Theory, Concepts and Terminology

Suggestion: Have Maptitude with a map open on computer so that we can refer to it for specific menu and interface items.

Organization of Spatial Objects

Spatial objects in the ***real world*** are represented, i.e., an abstraction of reality, in a GIS by three main geometric features:

- Point
- Line
- Area

In contrast to images, which in GIS are called ***rasters***, these geometric objects have a ***vector*** representation in either a the 2-dimensional or a 3-dimensional space.

These geometric features establish a hierarchy, which puts the object into relationships (topology) with one another:

- The arrangement of points defines a ***point pattern***.
- Lines are built from an *ordered sequence* of points. The two endpoints are called ***nodes***, whereas its curvature is defined by the sequence of ***shape-points***.

- A collection of lines, connected at their nodes, establishes a ***network***.
- An arrangement of line segments, connected in an *ordered sequence* with the first node joint to the last node, encloses polygon called an ***area***.
    - Areas have a central location, which for well-behaved polygons falls inside the area. This point is called a ***centroid***.
- A collection of areas defines a region.
    - *Adjacent* areas share a common line segment, which defines their mutual ***boundary***.

Maptitude is special in the sense that

- that its network data structure allows to build *advanced traffic models* (inherited from its big brother TransCAD) and
- that it enforces a strict topological relationships among adjacent area (common boundaries only stored once rather than for each polygon separately).

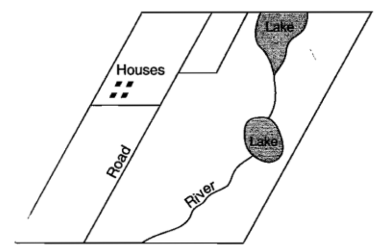
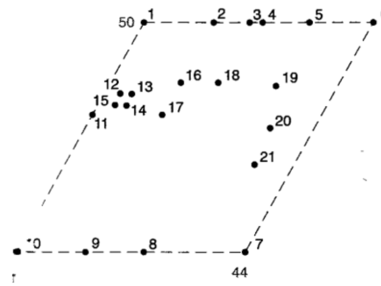
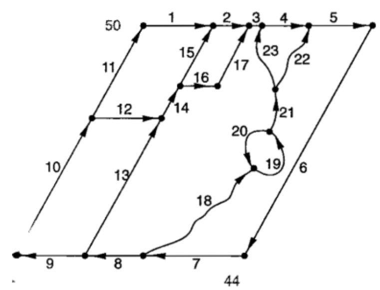


Figure 10.2 A sample map is represented by its component node, arc, and polygon components.



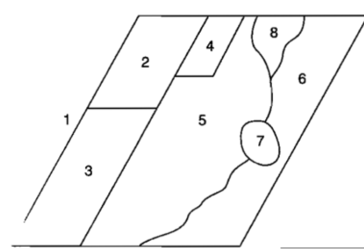
Nodes

ID #	Attribute	X,Y Coordinates
1	nul	1,50
2	nul	14,50
3	nul	21,50
4	nul	23,50
5	nul	32,50
6	nul	44,50
-	-	-
-	-	-
-	-	-
14	house	6,32
15	house	4,32
16	nul	14,37
17	nul	14,30
18	nul	21,37
19	nul	32,36
20	nul	35,27
21	nul	36,20



Arcs

ID #	Attibute	Start Node	End Node	X,Y Coordinates
1	map border	1	2	1,50...14,50
2	map border	2	3	14,50...21,50
3	map border	3	4	21,50...23,50
4	map border	4	5	23,50...32,50
5	map border	5	6	32,50...44,50
6	map border	6	7	44,50...44,1
-	-	-	-	-
-	-	-	-	-
-	-	-	-	-
14	road	17	16	14,30...14,37
15	road	16	2	14,37...14,50
16	road	16	18	14,37...21,37
17	road	18	3	21,37...21,50
18	river	8	21	25,1...36,20
19	shoreline	21	20	36,20...35,27
20	shoreline	20	21	35,27...36,20
21	river	20	19	35,27...32,36
22	river	19	5	32,36...32,50
23	river	19	4	32,36...23,50



