GIS Concepts Course

To Better Understand Geographic Information Systems, Their Use in Making Maps and Their Capabilities for Spatial Analysis

Tucson and Pima County, Arizona

September 2001

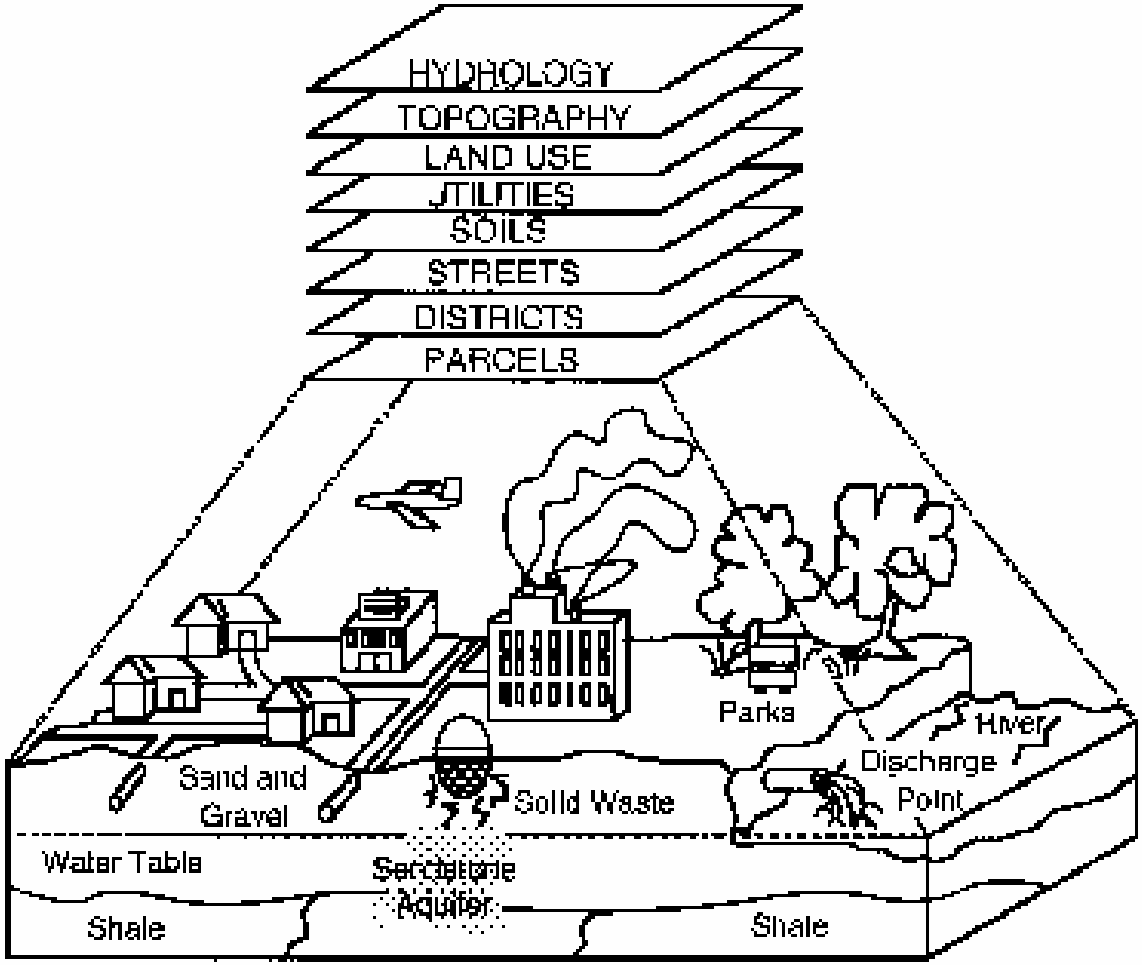
Benefits of GIS

- History:
  - From paper to digital.
  - From static to interactive.
  - From interactive to analytical.
- Benefits:
  - Map production.
  - Answer questions about location, condition, trends, patterns, and perform “what if…” modeling.
  - Analytical operations such as proximity, boundary, network and spatial joins.
  - Scientific component.

Topics To Be Covered

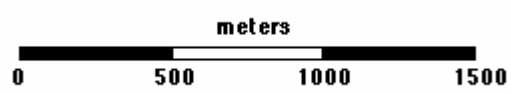
- History and benefits of GIS.
- Mapping principles.
- Spatial features.
- Feature attributes.
- Data processes.
- Advanced and new technology.
- Resources.

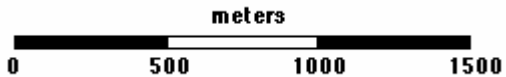
Example of Layers of Information



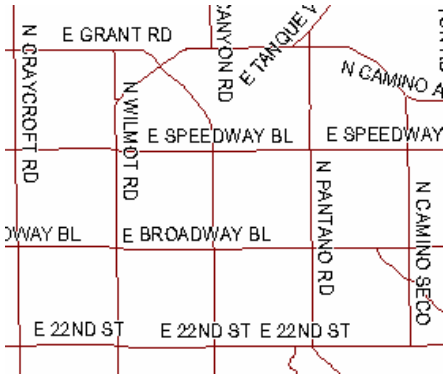
GIS view of the real world

Map Scale

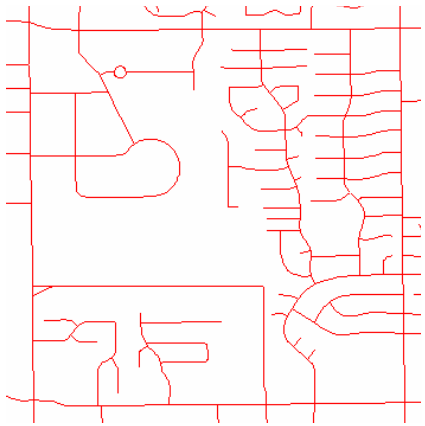


- Map scale is the extent of reduction required to display a portion of the Earth's surface on a map.
- Scale determines the informational content and size of the area being represented.
- Large scale = small area is displayed.
- Small scale = large area is displayed.
- Map scale can be represented in 3 basic ways:
  - Representative fraction: 1:24,000
  - Verbal scale: 1" = 2000'
  - Graphic Scale: 

