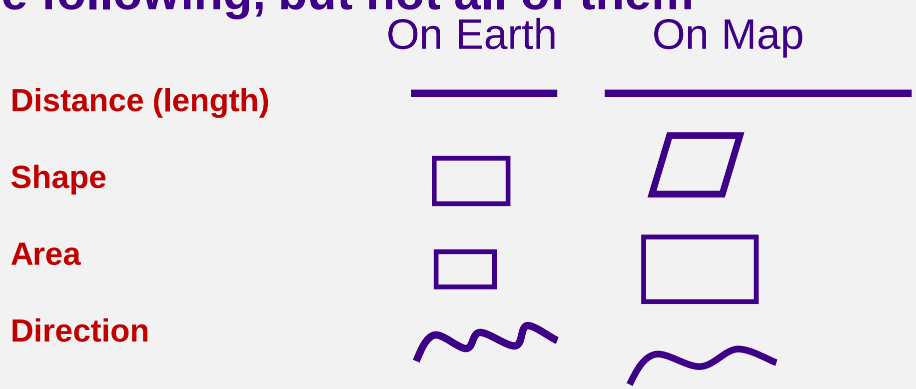
- **Distortion is inevitable because we are trying to represent a 3-D sphere on a 2-D plane.**



We are trying to represent **this** amount of the earth on

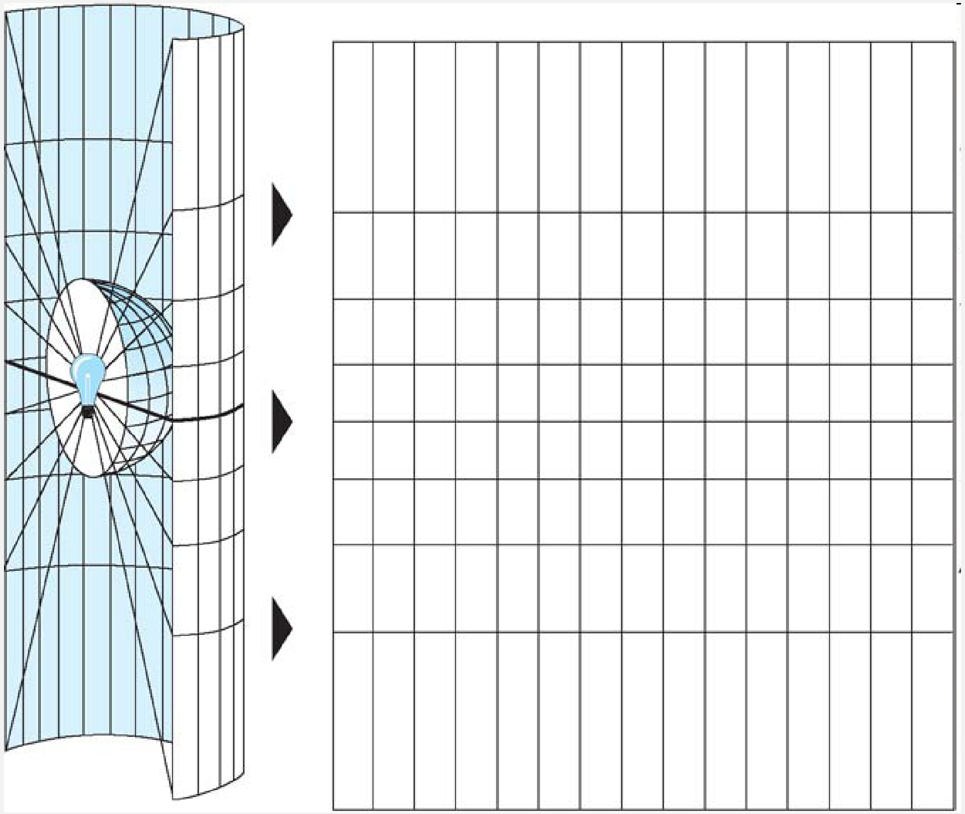
this amount of map space.

- **Any projection must distort the Earth in some way with respect to at least one of the following, but not all of them**



- **Consequently, there is no universal "best" map projection for each mapping project. Instead, the GIS professional must select the map projection best suited to his needs, which minimizes the distortion for the most important features to be portrayed on the map.**

