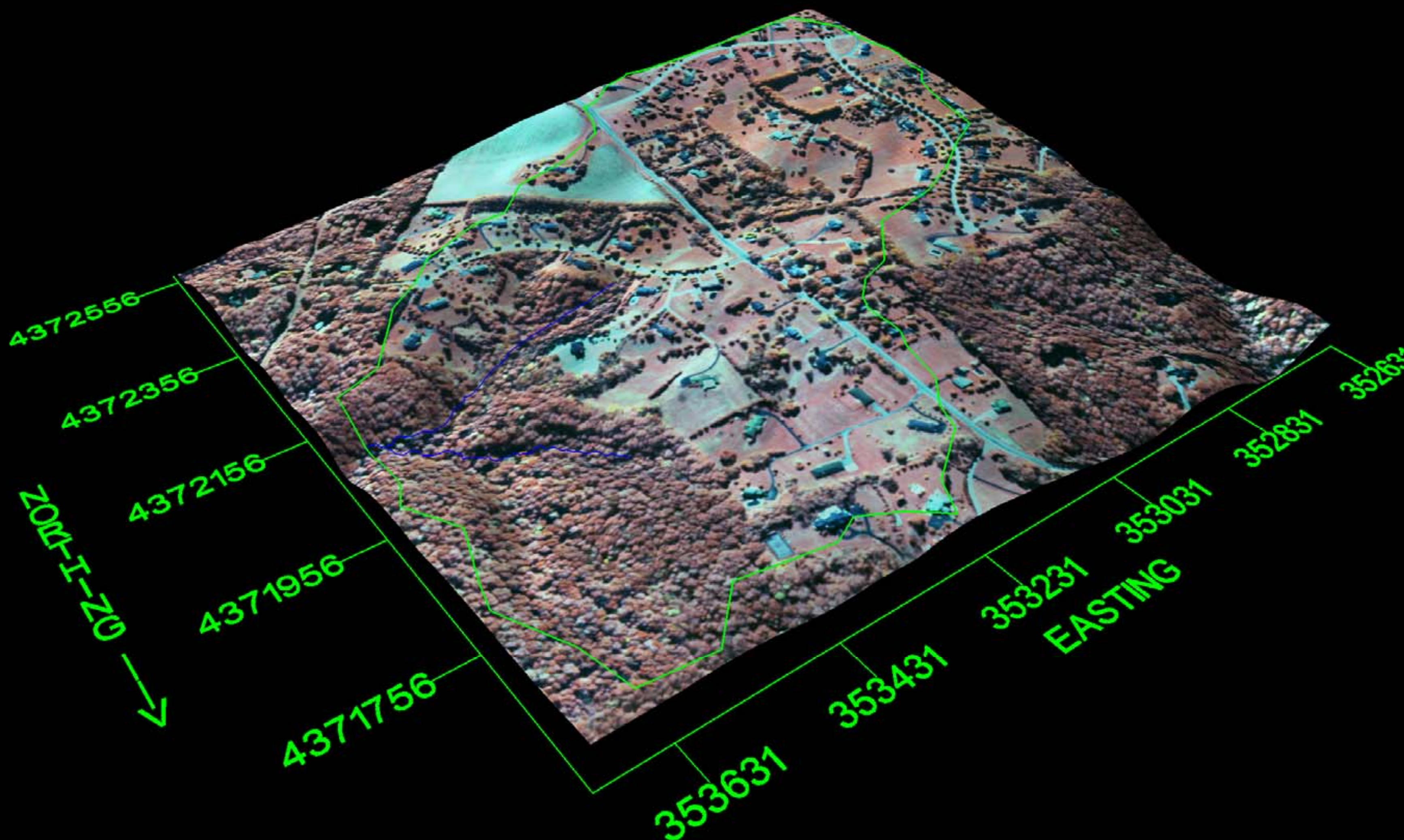
EEOS 281 – Introduction to Geographic Information Systems



EEOS 281 – Introduction to Geographic Information Systems

Course Description:

This course is an introductory course in geographic information systems (GIS). As with many other information systems, GIS requires that information be managed within a database structure. However, geographic information is fundamentally different compared to most other types of information and GIS is a very unique type of information system. In addition to managing information, what makes GIS such a powerful tool is the ability to implement spatial analytic procedures. This course will introduce you to the fundamentals of GIS and will demonstrate the versatility in the types of analysis that geographic information systems offer. No prior experience with GIS is expected, however familiarity with Microsoft Windows operating systems will be helpful.

EEOS 281 – Introduction to Geographic Information Systems

- Our **objectives** include:
  - Examine **fundamental concepts** of geographic information systems.
  - Review **geo-referencing systems** and explain how these systems are linked to digital geographic information.
  - Emphasize the importance of **cartographic principles** when presenting GIS output.
  - Discuss **GIS data structures** and highlight the advantages and disadvantages of each data structure.

EEOS 281 – Introduction to Geographic Information Systems

- Our **objectives** continued:
  - Review **basic principles of relational databases** and demonstrate how GIS objects are related to databases.
  - Provide examples of **how GIS is utilized** in real-world applications.
  - Reinforce topics discussed in lecture through **weekly laboratory exercises**.

EEOS 281 – Introduction to Geographic Information Systems

- Some **course policies**:

1. Regular attendance to lecture and lab is **essential**.
2. Students are **expected to do assigned reading before lecture sessions**, and come to class prepared to discuss the material.
3. Students are **expected to complete course assignments on-time**. Assignments submitted late will receive a reduction in points.

EEOS 281 – Introduction to Geographic Information Systems

- **Course policies** continued :

4. All assignments are expected to be completed and submitted in **TYPED** format (not handwritten). Handwritten assignments will not be accepted.
5. If you have multiple pages to submit for an assignment, please make sure you have the pages **STAPLED** together. Assignments that are not stapled will not be accepted.

EEOS 281 – Introduction to Geographic Information Systems

- **Course policies** continued :

6. All students are expected to adhere to the guidelines set forth by the **Code of Student Conduct**. Any violations of this code (e.g. plagiarizing from the Internet or copying the work of other students) will result in disciplinary action taken by myself and any further disciplinary action taken by the Office of the Dean of Student Affairs.

EEOS 281 – Introduction to Geographic Information Systems

- **Course policies** continued :

7. If you are a student with a **disability** that requires any assistive devices, services or accommodations, please contact the instructor.
8. Please adhere to the **posted GIS Lab Rules**
9. Please be **considerate of others in class**. In particular, please do not talk to others during lecture; it can be very distracting to everyone else in the room. Also, make sure your cell phone is off before class begins.

Course Introduction – Where and When

- **Lectures**:
  - S-3-020
  - Tuesdays from 2:00 - 4:30 PM

- **Labs**:
  - S-3-020
  - Thursdays from 2:00 - 4:30 PM

GIS's Focus Is On Where

- On the previous slide, I specified **where** using the names of buildings and room numbers
- Geographers often approach the concept of **where** using another representation of location – a **map**:

http://www.umb.edu/parking_transport/images/campus_map.jpg

But Where By Itself is Not So Useful

- **Where** – S-3-020
- **When** – Tuesdays from 2:00 - 4:30 PM
- **What** – EEOS 281 Lectures
- **Who** – Students enrolled in the course (you)
- **Who Else** – The instructor teaching the course
  - Name – David Tenenbaum
  - Position - Assistant Professor
  - Department - Environmental, Earth and Ocean Sciences

David Tenenbaum

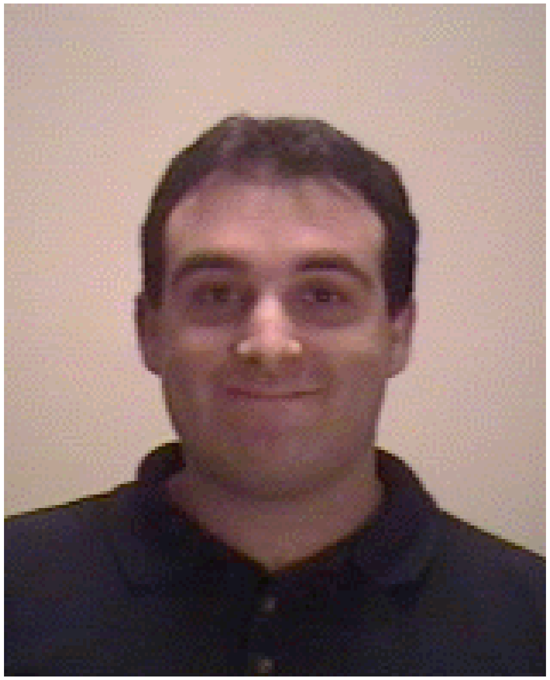
- Hon. B.Sc. at the University of Toronto
  - **Majors**: Physical and Environmental Geography & Environment in Society
- M.Sc. at the University of Toronto
  - **Thesis**: RHESSys-ArcView Integrated Modelling Environment
- Ph.D. at the University of North Carolina at Chapel Hill
  - **Dissertation**: Surface Moisture Patterns in Urbanizing Landscapes
- Canadian Government Lab Visiting Fellow at the Water & Climate Impacts Research Centre
  - **Research**: NAESI - In-Stream Flow Needs

