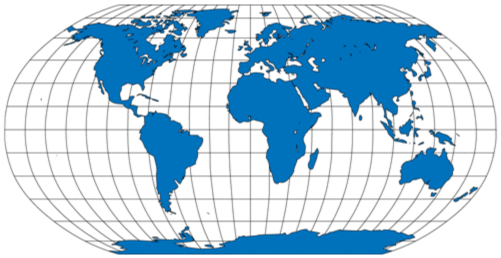
MAP PROJECTIONS

Map Projections



Session Objectives:

At the conclusion of this session, you will be able to:

- Develop a rudimental knowledge of map projections and datums.
- Minimize distortion in map projections.
- Understand the difference between map projections and coordinate systems.
- Choose the appropriate projection and datum for your map.

Datums, Projections, and Coordinate Systems

- "be afraid, be very afraid"

Coordinate Conversion: Cartesian (ECEF X, Y, Z) and Geodetic (Latitude, Longitude, and Height)

Direct Solution for Latitude, Longitude, and Height from X, Y, Z

This conversion is not exact and provides centimeter accuracy for heights < 1,000 km
(See Bowring, B. 1976. Transformation from spatial to geographical coordinates. Survey Review, XXIII: pg. 323-327)

$$\phi = \mathrm{atan}\left(\frac{Z + e'^2 b \sin^3\theta}{p - e^2 a \cos^3\theta}\right)$$

$$\lambda = \mathrm{atan2}(Y, X)$$

$$h = \frac{p}{\cos(\phi)} - N(\phi)$$

where:

ϕ, λ, h = geodetic latitude, longitude, and height above ellipsoid

X, Y, Z = Earth Centered Earth Fixed Cartesian coordinates

and:

$$p = \sqrt{X^2 + Y^2} \qquad \theta = \mathrm{atan}\left(\frac{Za}{pb}\right) \qquad e'^2 = \frac{a^2 - b^2}{b^2}$$

$N(\phi) = a / \sqrt{1 - e^2 \sin^2\phi}$ = radius of curvature in prime vertical

a = semi-major earth axis (ellipsoid equatorial radius)

b = semi-minor earth axis (ellipsoid polar radius)

$f = \frac{a - b}{a}$ = flattening

$e^2 = 2f - f^2$ = eccentricity squared

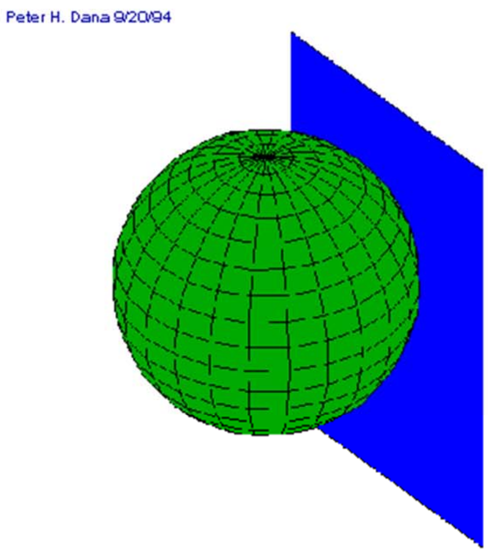
Map Projections

A spherical surface cannot be flattened without distorting it in several ways, so all maps must select and arrange distortions by means of a systematic transformation called a …

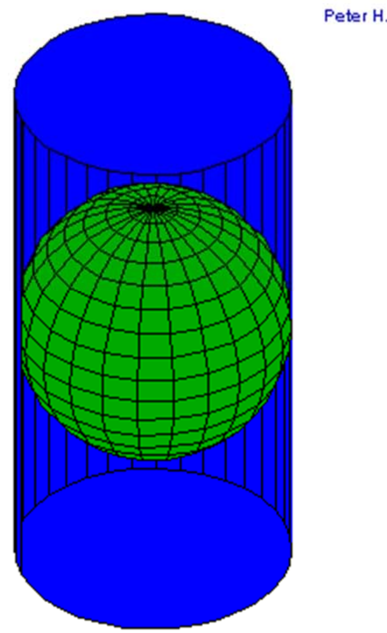
map projection

Map Projections

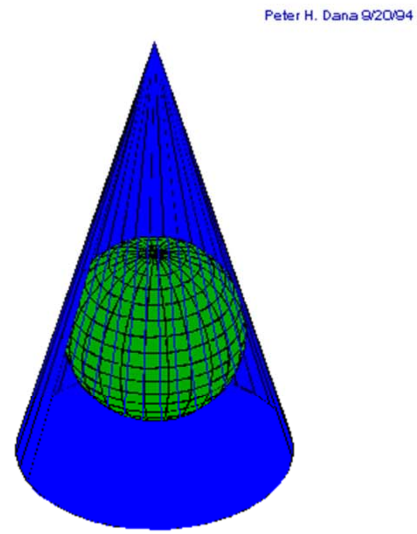
Projection Surfaces



Planar Projection Surfa



Cylindrical Projection Surface



Conical Projection Surface

Map Projections

Distortion

Projecting data from a 3-dimensional surface to a 2-dimensional surface introduces …