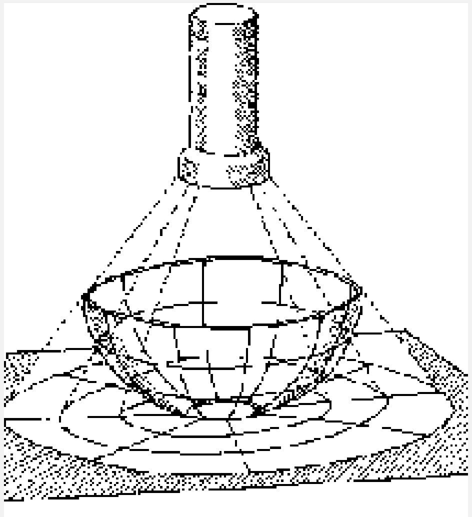
Projecting Onto a Flat Surface



- **What you need:**
  - A datum
  - A developable surface
  - A light source

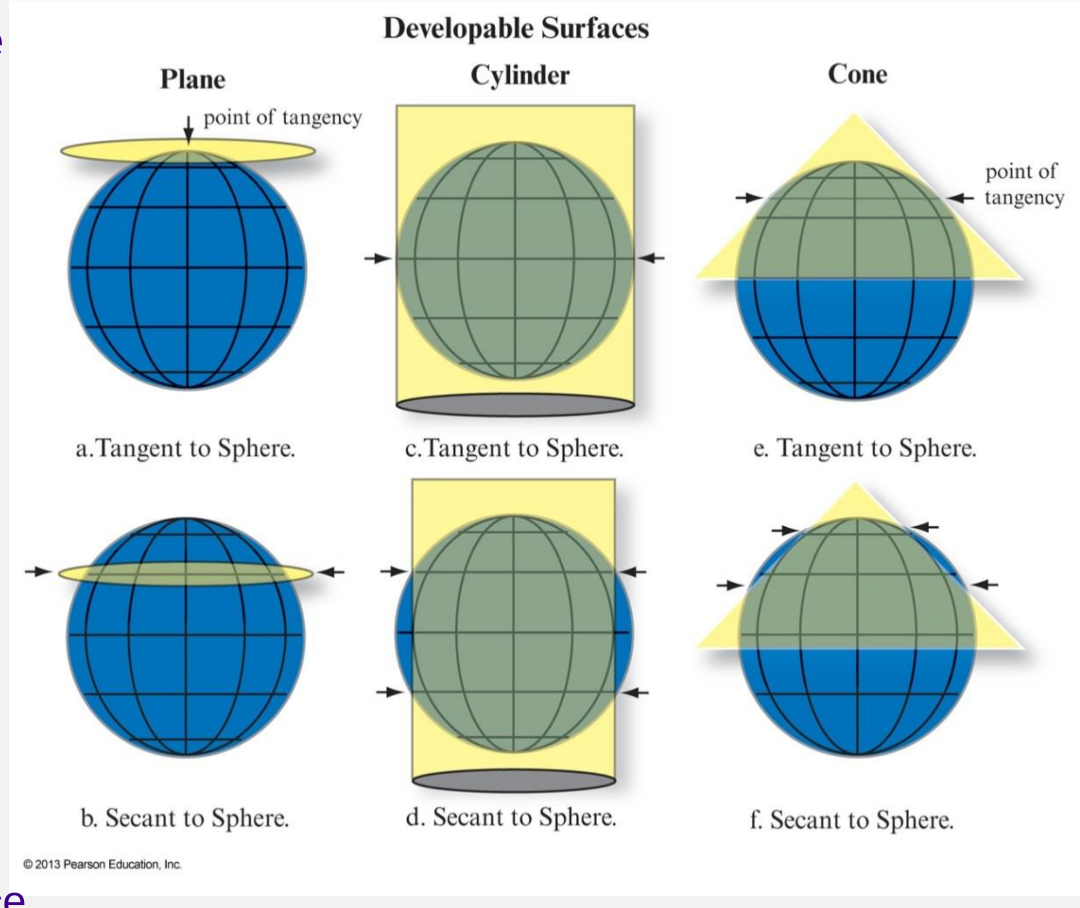
- **Position everything such that the light source shines through the datum and casts shadows on the developable surface.**

- **The result is your map.**



Projections Classified by Developable Surfaces

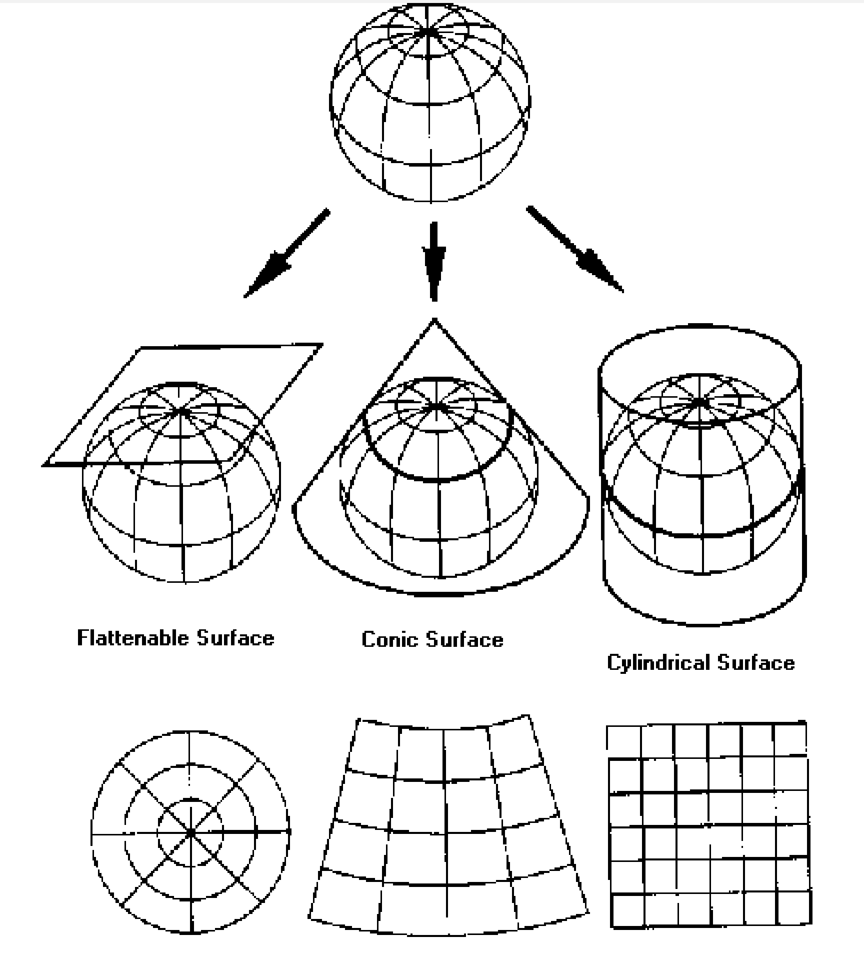
- A developable surface is a simple geometric form capable of being flatted without compressing or stretching.
- Three general families:
  - Planar
  - Cylindrical
  - Conical
- Two types
  - Touch (tangent)
  - Intersect (secant)
  - The place(s) where the sphere **intersects** the developable surface is the **most accurate** area of a map projection