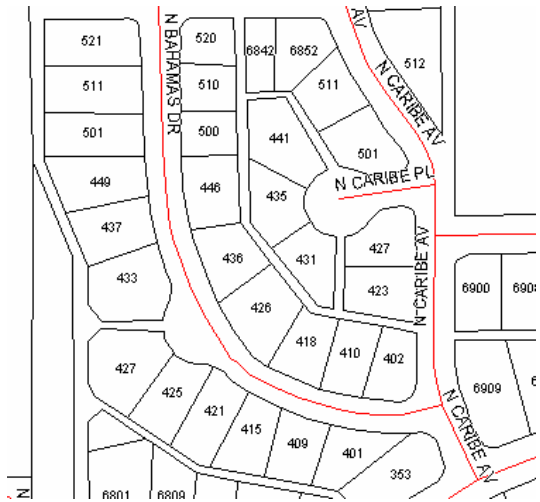
Map Scale - Example



Small scale
1:76,500



Medium scale
1:19,000

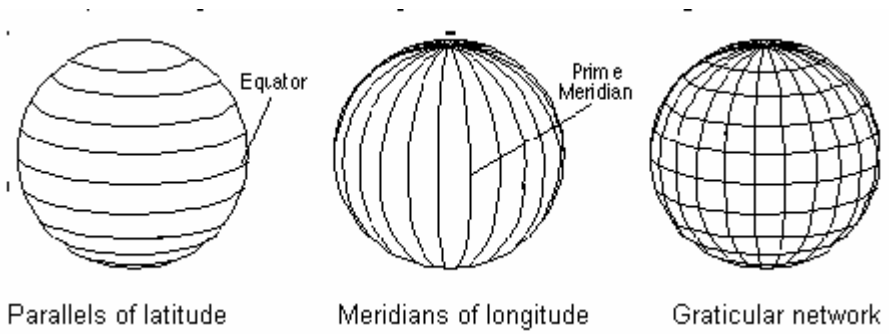


Large scale
1:2,500

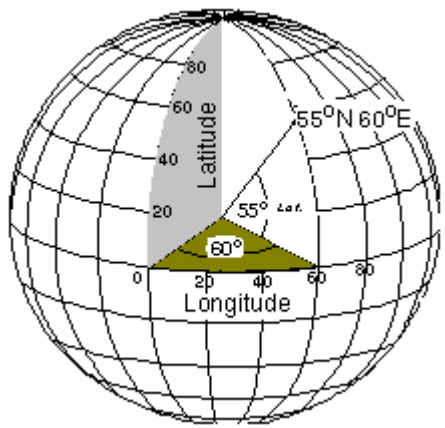
Coordinate Systems

- Spherical:
  - Spheres and spheroids.
  - Latitude/Longitude.
- Planar:
  - Cartesian coordinate system.
  - State Plane.
  - UTM (Universal Transverse Mercator).

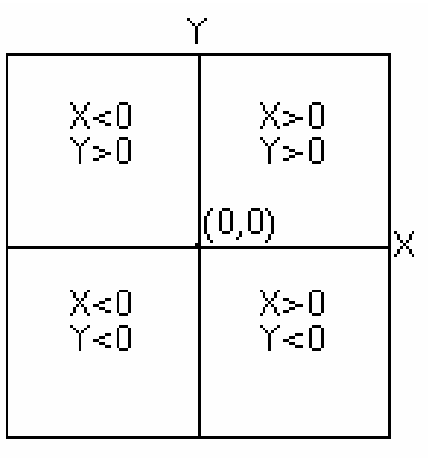
Coordinate Systems - Example



Spherical measurements



Latitude/Longitude



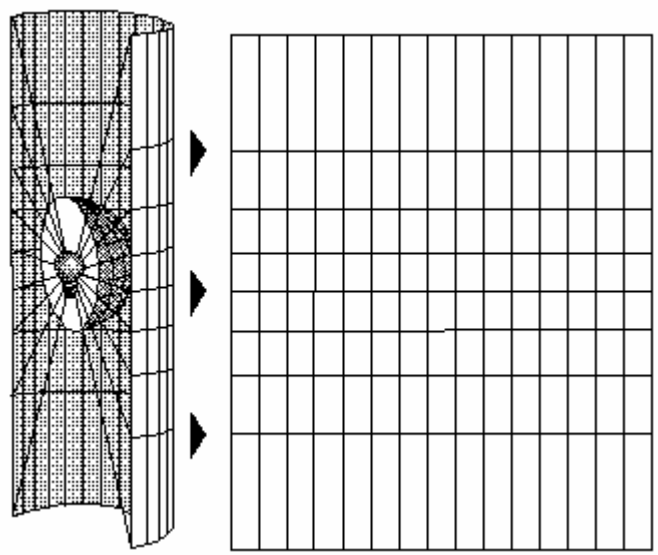
Cartesian coordinate system

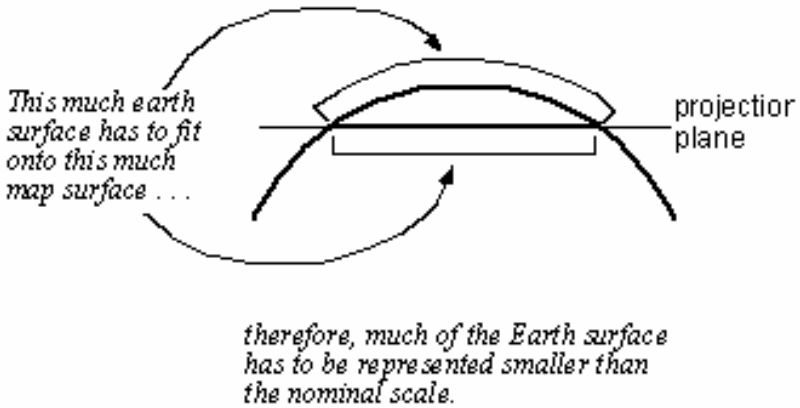
State Plane zones

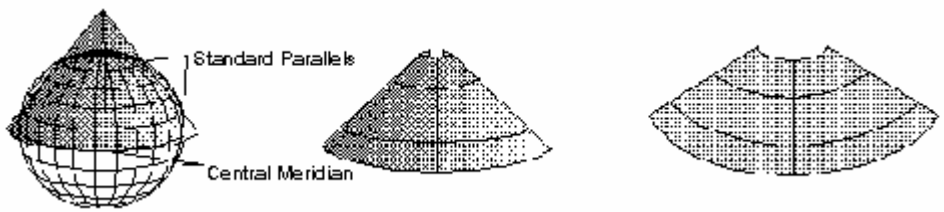
Map Projections

- Transforming three-dimensional space onto a two-dimensional map.
- This process inevitably (unavoidably) distorts at least one of these properties - shape, area, distance, direction - and often more.
- The advantage of a planar system is that measures of length, angle, and area are constant across the two dimensions.