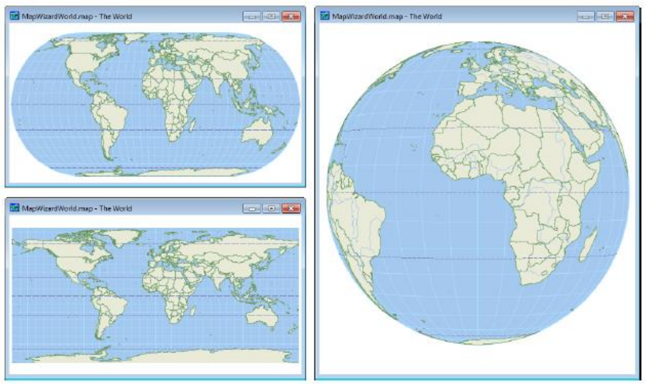
Polygons

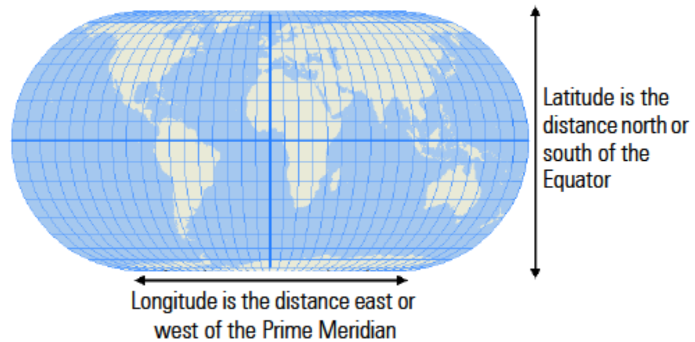
ID #	Attribute	Bounding lines
1	map exterior	1,2,3,4,5,6,7,8,9,10,11
2	nul	1,15,14,12,11
3	nul	12,13,9,10
4	nul	2,17,16,15
5	nul	3,23,21,20,18,8,13,14,16,17
6	nul	5,6,7,18,19,21,22
7	lake	19,20
8	lake	4,22,23

Projections and Coordinate Systems

The problem:

- How is a point on the elliptical surface of the Earth mapped onto a flat screen or o piece of paper?
    - ➢ This can only be done with some degree of ***distortion***.
- What reference system should be used for the location of a point on the Earth’s surface?





Good news:

- Maptitude’s “artificial intelligence” takes care of these tasks behind the scene and finds an ***optimal projection***. However, a user can interfere.
- All point coordinates are converted and saved in the ***common*** millionth of a degree ***longitude*** and ***latitudes*** format. That means, lowest locational precision is around ~ 1/3 foot or 10 cm.
- When Maptitude imports spatial data files in other formats (e.g., UTM zones) it tries its best (mostly successfully) to convert geographic locations into the long/lat format without user interference.

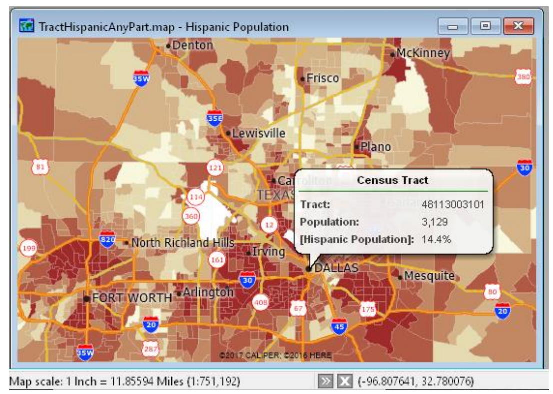
Spatial Scale

The spatial scale measures the relationship of one distance unit on the Earth's surface to the equivalent distance on the map.

