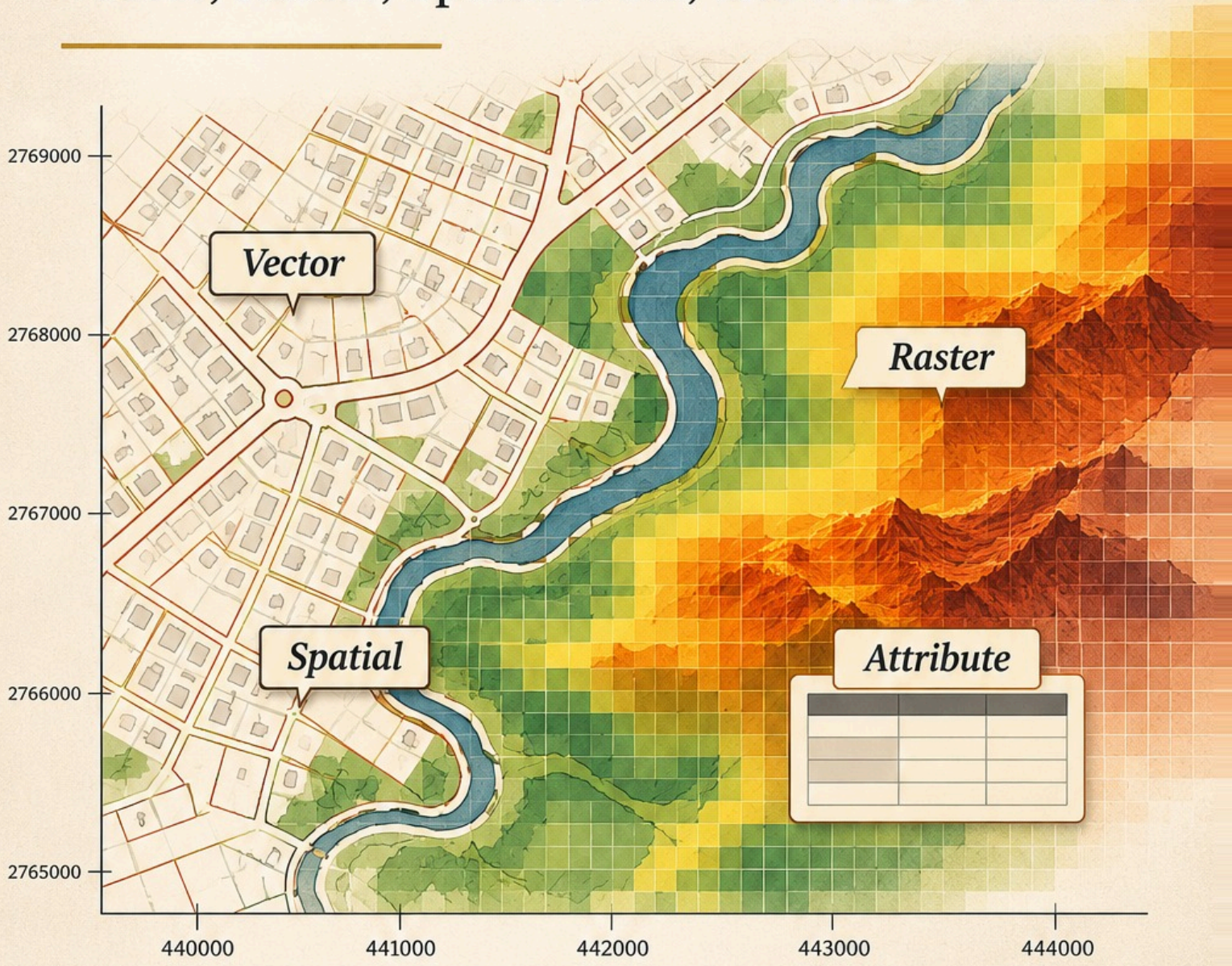
CADGISTools | ArcMap 10.8.2 Learning Series

EBOOK 02 | BEGINNER

Module 1 | GIS Fundamentals

GIS Data Types

Vector, Raster, Spatial Data, and Attribute Data



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PREFACE

In EBOOK 01 we asked what a GIS is. In this eBook we look inside it and ask what a GIS is made of.