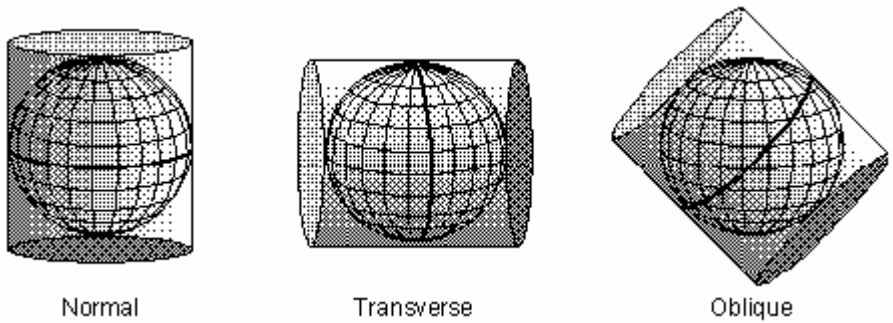
Map Projections - Example



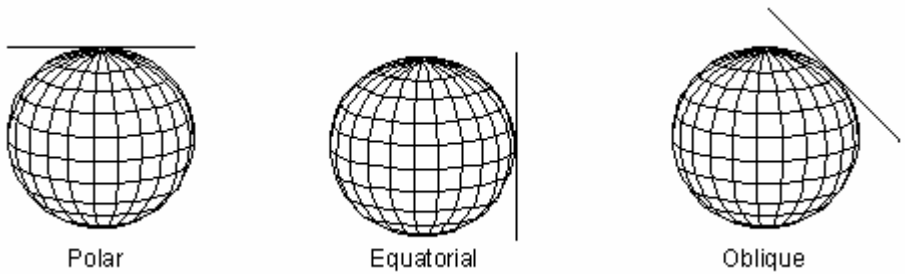




Conic projection



Cylindrical projections

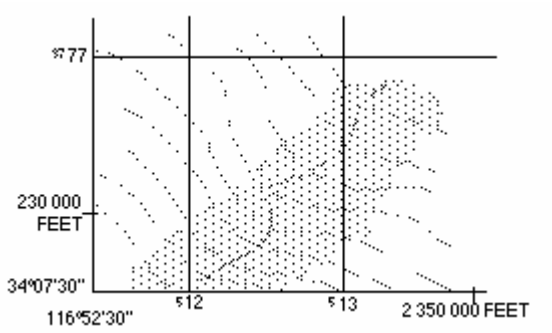


Planar projections

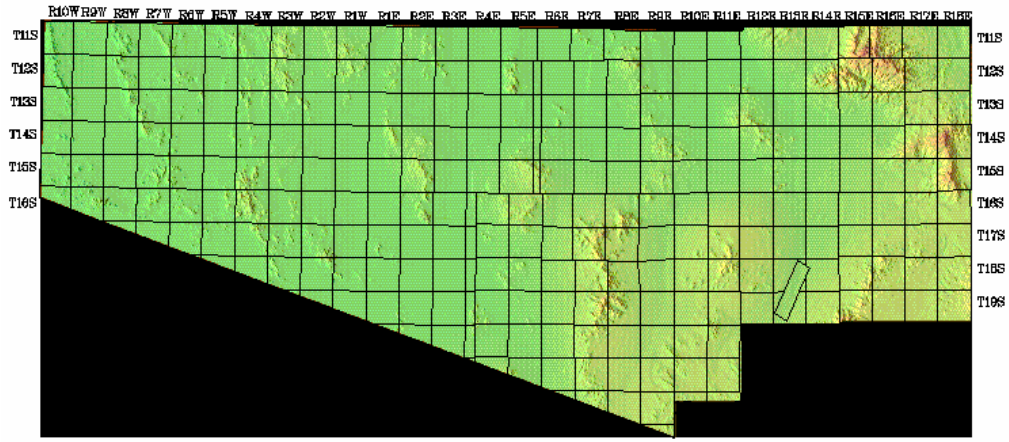
Ground Control

- Used for georeferencing map data to ground coordinates.
- Many different sources:
  - Map based.
  - Public Land Survey System (PLSS).
  - Survey.
  - Global Positioning System (GPS).

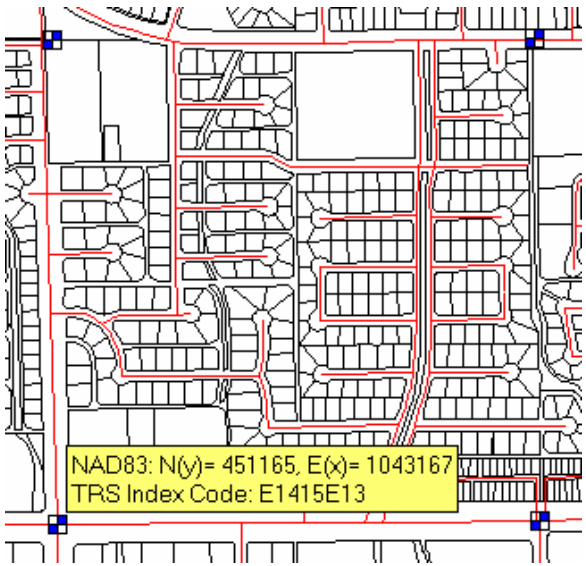
Ground Control - Example



Map based

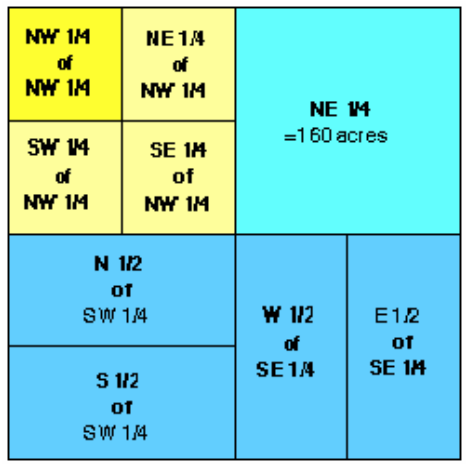


PLSS Townships



GPS control points

PLSS Sections

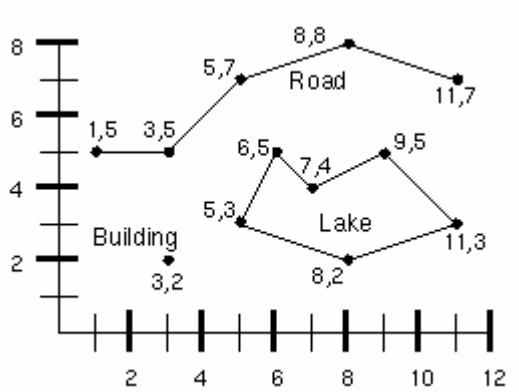


Section detail

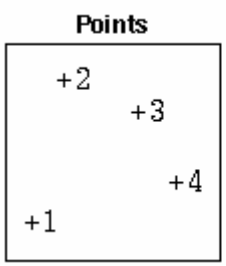
Spatial Feature Types

- Point.
- Line.
- Polygon.
- Text/Annotation.
- Complex.

