MAP PROJECTION
COORDINATE SYSTEMS
&
GIS REVIEW
MAP PROJECTIONS

Definition

A map projection is a portrayal of the earth’s surface (or portion of the earth’s surface) onto a flat surface.

There is no universally perfect projection system, thus there are a number of systems.

How projections are classified:

1. By their Area / Shape distortion
2. By the shape they are projected onto
PROJECTIONS - CLASSIFICATION

1. By their Area / Shape distortion
   • Equivalent (Equal Area): AREA is same on globe and flat map, but SHAPE is not.
   • Conformal: SHAPE (scale) is same on globe and flat map, but the AREA is not.

2. By the shape they are projected onto
   • Cylindrical: Projection of a sphere onto a cylinder.
   • Conic: Projection of a sphere onto a cone.
   • Azimuthal: Projection of a sphere onto a plane.
VISUALIZING PROJECTIONS

Origin:
- Point
- Line
- Inside
- Outside
MAP PROJECTIONS

Meridians
North-South lines
(such as Longitude)

Parallels
East-West lines
(such as Latitude)
Cylindrical Projections
- Straight meridians and parallels
- Meridians equally spaced
- Parallels unequally spaced

Common Cylindrical Projections
- Peters
- Mercator
- Universal Mercator
Cylindrical Projections - Peters

De-emphasizes exaggerations in the high latitudes
MAP PROJECTIONS

Cylindrical Projections Mercator

Emphasizes exaggerations in the high latitudes
Cylindrical Projections – Universal Transverse Mercator

Defines horizontal positions into 6° zones.

Each zone has a central meridian.

Is actually 60 projections!
Conic Projections

- Straight meridians, curved parallels
- Meridians radiate from poles
- Parallels may be equally spaced

Common Conic Projections
- Albers
- Lambert
- Polyconic
Conic Projections

Albers Equal Area Conic
Direction, area, and shape distorted away from the standard parallels.

Areas and directions are true only in limited portions of a map.

Used in regions with longer E-W orientation than N-S orientation.
Conic Projections

Equidistant Conic
Direction, area, and shape distorted away from the standard parallels.

Areas and directions are true only in limited portions of a map.

Used in regions near the equator.
Conic Projections

Lambert Conic

Direction, area, and shape distorted away from the standard parallels.

Areas and directions are true only in limited portions of a map.
Conic Projections

Polyconic

Scale is true along each parallel and along the central meridian.
MAP PROJECTIONS

Azimuthal Projections

- Straight or curved meridians, curved parallels
- Meridians radiate from poles
- Parallels may be equally spaced
MAP PROJECTIONS

Azimuthal Projections

Simplest is a tangential orthogonal (orthographic) projection.

Adequate for very small areas.

Scale and area distortion increases as distance from tangent center increases.
Azimuthal Projections

Azimuthal Equidistant

Used to show air-route distances.

Distances from the center are true, distortion radiates out from the center of the map.
MAP PROJECTIONS

Azimuthal Projections

Lambert Azimuthal Equidistant Area

Used to map large ocean areas.

Central meridian is a straight line, others are curved.
Definition: A system to represent points (lines, polygons, or other landscape features) in 2-dimensional or 3-dimensional space. Points are located in reference to a previously predetermined set of intersecting lines.

Introduced by Descartes (1596-1650), and based on right angle geometry. Referred to as Cartesian coordinates.

Types:

1) Latitude / Longitude (a commonly used coordinate system)
2) Universal Transverse Mercator (UTM)
4) State Plane
5) Metes and bounds
6) Public Land Survey (PLS)
7) Location specific (X,Y)
Geodetic datums

Coordinate systems are based on geodetic datums. Datums define the size and shape of the earth.

Initial point of a coordinate system is determined by projection, ellipse model, and datum.