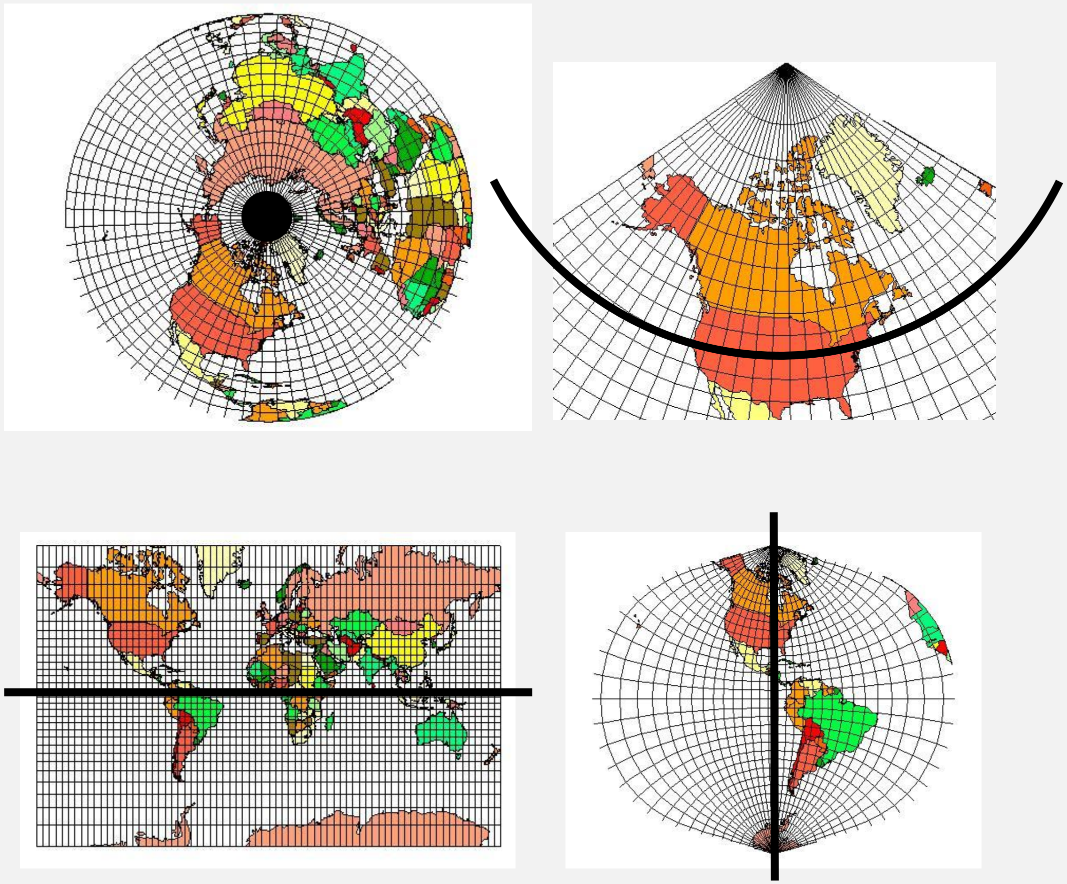
Poles Tropics Mid -Latitudes

Projections Classified by Developable Surfaces

Although these surfaces may start out as a cone or cylinder, they are always 'unfurled' to be totally flat

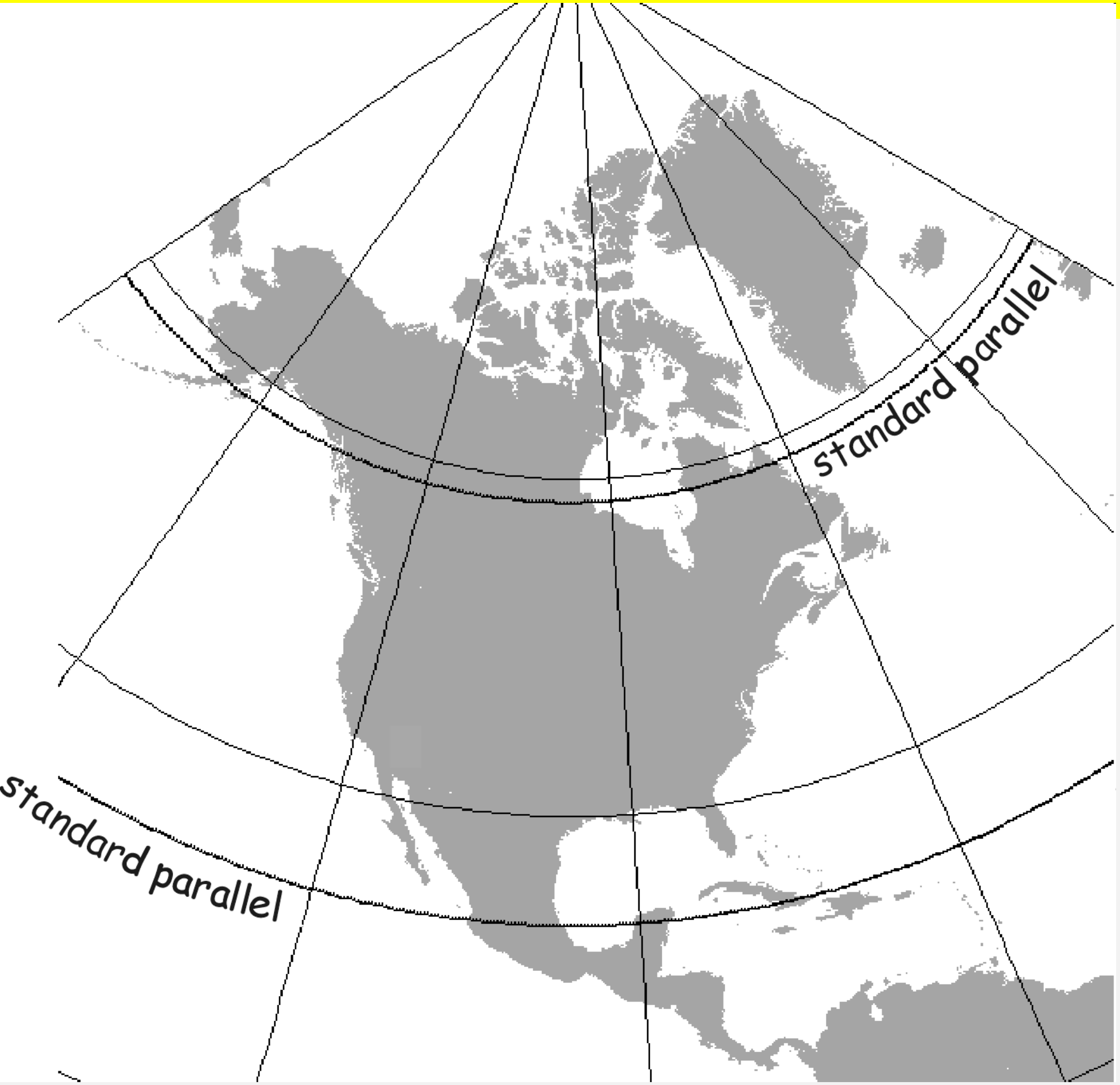


Standard Parallels



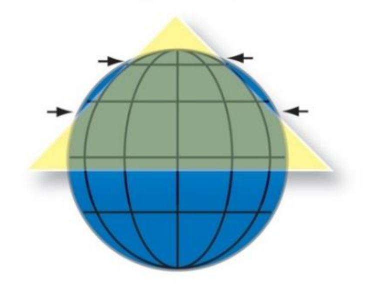
- These are the locations at which the developable surface meets the reference ellipsoid.
- Distortion is minimized in these areas.