One distinguishes between to ends of the scale spectrum:

- ***Small scale*** maps cover a ***large area*** on the Earth's surface, for which projection ***distortions*** will be pronounced. See the curvature of Texas's straight northern boundary at 36.5 degrees latitude (Missouri Compromise of 1820 prohibited slavery north of 36.5 degrees latitude)
- ***Large scale*** maps covering a ***small area***, for which the Earth's surface can easily be assumed to be flat.

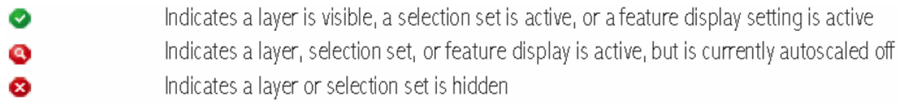
Small intermediate scale



Large intermediate scale

- Depending on the spatial scale, objects will be represented differently or even dropped to "fit into" the map, e.g., Dallas as just a point or a collection of census tracts.
  - ➢ This has implications of what kind of research questions can be asked and which analysis procedures can be performed.
- Maptitude has the capability to show specific objects in dependence of the current map scale.

- This is called ***auto-scaling***, which is predefined for most layers, but it also can be set by the user:



	Indicates a layer is visible, a selection set is active, or a feature display setting is active
	Indicates a layer, selection set, or feature display is active, but is currently autoscaled off
	Indicates a layer or selection set is hidden

Grouping of Similar Objects into a Layer

- A layer is a ***collection similar objects*** (e.g., populated places ranging from villages to metropolis).
- Associated with each layer may be definition of ***selection sets*** as well as the visualization of ***feature sets*** (village, town, city etc.), ***default visualization*** of the objects, a definition of a descriptive object ***label*** (a dot labelled by the city name), ***autoscaling*** information and their linked ***attribute table***.
- Recall, Maptitude layers do not need projection information because it uses the common lat/long format.
- Layers can be stored in different file formats on the hard-drive:
  - Compact geo-files ***.cdf** are the preferred file format because they draw fast and are small in size. However, the geometric outline of the objects cannot be changed.
  - Standard geographical files ***.dbd** can be edited but are larger and draw slower.
  - Geographic data are frequently shared as ESRI's shape files ***.shp**, which however have some drawbacks like the lack of a topology and varying map projections.
- Maptitude can ***import*** and ***export*** many different file formats.

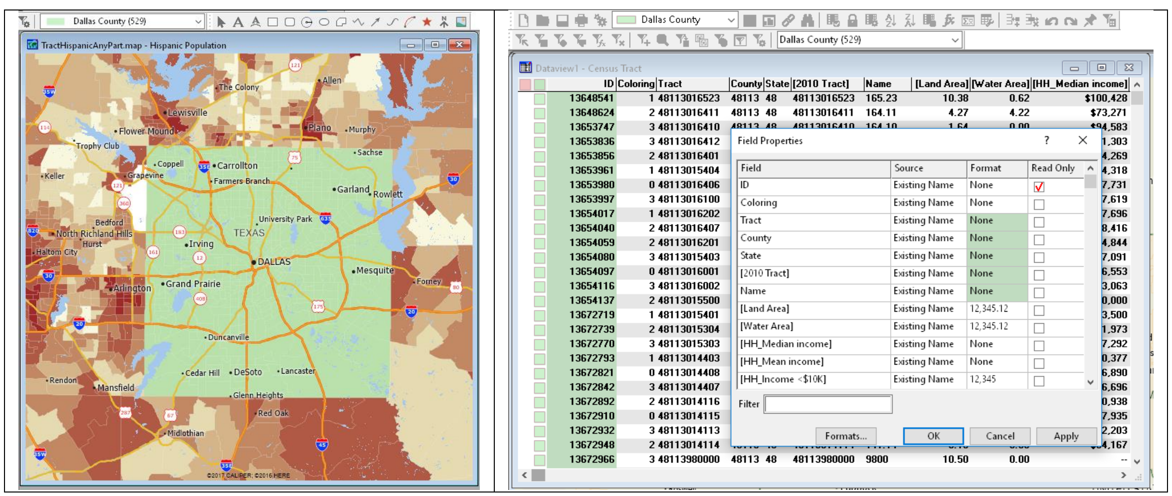
Linking Spatial Objects to Data Records and Data Views

- Internally each spatial object – i.e., point, line and area – in a layer has a unique identifier, which functions as reference to link records in a data table with matching unique identifier to the spatial object.
  - Lines are special because they have a unique identifier for the endpoints and a unique identifier for the line segment. Therefore, each can have its own attribute table.