distortion

Map Projections

Kinds of Distortion

- **Shape**
- **Area**
- **Distance**
- **Direction**

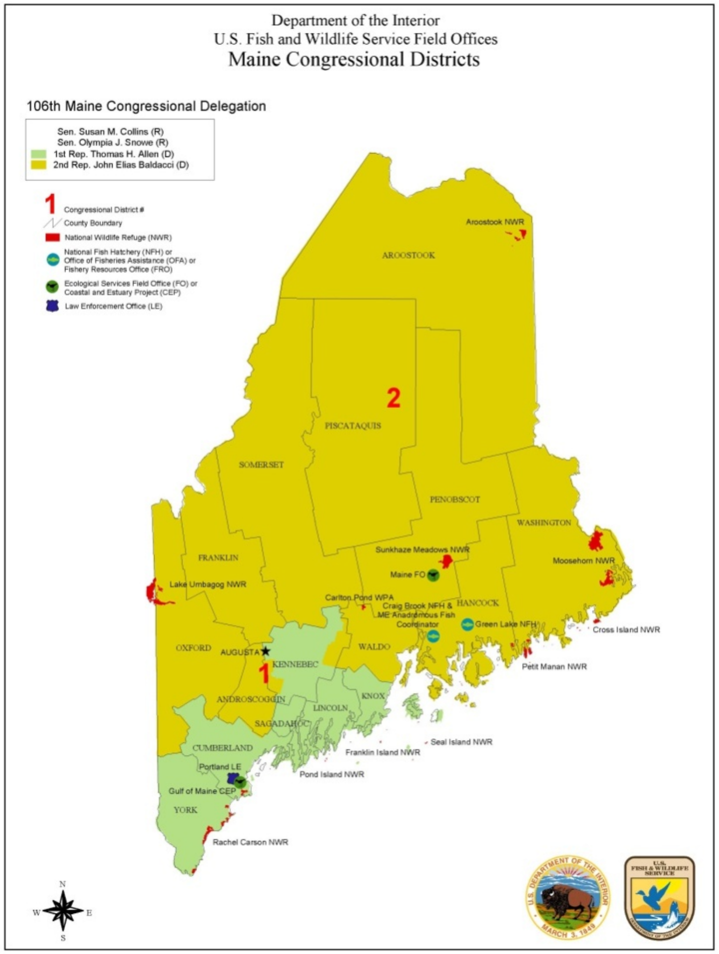
Map Projections

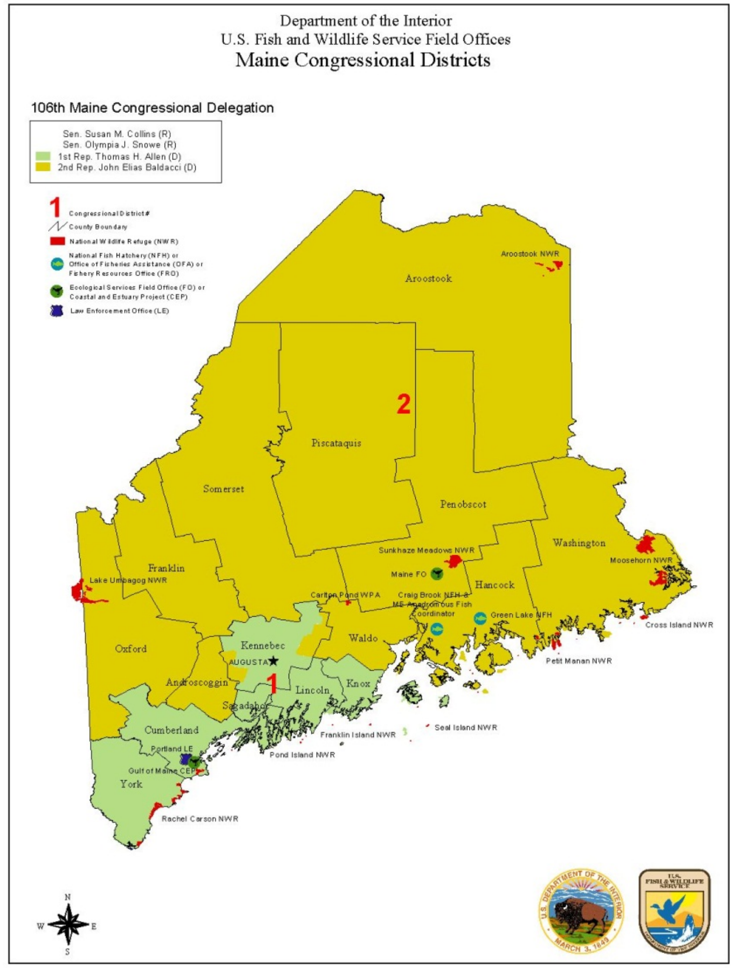
Correcting Distortion

- **Shape** : conformal projection
- **Area** : equal-area projection
- **Distance** : equidistant projection
- **Direction** : azimuthal projection