Every map, table and analysis in a GIS rests on data. Yet the words used to describe data, such as vector, raster, spatial, attribute, cell and field, can sound like a second language to a new learner. This is a common place for beginners to feel lost.

This eBook exists to make that vocabulary clear. It explains the two basic kinds of spatial data, vector and raster, and the attribute data that describe what is stored. It shows how they differ, how they work together and how to choose between them. Short worked examples let you check every idea with a pencil and a calculator.

The material has been gathered from relevant sources, compiled, organised in a logical order and presented in a reader-friendly format. It builds on established GIS knowledge developed by many practitioners, educators and organisations. The sources consulted are listed in Appendix C. The aim is clarity, logical progression and practical relevance.

It is written for students who are starting to study GIS, for beginners exploring geospatial technologies, and for anyone who prefers to build knowledge step by step. It is a starting point, not a complete course. Readers are encouraged to practise with real data and to read widely. More information about this series is available at www.cadgistools.com.



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ABOUT THE EXAMPLES	All maps, tables, coordinates and numbers in this eBook are invented for teaching unless a source is given. Do not use them as real geographic data or for real decisions. Pictures that look like software tables are schematic illustrations, not screenshots.
SERIES POSITION	Previous: EBOOK 01, Introduction to GIS. Next: EBOOK 03, Understanding Vector Geometry.

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INTRODUCTION

Welcome to GIS Data

A first, friendly look at the kinds of data a GIS uses, and how to choose between them.

What you will learn

In EBOOK 01 you learned that a GIS connects **where** things are with **what** they are. Now we look inside. What exactly does a GIS store, and in what form?

This eBook answers that question. You will meet the four ideas that sit under almost every GIS project: **spatial data**, **attribute data**, **vector data** and **raster data**. You will see how they differ, how they work together, and how to choose the right one for a job.

Why this topic matters

Every tool in ArcMap works on data of one kind or another. Some tools need a raster, some need a vector layer, and many need a table. When you know what kind of data you have, you can predict which tools will work and what can go wrong. A surveyor stores parcels as polygons with attributes. A planner studies land use from a satellite image. A flood analyst combines an elevation raster with parcel polygons. In every case someone has chosen a data type. Chapter 5 shows how to choose.

Before you start

- You should have read EBOOK 01, or know what a layer, a feature, an attribute table and a coordinate are. Short recaps are given when needed.
- You need simple arithmetic and a calculator. Every calculation is shown step by step. ArcMap is optional (Section 6.3).
- All maps, tables and numbers here are invented for teaching. Never use them as real data. Sources are listed in Appendix C.

Learning objectives

When you finish this eBook, you will be able to:

1. Explain the difference between spatial data and attribute data, and how they stay linked.
2. Describe vector data and name its three geometry types, with an example of each.
3. Describe raster data using the words cell, row, column, value, cell size and extent.
4. Calculate the cells in a raster, and explain how cell size changes the amount of data.
5. Calculate the length and area of a simple vector feature from its coordinates.
6. Tell discrete data from continuous data, and choose between vector and raster.
7. Choose a suitable field type (text, whole number, decimal or date) for an attribute.
8. Recognise other data types and find data properties in ArcMap 10.8.2.

How to use this eBook

Read the chapters in order. Each chapter ends with a summary. Boxes use the same colours and labels as in EBOOK 01:

KEY CONCEPT | SIMPLE EXPLANATION | REAL-WORLD EXAMPLE | IMPORTANT | COMMON MISTAKE | TECHNICAL NOTE | CHECK YOUR UNDERSTANDING | PRACTICE TASK

CHAPTER 1

What Is GIS Data?

Before we study the types, see what GIS data is made of and how it can be sorted.