Standard Parallels



- **Is this a planar, cylindrical, or conic projection?**
- **Is it tangent or secant?**

Answer: it is conic (meridians are straight lines, parallels are arcs) and secant (2 standard parallels)



f. Secant to Sphere.

Projections Classified by What's Preserved

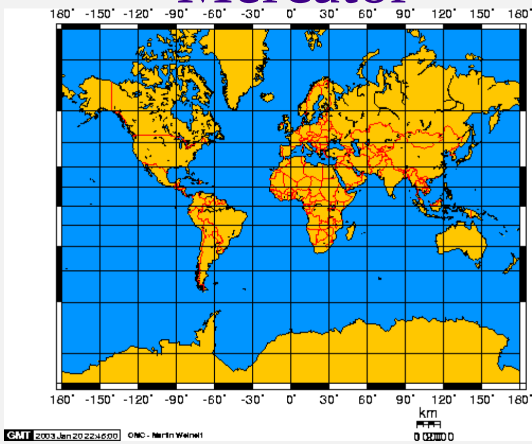
- **All projections contain distortions of some sort, but they often also preserve some aspects of the world.**
- **Equal area projections preserve the area of features (popular in GIS).**
- **Conformal projections preserve the shape of small features (good for presentations), and show local directions (bearings) correctly (useful for coastal navigation!).**
- **Equidistant projections preserve distances (scale) to places from one point, or along one or more lines.**
  - Scale can never be correct everywhere on any map.
- **True direction projections preserve bearings (azimuths) either locally (in which case they are also conformal) or from center of map.**
- **We explore the effects of some of these properties in the Mapping Carbon Footprints lab.**

Azimuth: *angle between a great circle (line on globe) and a meridian.*

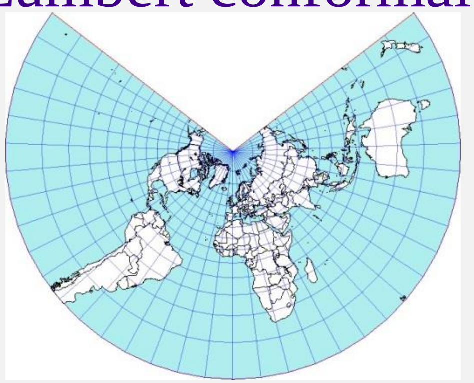
No flat map can preserve both area AND shape