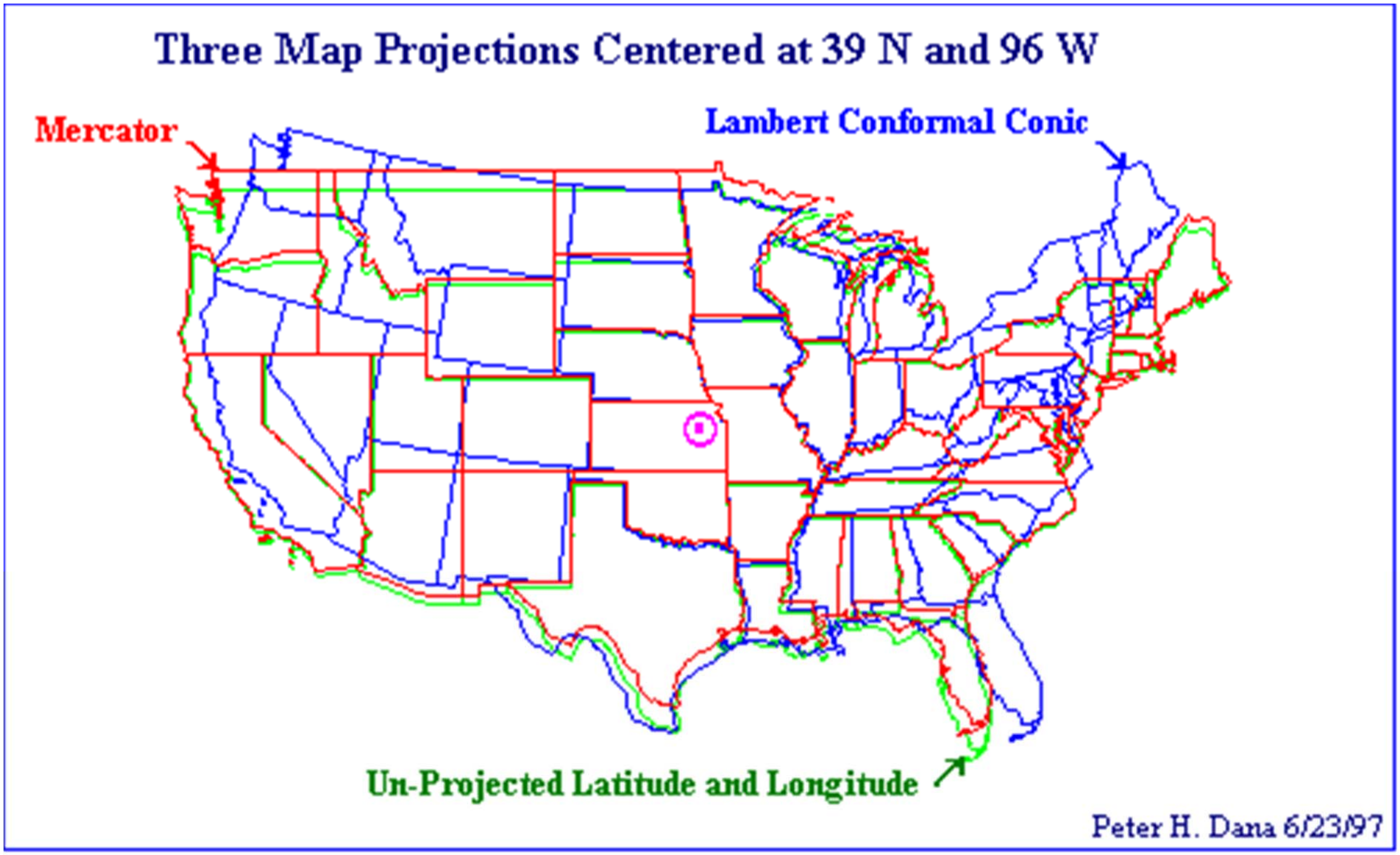
Map Projections

Distortion Example





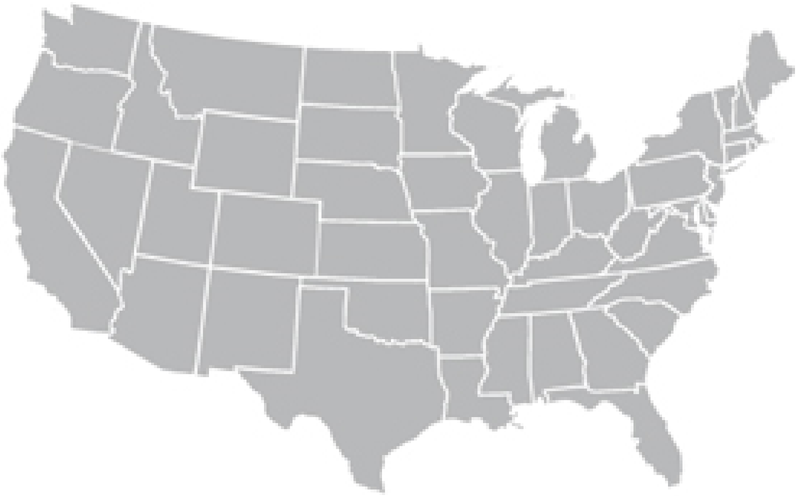