IN THIS CHAPTER

- The two questions every GIS dataset answers
- Spatial data and attribute data in one sentence each
- Vector and raster: two ways to store shape
- A map of the data types in this eBook

1.1 Starting point: a model of the world

EBOOK 01 explained that a GIS does not store the real world. It stores a **model**: a simplified version made on purpose for a job (EBOOK 01, Section 5.1). Data are the pieces of that model.

Think again of the clinic problem. To answer "which houses are within 300 m of the clinic?", the GIS needed the position of each house, the position of the clinic, and the number of people in each house. Some of these facts are about **place**. Others are about **description**. A GIS keeps both.

1.2 Two questions every dataset answers

For each thing it holds, a GIS dataset answers two questions: **Where is it?** and **What is it like?** These questions split GIS data into two kinds.

- **Spatial data** answer "Where is it, and what shape does it have?" Example: the corner coordinates of a land parcel.
- **Attribute data** answer "What is it like?" Example: the parcel's land use is residential and its area is 5,400 m².

SIMPLE EXPLANATION The hotel website

A hotel website shows a pin on a map. The pin is **spatial data**: it says where the hotel is. Click the pin and a card opens with the hotel's name, price and rating. The card is **attribute data**: it says what the hotel is like. The website keeps the two linked. A GIS does the same.

1.3 Two ways to store the shape

Spatial data must be stored in some form. Two forms are used again and again. **Vector data** store features as shapes made from coordinates: points, lines and polygons. **Raster data** store an area as a grid of equal cells, and each cell holds a value. EBOOK 01 (Sections 5.2 and 5.3) gave a first look. This eBook goes further.

Figure 1.1 shows how the ideas fit together. Read it from the top. GIS data split into spatial and attribute data. Spatial data are stored as vector or raster, and sometimes in less common forms that Chapter 6 introduces. Attribute data are stored in tables. In a vector dataset, each feature is linked to one table row. In a raster, the cell value itself is the data.

KEY CONCEPT Two different splits

Spatial or attribute? This split is about *what* is stored: place or description.
Vector or raster? This split is about *how* the place is stored: shapes or cells.

Do not mix them up. Vector and raster are both kinds of spatial data.

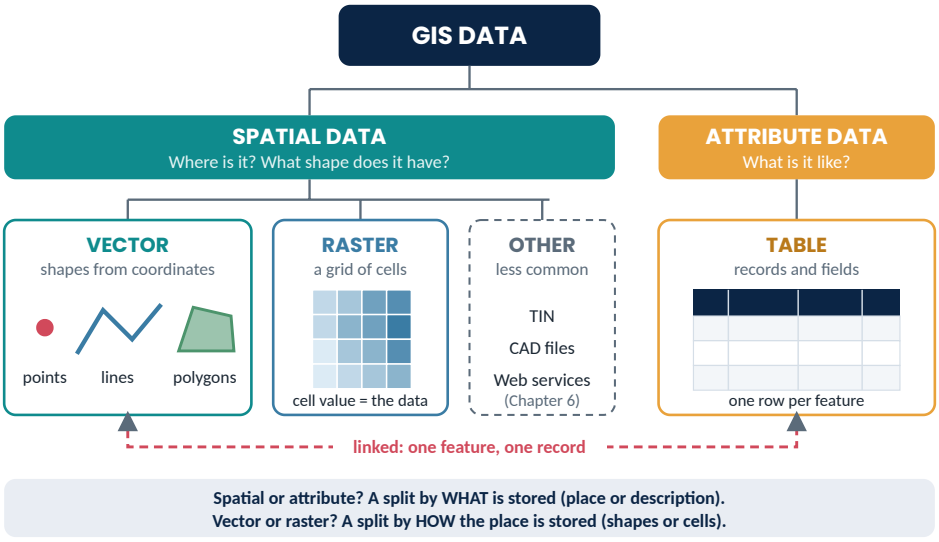


FIGURE 1.1 The data types in this eBook. The dashed box holds less common types. The red dashed arrow shows that each vector feature is linked to one table record.

CHECK YOUR UNDERSTANDING

1. A web map shows a red pin for a school. A pop-up shows its name and its number of students. Which part is spatial data and which is attribute data?
2. True or false: "Vector data are spatial data, but raster data are not." Explain your answer.