- ***Several*** tables can be linked together, as long as they share a common unique identifier. The information in an added table is now assigned to spatial objects in a layer.
- The attribute fields can be [a] categorical scaled (simple classification of objects), [b] ordinal scaled (ranking of objects with possible ties) and [c] interval/ratio scaled (metric measurement of an attribute of a spatial object).
- Numerically, attribute fields are stored as character strings, integer numbers or real numbers.
- An appropriate format can be assigned to each field. In addition, value labels for categorical fields can be defined.

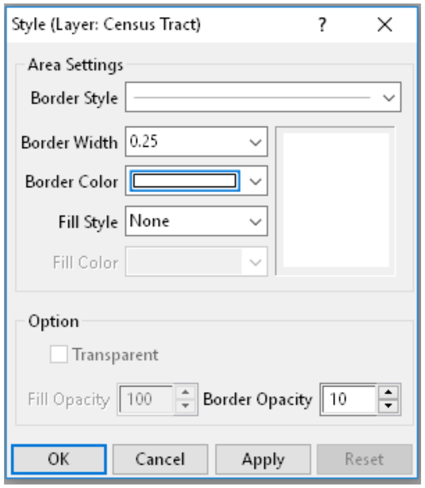
Selecting Spatial Objects

- Selection sets group spatial object together, which share common properties.
- Efficient use of selection sets makes Maptitude a very powerful geo-spatial analysis tool.
- Operation can be performed just on selected spatial objects or all objects depending on the selection status.

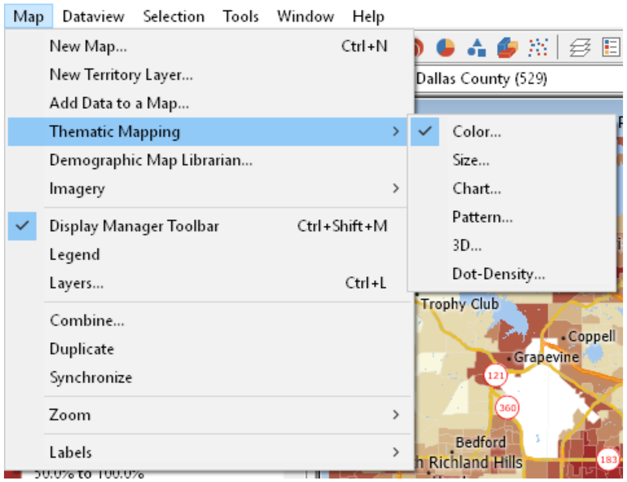


- Based on the attribute information – or by the geographic location of objects – of each record a subset of spatial objects can be selected.
  - ➢ Be careful, some fields look like being numeric but the values are stored as character strings. E.g., **`County = "48113"`** identifies the 529 census tracts of Dallas County.

Visualization of Spatial Objects



- Each spatial object (point, line and area) has a basic visualization style, which can be dynamically overwritten by the attribute information of a spatial objects:
  - For categorical data different feature display classes can be defined (e.g., different classes of water bodies)
  - For ordinal and metric data, cartographic themes can be defined based on the attribute values of the objects:



- Visualization of variable measurement levels and spatial object types:

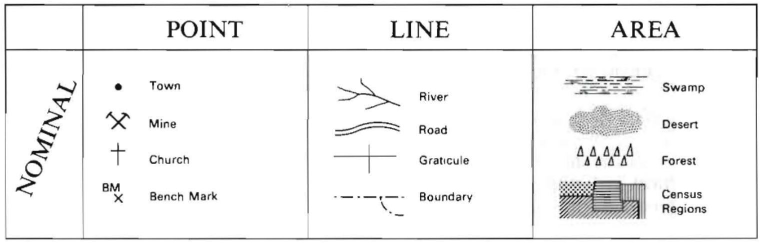


Figure 16.1 Examples of differentiation of point, line, and area features on a nominal scale of measurement.