Map Projections



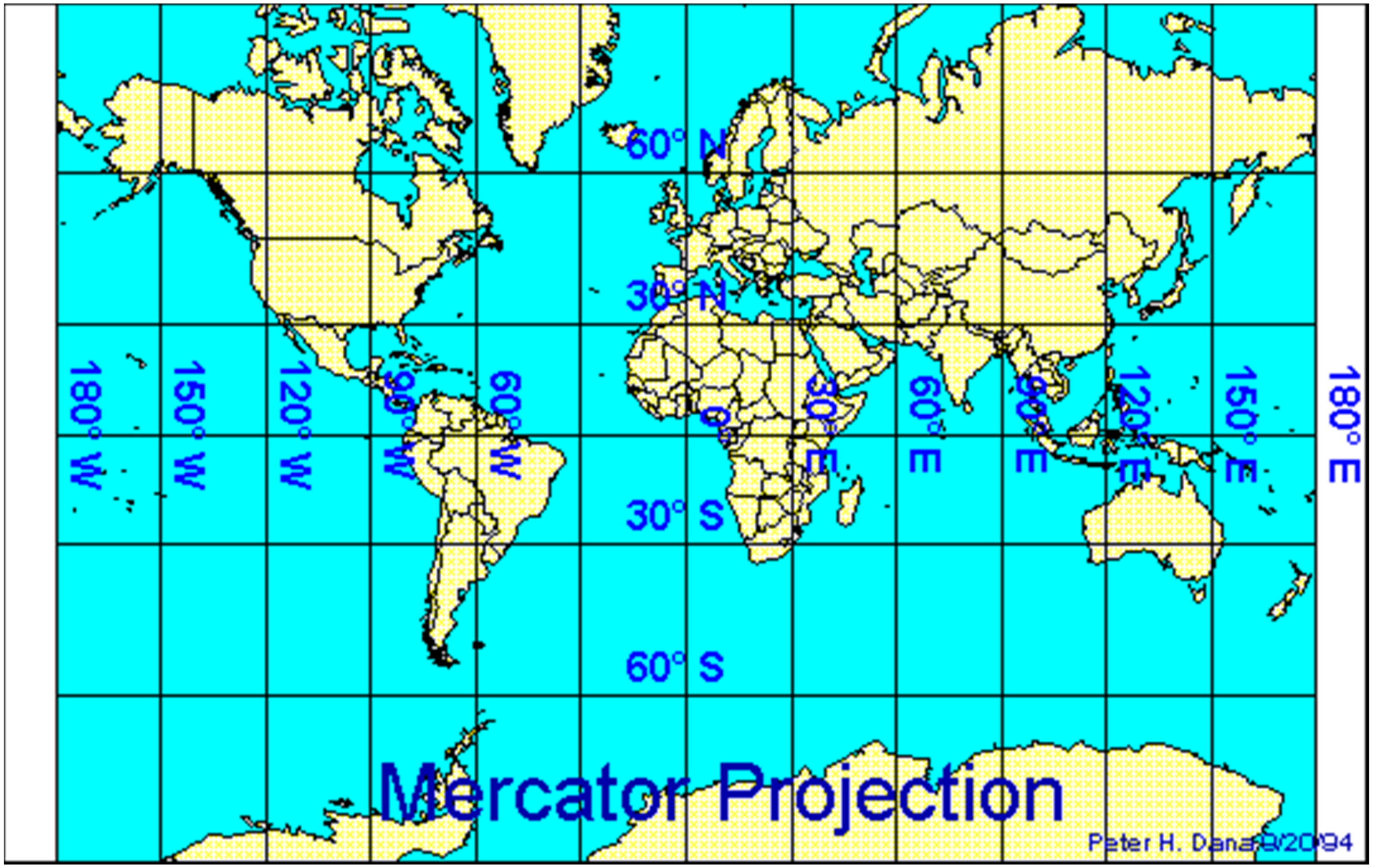
Map Projections

LAMBERT

ALBERS



Map Projections