CHAPTER SUMMARY

- Every GIS dataset answers two questions: where is it, and what is it like?
- Spatial data hold place and shape. Attribute data hold description.
- Vector and raster are two ways to store spatial data. Neither is "the" spatial data.
- Tables store attribute data. A vector feature links to one record. A raster cell holds its own value.

CHAPTER 2

Spatial Data and Attribute Data

What each kind of data holds, how the two are linked, and how attribute values are stored.

IN THIS CHAPTER

- Spatial data: location and shape
- Attribute data: description
- How a feature and its record stay linked
- Field types for attribute values

2.1 Spatial data: where and what shape

Spatial data say where something is and what shape it has. A GIS stores this as **coordinates**: pairs of numbers (x, y) that fix positions on the Earth or on a flat map grid (EBOOK 01, Section 5.5). One point needs one pair. A road needs a series of pairs. A park boundary needs a closed series.

Size can be worked out from the coordinates too. The length of a road and the area of a parcel are not typed in by hand. The GIS calculates them from the shape. You will do this by hand in Section 3.3. Remember that coordinates only have meaning inside a coordinate system, which a later eBook explains.

2.2 Attribute data: describing the feature

Attribute data say what a feature is like. They are kept in a table. Esri's help describes an attribute as information stored about a feature [9]. Each feature has one **record** (a row). Each property has one **field** (a column). The value where a record and a field meet is an **attribute value**. EBOOK 08 studies attribute tables in depth.

2.3 The link between the two

A GIS must know which row belongs to which shape. In a geodatabase feature class, each feature is one row in a table, and each attribute is a column [4]. One column, the **shape field**, stores the geometry. Another, the **ObjectID field**, gives each row a unique identifier [4, 5]. A shapefile does the same job with several files that work together [12]. EBOOK 04 and EBOOK 05 explain both.

Figure 2.1 shows four parcels. Each parcel is a polygon on the map and one record in the table. Parcel P-102 is selected, so its polygon and its row are highlighted together. Selecting records in a table highlights the matching features on the map [16].

KEY CONCEPT One feature, one record

Each feature has exactly one record, and each record belongs to exactly one feature. This one-to-one link lets you click a shape and read its facts, or select a row and see its shape.

Tables without shapes. Not every table has a shape. A spreadsheet of tax payments has rows but no geometry. If it has a ParcelID column that matches the parcel layer, a GIS can connect the two. Data like this are called **non-spatial data**. EBOOK 07 explains how spatial and non-spatial data work together.

2.4 Field types: how each value is stored

Each field stores one type of value. The type decides what you can do with the values and how much space they use. Table 2.1 lists the six types you will meet most often [5].

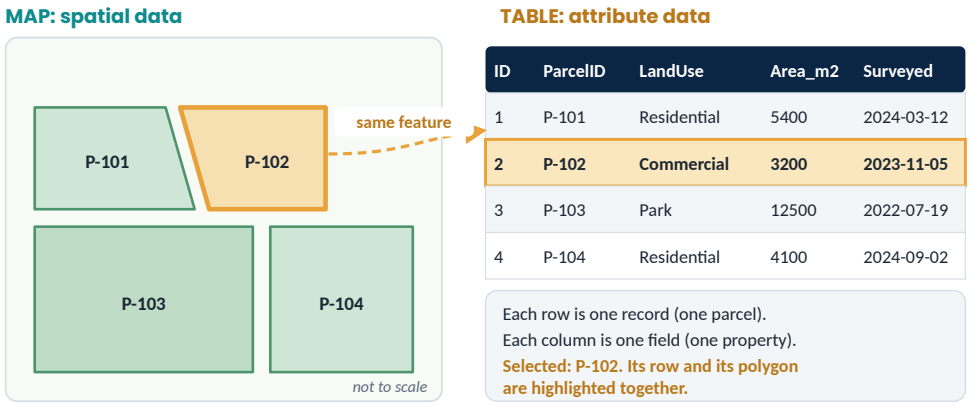


FIGURE 2.1 One feature, two views. The map holds the spatial data. The table holds the attribute data. The two stay linked. The drawing is a schematic with invented data.