Common datums used in the western U.S.:
- North American Datum 1927 (NAD27)
- North American Datum 1983 (NAD83)
- World Geodetic System 1984 (WGS84)
- GRS-80 (spheroid or ellipse model)
- Clarke 1866 (spheroid or ellipse model)

Ellipse models are like datums; they represent the entire globe where datums may be local. They are always used in conjunction.
COORDINATE SYSTEMS

Geodetic datums: ellipse (spheroid) models

• **Topographical surface** of the earth is the actual surface of land and sea at some moment in time.

• **Sea level** is the average surface of the oceans. Tidal forces and gravity differences cause this smoothed surface to vary.

• **Gravity models** attempt to describe variations in the gravity field. Local variations in gravity cause this surface to be irregular.
Latitude-Longitude System (Geodetic)
Most commonly used coordinate system.

No transformations necessary between areas.

Scale, shape, and direction distortion all increase with increasing area of interest.
The plane systems treat small portions of the earth as flat surfaces.

The State Plane system consists of 111 separate zones within the United States.

The origin of each coordinate system is always the SW corner of the zone, to avoid the use of negative coordinates.

Units of measure are feet (US Survey Foot).
**State Plane System**

Straight-line distances between two points can be calculated using the Pythagorean theorem. (A small amount of distortion is involved).

**Advantage:** only a small amount of distortion due to projection of the area onto a plane.

**Disadvantage:** large number of zones, and no transformation formula to convert measurements between zones.
US PUBLIC LAND SURVEY SYSTEM

- PLSS enacted by Congress - 1785
- Idea: townships: squares 6 mi divided in 36 mi²
**Method of Subdivision**

- Initial point – established by astronomical observations
- Initial meridian: N – S
- Base line: E – W (parallel)
- The axes of the system
- >30 systems
- Each meridian:
  - named and numbered
- From initial point: tracts 24 mi x 24 mi
- Each tract: 16 townships (4 x 4)
- Each township: 36 sections of 1 mi²
Public Land Survey (PLS)

From the initial point (convergence of baseline and principal meridian), “tracts” are first laid out, 24 miles each direction.

Tracts were designed to account for changes in the landscape due to the curvature of the earth. Thus, meridians do not line up at parallels.
Public Land Survey (PLS)

Then 16 townships are laid out within each tract.

Ex: T2N R3W, Base Line, Principal Meridian

2 townships (township lines) north of the baseline, 3 townships (range lines) west of the principal meridian
Public Land Survey (PLS)

Then 36 sections are laid out within each township.

Each section 1 sq. mi. (640 ac).

Numbered from NE corner.
Public Land Survey (PLS)

Sections may be subdivided

Example:

SE ¼ of NW ¼ of Section 21, T2N, R3W, Baseline, Principal Meridian
US Public Land Survey System

Public Land Survey (PLS)

Example of PLS and ownership boundaries from Jackson County, OR.
USGS TOPOGRAPHIC MAPS

Topographic Maps

Most comprehensive system of maps about the United States.

Contain coordinates in:

• Latitude / Longitude
• UTM
• State Plane

Available in both hard copy and digital form.

SUMMARY OVERVIEW

Projections
- Projects features of the earth onto a flat plane.
- No universal projection. Must choose the one that best fits use of map.

Datums
- Define a conceptual surface for the earth.
- Coordinate system attached to the datum.
- Datums vary by how they were created (modelled) and when.

Coordinate Systems
- A method of determining location given a projection and datum.
- Cartesian systems more useful in modern age (computers)
- Metes-and-bounds, and PLSS are legacy systems.
GIS REVIEW
A GIS organizes and stores information about the world as a collection of thematic layers that can be linked by geography.

Each layer contains features having similar attributes, like streets or cities, that are located within the same geographic extent.
GIS Review

The way how we represent geometric objects affects the way we can display and analyze information.

River

Set of lines

Set of polygons (have area)

A trough based on elevation values, calculate its profile, rate of descent, watershed it drains
GIS REVIEW

GIS helps in abstracting real-world entities into a geometric representation of those entities.
Three main components of geographic data:

• GEOMETRY - the geographic features associated with real-world locations. Geographic features are abstracted into points, lines, or polygons.

