FE 257. GIS and Forest Engineering Applications

Week 6

Week 6

- Last week
  - Chapter 8
    - Combining and splitting landscape features and merging GIS databases
  - Chapter 11
    - Overlay processes
- Questions?
- Next week
  - Chapter 13: Raster GIS Database Analysis
  - Chapter 9: Associating Spatial and Non-spatial Databases

This week's topics

- Chapter 2
  - Map projections: pp. 27-37
  - Where in the world are my data?

Geographic Information Systems

Applications in Natural Resource Management

Chapter 2
GIS Databases:
Map Projections, Structures, and Scale

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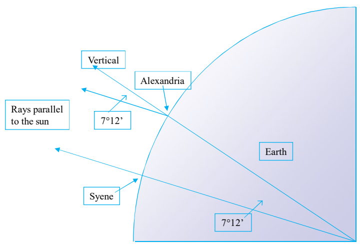
Chapter 2 Objectives

- **Definition of a map projection, and the components that comprise a projection**
- Components and characteristics of a raster data structure
- Components and characteristics of a vector data structure
- The purpose and structure of metadata
- Likely sources of GIS databases that describe natural resources within North America
- Types of information available on a typical topographic map and
- Definition of scale and resolution as they relate to GIS databases

Big questions…

- What is the size and shape of the earth?
- Geodesy: the science of measurements that account for the curvature of the earth and gravitational forces
- We are still refining our approximation of the earth's shape but are relying on GPS measurements for much of this work



360 / 7°12' = 1/50

500 miles * 50 = 25,000

Figure 2.1. Eratosthenes' (276-194 BC) approach to determining the Earth's circumference.

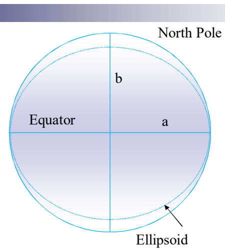


Figure 2.2. The ellipsoidal shape of the Earth deviates from a perfect circle by flattening at the poles and bulging at the equator.
Isaac Newton (end of the 17th century) theorized this shape.
Field measurements, beginning in 1735, confirmed it.

Earth measurements & models

- Datums
  - Horizontal and vertical control measurements
- Ellipsoids (spheroids)
  - The big picture
- Geoids
  - Gravity and elevation

Horizontal Datums

- Geodetic datums define the orientation of the coordinate systems used to map the earth
  - Where do X, Y, and Z (vertical datum) start?
- Hundreds of different datums exist
- Referencing geodetic coordinates to the wrong datum can result in position errors of hundreds of meters
- ________________________________
  - NAD83 preferred
  - Uses center of the earth as starting point
  - Many GPS systems use WGS84

Vertical Datums

- ________________________________
- National Geodetic Vertical Datum of 1929
  - NGVD29
  - 26 gaging stations reading mean sea level
- North American Vertical Datum of 1988
  - NAVD88
  - 1.3 million readings
  - Has become the preferred datum in the US

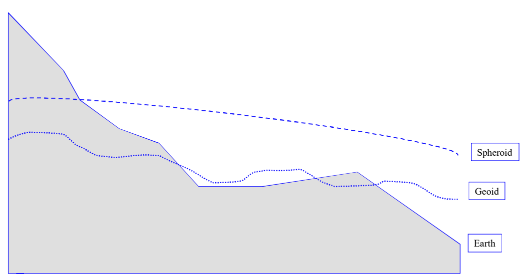
Spheroids

- Newton defined the earth as an ellipse rather than a perfect circle (1687)
  - Spheroids are also called ellipsoids
- Represents the elliptical shape of the earth
- Flattening of the earth at the poles results in about a twenty kilometer difference at the poles between an average spherical radius and the measured polar radius of the earth
- Clarke Spheroid of 1866 and Geodetic Reference System (GRS) of 1980 are common
- WGS84 has its own ellispoid

Geoids

- Attempts to reconcile the non-spherical shape of the earth
- Earth has different densities depending on where you are and gravity varies
- A geoid describes earth's mean sea-level perpendicular at all points to gravity
  - Coincides with mean sea level in oceans
  - Geoid is below ellipsoid in the conterminous US
- Important for determining elevations and for measuring features across large study areas

Figure 2.3. Earth, geoid, and spheroid surfaces



Coordinate Systems

- Used to describe locations
- Many basic coordinate systems exist
  - Instrument (digitizer) Coordinates
  - State Plane coordinates
  - UTM Coordinates
  - Geographic
- Rene Descartes (1596-1650) introduced systems of coordinates
- Two and three-dimensional systems used in analytical geometry are referred to as Cartesian coordinate systems

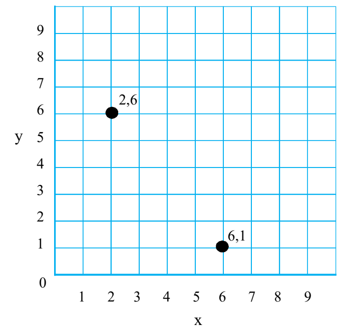


Figure 2.4. Example of point locations as identified by Cartesian coordinate geometry.