TABLE 2.1 Common ArcGIS field types *Ranges are those Esri gives for file and personal geodatabases. They differ slightly in other formats [5].

Field type	What it stores	Range and size*	Example field
Short integer	Whole numbers	−32,768 to 32,767; 2 bytes	Number of floors
Long integer	Whole numbers, larger	−2,147,483,648 to 2,147,483,647; 4 bytes	Population of a city
Float	Numbers with decimals	Very large range; 4 bytes	Rainfall in mm (12.7)
Double	Numbers with decimals, more room	Even larger range; 8 bytes	Parcel area; coordinates
Text	Letters, digits and symbols	Characters are stored as Unicode	Parcel ID “P-101”
Date	A date, a time, or both	–	Survey date

WORKED EXAMPLE Choosing field types

GIVEN	Five fields for a parcel table: (a) a parcel ID such as **P-101**; (b) the number of floors, from 1 to 12; (c) the population of a district, up to 1,250,000; (d) a pipe diameter in metres, such as **0.25**; (e) a survey date.
REQUIRED	A suitable field type for each, with a reason.
STEP 1	(a) The ID contains a letter and a dash, so it is **Text**.
STEP 2	(b) Whole numbers from 1 to 12 fit inside −32,768 to 32,767, so **Short integer** is enough.
STEP 3	(c) 1,250,000 is larger than 32,767, so Short integer is too small. It fits inside the Long integer range, so use **Long integer**.
STEP 4	(d) 0.25 has decimals, so use **Float** or **Double**. Double has more room. (e) A survey date is a **Date**.
CHECK	For each answer, test the largest value you expect against the range in Table 2.1. If it does not fit, move up to the next type.

CHECK YOUR UNDERSTANDING

1. In a feature class, what is a row called? What is a column called?
2. Which field type would you choose for “number of floors” and which for “parcel ID P-101”?

COMMON MISTAKE Storing numbers as text

"Population is stored as Text." This happens because the values look like numbers. The problem is that text is sorted one character at a time, so "1250" comes before "300", and text values cannot be added up. The fix is to choose the type by what you will *do* with the value. Use a number type for counting and measuring. Use Text for IDs and codes, such as post codes with a leading zero.

CHAPTER SUMMARY

- Spatial data store location and shape as coordinates. Attribute data describe the feature in a table.
- Each feature has one record. The shape field and the ObjectID field help keep the two linked.
- Non-spatial tables have no shapes, but can be linked to features by a shared ID.
- Choose a field type by the values you will store and the work you will do with them.

CHAPTER 3

Vector Data

Points, lines and polygons: how a GIS stores things with clear shapes and edges.

IN THIS CHAPTER

- Vector data in plain English
- The three shapes: point, line and polygon
- Measuring length and area from coordinates
- Where vector data are kept, and when to use them

3.1 Vector data in plain English

Imagine tracing a map with a pen. You draw a dot for a well, a line for a river and a closed outline for a lake. **Vector data** work the same way. Each thing, called a **feature**, is stored as a shape built from coordinates. A feature is one real-world thing on the map, such as one well or one road (EBOOK 01, Section 5.2).

Vector data suit things that are separate objects with clear edges. Esri calls these **discrete** data: objects with clear, definable boundaries, such as lakes, buildings, roads and parcels [3].

3.2 The three shapes

Every vector feature is a point, a line or a polygon. Figure 3.1 shows one of each, and Table 3.1 adds what a GIS can measure.