Conformal

Mercator

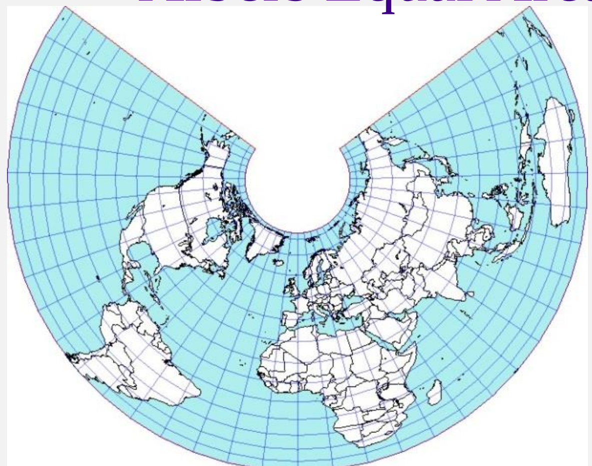


Lambert conformal conic



Equal-Area

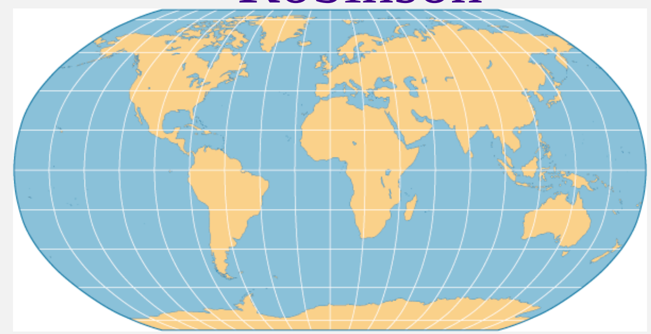
Albers Equal Area



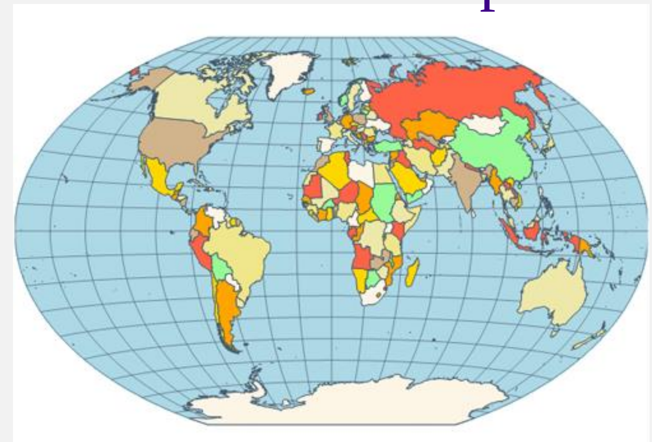
Sinusoidal

Compromise

Robinson

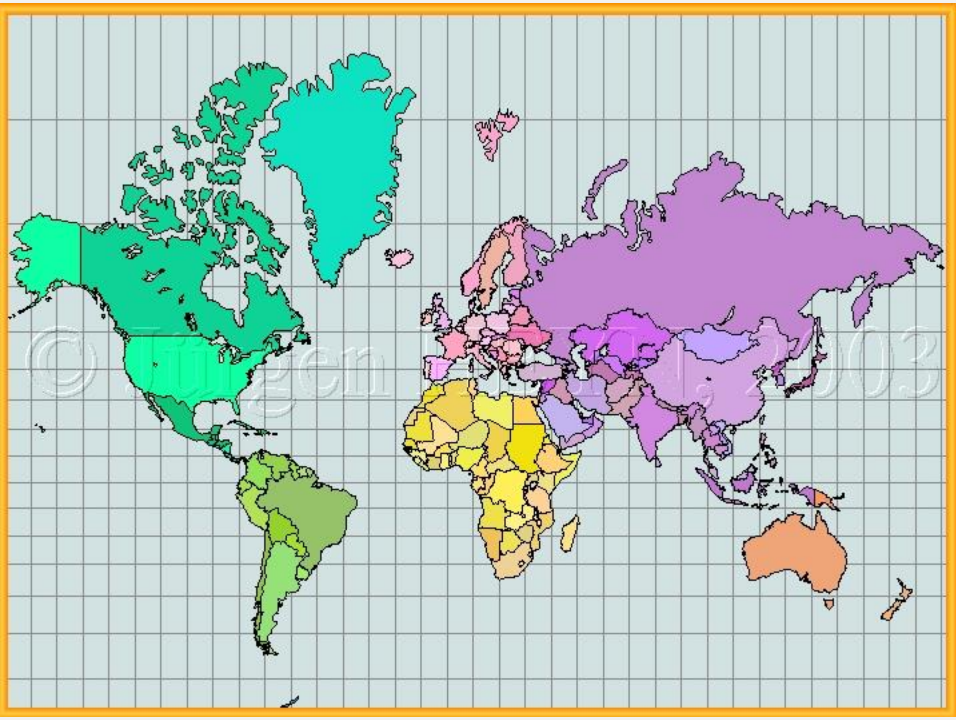


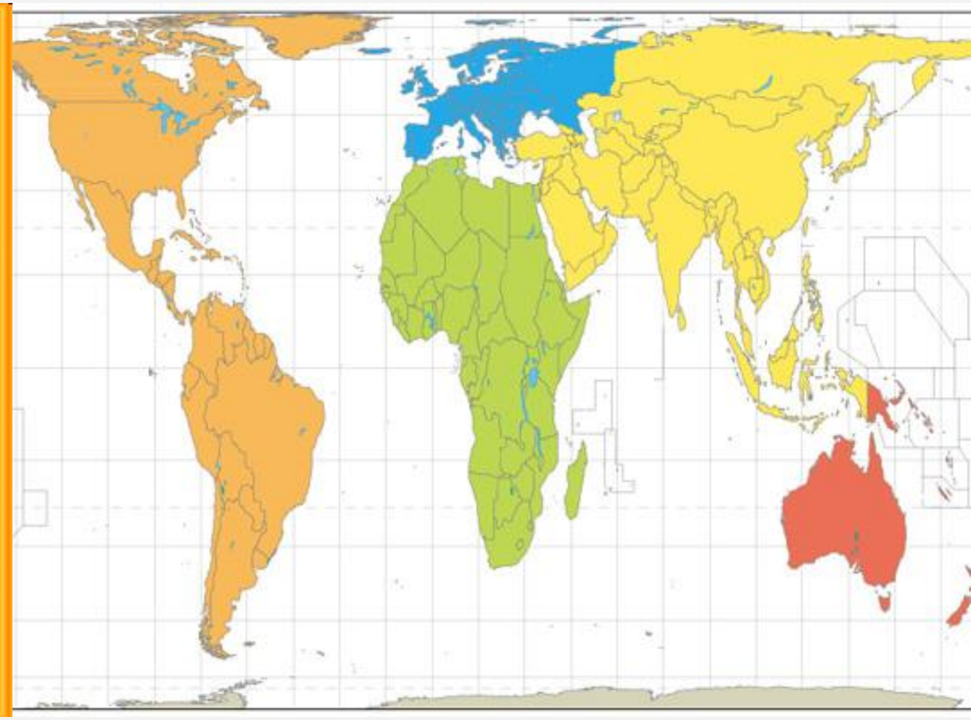
Winkel Tripel



Angle vs. Area

- Mercator (left) – **preserves angles and shapes.**
- Gall-Peters (right) – **preserves area**, does a poor job at preserving shape.

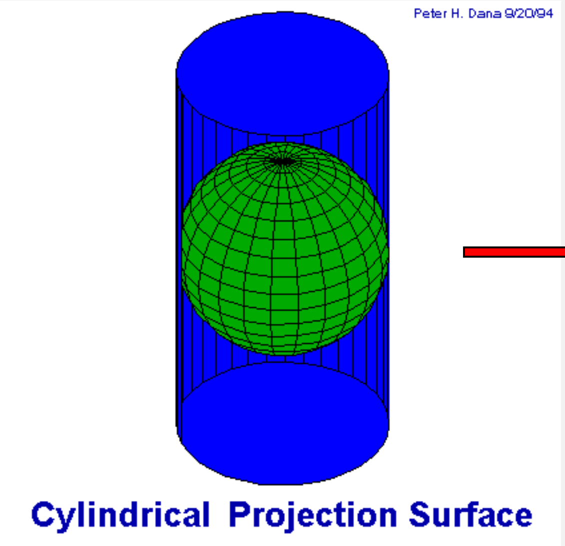


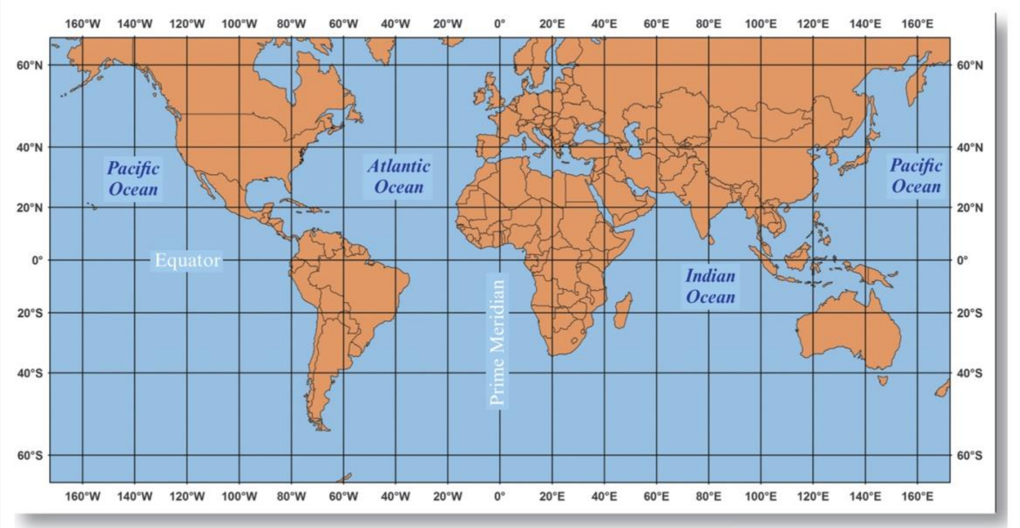


- **Notice** how differently each projection shows the **relative size of countries.**
- But, also notice how distorted some country shapes are in the Gall-Peters projection.
- **What purpose would each projection be best at achieving?**

