FOR 421/521. Spatial Analysis of Forest Landscapes

Map Projections

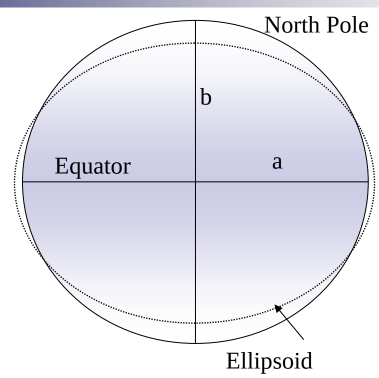


Figure 2.2. The ellipsoidal shape of the Earth deviates from a perfect circle by flattening at the poles and bulging at the equator.

Isaac Newton (end of the 17^{th} century) theorized this shape.

Field measurements, beginning in 1735, confirmed it.

Projections

- Map projections are attempts to portray the surface of the earth or a portion of the earth on a flat surface
  - 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:
  - Lambert, Albers, Mercator

Projections

- There are several components that make up a projection:
  - Projection type (the strategy that drives projection parameters)
  - Coordinates
  - Datum
  - Spheroid or Ellipsoid
  - Geoid
- Most full-featured GIS can project coordinate systems to represent the earth's spheroid on a flat surface (map)
  - ArcGIS is license dependent

Projections

- GIS analysis relies strongly on covers being in the same coordinate system or projection
- Failure to ensure this condition may lead to bad results
- You should always try to get information about the projection of any spatial themes that you work with
  - Metadata- data about data

Projections

- Transforming the three dimensional earth to a flat 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:
  - Planar
  - Cylindrical
  - Conic

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

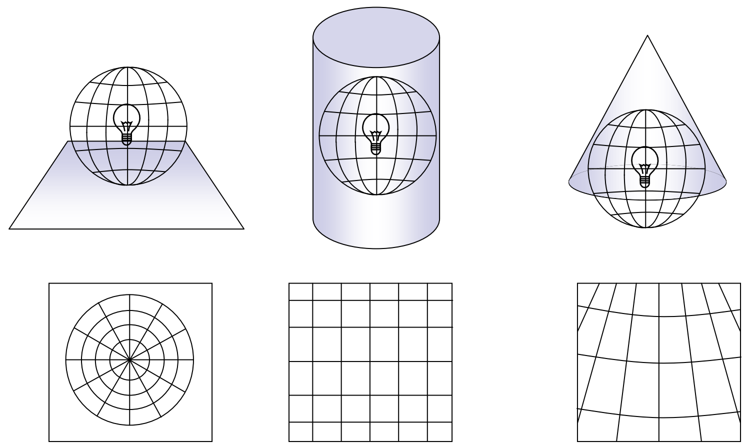


Figure 2.7. Examples of secant azimuthal, cylindrical, and conic map projections.

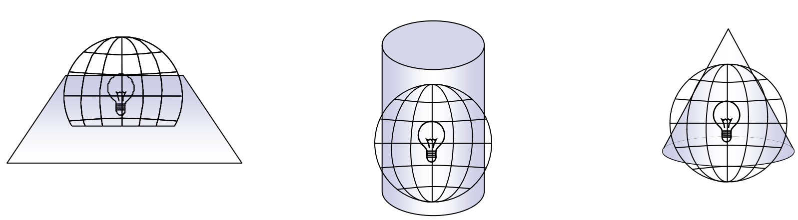
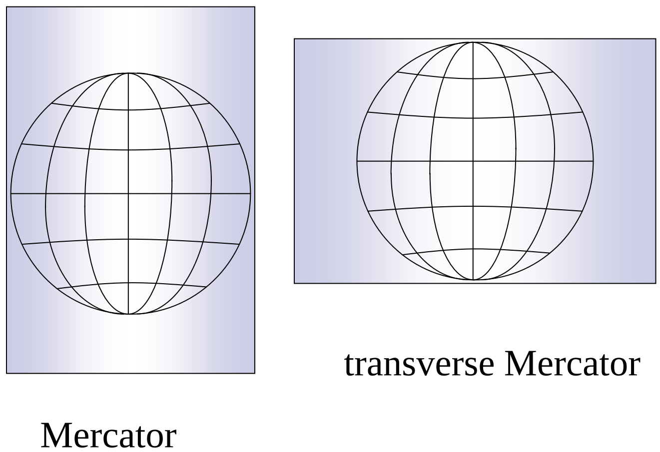


Figure 2.8. The orientation of the Mercator and transverse Mercator to the projection cylinder.



