## Topic Series 02

# Spatial Information Concepts

The beginnings of GIS understanding are seated in being able to **think spatially**. We need to begin thinking of the world as a complex set of entities that can be characterized through varies models of **relationships in geographic space**. In the same way that biological organisms can be characterized by their different interacting parts, we must must begin to think of complex associations of geographic features and how they relate and interact.

> e.g. Cells group together to form tissues, tissues group together to form organs, organs and tissues group together to form the organism, etc. Trees group together to form stands, stands group together to form compartments, compartments form management districts, these in turn interact with other ownerships at the landscape level.

To begin with the organization of geographic nature of the world, we must consider how most things of geographic context can be represented. First consider the concepts of spatial vs. non-spatial data.

## Spatial (geographic) Data

**Spatial data** as something mappable **(pg 62).** I agree that location information about a piece of property (the **coordinates** of the bounding box) is spatial. My opinion is that an address is not spatial because it does not uniquely identify a feature with a position that is mappable in geographic coordinates. An address can uniquely identify a location but the mappable coordinates are not known until you go to the base coordinate information such as lat./long. (the spatial data) for the bounding box of the parcel. Unambiguous spatial locations are unique. 15 Oxford CRT may occur in Oxford, MS and Oxford England.

The characteristics that describe interrelationships between spatial data include: **proximity** (nearness relative measure) and **distance (pg 66).**

**Non-spatial data** are the characteristics of features that are not mappable but are descriptive of the features (name of owner, type of soil, vegetation type, timber volume).

## Geographic Entities

Geographic entities we encounter in the world can be represented by **points, lines, polygons** (enclosed areas), or **surfaces** **(pg 64).**

> **Points** - even though they may have actual area, for the purposes of mapping, these are **single locations** (e.g. well heads, light poles, sometimes houses).
>
> **Lines** - represent features that have **length** dimensions (although they can also have attributes that tell us width, as in road width). (e.g. roads, streams, trails, boundaries)
>
> **Polygons** - lines that enclose an area with common attributes (e.g. agricultural field, forest stand, lake, residential lot) and have **area, perimeter and shape** characteristics that are often used in geographic analysis.
>
> **Surfaces** - 3-D representations of entities with **horizontal area** and **depth** or **height** (elevation model)

**Attributes**, as previously mentioned, are the information used to describe characteristics of spatial entities.

An important characteristic of many features, particularly those influenced by man's changes of the environment is time. It should also be recognized that characteristics of spatial data can change over time: locations of entities can change (e.g. a road is moved to eliminate dangerous curve), shape and size can change (e.g. progression of a timber harvest).

## Spatial Reference/Location (overhead of globe)

**Absolute location** of geographic entities is often determined by reference to the global coordinate system of **Latitudes and Longitudes** (spherical coordinates). Latitudes are measured 0-90 degrees north or south of the equator. Longitudes are measured in degrees east or west of the **prime meridian** that runs through Greenwich, England (0-180 degrees).

**Relative location** in GIS is important in establishing relationships such as **proximity or distance** among entities.

## Spatial Pattern (overhead of patterns)

Sometimes we are interested in the way features relate in terms of their proximity to other features. We must be aware of relative proximity relationships to plan for geographic data collection or sampling. This is done by looking at the spacing among features: **regular, clustered, or random**. A regular pattern might be seen in locations of trees in an orchard. Clustered patterns are frequently seen in socio-economic data such as population densities. Some advanced functions of GIS examine relationships based on measurements of pattern or distribution of the features of interest. In more advanced study of spatial data, we are interested in the strength of relationships of spatial entities to help us predict information (**spatial correlation** example: relationship of soils and geologic parent material). **What pattern would you least expect to encounter?**

## Geographic Data Collection

General ways we go about collecting geographic data:

1. Surveying (various engineering equipment e.g. Theodolites)
2. GPS
3. Remote Sensing (airborne and satellite; more details on this later)

In order to account for all the variability in the landscape, we may resort to various sampling schemes such as **random vs. systematic** over either **homogeneous vs. stratified** geographic base.