Mercator

- **The Mercator projection is the best-known cylindrical projection.**
  - **Was developed by Gerardus Mercator in 1569 for navigation purpose.**
  - **The cylinder is wrapped around the Equator.**
  - **The poles are typically not shown in a Mercator map projection because of the extreme distortion in these areas .**
  - **The Mercator map projection is excellent for mapping equatorial regions.**
  - **The Mercator projection is conformal, therefore it is best suited for navigation**
    - **The use of Mercator for nautical charting is universal.**

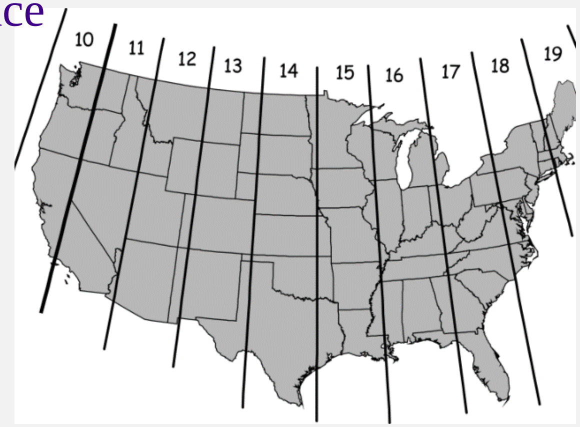




a. Mercator conformal map projection.

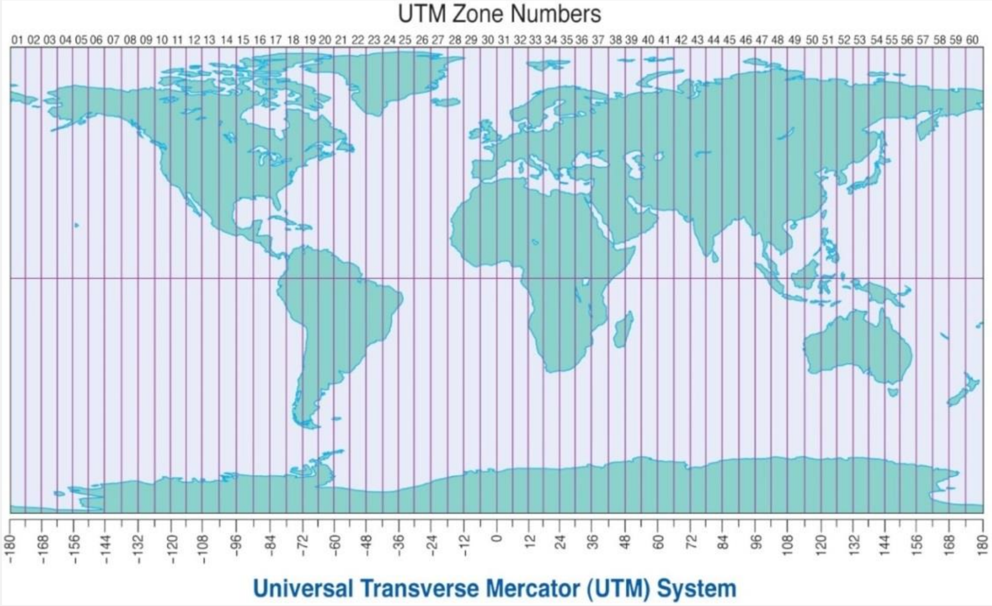
Universal Transverse Mercator (UTM)

- A type of cylindrical projection
  - Transverse Mercator because the cylinder is wrapped around the poles, not the Equator.
  - UTM is secant, with two standard parallels located some distance out on both sides of the central meridian.
  - Uses a system of 60 zones being 6 degree longitude wide.
    - *Zone 1: from 180W to 174W centered on 177W*
  - Extent
    - The north zone extends from the Equator to 84N latitude .
    - The south zone extends from the Equator to 80S latitude.