Spatial Feature Types - Example

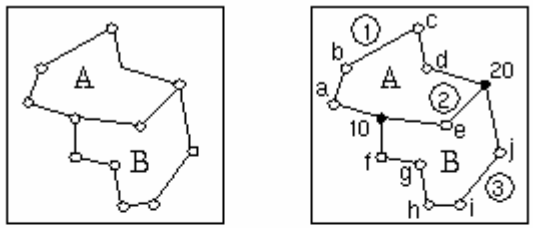


Points, lines, and polygons in Cartesian space



Point Number	x,y Coordinates
1	2,2
2	3,6
3	5,5
4	6,3

Points and their storage characteristics

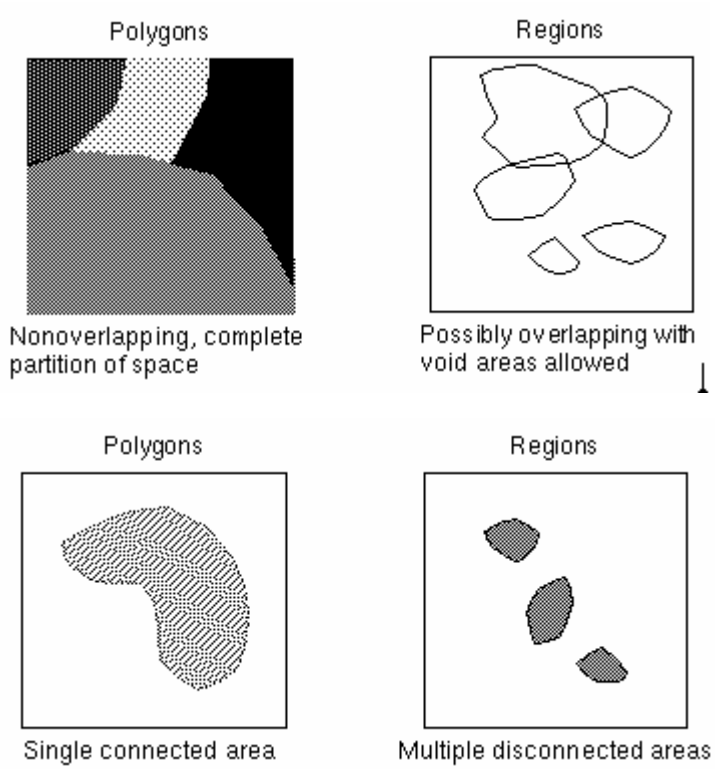


Arc Number	Start Node	Vertices	End Node
1	20	d, c, b, a	10
2	10	e	20
3	10	f, g, h, i, j	20

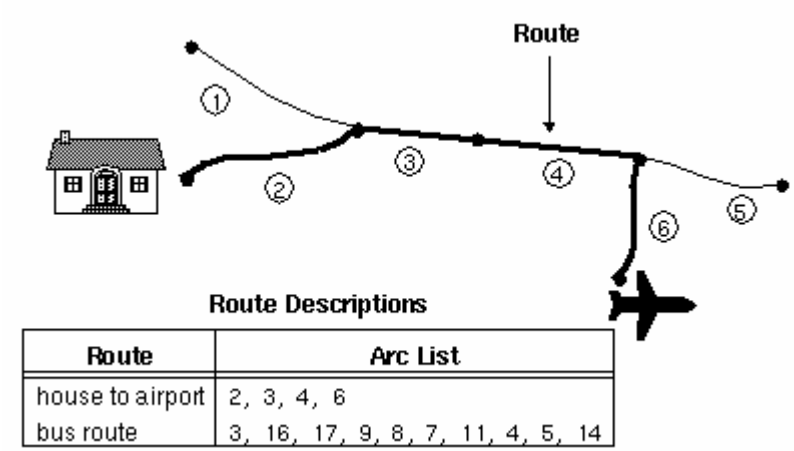
Polygon	Arc List
A	1, 2
B	2, 3

Lines, polygons and their storage characteristics

Spatial Feature Types - More

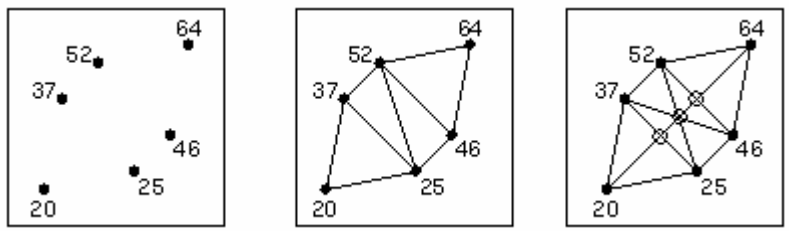


Regions



Route	Arc List
house to airport	2, 3, 4, 6
bus route	3, 16, 17, 9, 8, 7, 11, 4, 5, 14

Dynamic segmentation

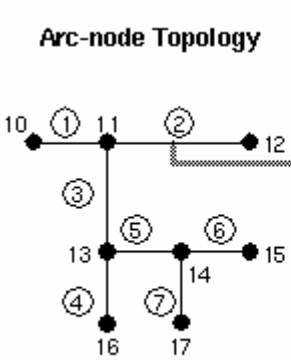


Triangular Irregular Network (TIN)

Topology

- The mathematical representation of the relationships between spatial features.
- Connectivity: lines connect to each other at their endpoints.
- Area definition: connected lines surrounding an area define a polygon.
- Contiguity: lines have left and right sides as well as direction.

Topology - Example

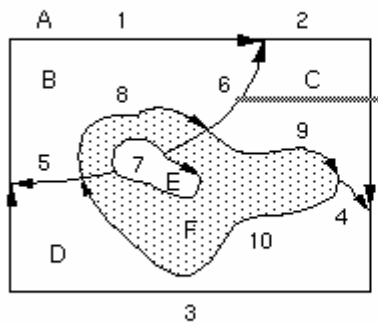


Arc-node Topology

Arc-node List

Arc	From-Node	To-Node
1	10	11
2	11	12
3	11	13
4	13	16
5	13	14
6	14	15
7	14	17

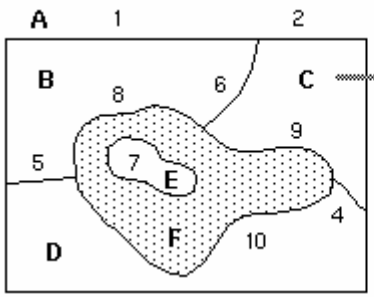
Connectivity



Left-Right Topology

Arc	Left Polygon	Right Polygon
1	A	B
2	A	C
3	A	D
4	C	D
5	D	B
6	B	C
7	F	E
8	B	F
9	C	F
10	D	F

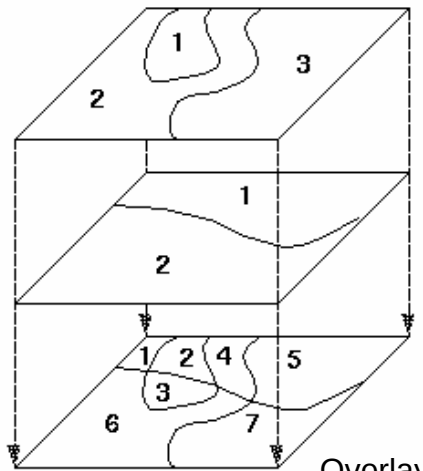
Contiguity



Polygon-Arc Topology

Polygon	Arc List
B	1, 6, 8, 5
C	2, 4, 9, 6
D	3, 5, 10, 4
E	7
F	8, 9, 10, 0, 7

Area definition



Soil Types

Crop Productivity (bushels/acre)