How to reach me

David E. Tenenbaum, Ph.D.
Assistant Professor
EEOS, UMass Boston

Office: Science Building S-1-60

Email: david.tenenbaum@umb.edu
Tel: 617-287-7396

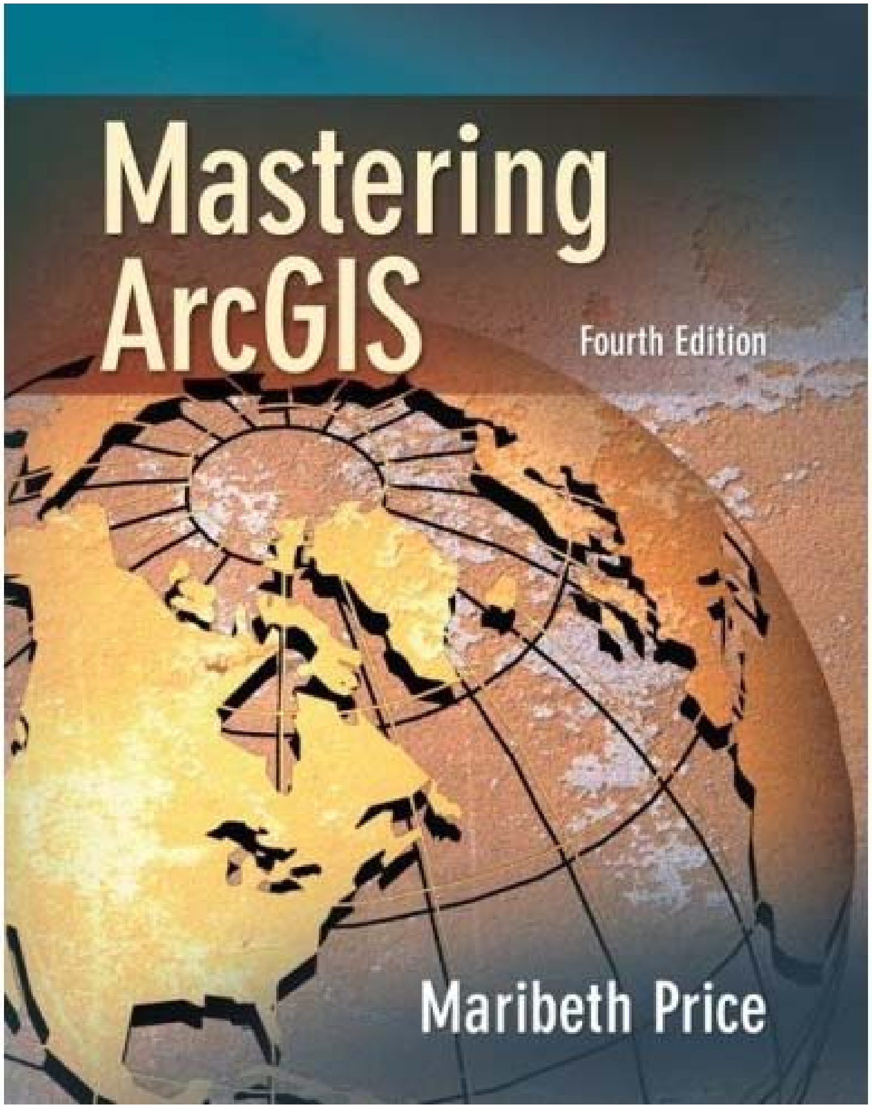


EEOS 281 – Introduction to Geographic Information Systems

- **Course Web Page:**
  - **http://www.faculty.umb.edu/david.tenenbaum/eeos281**
- **Read** the background material from the text
- **Download/read** sections of course material online
  - At least skim these before class so you are familiar with the material we will cover
- Lectures will closely follow (though not exactly) the **topics / structure** outlined in syllabus

EEOS 281 – Introduction to Geographic Information Systems

- **Text:** Mastering ArcGIS, 4th Edition. McGraw-Hill, 2010. ISBN 978-0-07-352284-5.



EEOS 281 – Introduction to Geographic Information Systems

- **Lab Sessions:**
  - Thursdays 2:00 - 4:30 PM S-3-020

- **Assignments:**
  - Lab sessions are intended to provide you with **hands-on experience** using GIS. The GIS software used in this course will be ArcGIS 9.3. In most instances, you will **not be able to complete the assignment** during our allotted lab periods. It is your responsibility to **complete the assignments before the due date**. You can access the computer lab anytime during open lab hours. If the GIS Lab (S-3-20) is not open or a scheduled class is using the lab, you can access the secondary GIS Lab in S-3-34. This room is accessible 24/7 through the use of a keypad combination.

EEOS 281 – Introduction to Geographic Information Systems

- **Assignments** continued:
  - Assignments will generally be **due 1 week after** they are assigned at the **beginning of the lab session**
  - Most consist of **3 parts**:
    - **Chapter Review Questions**, which you can do anytime
    - **Tutorial Questions**, which you ideally do as you are completing the steps of the tutorial
    - **Exercise Questions**, which you ideally do after you have completed the tutorial
- **Lateness:** **-10%** of total mark per weekday
  - Assignments **more than a week overdue** **WILL NOT** be accepted
  - Approach your TA for **extenuating circumstances**

Course Schedule

Date	Session	Content (Chapter Review Questions)
Tues. Sept. 7	Lecture 1	Course Introduction, GIS Data – pp. 1-6, 17-34. (1, 3, 4)
Thurs. Sept. 9	Lab 1	Exercise 01
Tues. Sept. 14	Lecture 2	Mapping GIS Data – pp. 63-76. (1, 3, 9)
Thurs. Sept. 16	Lab 2	Exercise 02
Tues. Sept. 21	Lecture 3	Coordinate Systems – pp. 387-404. (1, 3, 8)
Thurs. Sept. 23	Lab 3	Exercise 03
Tues. Sept. 28	Lecture 4	Presenting GIS Data – pp. 107-120. (1, 5, 6)
Thurs. Sept. 30	Lab 4	Exercise 04
Tues. Oct. 5	Lecture 5	Attribute Data and Queries, pp. 153-164 (2, 6), 191-202. (1, 2, 7)
Thurs. Oct. 7	Lab 5	Exercise 05
Tues. Oct. 12	Lecture 6	Spatial Joins, pp. 221-236. (1, 5, 6)
Thurs. Oct. 14	Lab 6	Exercise 06
Tues. Oct. 19	Lecture 7	Mid-term Review
Thurs. Oct. 21	Mid-Term	Mid-term Examination

Course Schedule

Date	Session	Content (Chapter Review Questions)
Tues. Oct. 26	Lecture 8	Geoprocessing, pp. 251-263. (4, 5, 7)
Thurs. Oct. 28	Lab 7	Exercise 07
Tues. Nov. 2	Lecture 9	Geocoding, pp. 359-370. (4, 5, 7)
Thurs. Nov. 4	Lab 8	Exercise 08
Tues. Nov. 9	Lecture 10	Raster Analysis, pp. 285-300. (1, 2, 5, 6, 8 – 10)
Thurs. Nov. 11	Veteran's Day	Veteran's Day (no class)
Tues. Nov. 16	Lecture 11	Basic Editing, pp. 425-432. (1, 3, 5)
Thurs. Nov. 18	Lab 9	Exercise 10
Tues. Nov. 23	Lecture 12	Geodatabases, pp. 501-510. (1, 3, 4, 6, 10)
Thurs. Nov. 25	Thanksgiving	Thanksgiving (no class)
Tues. Nov. 30	Lecture 13	More Editing Techniques, pp. 459-468. (1, 4, 5)
Thurs. Dec. 2	Lab 10	Exercise 12
Tues. Dec. 7	Lecture 14	Remote Sensing
Thurs. Dec. 9	Lab 11	TBA
Tues. Dec. 14	Lecture 15	Final Review
Tues. Dec. 21	Final Exam	Final Exam

EEOS 281 – Introduction to Geographic Information Systems

Examinations:

This introductory course in geographic information systems is designed to provide you with **both theoretical knowledge and practical knowledge of GIS**. While the **assignments** are primarily devoted to developing and assessing your **hands-on GIS skills**, the mid-term and final **examinations** are designed to ensure that you have **grasped the underlying principles** that underpin how you use GIS. It is **critical** that you do your **weekly reading before class**, and be an **active participant in lecture sessions** to make sure that you understand the key concepts. The Summaries and Chapter Review Questions provided in the required textbook provide excellent opportunities to check and see if you've grasped the material.