We will often in a geospatial context, make inferences based on our sample data. If we are interested in predicting observations that occur between geographic knowns, we are

**interpolating**. If we are making predictions outside the bounds of our geographic knowns, we are **extrapolating** (can be dangerous). A common inferencing task used in GIS is to interpolate surfaces (elevation models) from discrete elevation points (**Lidar overhead**).

## Maps and Their Characteristics (overhead from ArcView)

The logical culmination in aggregation of spatial information into a document is the map. We use maps to descriptively **model spatial phenomena**. In this course, we'll spend a fair amount of time using GIS to develop and analyze spatial information with the outputs (answers) often being maps.

There has been a shift in mapping from the **communication paradigm** (the map is the final product) to an **analytical (or holistic) paradigm** (all data held in computer and the output is based on particular user needs). Another way of looking at this is that the paper map has all information depicted and the user must determine how to interpret the information needed for the task at hand. Whereas the GIS has all information held electronically and the user only displays what is relevant to the application needs.

## Map Scale (overhead on scale)

Scale is important as it relates to the detail (and accuracy) of information that can be presented to the user. A common way of expressing scale is the **verbal equivalent**. This is frequently used in field disciplines, architecture, and engineering. The **RF or representative fraction** is used in mapping and remote sensing. **Graphic scales** are used on hard-copy maps. Note that the **graphic scale is correct regardless of reduction or enlargement** of the manuscript while the other two types are only correct for the original printing scale of the manuscript.

## Map Symbology and other Information (overhead from ArcView)

In order to interpret the information on a map, the user must have a **scale,** a **geographic frame of reference** (projection, north location) and a **legend**. The user should also know the **source of the data**, the **date the map** was compiled (age or currency), **who compiled** it, etc.

## Map Projections (overhead of projections)

It is not possible to map features of the globe onto a flat reference system without inducing some form of error or distortion in the data. Therefore, cartographers have developed a set of techniques called **map projections** to depict geographic entities in two dimensions with reasonable accuracy.

There are four general groups (families) of map projections: **planar, cylindrical, conic, and azimuthal**. It is not possible to maintain all correct characteristics of the original global relationships in a flat map. The properties we seek to preserve include: **angle (shape), distance, direction and size.**

If we want to keep correct **angular correspondence**, we use a **conformal projection**.
To **preserve area**, an **equal area projection** is used. Accurate **measures of distance** are maintained in **equidistant projections**. **Direction (important in navigation)** is best maintained in **azimuthal projections**. **(overhead on types of projections)**

## Map Grid Systems (overhead)

In order to reference our geographic entities on the computer systems of GIS, we adopt a grid system of coordinates (planar) to reference entity locations. These are generally based on simple **Cartesian geometry** (rectangular grid). In some systems, such as the **Universal Transverse Mercator (UTM)** we refer to **x coordinates as eastings** and **y coordinates as northings**. The UTM system divides the earth into 60 vertical zones of 6 degrees of longitude (each zone utilizes a separate Mercator Projection to reduce distortion.

Another common grid system you will encounter is the **State Plane Coordinate System** (our Starr Forest database is in this system). Each state has a separate system so use of this is generally restricted within the individual states.

The **Public Land Survey System** (sometimes referred to as the **Government Land Office; GLO,but really it is General Land Office**) is based on a system that subdivides land by 36-square mile blocks called townships. The primary grid is township and range (y,x). Within each township are 36 sections (one square mile blocks). Each section can be divided into quarter sections, and half or quarter-quarter sections (40 acres).

All grids must depend on a reliable starting point for accuracy. The starting point is referred to as a **datum**. The datum is based on the fact that the earth is not a true sphere but is an **ellipsoid (squashed sphere)**. **You may encounter different datums in GIS** and should be aware that data stored in different datums are not comparable. We fix this by being able to computationally change the datums and projections of data sets so that the coordinate systems match. (e.g. **Changing from NAD27 - older 7.5 minute maps to NAD83 or WGS84 newer datum used in US**) We also encounter differences in projections and datums when we incorporate products from remote sensing. For these reasons, it is crucial to have a significant amount of quality checks in complex GIS operations.