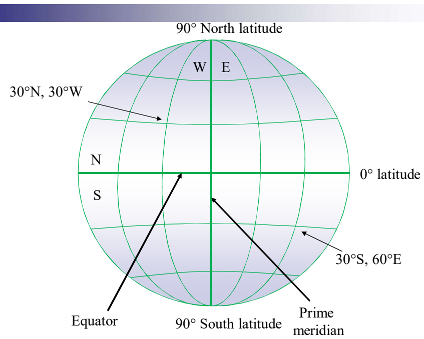
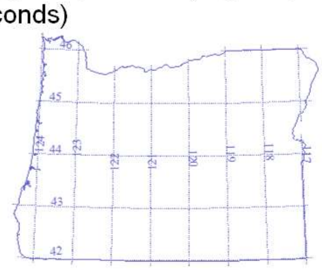


Figure 2.5. Geographic coordinates as determined from angular distance from the center of the Earth and referenced to the equator and prime meridian.

Geographic coordinates

- Longitude, latitude (degrees, minutes, seconds)



Map Projections

- Map projections are attempts to fit the surface of the earth or a portion of the earth on a flat surface
  - Earth features displayed on a computer monitor or on a map
  - Earth is not round, has a liquid core, is not static, and has differing gravitational forces
- Distortions of conformality, distance, direction, scale, and area always result
- Many different projection types exist:
  - ______________________________________

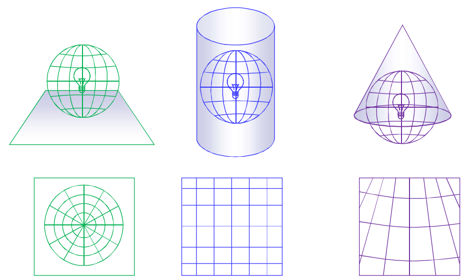
Map projection process: 2 steps

- Measurements from the earth are placed on a three-dimensional globe or curved surface that reflects the reduced scale in which measurements are to be viewed or mapped
  - This is the reference globe
- Measurements placed on the three-dimensional reference globe are then transformed to a two-dimensional surface

Envisioning map projections

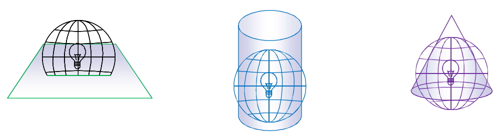
- Transforming three-dimensional earth measurements to a two-dimensional map sheet
- Visualize projecting a light from the middle of the earth and shining the earth's features onto a map
- The map sheet may be:
  - __________
  - Cylindrical
  - Conic

Figure 2.6. The Earth's graticule projected onto azimuthal, cylindrical, and conic surfaces.



Azimuthal Cylindrical Conic

Figure 2.7. Examples of secant azimuthal, cylindrical, and conic map projections.



Azimuthal Cylindrical Conic

Map projections within GIS

- There are several components that make up a projection:
  - Projection classification (the strategy that drives projection parameters)
  - Coordinates
  - Datum
  - Spheroid or Ellipsoid
  - Geoid
- Most full-featured GIS can project coordinate systems to represent earth measurements on a flat surface (map)
  - ArcGIS handles most projections

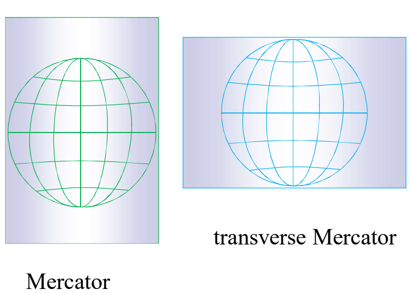
Map projection importance

- GIS analysis relies strongly on covers being in the same coordinate system or projection
  - Do not trust "projections on the fly"
  - This is the visual referencing of databases in different projections to what appears to be a common projection
- Failure to ensure this condition will lead to bad analysis results
- You should always try to get information about the projection of any spatial themes that you work with
  - Metadata- ______________________

The classification of map projections according to how they address distortion

- Conformal
  - Useful when the determination of distances or angles is important
  - Navigation and topographic maps
- Equal area
  - Will maintain the relative size and shape of landscape features
- Azimuthal
  - ____________________________________

Figure 2.8. The orientation of the Mercator and transverse Mercator to the projection cylinder.