EEOS 281 – Introduction to Geographic Information Systems

Grading:

Assignments	**50%**
Mid-term (Oct. 21)	**20%**
Final exam (Dec. 21)	**20%**
Class Participation	**10%**

What is GIS?

- GIS (usually) stands for **Geographic Information System**.
- A GIS is an immensely powerful **computer mapping and analysis system**.
- It links **geographic locations with information about them** so you can create maps and analyze information in new ways.
- It includes **techniques** for acquisition, storage, manipulation, analysis, and display of spatial data.

What is GIS?

- A GIS is a **system** of computer software, hardware, and data, and **personnel** to help manipulate, analyze and present **information** that is tied to a **spatial location**
  - **spatial location** - usually a geographic location
  - **information** - visualization of analysis of data
  - **system** - linking software, hardware, and data
  - **personnel** - a thinking explorer who is key to the power of GIS

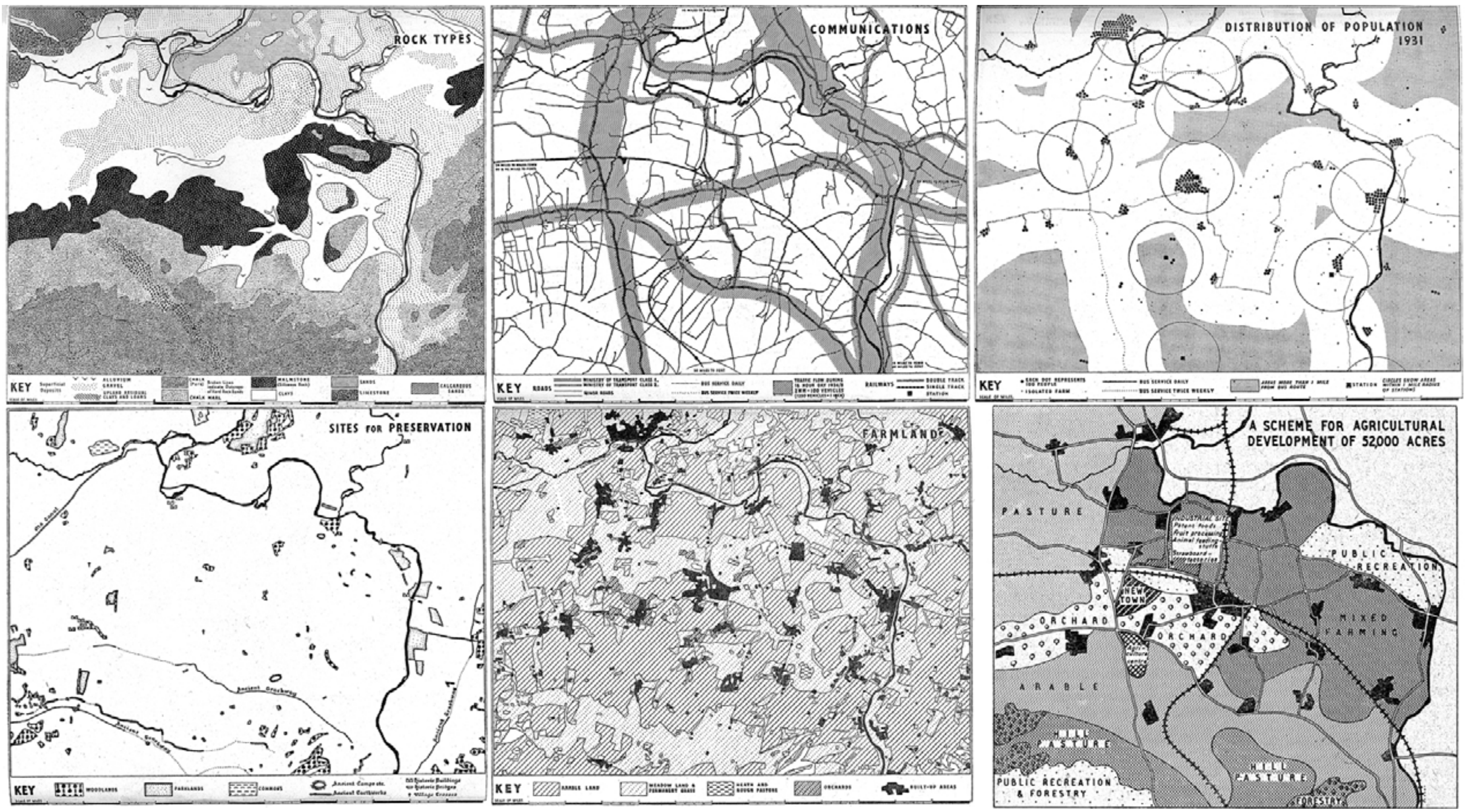
Geographic Information

- Includes knowledge about **where** something is
- Includes knowledge about what is at a given **location**
- Can be very detailed:
  - e.g. the locations of all buildings in a city or the locations of all trees in a forest stand
- Or it can be very coarse:
  - e.g. the population density of an entire country or the global sea surface temperature distribution
- There is always a **spatial** component associated with geographic information

A Brief History of GIS

- GIS's origins lie in **thematic cartography**
- Many planners used the method of **map overlay** using manual techniques
- Manual map overlay as a method was first described comprehensively by **Jacqueline Tyrwhitt** from Britain in a1950 planning textbook
- **Ian McHarg** used blacked out transparent overlays for site selection in *Design with Nature* published in 1969.

Tyrwhitt: Town & Country Planning



A Brief History of GIS (continued)

- The **1960s** saw many new forms of geographic data and mapping software
- **Computer cartography** developed the first basic GIS concepts during the **late 1950s and 1960s**
- **Linked software modules**, rather than stand-alone programs, preceded GISs
- **Early influential data sets** were the World Data Bank and the GBF/DIME files by the US Census Bureau
- **Early systems** were CGIS, MLMIS, GRID and LUNR
- The Harvard University ODYSSEY system was influential due to its **topological arc-node (vector) data structure** in the 70s

Chapter 1. GIS Data

Objectives:

- Understanding how real world features are **represented** by GIS data
- Knowing the **differences between the raster and vector** data models
- Getting familiar with the basic elements of **data quality** and **metadata**
- Learning the **different types of GIS files** used by ArcGIS
- Learning to **use ArcCatalog** to view and manage GIS data
- Learning about **layers** and their properties

Objects in the Real World → Map Objects

Objects in the real world, such as cities, roads, soils, rivers and topography must first be portrayed as map objects.

- **Point objects**: These are objects with only a location, no length or area
- **Line objects**: These are objects with several locations strung out along the line in sequence, and are too narrow to represent their width.
- **Area objects**: These consist of one or more lines that form a loop.