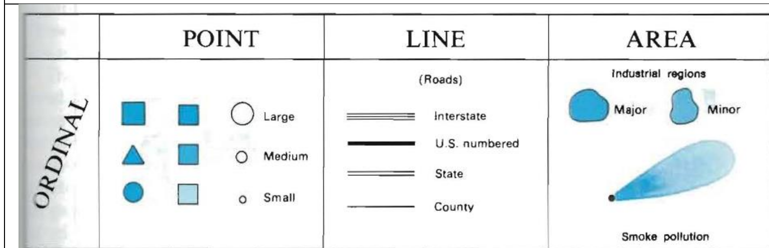


Figure 16.2 Examples of differentiation of point, line, and area features on an ordinal scale of measurement.

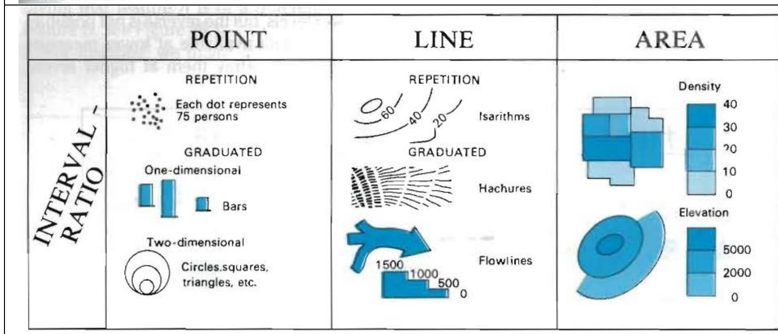
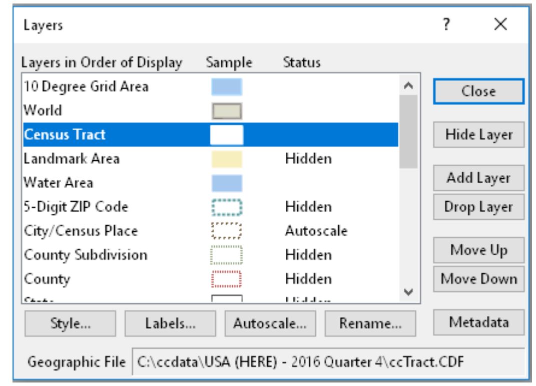


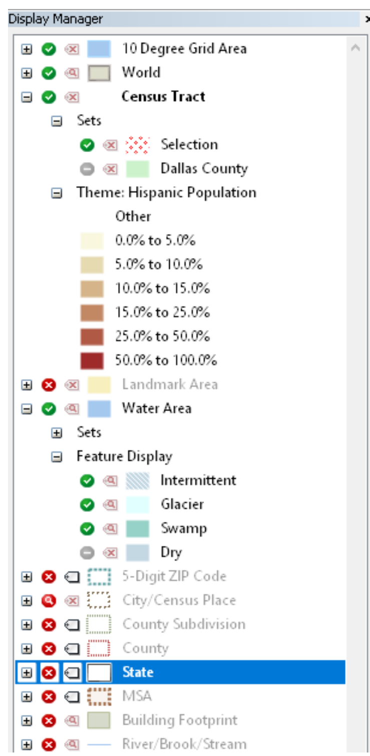
Figure 16.3 Examples of differentiation of point, line, and area features on an interval or ratio scale of measurement.