Map Projections
Area Distortion

MERCATOR PROJECTION

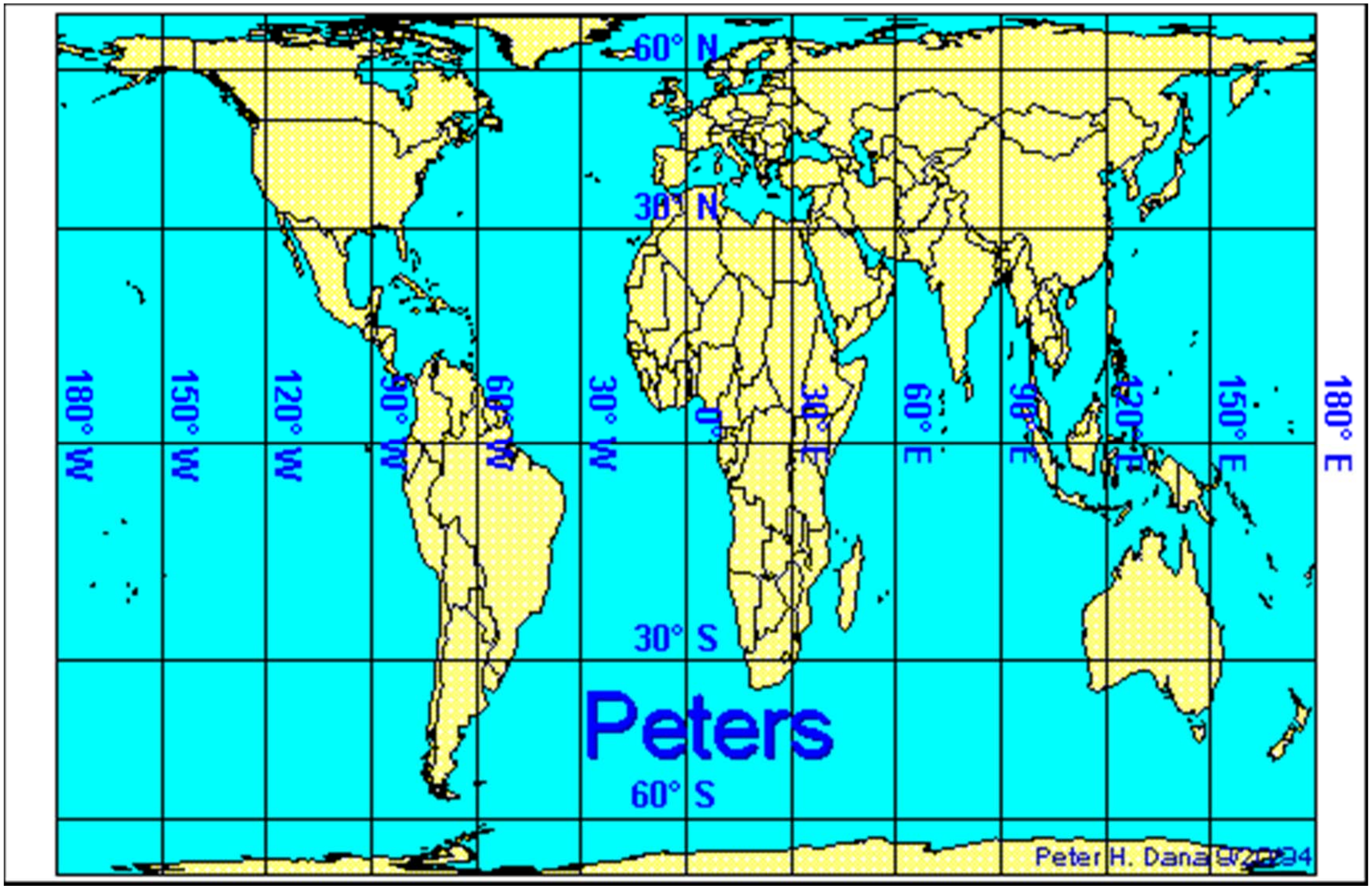
Europe : 4 million square miles