Portraying Objects in the Real World as Map Objects

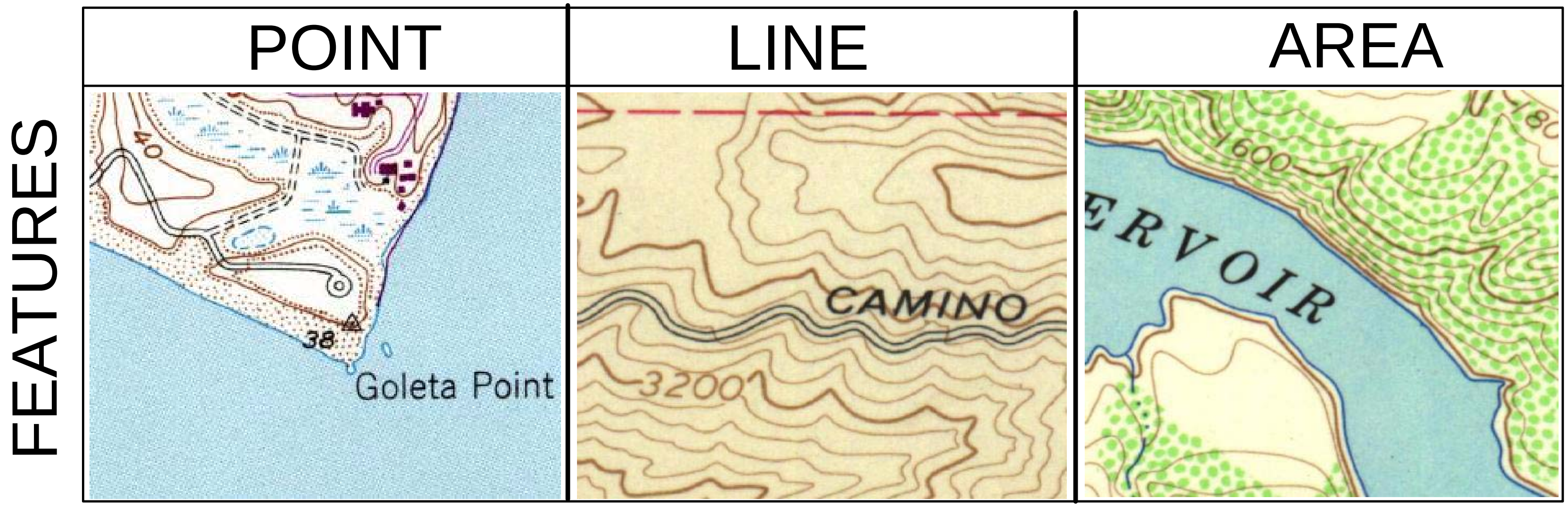
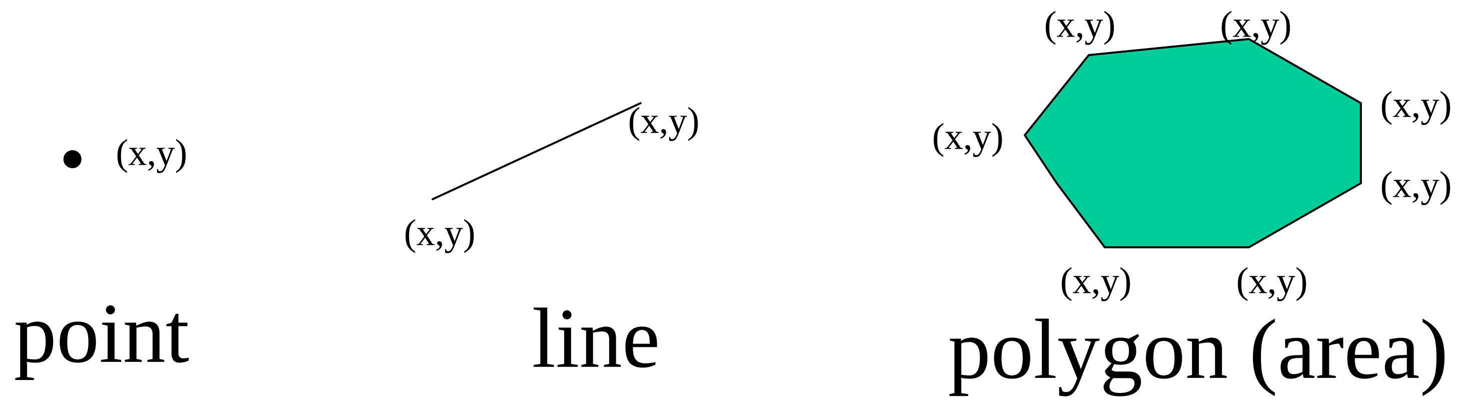


Figure 1.2 The Feature Model: Examples of a point feature (38 foot elevation bench mark), a line fea ture (road, contours) and area features (reservoir, vegetation).

GIS Data Models

- A GIS map is a **scaled-down** digital representation of **point, line, area, and volume** features.
- A **logical data model** is how data are organized for use by the GIS.
- Traditionally there are **two GIS data models** used:
  – Vector
  – Raster

Geographic Features (Vector Model)



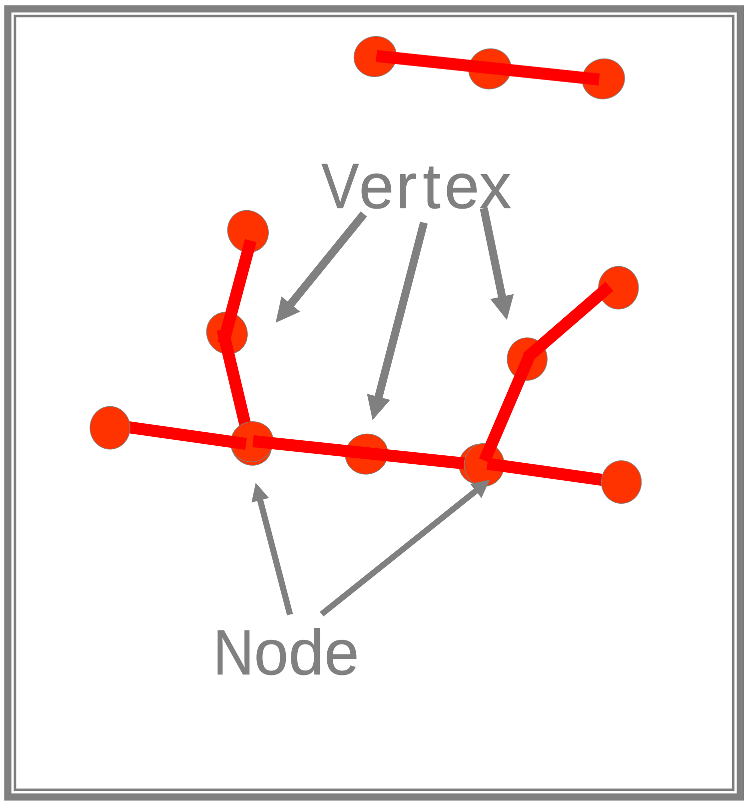
•**A point:** specified by a pair of (x,y) coordinates, representing a feature that is too small to have length and area.

•**A line:** formed by joining two points, representing features too narrow to have areas

•**A polygon (area):** formed by a joining multiple points that enclose an area

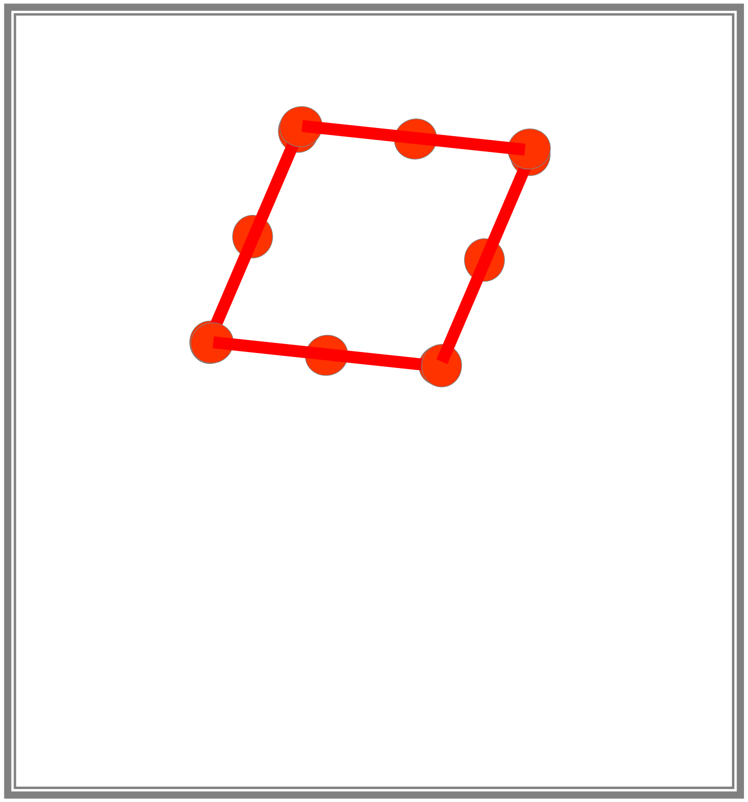
Vector Data Model - Objects

- Lines/Arcs
  - these are formed by **joining** multiple points
  - points at the junctions of lines are called **nodes**