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
  - Maintains direction on a mapped surface

Common US Projection Examples

- 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

Coordinate Systems

- Used to describe the location of an object
- 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

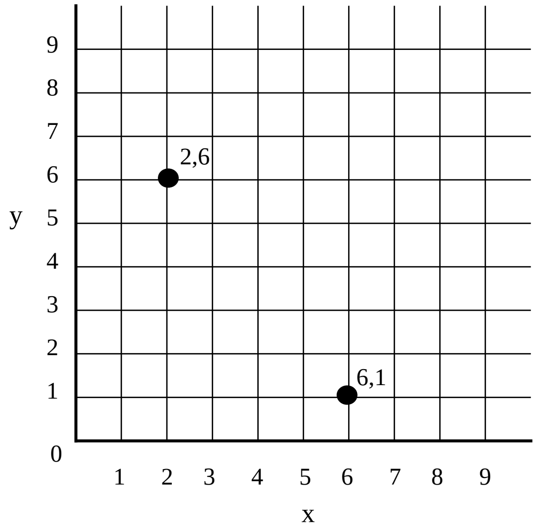


Figure 2.4. Example of point locations as identified by Cartesian coordinate geometry.

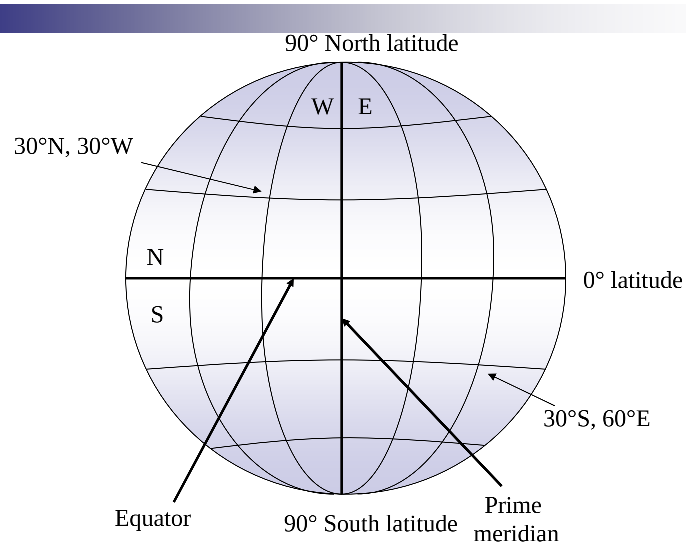
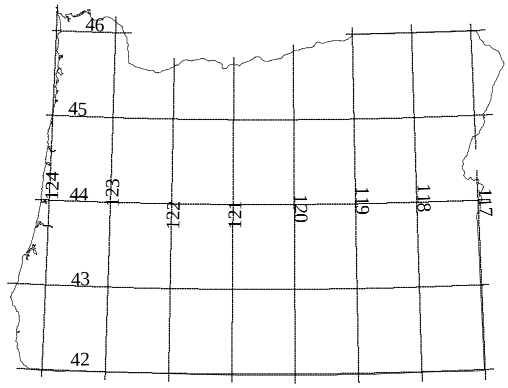


Figure 2.5. Geographic coordinates as determined from angular distance from the center of the Earth and referenced to the equator and prime meridian.