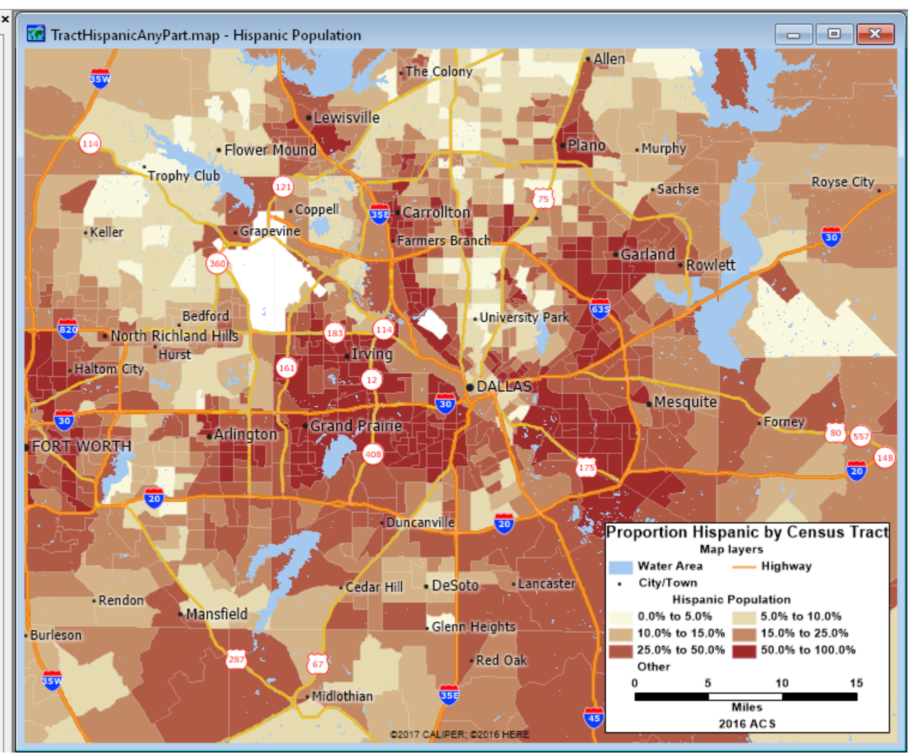
- See [ColorBrewer]() for the visualization of area attributes with hues (different colors) and chromas (different intensities) for [a] sequential gradients, [b] diverging branches around a neutral value and [c] qualitative themes.

Organization of Layers into a Maps.

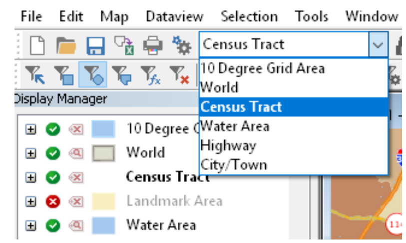


- Each map is a collection of one or more layers.
- The ***drawing sequence*** of layer is important. For instance, if an area with a solid fill-color is drawn after other layers, it will cover the underlying layers visually up.
  - The drawing order of layers can be changed in the **Layers** tool
  - An area's fill-color can be set to be partially transparent to mitigate covering underlying layer up in the **Style…** menu.
- The ***display manager*** shows a list of all layers in map
  - in their drawing order,
  - whether a layer is visible or hidden and whether only specific features are visual
  - the defined attributes like sets etc.
- Double clicking on a layer in the display manager allows changing attributes like the style.
- Right-clicking on a layer opens further options.
- The display manager will not print with a map.





- Maps may have a ***legend*** and a ***north arrow***, which can be shifted and edited by clicking on them with the pointer tool. The legend will be shown with the map when it is printed.
- Right-clicking into a map open further options up.
- Each map has an active ***working layer*** on which usually operations can performed and which is the reference layer for across-layer operations such as overlays.



- The data view of an active layer can be opened with **Dataview ▶ New Dataview**

Tips

- Many spatial analysis procedures are documented online encyclopedia http://www.spatialanalysisonline.com/
- By default, layers which come with Maptitude are found in the directory **C:\ccdata**.
- Tutorial data are found in the user directory **C:\Users\Michael\Documents\Caliper\Maptitude 2017**