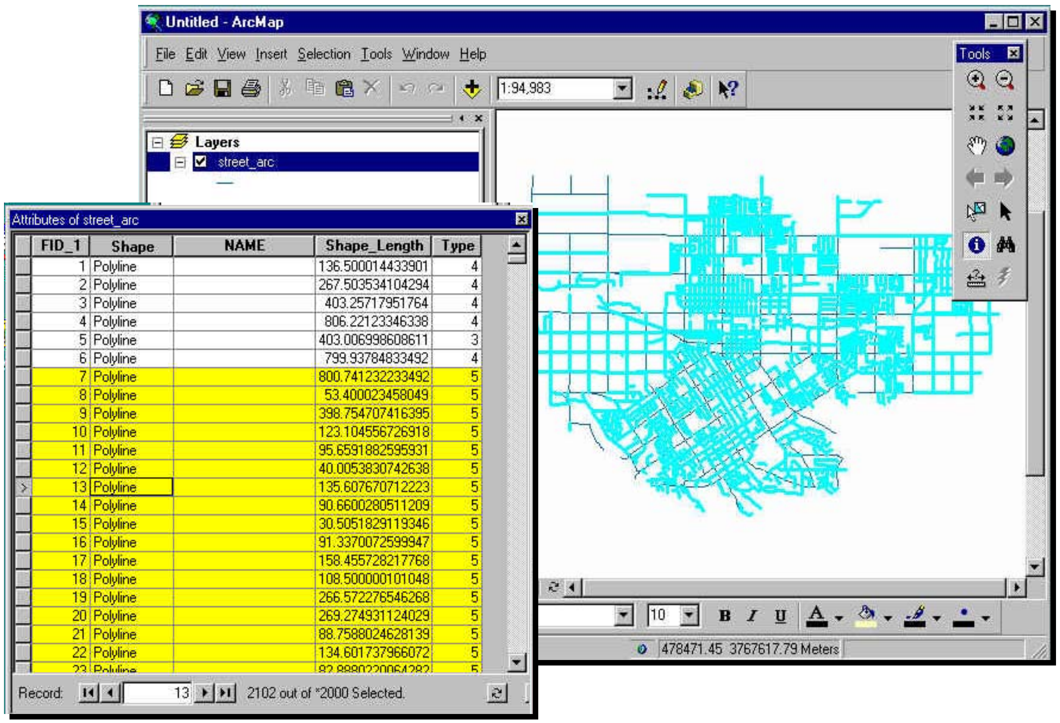


Vector Data Model - Objects

- Polygons
  - these are composed of **multiple lines or arcs**
  - They are required to have the property of **closure**, meaning that the multiple lines/arcs must form a **closed shape** for it to be a polygon



Georelational Data Model



•Spatial features are **linked** to attributes in a separate table by means of a **unique feature identification code** or **FID**.

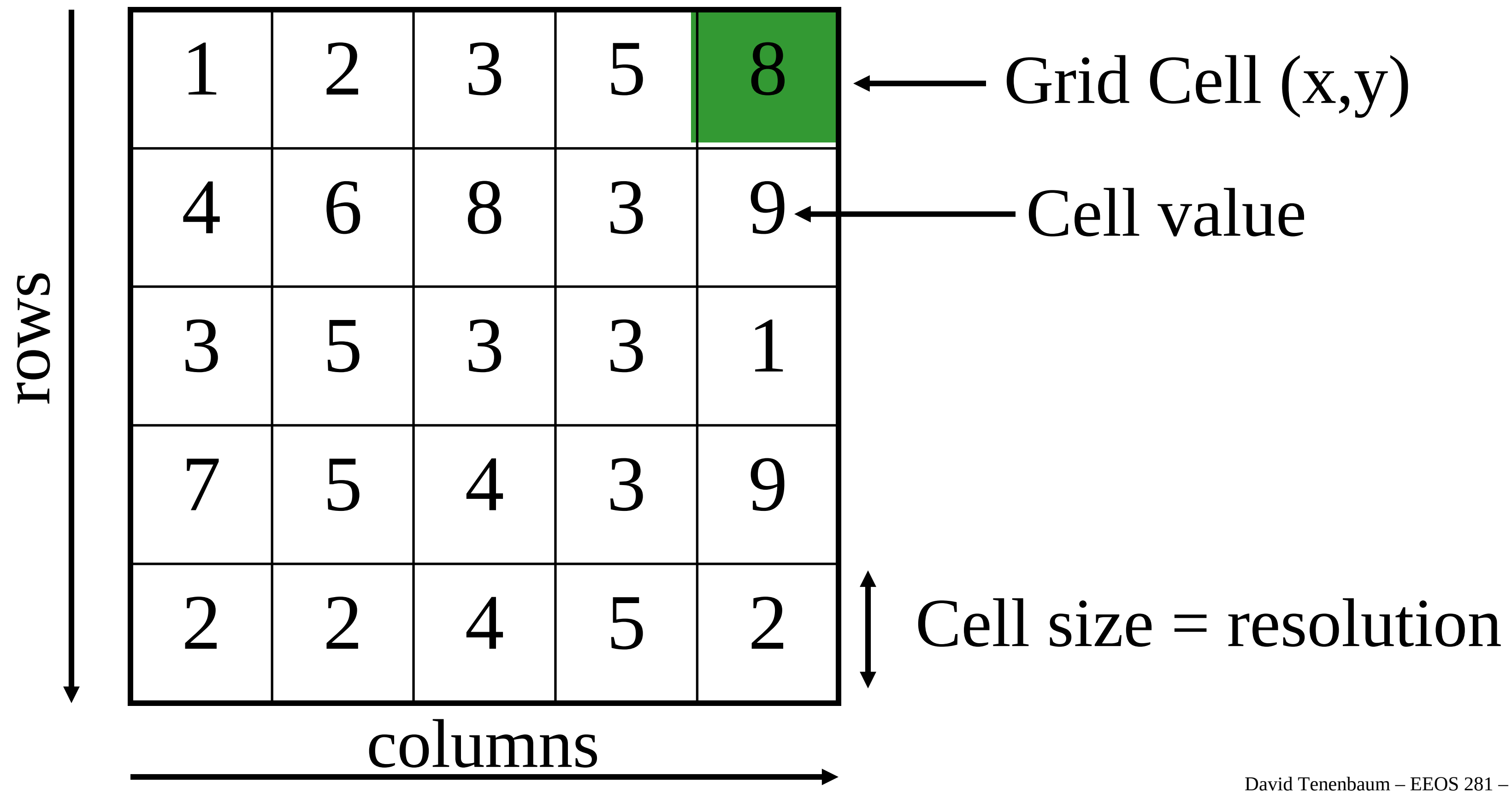
•Each feature corresponds to **one and only one** line (record) in the table.

Raster Data Model

- A representation of the world as a surface divided into a **regular grid of cells.** Raster models are useful for storing data that **varies continuously** such as in an aerial photograph, a satellite image, a surface of chemical concentrations, or an elevation surface.
- **One grid cell** is **one unit** or holds **one attribute**.
- **Every** cell has a **value**, even if it is **"missing."**
- A cell can hold **a number (absolute values) or an index value (coded values)** standing for an attribute.
- A cell has a **resolution**, given as the cell size in ground units.

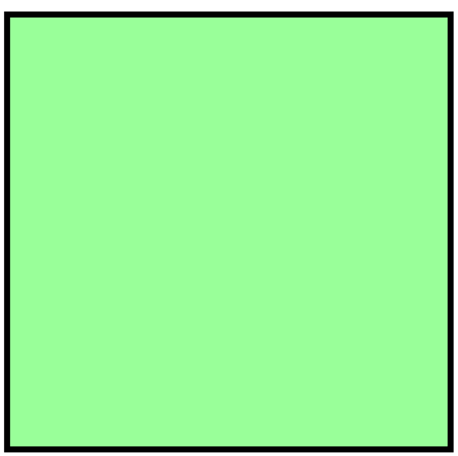
Raster Data Model

•The raster data model represents the Earth's surface as an **array** of two-dimensional grid cells, with each cell having an associated value:

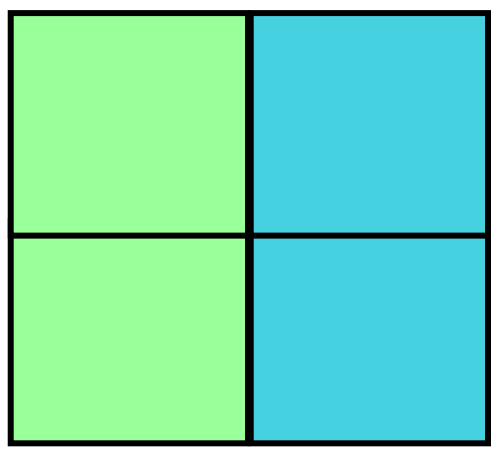


Cell Size & Resolution

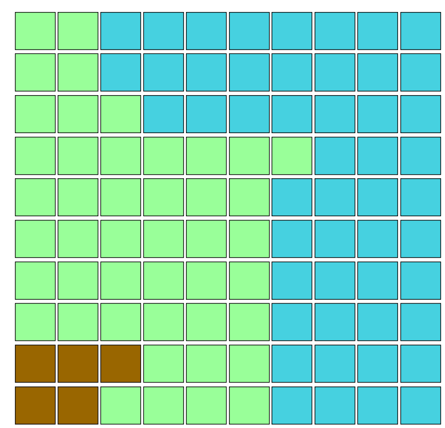
- The **size** of the **cells** in the raster data model determines the **resolution** at which features can be represented
- The selected **resolution** can have an **effect** on how features are represented:



10 m Resolution



5 m Resolution

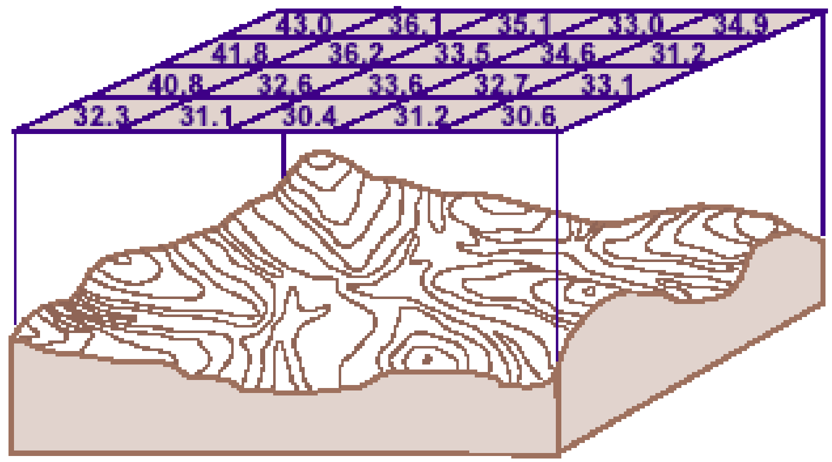


1 m Resolution

Discrete and Continuous Rasters

- **Discrete data**
  - Models **bounded** data
    - Land use, zoning, and so on
  - Stored as **integer values**

- **Continuous data**
  - Models **surfaces**
    - Elevation, distance
  - Stored as **floating-point or integer values**

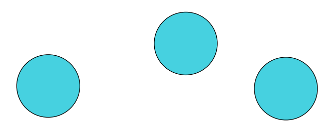


Raster Data Model - Discrete

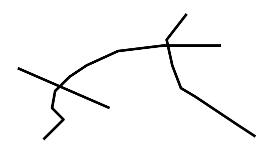
The raster data model can represent discrete objects, but does so **differently** from the vector model:

Geographic Primitives

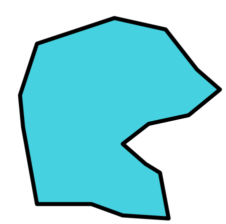
- Points
  - 0 dimensional



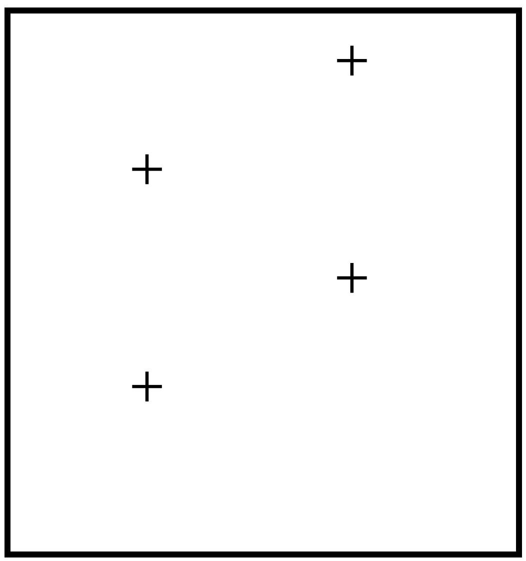
- Lines
  - 1 dimensional

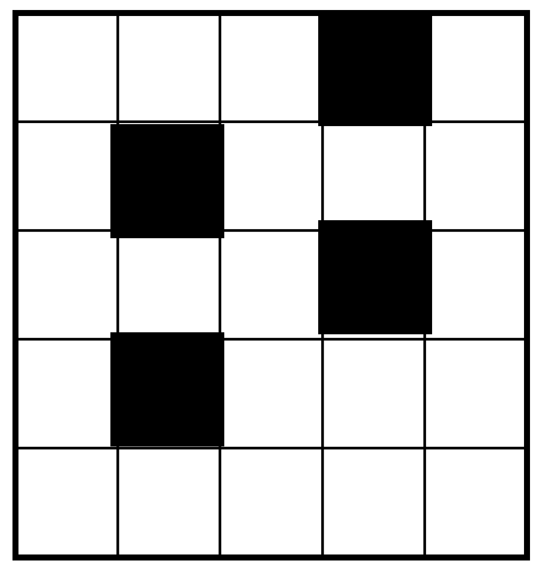


- Polygons
  - 2 dimensional



Raster Data Model - Points

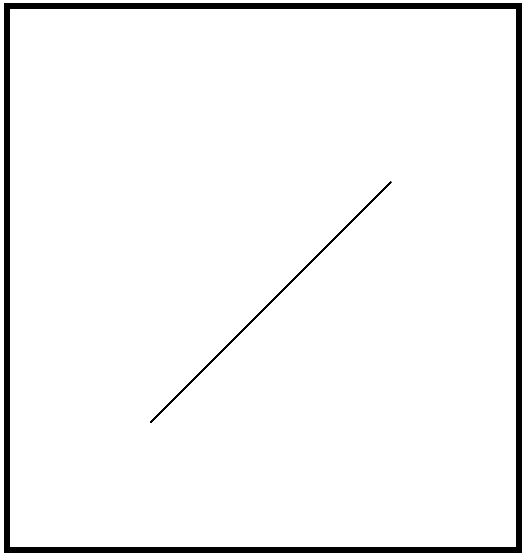


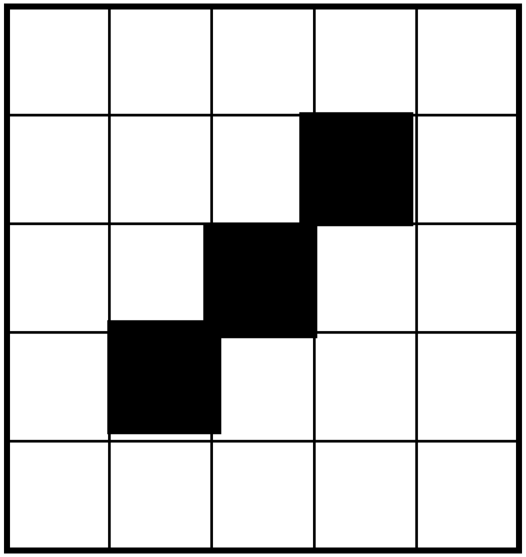


1 point = 1 cell

What problem do we have here? How can we solve it?

Raster Data Model - Lines

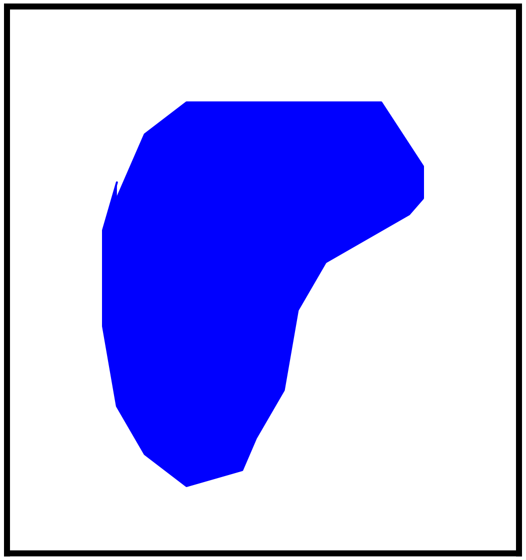


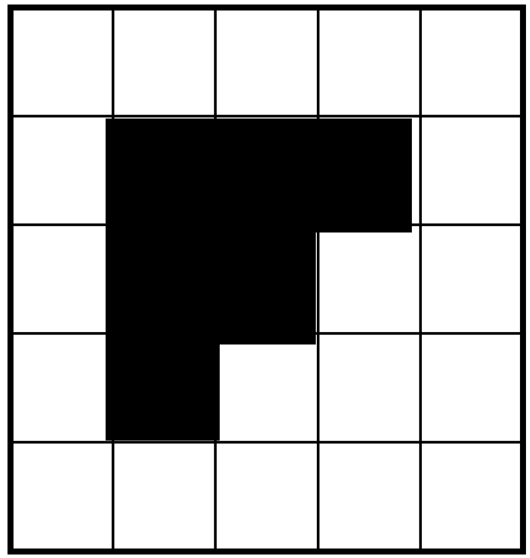


A line = a series of connected cells that portray length

Is there a problem with this representation?

