WHAT IS PROJECTION?

Projection is how the 3D earth is mapped on a 2D planar surface (paper map or digital GIS). All projections have some error, but each differs in the type of error. Listed below are projection characteristics:

- **Conformality, or “Conformal” projections**
  - Preserves **shape**.
  - When the scale of a map at any point on the map is the same in any direction, the projection is conformal. Meridians (lines of longitude) and parallels (lines of latitude) intersect at right angles.

- **Area, or “Equivalent” projections**
  - Preserves **area**.
  - When a map portrays areas over the entire map so that all mapped areas have the same proportional relationship to the areas on the Earth that they represent, the map is an **equal-area**, or equivalent, map.

- **Distance**
  - A map is equidistant when it portrays distances from the center of the projection to any other place on the map.

- **Direction**
  - A map preserves direction when azimuths (angles from a point on a line to another point) are portrayed correctly in all directions.

COMMON GLOBAL PROJECTIONS

- **Geographic**
  - $1^\circ$ Latitude = $1^\circ$ Longitude
- **Mercator** (i.e. Universal Transverse Mercator, UTM)
  - Developed for navigation.

COMMON CALIFORNIA PROJECTIONS

1. **Universal Transverse Mercator (UTM)**
   - Calif. is split between zones 10 & 11 of the UTM grid.
   - Global coverage, grid with false local origins, which minimizes error for each region.
   - UTM requires that error must not exceed 1/1000 (0.1%) anywhere on the map. At the center of the zone, the error is 1/2,500 (0.04%).
   - The scale factor at center is 99.96, at edges is 100.04. That is, a feature measuring 100 meters on the ground would measure 99.96 meters if it were in the center of a zone and 100.04 meters if at the edge of a zone.

2. **Stateplane**
   - In Calif. Stateplane, we use the Lambert Conformal Conic projection (each state uses diff. type).
   - State plane requires that error must not exceed 1/10,000 (0.01%). That is, a feature measuring 100 meters on the ground would measure 99.99 meters or 100.01 meters depending on position on map.

3. **Teale-Albers**
   - Albers is an equal-area conic, with 2 parallels.
   - Projection error must not exceed 1.25%.
   - The “Teale” Albers projection is used for all distributed state-wide spatial data.

COMMON U.S. PROJECTIONS

- **Geographic**
- **Albers**
- **Lambert**
- **Mercator**

Left: Several different examples of projection types, including conformal, equivalent, and a compromise between the two.

http://gif.berkeley.edu
**WHAT IS A DATUM?**

A datum is the mathematical model that fits the earth to an ellipsoid. It is a reference from real-world to this ellipse.

Common global ellipsoids are:
- WGS84 (World Geodetic Survey, 1984)
- GRS80 (Global Reference System, 1980)
- Clarke 1866 ellipsoid (used with California’s State-wide Teale Albers projection)

In North America, the horizontal datums are:
- NAD83 datum (North American Datum, 1983) – same as WGS84.
- NAD27 datum (North American Datum, 1927) – same as Clarke 1866.

**WHICH DATUM DO YOU USE?**

All of them are correct, it just depends on whatever is appropriate for your area:
- WGS84: if you are going to compare with GPS data you have collected elsewhere in the world.
- NAD83: if you are in N. America, and are collecting raw data.
- NAD27: if you are in N. America, and want to match your NAD27 topo maps.

**HORIZONTAL DATUM SHIFT**

Datum shifts are differences in the mathematical formulas between datum. Datum shifts *must* be taken into account when re-projecting data, or comparing data of different datum, or else error will be introduced:
- Datum shift in California:
  - 100 m shift in the eastward direction
  - 200 m shift in the northward direction

USGS Topo maps are NAD27

Most GPS are set to WGS84 out-of-the-box (same as NAD83).

You convert between datum using NADCON transformation → do this in ArcGIS!

**VERTICAL DATUM SHIFT**

- Sea level for an area is measured over a period of time. This is called a tidal epic.
- Sea level is rising
- These tidal epics are used to develop the vertical datum for an area
  - NGVD 29 (The National Geodetic Vertical Datum of 1929) derived from measurements at 26 tide stations along the coasts of the US and Canada
  - NAVD 88 (The North American Vertical Datum of 1988) was created in 1991 from measurements in Mexico, the US, and Canada
- In our area, vertical datum shifts are ~1m. This is crucial, as tide heights have legal ramifications.