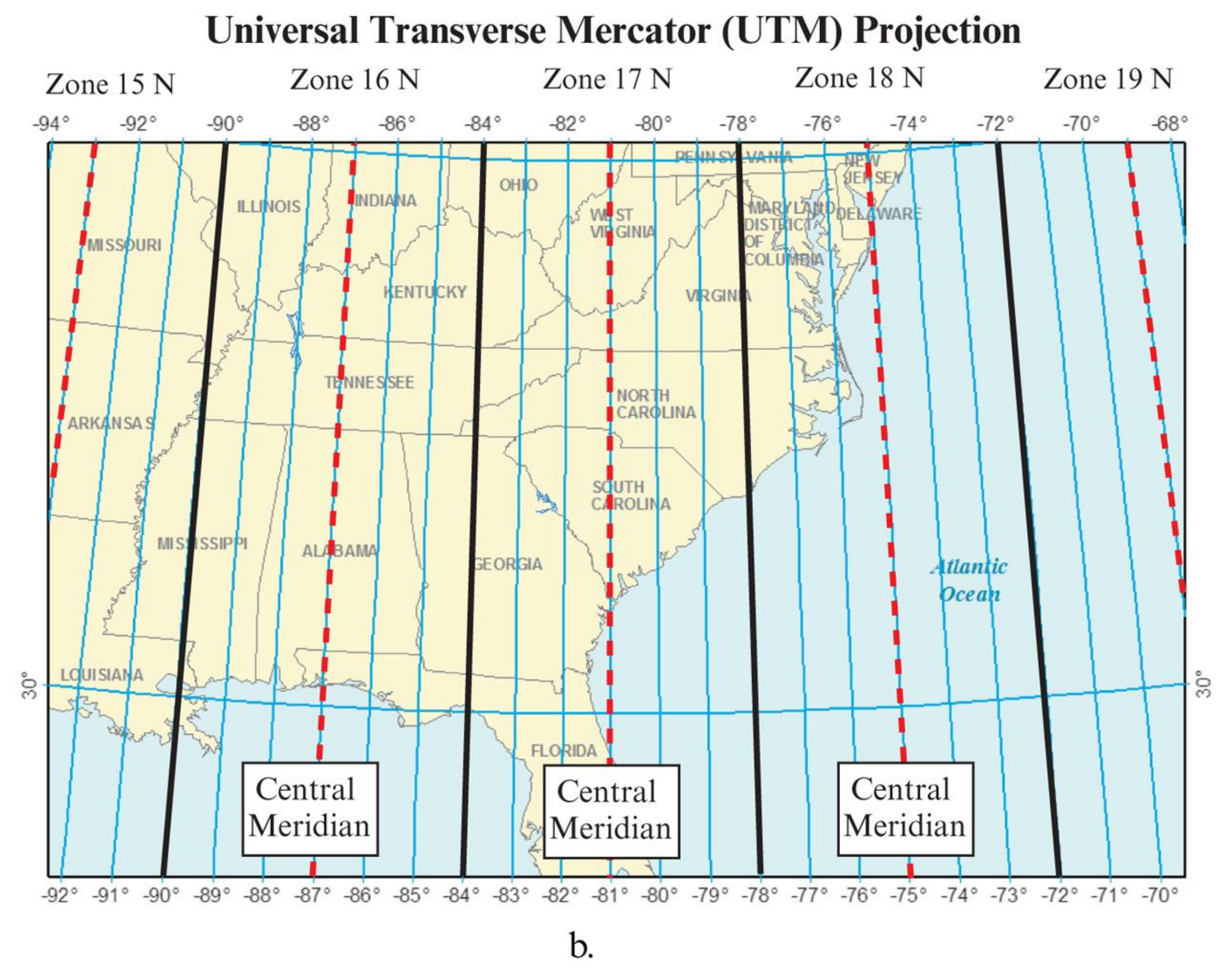
- Washington is split across **2 UTM zones** (10N, 11N)

- Texas is split across **3 UTM zones** (13N,14N,&15N)



UTM

- **UTM is often used for mapping large areas that are mainly north-south in extent**



Implications of the Zone System

- UTM coordinates are in meters, making it easy to make accurate calculations of short distances between points.
- Because each zone defines a different projection (60 different projections!), maps will not fit together across a zone boundary.
- Therefor, it is often difficult to use a UTM map projection when the study area crosses multiple UTM zones from east to west.
- Zones become a problem at high latitudes above 80 degree latitude.
- Jurisdictions that span two zones must make special arrangements
  - Use only one of the two projections, and accept the greater-than-normal distortions in the other zone.
  - Use a special zone, with its own central meridian selected to pass directly through the city’s center.
  - E.g. CA spans UTM zones 10 and 11

Local Systems: State Plane Coordinates (SPC)

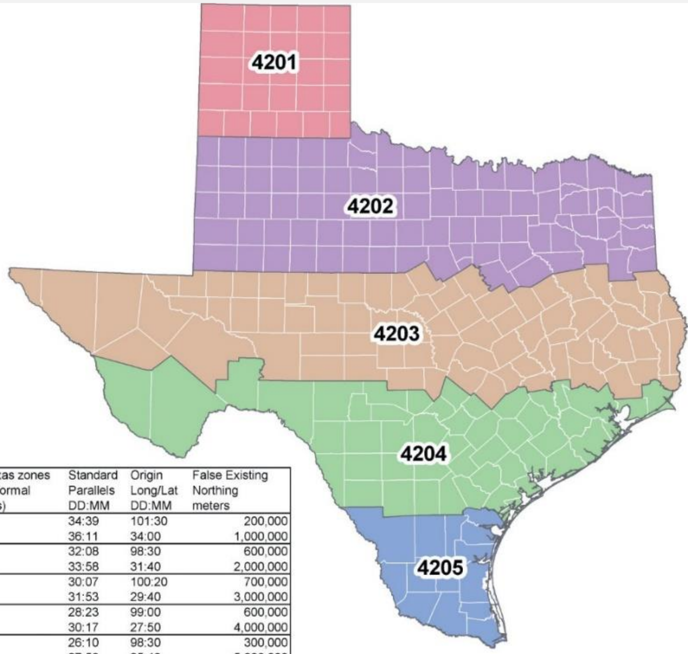
- **All US states have adopted their own specialized SPCs in 1930s**
  - Provides less distortion than UTM.
  - Used for applications needing very high accuracy, such as surveying.
  - Projections were chosen to minimize distortion over the area of the state, so choices were often based on the state's shape and geographical location on the sphere.
  - Some large states decided that distortions were still too great, so they designed their SPCs within internal zones.
  - Several different types of projections are used by the system.
  - The original units for the SPC was based on NAD 27 datum in feet.
  - Recently, SPC was revised to be based on NAD83 in meter.
  - Most local government data are based on the use of SPC.
  - It is not a good choice if the study area crosses multiple states.