Raster Data Model - Areas



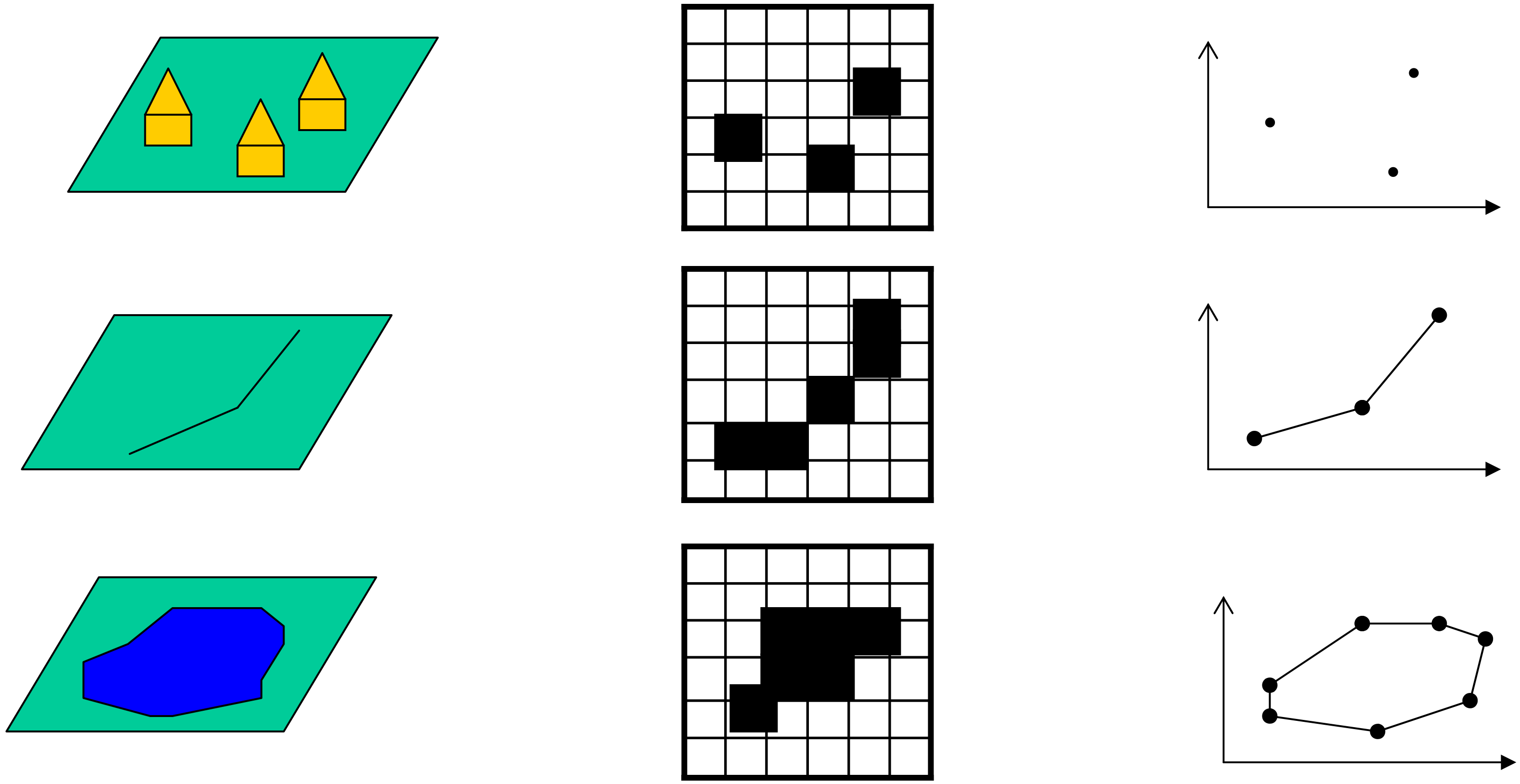


Area = a group of connected cells that portray a shape

What problems could we have with this representation?

Raster and Vector Data Model Comparison

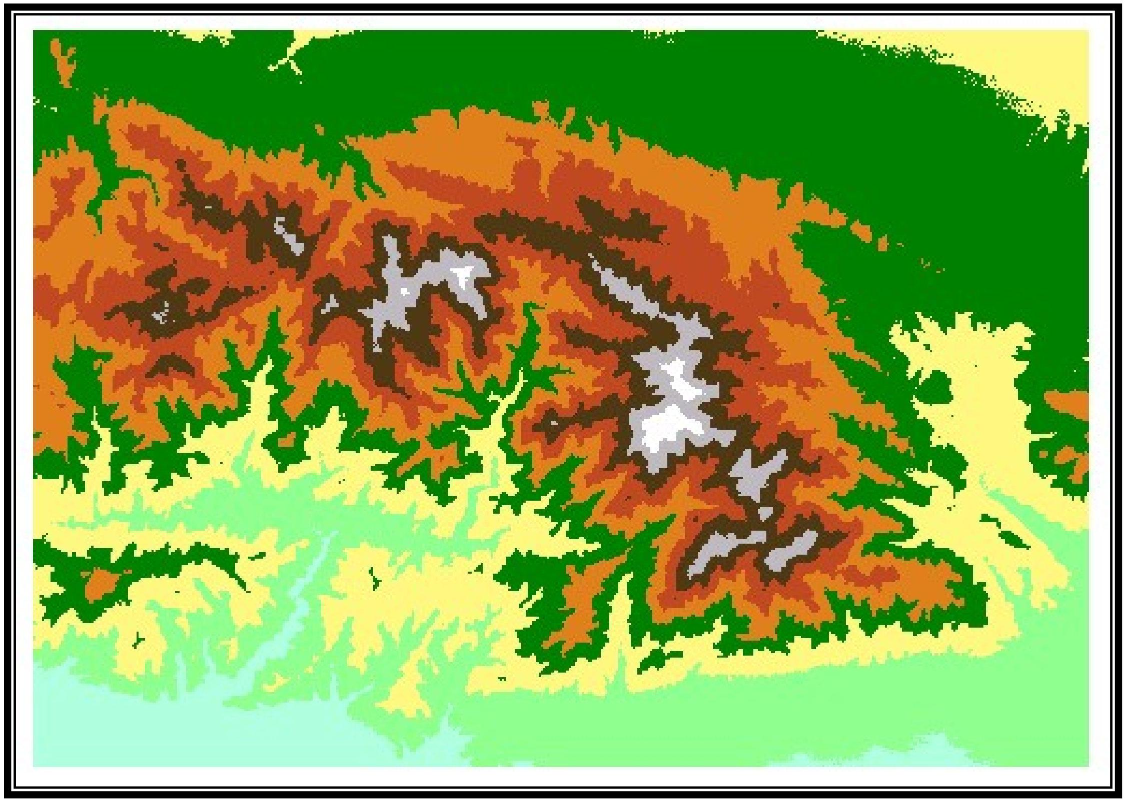
Real World Features | **Raster** | **Vector**



"A raster model tells what occurs everywhere, while a vector model tells where every thing occurs"

Continuous Raster Data Set

•In this instance, the **value** of the cell is actually the value of the phenomenon of interest, e.g. elevation data (whether floating point or integer):



Georeferencing

- **GOAL:** To assign a **location** to all the features represented in our geographic information data
- In order to do so, we need to make use of the following elements:
  - ellipsoid/geoid
  - datum
  - projection
  - coordinate system
  - scale

To determine a position on the Earth, you'll need to understand how these elements relate to each other in order to specify a position

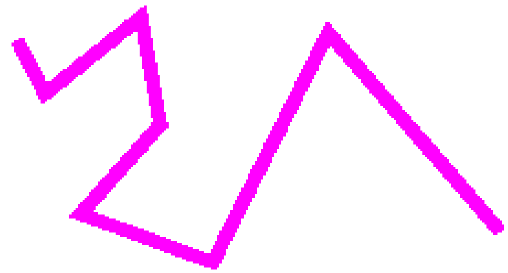
- During the next few lectures you will be introduced to these elements

Coordinate Systems

- A coordinate system is a **standardized method** for **assigning numeric codes to locations** so that locations can be found **using the codes alone**.
- Standardized coordinate systems use **absolute locations**.
- In a coordinate system, the x-direction value is the **easting** and the y-direction value is the **northing**. Most systems make both values positive.

Two Vector Models: Spaghetti and Topological

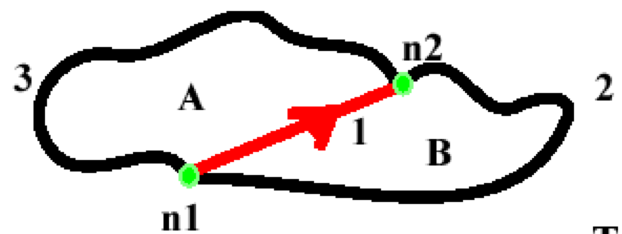
Spaghetti



Vector-based line

4753456	623412
4753436	623424
4753462	623478
4753432	623482
4753405	623429
4753401	623508
4753462	623555
4753398	623634

Topological

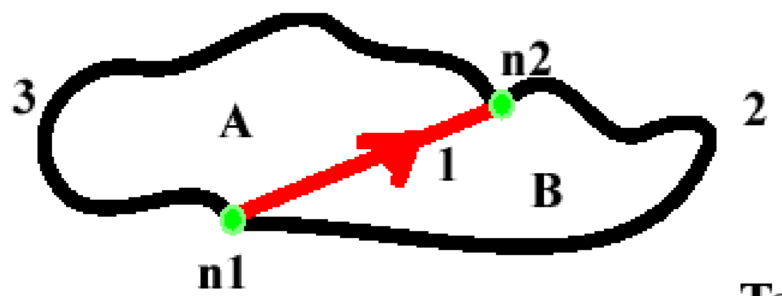


Topological Arcs File

Arc	*From*	*To*	*PL*	*PR*	*n1x*	*n1y*	*n2x*	*n2y*
1	n1	n2	A	B	x	y	x	y

Topology

- A **spatial data structure** used primarily to ensure that the associated data forms a **consistent and clean topological fabric**. For instance, the **arc-node topology**: Typically the arc is stored as the base unit, storing with it the polygon left and right, the forward and reverse arc linkages and the arc end nodes.