Cartesian Coordinate Example

- Geographic: Longitude, latitude (degrees, minutes, seconds)



Horizontal Datums

- Geodetic datums define orientation of the coordinate systems used to map the earth
- Hundreds of different datums exist
- Referencing geodetic coordinates to the wrong datum can result in position errors of hundreds of meters.
- NAD27 and NAD83 common in US
  - NAD83 preferred
  - Uses center of the earth as starting point
  - Many GPS systems use WGS84

Vertical Datums

- For use when elevation is of interest
- 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

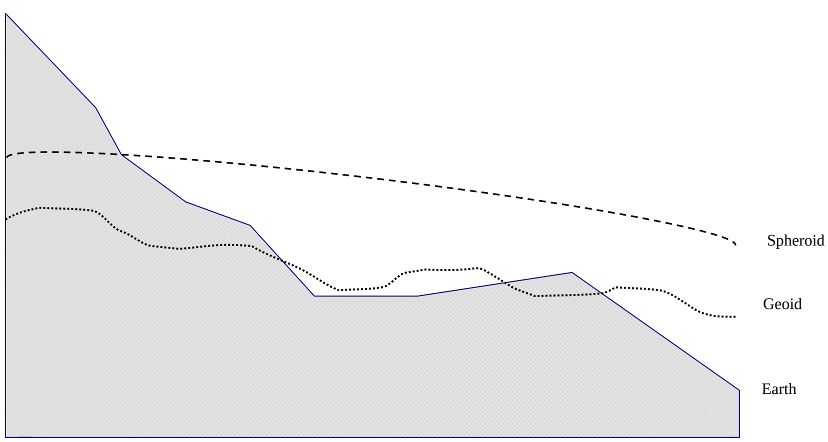
Spheroids

- 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

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 large study areas

Earth, geoid, and spheroid surfaces



Common Oregon projections

- State
  - Oregon Centered Lambert, NAD83
  - More about this later
- USGS, USFS
  - UTM (Universal Transverse Mercator) zone 10, NAD27
- McDonald Forest
  - Oregon State Plane North, NAD27

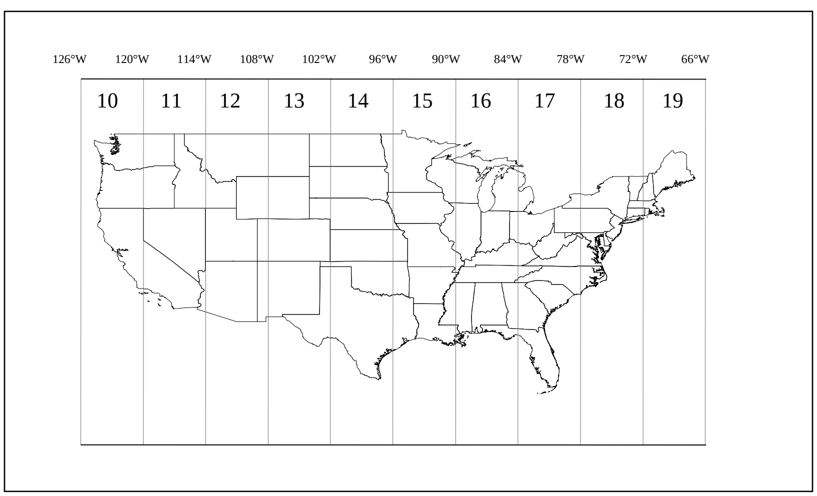
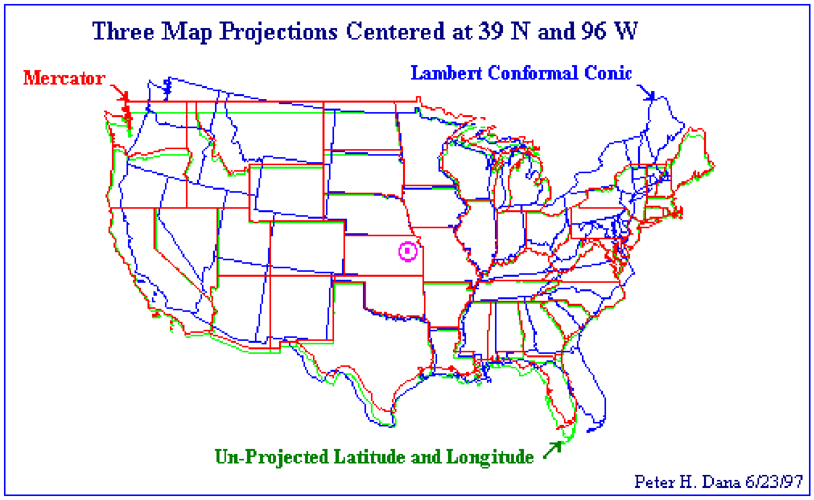
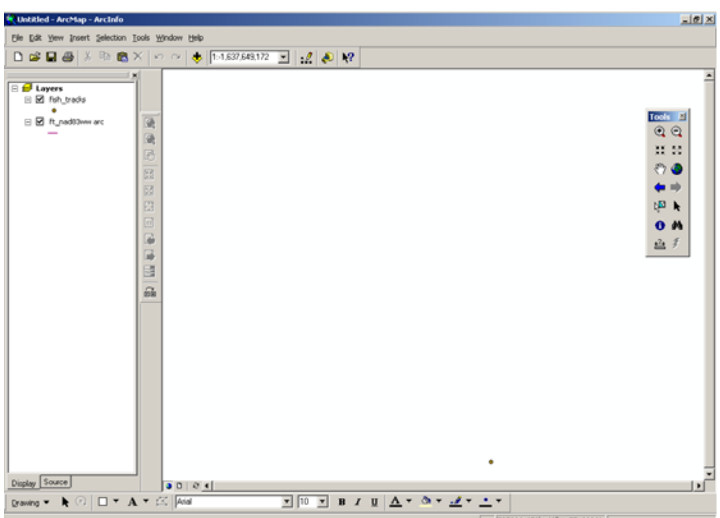