TABLE 3.1 The three vector shapes

Shape	What it represents	How it is stored	What a GIS can measure
Point	A place that is small at this map scale	One pair of coordinates (x, y)	Its position
Line (polyline)	A long, thin thing	Connected pairs of coordinates; the corner points are vertices	Length
Polygon	An area with a boundary	A closed series of pairs; the last vertex meets the first	Perimeter and area

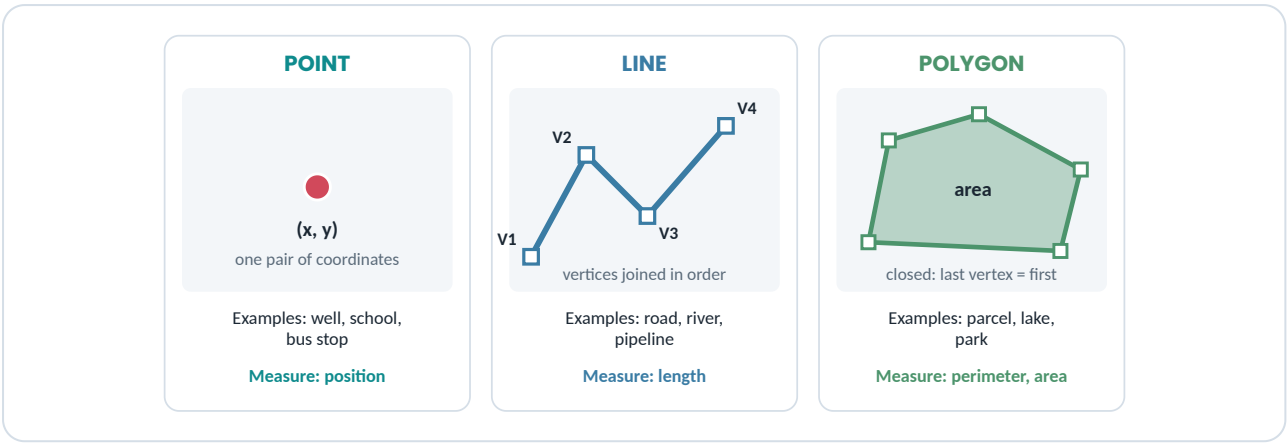


FIGURE 3.1 Point, line and polygon. A line and a polygon are built from corner points called vertices. The drawings are schematic.

> **TECHNICAL NOTE** The same thing can change shape
>
> A city may be a point on a map of a country but a polygon on a map of its region. The shape depends on the map scale and the job. EBOOK 03 explains how to choose.

3.3 Measuring from coordinates

Because vector features are made of coordinates, a GIS can measure them. The distance formula from EBOOK 01 gives the length of each straight segment. Here is a worked example with parcel P-101 from Figure 2.1.

WORKED EXAMPLE Perimeter and area of parcel P-101	
GIVEN	Vertices A (100, 100), B (180, 100), C (200, 160) and D (100, 160). All values are in metres on a flat grid.
REQUIRED	The perimeter (m) and the area (m²).
FORMULA	Segment length $d = \sqrt{((x_2 - x_1)^2 + (y_2 - y_1)^2)}$. Rectangle area = width × height. Triangle area = ½ × base × height.
STEP 1	Side lengths. AB: 180 − 100 = 80, so 80 m. BC: dx = 20 and dy = 60, so $d = \sqrt{(400 + 3{,}600)} = \sqrt{4{,}000} = 63.246$ m. CD: 200 − 100 = 100, so 100 m. DA: 160 − 100 = 60, so 60 m.
STEP 2	Perimeter = 80 + 63.246 + 100 + 60 = 303.246 m.
STEP 3	Split the parcel with a vertical line through B (Figure 3.2). The rectangle is 80 m by 60 m: 80 × 60 = 4,800 m². The triangle has base 20 m and height 60 m: ½ × 20 × 60 = 600 m².
STEP 4	Area = 4,800 + 600 = 5,400 m².
ANSWER	**Perimeter ≈ 303.2 m. Area = 5,400 m².** The area matches the Area_m2 value for P-101 in Figure 2.1.
CHECK	The parcel is a trapezoid with parallel sides of 80 m and 100 m, 60 m apart: (80 + 100) ÷ 2 × 60 = 90 × 60 = 5,400 m². This matches. Coordinates are whole metres, so one decimal place is enough.

> **IMPORTANT** When these formulas are valid
>
> Flat-grid formulas work only when the coordinates are on a flat grid with one unit, such as metres (EBOOK 01, Section 5.6). GIS software uses a general method that works for any polygon and handles the Earth's shape correctly when you use its measuring tools.