South America : 7 million square miles

AFRICA VS GREENLAND

Map Projections

Correcting Distortion



Map Projections

UTM – Universal Transverse Mercator

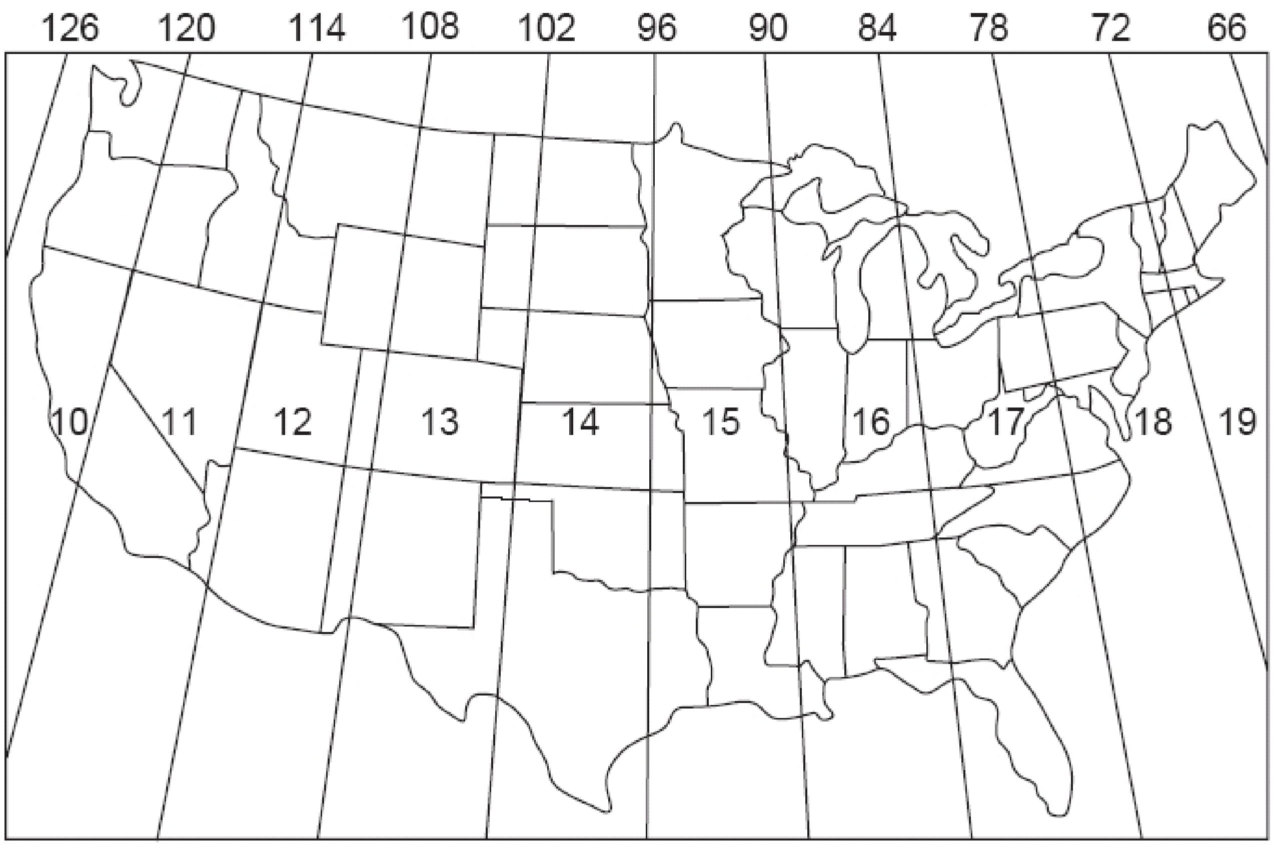
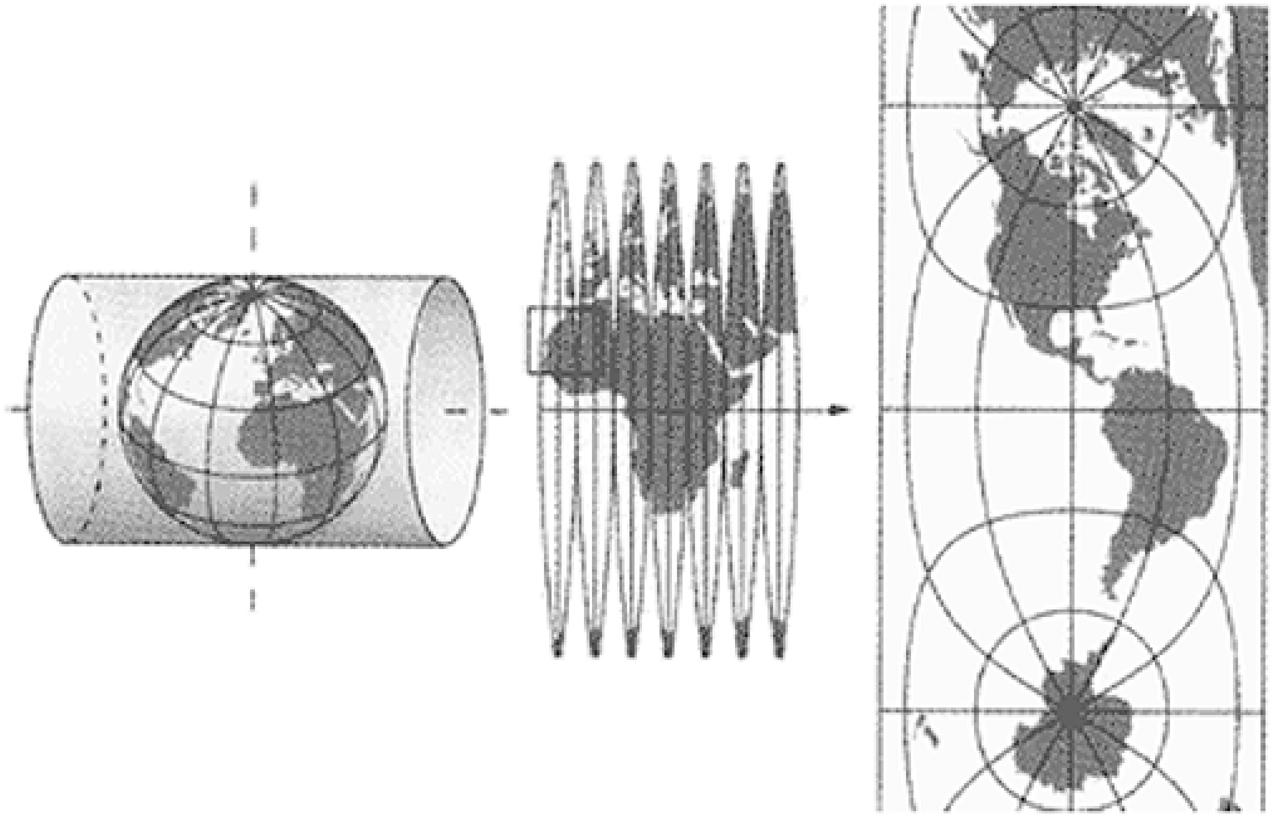