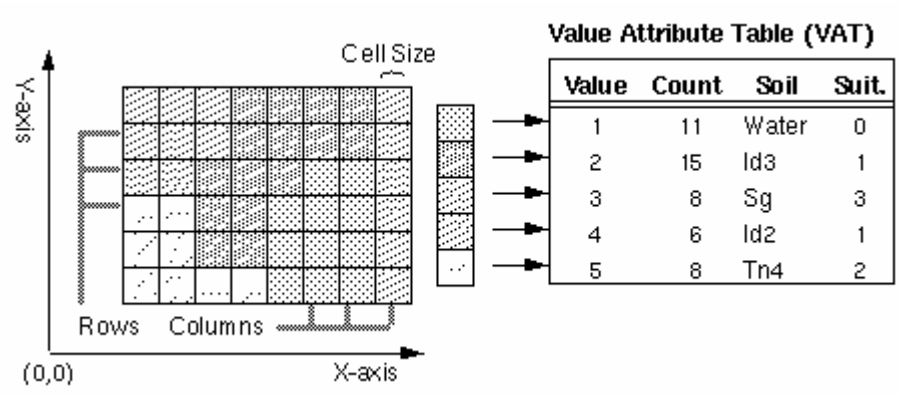
Combined Layers

Overlay analysis

Spatial Data Models

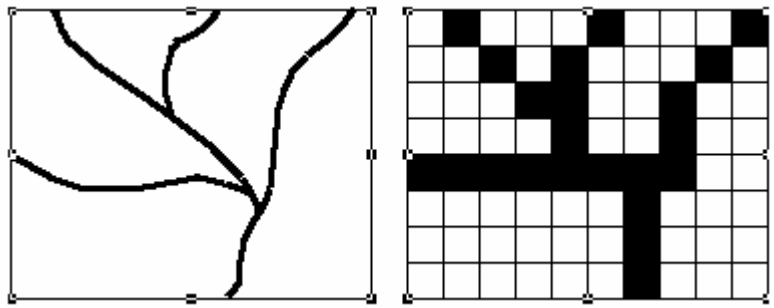
- Vector:
  - Points, lines, polygons.
- Raster:
  - Cells in a matrix organized in rows and columns.
  - Each cell has a numeric value.
  - Accuracy depends on cell size.
  - Digital images are rasters.

Spatial Data Models - Example

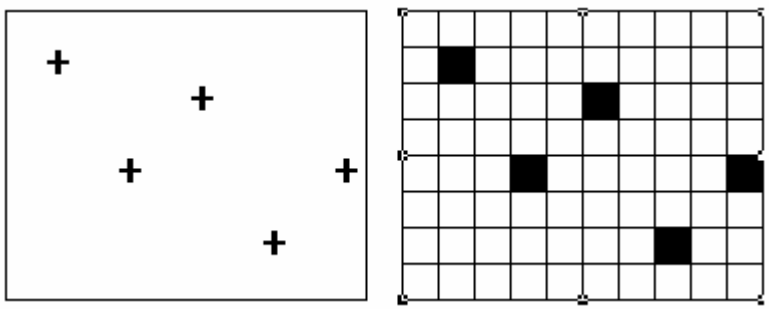


Value	Count	Soil	Suit.
1	11	Water	0
2	15	Id3	1
3	8	Sg	3
4	6	Id2	1
5	8	Tn4	2

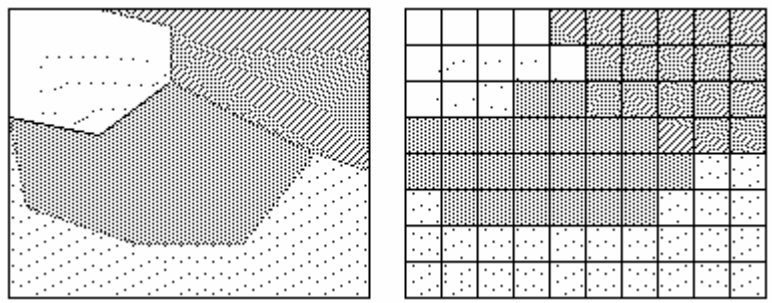
Raster storage characteristics



Line features represented in a raster



Point features represented in a raster

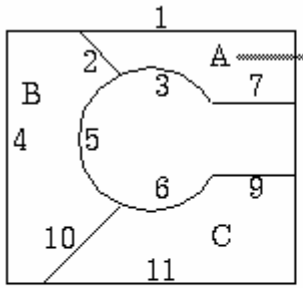


Polygon features represented in a raster

Linking Spatial Data To Attribute Data

- Attribute data is stored in a database table.
- Each record in the table stores attribute information about a single spatial feature or a group of features with similar characteristics.
- Spatial features are linked to their attribute data through a unique identifier.

Linking Spatial Data To Attribute Data - Example



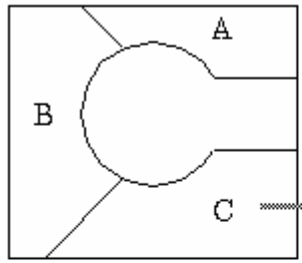
Polygon-Arc Topology

Polygon	Arc List
A	1, 7, 3, 2
B	2, 5, 10, 4
C	6, 9, 11, 10

Polygon Attribute Table

Polygon	Area	Parcel Number	Land Use
A	12,001	11-115-001	R1
B	15,775	11-115-002	R1
C	19,136	11-115-003	R3

One-to-one relationship



PARCEL.PAT

Polygon	Area	Parcel Number	Land Use
A	12,001	11-115-001	R1
B	15,775	11-115-002	R1
C	19,136	11-115-003	R3

Owner

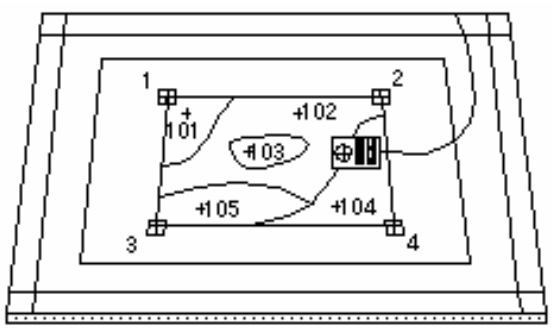
Parcel Number	Owner
11-115-001	Brown, C.
11-115-002	Greene, J.
11-115-003	Smith, L.
11-115-003	Cleaver, T.
11-115-003	Koop, C

One-to-many relationship

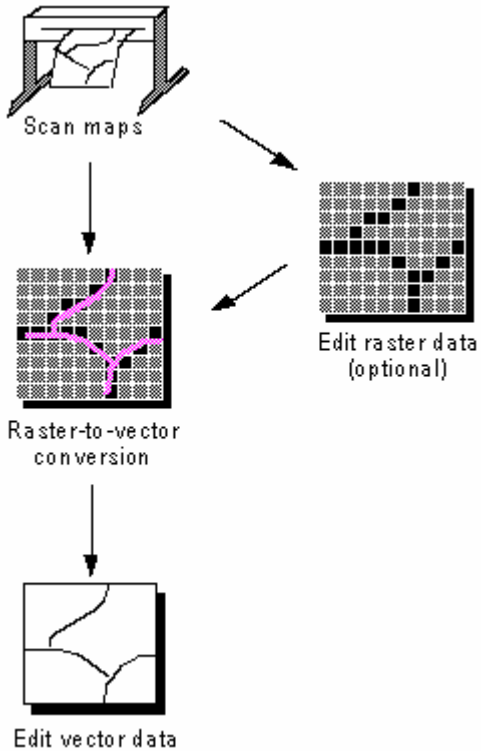
Data Input

- Sources of data.
- Data input:
  - Digitizing: paper maps, heads-up.
  - Scanning.
  - Coordinate geometry (COGO).
  - GPS.
  - Utilizing existing data.
- Quality Assurance/Control (QA/QC)

