Map Projections and Layout

A. Michelle Lawing
Ecosystem Science and Management
Texas A&M University
College Station, TX 77843
alawing@tamu.edu
Importance of understanding map projections

• You need a map projection to create a map

• All projections distort the surface

• Gain better understanding of which distortions are acceptable

• Subject of pure mathematics fields of differential geometry and projective geometry

South America Projections
Map Projection - Definition

• Systematic transformation of latitudes and longitudes of locations of a sphere or ellipsoid into locations on a plane

• A great illustration of the concept of map projections is from a 1921 book, Elements of map projection with applications to map and chart construction, written by Deetz and Adams.
Fig. 42.—Man’s head drawn on globular projection.

Fig. 43.—Man’s head plotted on orthographic projection.

Fig. 44.—Man’s head plotted on stereographic projection.

Fig. 45.—Man’s head plotted on Mercator projection.
Geographic Coordinate System

- Defines locations on earth using a 3D spherical surface
- It contains an angular unit of measure, prime meridian, and a datum
Latitude and Longitude

- Reference for locations on earth
- Angles of measure from earth’s center
- Angles are degrees or grads
- Not uniform units of measure
Longitude

• Meridians converge at the poles
• 1° Longitude at the equator = 111 km
• 1° Longitude at 60° Latitude = 55.8 km
• 1° Longitude at 90° Latitude = 0 km
Prime Meridians

- Origin of the longitude lines (0)
- Usually use Greenwich, England
Prime Meridians

Laser projected from the Royal Observatory in Greenwich marking the Prime meridian
Spheres and spheroids

- Size and shape of a geographic coordinate system is defined by a sphere or spheroid.
- Earth is best represented by a spheroid.
- Sometimes treated as a sphere to make mathematical calculations easier.
Geodetic Datum

• A coordinate system and a set of reference points to locate places on earth
• Mathematically, a round surface is created to approximate the surface of the earth (spheroid)
• Calculations are made to “fit” the model to the surface of the earth
• Different models and different ways to fit the models contribute to the numerous datums defined
Geodetic Datum

- Types of Datum
  - Earth centered (WGS84, NAD83)
  - Local (NAD27, ED50)

- World Geodetic System 1984
  - Best earth fitting spheroid
  - Satellite data
Datums

- North American Datums
  - NAD27
    - Clarke 1866 spheroid
    - Meades Ranch, KS (1880’s)
  - NAD83
    - GRS80 spheroid
    - Earth-centered datum
    - GPS-compatible
    - Based on earth and satellite observations
Projected Coordinate System

- Defined on a flat, two-dimensional surface
- Planar coordinate system
- Lengths, angles, and areas are constant across the surface
- Locations are identified based on a grid, origin is at center of grid
Map projections

- Whether you represent the earth as a sphere or spheroid, you have to go from 3D to 2D
- Mathematical transformation
- Visualize shining a light through the earth onto another surface
Map projections

• All projections cause distortion in shape, area, distance, or direction
• Remember the orange peel
• Here, data near the poles are stretched

Aside: “Data are” NOT “Data is”
Map projections

This much earth surface has to fit onto this much map surface...

therefore, much of the earth’s surface has to be represented smaller than the nominal scale.
Conformal projections maintain shape
Equal-area projections maintain area
Equidistant projections maintain distance
True-direction projections maintain direction
Projection surfaces

Map Projection Families
Establish point of contact

- **Tangent** – projection surface touches sphere
- **Secant** – surface cuts through sphere
- **No distortion at contact point/s**
- **Distortion increases away from contact point/s**
Cylindrical projection

Normal

Transverse

Oblique
Conic projection

- Standard parallel
- Central meridian
Planar projection

- Polar
- Equatorial
- Oblique
Planar projection - focus

Gnomonic

Stereographic

Orthographic