Common Map Projections

- Lambert (Conformal Conic)- Area and shape are distorted away from standard parallels
  - Used for most west-east State Plane zones
  - There is also a Lambert Azimuthal projection that is planar-based
- Albers Equal Area (Secant Conic)-
  - Maintains the size and shape of landscape features
  - Sacrifices linear and distance relationships
- Mercator (Conformal Cylindrical)- straight lines on the map are lines of constant azimuth, useful for navigation since local shapes are not distorted
  - Transverse Mercator is used for north-south State Plane zones

Planar coordinate systems

- Used for locating features on a flat surface
- Universal Transverse Mercator
  - The most popular coordinate system in the U.S. and Canada
  - Even used on Mars
  - 1:2,500 accuracy
- State plane coordinate system
  - Housed within a Lambert conformal conic or Tranverse Mercator projection
  - 1:10,000 accuracy

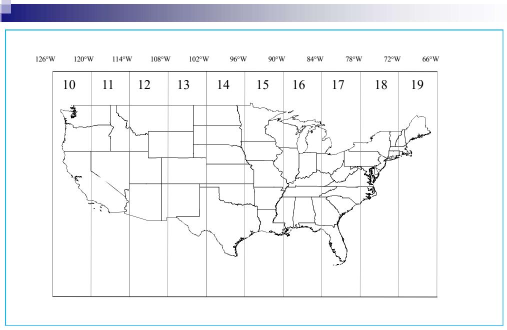


Figure 2.9. UTM zones and longitude lines for the U.S.

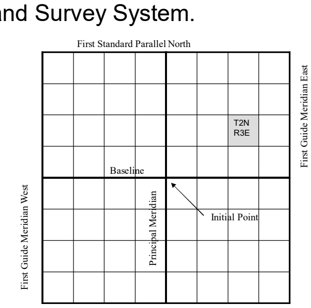
Where do coordinates come from?

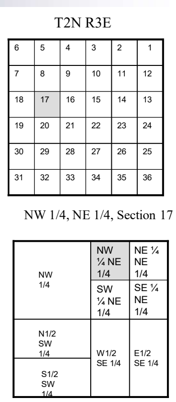
- Many measurements
- Initially these are manual measurements
  - ____________________________________
    ____
  - The Dominion Land Survey within Canada
- GPS is now used to refine measurements and support coordinate systems

Public Lands Survey System

- The mapping of the U.S. and where U.S. coordinates originated from
- Thomas Jefferson proposed the Land Ordinance of 1785
  - Begin surveying and selling (disposing) of lands to address national debt
- Surveying begins in Oregon in 1850
- U.S. not linked by the PLS until 1903!
  - Provided first quantitative measurement from coast-to-coast

Figure 2.10. Origin, township, and section components of the Public Land Survey System.





Projection challenges

- Within several miles of Oregon State University, you would find several different map projections being applied to spatial databases
- Siuslaw National Forest
  - UTM (Universal Transverse Mercator) zone 10, NAD27
- Benton County Public Works & McDonald Forest
  - Oregon State Plane North, NAD83/91
- OSU Departments
  - Various map projections
- A potential solution
  - Create a map projection customized for Oregon
  - Oregon Centered Lambert, NAD83

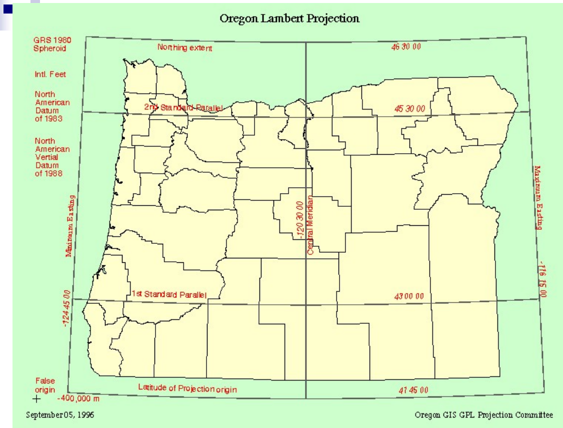
Oregon's Projection

- Selected by state leaders in 1996
  - Designed to centralize projections used by state agencies
- Projection: LAMBERT
- Datum: NAD83
- Units INTERNATIONAL FEET, 3.28084 units = 1 meter (.3048 Meters)
- Spheroid GRS1980

Oregon's Projection Specifics

- 43 00 00.00 /* 1st standard parallel
- 45 30 00.00 /* 2nd standard parallel
- -120 30 0.00 /* central meridian
- 41 45 0.00 /* latitude of projection's origin

- -400,000.00 /* false easting (meters), (1,312,335.958 feet)
- 0.00 /* false northing (meters)



Finding projection information

- Should always be part of the metadata document
  - Example: the Oregon Geospatial Enterprise Office
    - https://www.oregon.gov/geo/Pages/format.aspx
  - Can also be stored as part of a shapefile
  - The .prj part of the shapefile will contain projection information but it is not created automatically- a user must create the file

Projection information

- Within ArcGIS, you can examine projection information (if it exists) by examining a layer's properties
- Without the projection information, you'll need to do detective work
  - Probability for success: low
- Wing, M.G. 2011. Measurement differences resulting from analyzing natural resource spatial databases referenced to multiple map coordinate systems. Mathematical and Computational Forestry & Natural Resource Sciences 3(2):53-63.