Arc	*From*	*To*	*PL*	*PR*	*n1x*	*n1y*	*n2x*	*n2y*
1	n1	n2	A	B	x	y	x	y

Vector Data Model - Topology

- Topology defines spatial relationships. The arc-node data structure supports the following topological concepts:
- **Area definition:** Arcs connect to surround an area, defining a polygon
- **Containment:** Nodes (or arcs) can be found within a polygon
- **Connectivity:** Arcs connect to each other at shared nodes
- **Contiguity:** Arcs have a defined direction, and left and right sides

The Role of Error

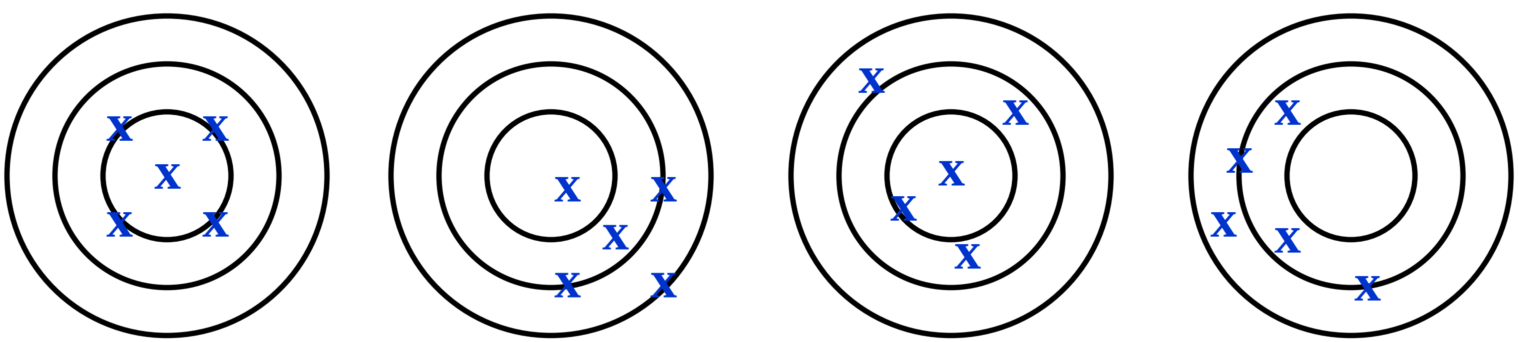
- **Enforcement** for map data is usually by **using topology**
- Map and attribute data errors are the **data producer's responsibility**, but the GIS user must understand error
- **Accuracy and precision** of map and attribute data in a GIS **affect all other operations**, especially when maps are compared across scales

Precision and Accuracy

- When describing error we need to distinguish between **two characteristics**:
  - **Accuracy** refers to the **amount of distortion** from the true value in a measurement
  - Precision refers to the **variation among repeated measurements**, and also to the **amount of detail** in the reporting of a measurement

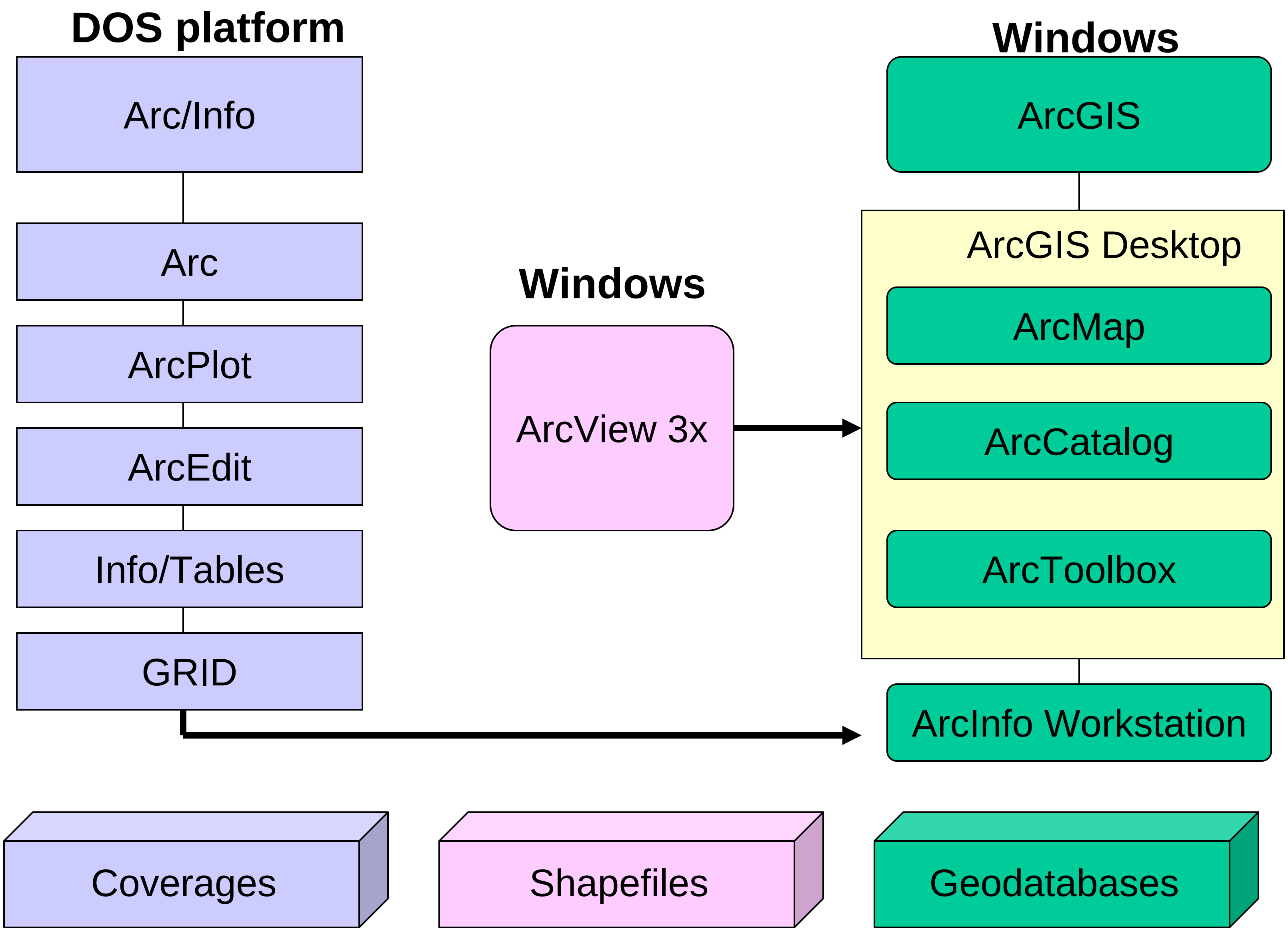
Precision and Accuracy

- These related concepts are often confused:
  - **Precision** refers to the exactness associated with a measurement (i.e. closely clustered)
  - **Accuracy** refers to the extent of systematic bias in the measurement process (i.e. centered on the middle)



Precise & Accurate | Precise & Inaccurate | Imprecise & Accurate | Imprecise & Inaccurate

ESRI's GIS Structure



Application Software

ArcMap, ArcCatalog, ArcToolbox, and ModelBuilder:

- **ArcMap** - for cartography, map analysis, and editing
- **ArcCatalog** - organizes and manages all GIS information: maps, data sets, models, metadata, and services. including
  - Browse and find geographic information
  - Record, view, and manage metadata
  - Define, export, and import geodatabase schemas and designs
  - Search and browse GIS data on local networks and the Web
- **ArcToolbox** - geoprocessing functions including tools for
  - Data management
  - Data conversion
  - Vector analysis
  - Geocoding
  - Statistical analysis
- **ModelBuilder** – for building models!

Data Formats in Arc Products

- **ArcView 3.x**
  - Shapefile
- **ArcInfo**
  - Coverage
  - GRID
- **ArcGIS**
  - Geodatabase
  - (.mdb)
  - (.gdb)

Next Topic:

Mapping GIS Data