Figure 2.9. UTM zones and longitude lines for the U.S.

When projections don’t match…



ArcGIS Response to Projection Mismatch



ArcGIS Projection Capabilities

- ArcGIS Projection Abilities
  - ArcView will allow you to project shapefiles
  - ArcEditor and ArcInfo will allow you to project shapefiles and coverages

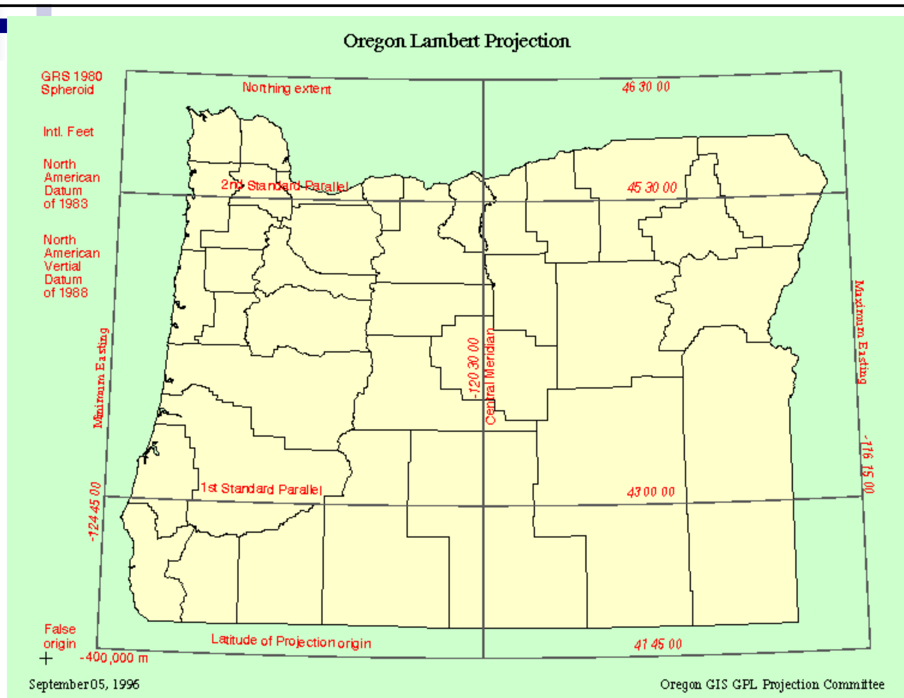
Oregon's Projection

- Selected by state leaders 6-7 years ago
  - 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
  - See Oregon Geospatial Data Clearinghouse for example
- Can also be stored as part of an ArcInfo coverage or an ArcView shapefile
  - The .prj part of the shapefile will contain projection information but it is not created automatically- a user must create the file
  - Within ArcGIS, you can examine projection information (if it exists) by examining a layer's properties
  - You can return projection information in workstation ArcInfo with the DESCRIBE command
- Without projection information, you'll need to do detective work