• ATTRIBUTES - descriptive characteristics of the geographic features.

• BEHAVIOUR - geographic features can be made to allow certain types of editing, display, or analysis.
BASIC GIS TOOLS

Display data
(create maps)

Query data
(extract new information)
A spatial query - expression used to select features based on their spatial relationships to other features.

For example spatial queries select features if:

- the features of one dataset fall within or contain the features of another dataset;
- the features of one dataset are within a specified distance of the features of another dataset;
- the features of one dataset overlap or cross the boundaries of features of another dataset.
1. Select features based on their position in relation with other features

SELECT BY LOCATION

- intersect
- are within a distance of
- completely contain
- are completely within
- have their center in
- share a line segment with
- touch the boundary of
- are identical to
- are crossed by the outline of
- contain
- are contained by
2. Select features based on their attributes

SELECT BY ATTRIBUTE
Spatial extraction
- Clipping subsets
- Clipping features
- Dissolving features

Proximity analysis
- Nearest neighbor
- Buffering

Overlay analysis
- Analysis with union
- Analysis with intersection
Basic GIS Tools - Querying Your Data
Spatial Analysis Tools

Creating subsets
Basic GIS Tools - Querying Your Data
Spatial Analysis Tools

Clipping features

Input Layer + Clip Layer → Output Layer

Parcels Layer (study area extent)

Soil Layer

Parcels Layer

Clipped Soil Layer
Dissolving features

Original Layer Attributes:
- Soil_Code
- Geology_Code

Soil Layer

Geology Layer
Nearest Neighbor
Buffering

- **INPUT**: Points
- **OUTPUT (polygon)**: Polygon around points
  - 200 feet around wells
  - 100 feet around a parcel
  - 50 feet from street centerline
Type of overlay operations
Basic GIS Tools - Querying Your Data
Spatial Analysis Tools

Analysis with union

Input coverage
Union coverage
Output coverage

Vegetation Layer
Soil Layer
Output Layer
Analysis with intersect
What happened after data analysis ends?

The information has to be presented in the proper format to the end user.

MAPS
Information presented on a map should be appropriately sized and attractively arranged.
Basic GIS Tools - Display Data

Layout View

Data frame  Title  Neatline

Legend  Scale bar  North arrow  Data frame

Virtual page
Graphic devices such as borders, graphs, and logos help organize a map layout.
BASIC GIS TOOLS – DISPLAY DATA

Title
Source Information
Legend
Inset
North Arrow
Scale Bar
Border
Neatline
TIPS

- Number of colours for a layer: max 5
- Colours type: as different as possible
- Number of symbols for a layer: 4
- Number of features on the map:
  - Paper map: no limit
  - Digital maps: easy to “read” the map in less than 10 s
- Font size:
  - Paper map: user defined
  - Digital maps: minimum 24 points (1 point=1/72 inch)

**NOT ALL THE DETAILS ARE IMPORTANT**
CONCLUSIONS

• Present the results in a clear and efficient manner to other people.

• Maps are often the preferred method for accomplishing tasks that no other medium can match.
**ArcGIS**

- GIS Software developed by ESRI
- Almost standard in forestry
- ArcMap, ArcCatalog and ArcTools
- Store the data into specific formats:
  - Shapefile
  - Coverage (info file)
  - Geodatabase (mdb file)
- Each file contain minimum two types of information
  - Spatial information (geography)
  - Database information
SHAPEFILE

- Easiest file to work with:
  - Storage
  - Transfer
- A GIS file containing minimum 3 files:
  - .shp - shape format; the geometry
  - .shx — shape index format; a positional index of the feature geometry
  - .dbf — attribute format; columnar attributes for each shape
- Optional file:
  - .prj — projection format; the coordinate system and projection information
  - .sbn and .sbx — a spatial index of the features
All results HAVE to be connected to an ArcGIS file

All maps in two formats:
- Paper
- Electronic

Bonus: points
- Include pictures into the ArcGIS file
- Originality in ways of incorporating other information under the ArcGIS platform