•Each zone uses either a locale transverse Mercator projection or a Lambert conformal projection

•Depends on the location and shape of the state

•**Lambert conformal** is good at maintaining accuracy along **east-west** lines – good for **'long' states.**

•**Transverse Mercator** is better at maintaining accuracy along **north-south** lines – good for **'tall' states.**



Zone Codes (Texas zones are Lambert conformal Conic Projections)	Standard Parallels DD:MM	Origin Long/Lat DD:MM	False Existing Northing meters
North TX N 4201	34:39 36:11	101:30 34:00	200,000 1,000,000
North Central TX NC 4202	32:08 33:58	98:30 31:40	600,000 2,000,000
Central TX C 4203	30:07 31:53	100:20 29:40	700,000 3,000,000
South Central TX SC 4204	28:23 30:17	99:00 27:50	600,000 4,000,000
South TX S 4205	26:10 27:50	98:30 25:40	300,000 5,000,000

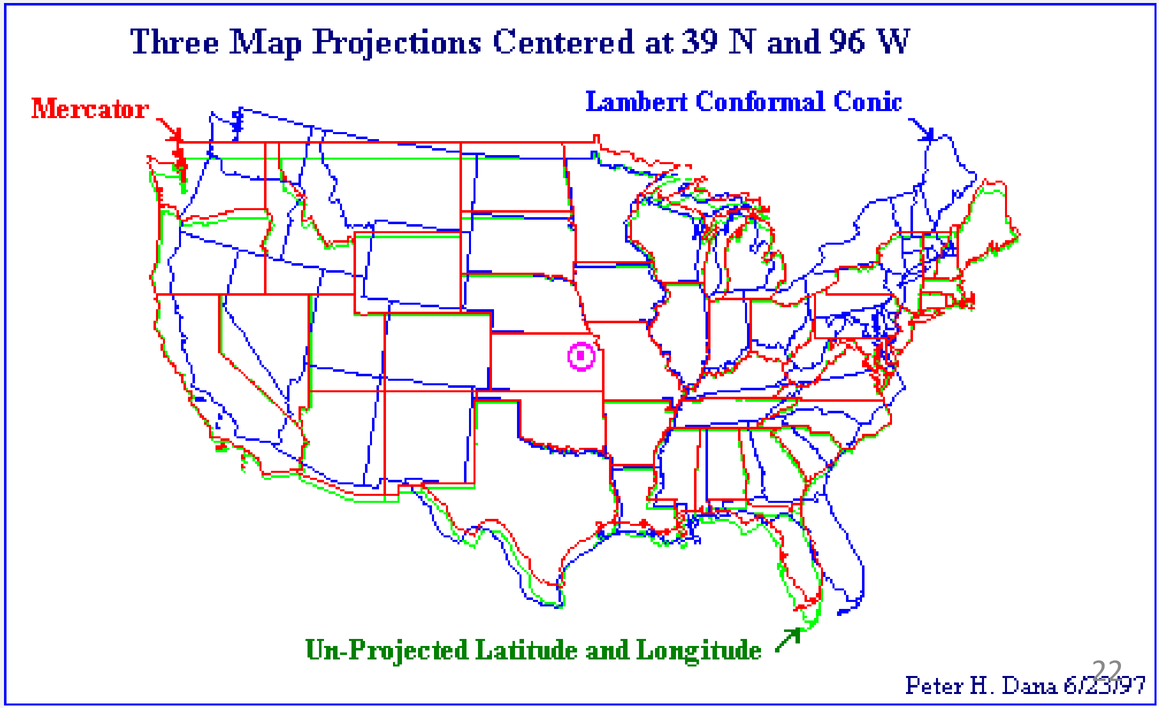
Some projections try to make social/political point…

How Do I Choose?

- **Consider the:**
  - Use and **purpose** of the map
  - **Scale and area** to be shown on the map
  - Property that is critical to **preserve**
- **General rules of thumb:**
  - A country in the tropics is probably best represented with a cylindrical projection.
  - A country in the temperate zone (mid -latitudes) is probably best represented with a conical projection.
  - A polar area is probably best represented with an azimuthal projection.
  - If you are performing some form of analysis, make sure that you choose a projection that preserves the spatial aspect that is being analyzed.
    - For example, don't calculate distance using a projection that doesn't preserve distance.

Projections and GIS

- **It is easy to forget to check on the projection of your data – but you shouldn't do this!**
- **You want to make sure that:**
  - You are using a good projection for the task at hand
  - All of your data is using the same projection
- **GIS layers that are created using different projections will not line up correctly!**
  - You will therefore need to re-project the data
  - Sometimes ArcGIS will do this for you automatically… but, don't risk it!
  - We'll explore this more through lab



Georeferences as Measurements

- **Some georeferences are metric**
  - They allow maps to be made and distances to be calculated
    - E.g. distance from the Equator or from the Greenwich Meridian
- **Others are based on ordering**
  - E.g. street addresses in most parts of the world order houses along streets
- **Others are only nominal**
  - Placenames do not involve ordering or measuring

Table 5.1 Some commonly used systems of georeferencing.

System	Domain of uniqueness	Metric?	Example	Spatial resolution
Place-name	varies	no	London, Ontario, Canada	varies by feature type
Postal address	global	no, but ordered along streets in most countries	909 West Campus Lane, Goleta, California	size of one mailbox
Postal code	country	no	93117 (U.S. zip code); WC1E 6BT (UK Unit Postcode)	area occupied by a defined number of mailboxes
Telephone calling area	country	no	805	varies
Cadastral system	local authority	no	Parcel 01452954, City of Springfield, MA	area occupied by a single parcel of land
Public Land Survey System	Western Canada and United States only, unique to Prime Meridian	yes	Sec 5, Township 4 N, Range 6E	defined by level of subdivision
Latitude/ longitude	global	yes	119 degrees 45 minutes West, 34 degrees 40 minutes North	infinitely fine
Universal Transverse Mercator	zones six degrees of longitude wide, and N or S Hemisphere	yes	563146E, 4356732N	infinitely fine
State Plane Coordinates	United States only, unique to state and to zone within state	yes	55086.34E, 75210.76N	infinitely fine

Conclusions

- There are several different systems which we may use to georeference data.
- Common referencing systems vary around the world.
- There are three basic types of map projections; cylindrical, planar, and conic.
- Global coordinate systems all differ and may distort how the data is displayed on a GI System.

Questions ?

https://www.google.com/url?sa=i&source=images&cd=&cad=rja&uact=8&ved=2ahUKEwihuqvgkpjcAhU3IDQIHZbqB8QQjRx6BAgBEAU&url=http%3A%2F%2Fwww.cityofrockhill.com%2Fdepartments%2Finformation-technology-services%2Fmore%2Finformation-technology-services%2Fgeographic-information-systems-gis-%2Fgis-frequently-asked-questions&psig=AOvVaw2fEUXAIjbJY26W-bnjS0wY&ust=1531436220322311

Upcoming

- Friday (Lecture) : Georeferening (Cont ..)
- Submit Assignment 00 and Lab 01
- Readings updated on canvas.
- Week 3, GIS Lab 03 Assigned.