Figure 1. The Universal Transverse Mercator grid that covers the conterminous 48 United States comprises 10 zones—from Zone 10 on the west coast through Zone 19 in New England.

Map Projections

UTM – Universal Transverse Mercator



Map Projections

State Plane Coordinate System

Map Projections

State Plane Coordinate System

Projected Coordinate System:
NAD_1983_StatePlane_Tennessee_FIPS_4100_Feet
Projection: Lambert_Conformal_Conic
False_Easting: 1968500.00000000
False_Northing: 0.00000000
Central_Meridian: -86.00000000
Standard_Parallel_1: 35.25000000
Standard_Parallel_2: 36.41666667
Latitude_Of_Origin: 34.33333333
Linear Unit: Foot_US

Map Projections

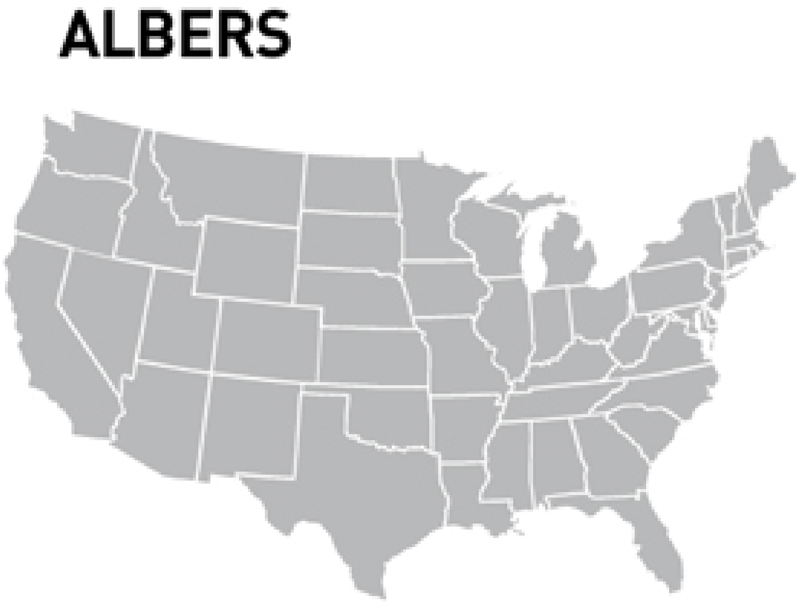
Map Projections

How this fits into Map Design

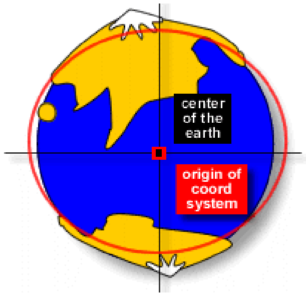
- You should choose a map projection that relegates distortion to places on your map that are not important to your message.
- At small scale, your projection choice will determine the overall “look” of your map.

Map Projections

How this fits into Map Design



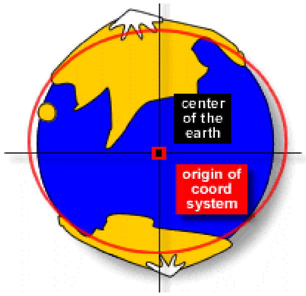
Datums



- Wikapedia: A datum is a reference point on the earth's surface against which position measurements are made, and an associated model of the shape of the earth for computing positions.

- National Geospatial Intelligence Agency: A datum is a point, a line, or surface used as a reference in surveying and mapping. A geodetic datum is a mathematical model of the earth used to calculate the coordinates on any map.

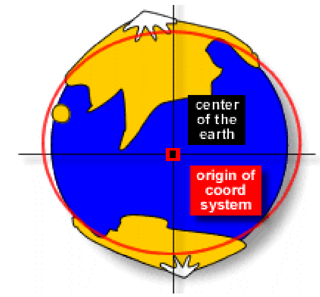
Datums



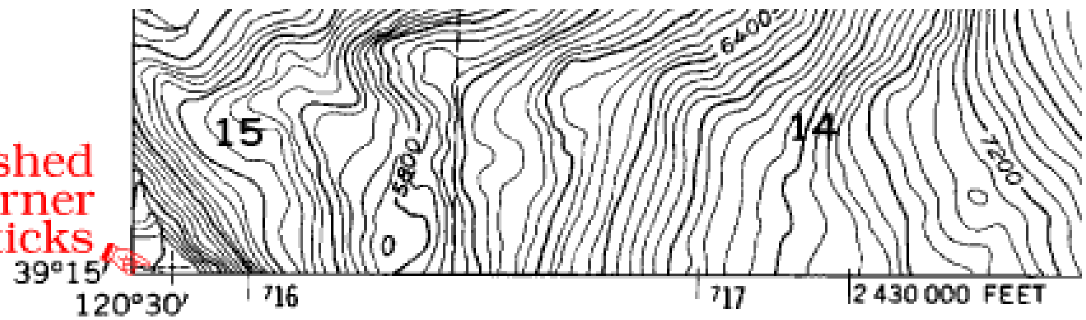
- NAD-27 : Clarke's 1866 ellipsoid
  (best-fitted for the United States)

- NAD-83 : 1980 Geodetic Reference System
  GRS 80 (best fitted for the entire Earth)

Datums



Dashed corner ticks



Mapped, edited, and published by the Geological Survey

Control by USGS and NOS/NOAA

Topography from aerial photographs by multiplex methods
Aerial photographs taken 1953. Field check 1955

Map datum

Polyconic projection. 1927 North American datum
10,000-foot grid based on California coordinate system, zone 2
1000-meter Universal Transverse Mercator grid ticks,
zone 10, shown in blue

Datum offset

To place on the predicted North American Datum 1983
move the projection lines 15 meters north and
89 meters east as shown by the dashed corner ticks

Some final advice…

- Making a small scale map to display geographic features? Use a conformal projection such as Lambert Conformal Conic

- Making a map to perform area calculations? Use an equal area projection like Albers Equal Area.