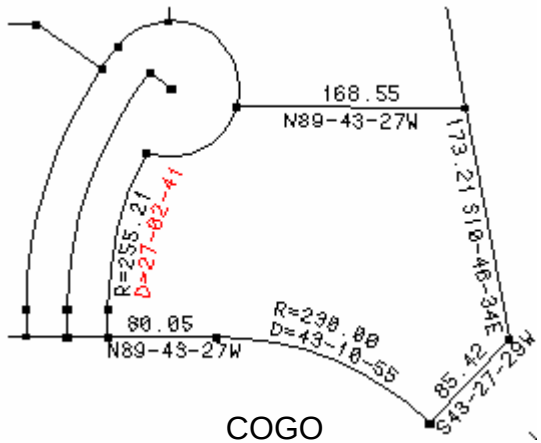
Data Input - Example



Digitizing



Scanning

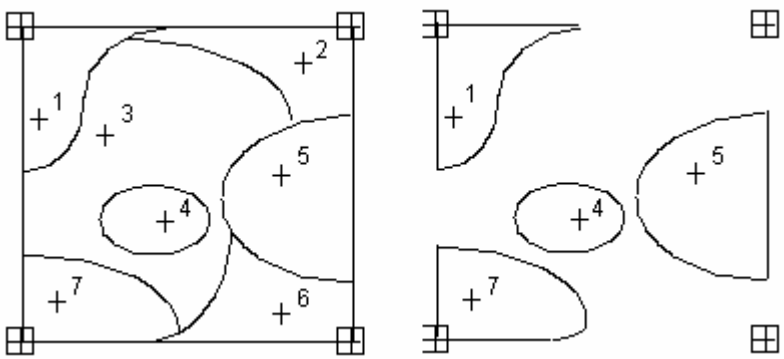


COGO

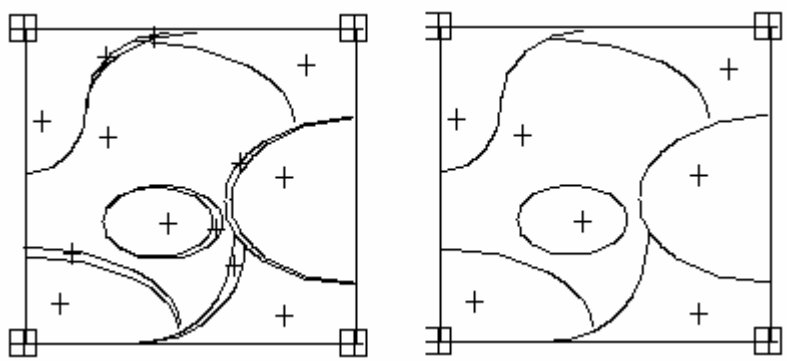
Data Manipulation/Analysis

- Logical operations:
  - Feature extraction, merging.
- Proximity analysis:
  - Buffers, distance comparisons, Thiessen.
- Boundary operations:
  - Clip, erase, update, split, append.
- Spatial joins:
  - Point-in-polygon, line-in-polygon, polygon-in-polygon.

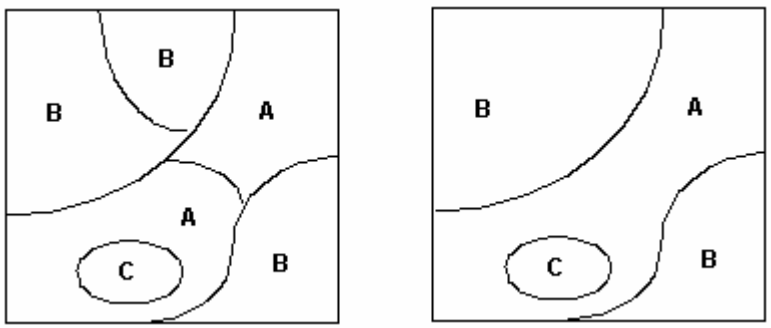
Data Manipulation/Analysis
Logical operations:



Reselect

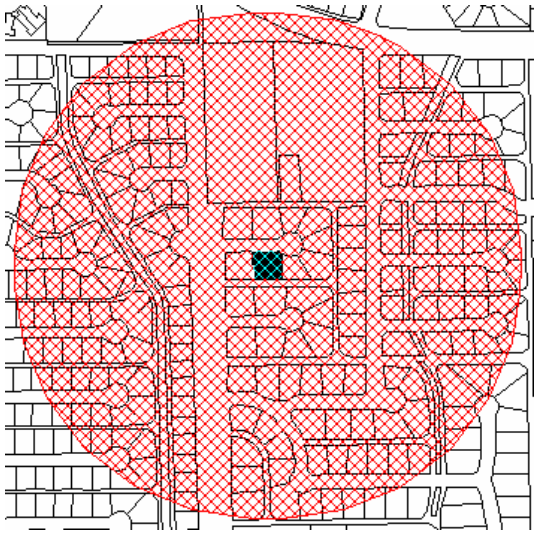


Eliminate

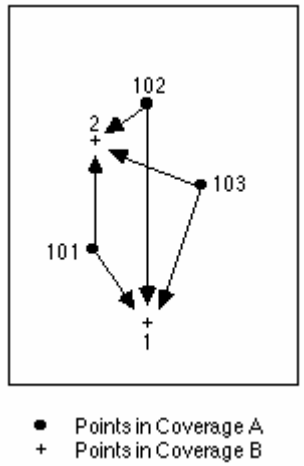


Dissolve

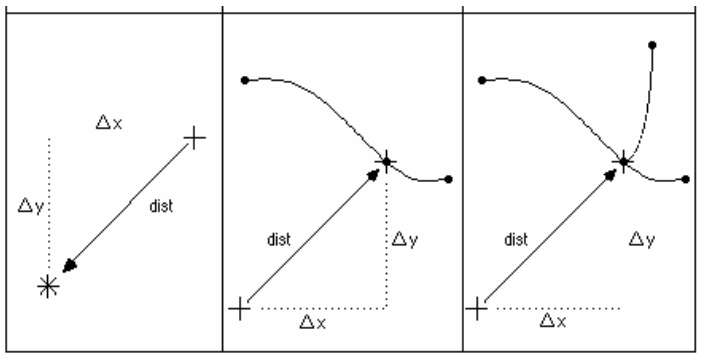
Data Manipulation/Analysis
Proximity Analysis:



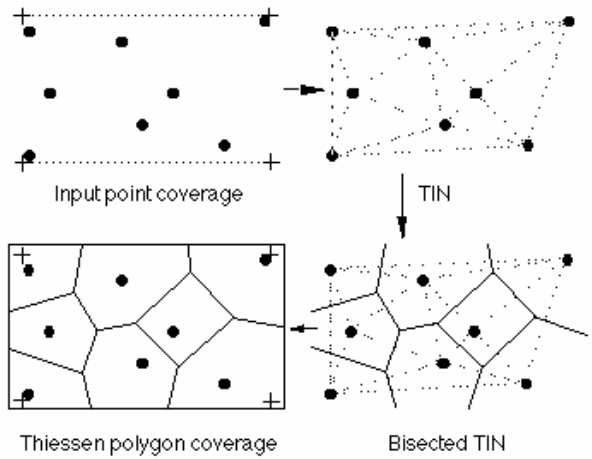
Buffer



Point distance

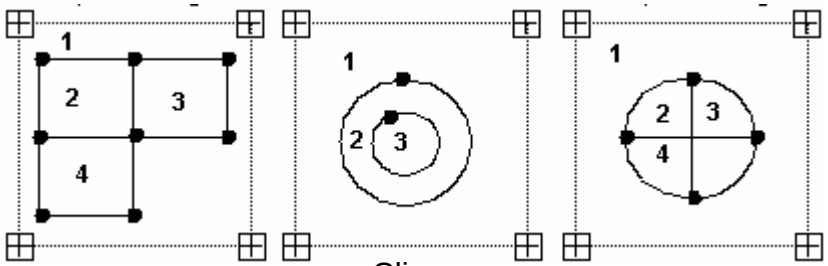


Near

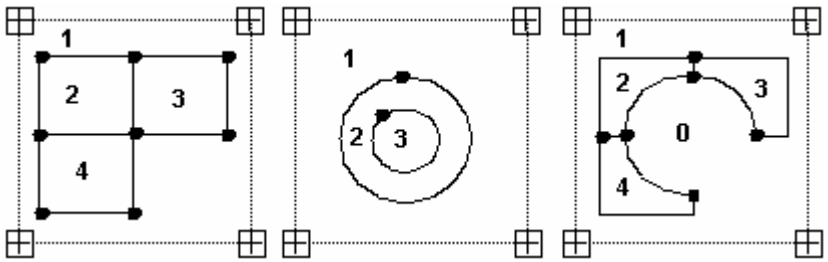


Thiessen

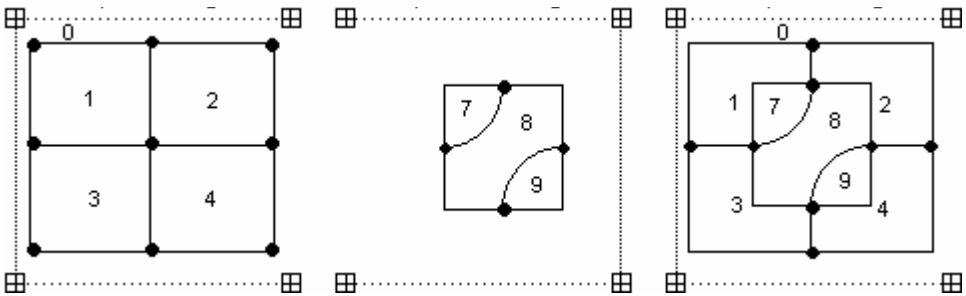
Data Manipulation/Analysis Boundary operations:



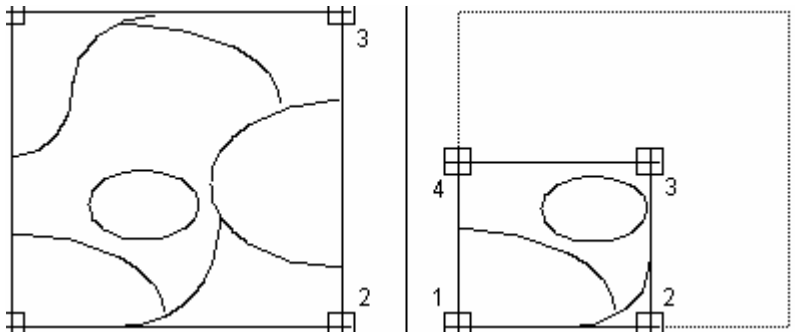
Clip



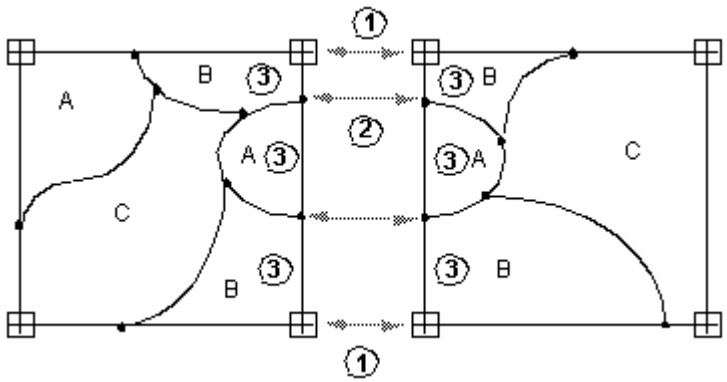
Erase



Update

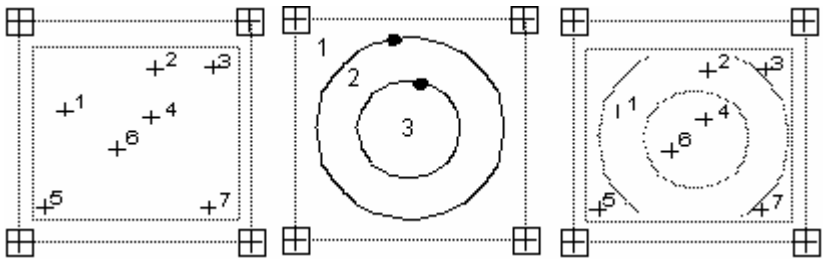


Split

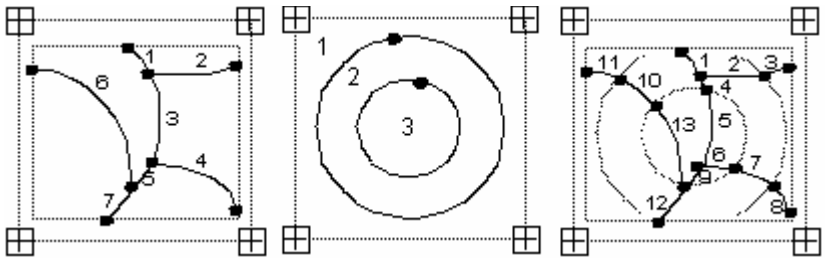


Append

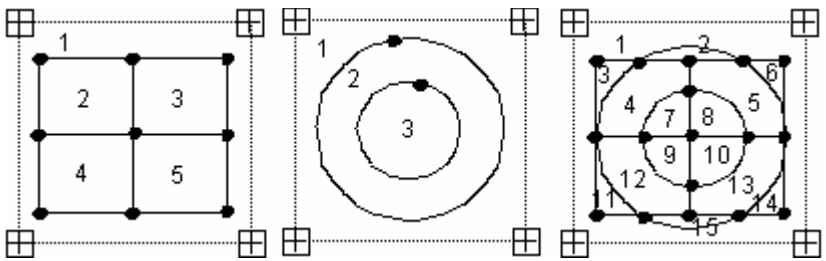
Data Manipulation/Analysis
Spatial Joins:



Point-in-polygon



Line-in-polygon

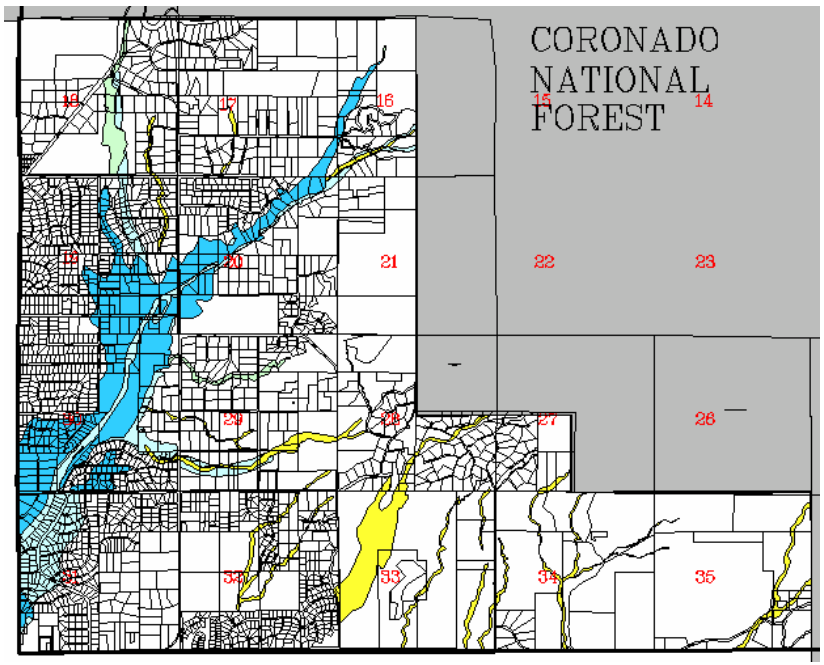


Polygon-in-polygon

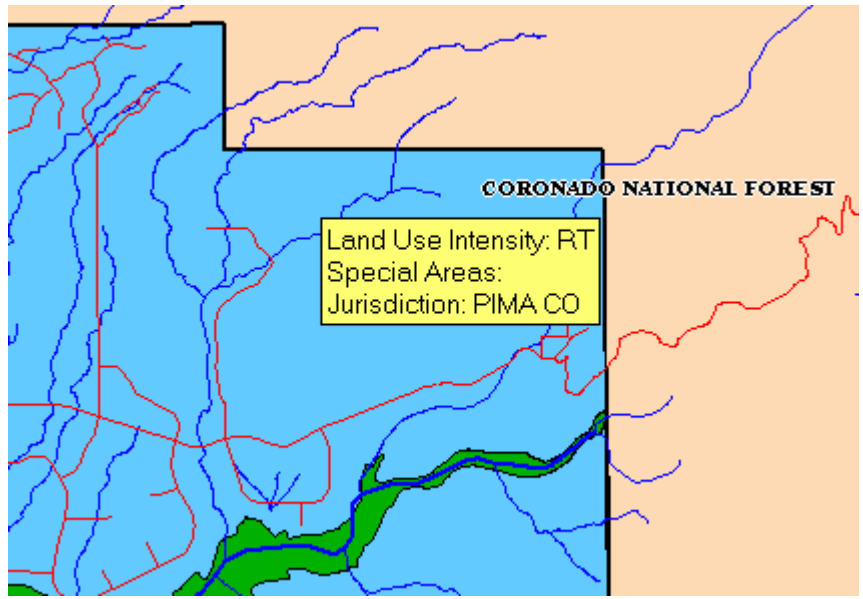
Data Output

- Maps:
  - Digital: static, interactive, display and query, web-based.
  - Hardcopy: small/large format.
- Reports:
  - Tabular, graphs, charts.

Data Output
Maps:



Static



Interactive (web-based)

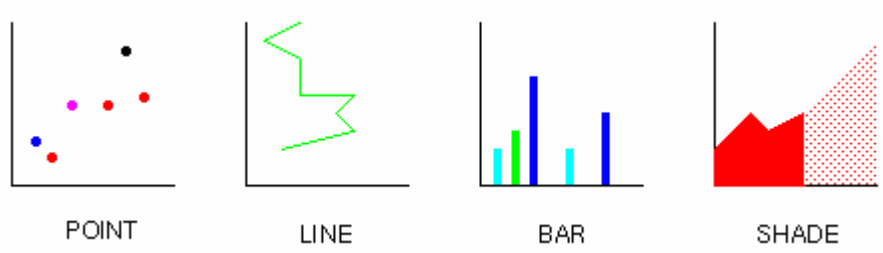
Data Output Reports:

```
                    AVERAGE PRICE REPORT

PART                DATE SUPPLIER      PURCHASE        VALUE
AVERAGE
NUMBER              RECEIVED NAME         PRICE      ON HAND
COST

A101     RECEIVED   5/ 3/1980 ACME         4.25       212.50
4.25
A101     RECEIVED   5/ 4/1980 ACME         4.25       106.25
4.25
                                                     ---------
AAAAAAA
SHPS RCVD                  2              4.25       318.75
```

Tabular

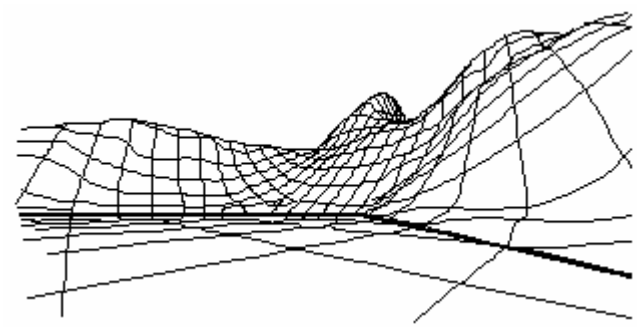


Graphic

Advanced and New Technology

- Data storage:
  - Spatially enabled databases.
  - Geodatabases.
- Surface modeling.
- Digital imagery.
- Ground Positioning System (GPS)
- Mobile GIS and Location Based Services

Advanced and New Technology - Example



3-D surface

Digital image

Topics Covered in Course

- History and benefits of GIS.
- Mapping principles.
- Spatial features.
- Feature attributes.
- Data processes.
- Advanced and new technology.
- Resources.

Resources

- See handout.

- "The Nature of Geographic Information"
  The GIS Primer
  http://www.innovativegis.com/education/primer/nature.html
- "Fundamental GIS Concepts"
  The GIS Primer
  http://www.innovativegis.com/education/primer/concepts.html

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