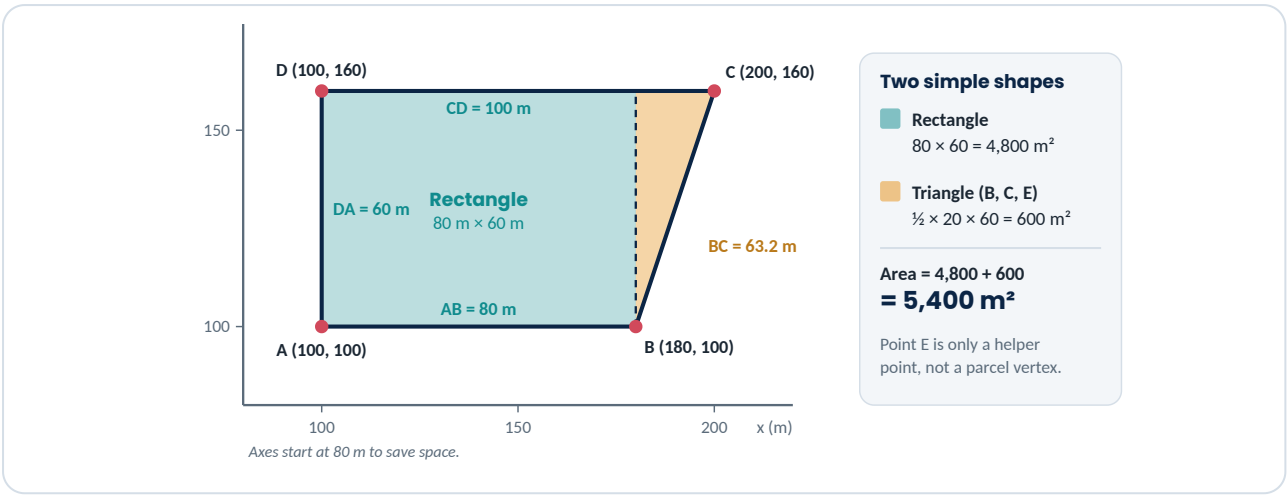


FIGURE 3.2 The worked example on a flat grid. The dashed line splits the parcel into a rectangle and a triangle. Point E is only a helper point.

3.4 Where vector data are kept

Vector data are saved in files and geodatabases. Two names matter now.

- **Feature class.** Esri describes a feature class as a collection of features that share the same spatial representation and the same set of attribute columns [4]. It holds **one geometry type only** [4]. A parcel layer (polygons) and a well layer (points) are therefore two feature classes.
- **Shapefile.** A simple file format that stores the locations and the attributes of features, which can be points, lines or polygons [12]. It has no topology [12]. ArcGIS shows a shapefile as one item, but it is made of several files [12].

3.5 Strengths and limits of vector data

- **Strong:** clear, sharp edges for objects with boundaries; position and size can be calculated from the stored coordinates; every feature can carry many attributes.
- **Weak:** things that change gradually and have no natural edge, such as temperature or noise, are hard to draw as shapes; quality depends on how and at what scale the shapes were captured.

CHECK YOUR UNDERSTANDING

1. Which shape would you use for (a) a bus stop, (b) a canal and (c) a school playground, on a map of one town?
2. Why can one feature class not hold both wells (points) and parcels (polygons)?
3. Use the distance formula to find the length of a line from (0, 0) to (60, 80).

CHAPTER SUMMARY

- Vector data store features as points, lines and polygons made from coordinates.
- Points give position, lines give length, polygons give perimeter and area.
- A GIS calculates length and area from the stored coordinates.
- A feature class holds one geometry type. A shapefile is made of several files.
- Vector data suit separate objects with clear edges.

CHAPTER 4

Raster Data

Grids of cells: how a GIS stores images and surfaces, and why cell size matters.

IN THIS CHAPTER

- Rows, columns and cells
- Cell size and resolution
- Discrete and continuous rasters
- NoData and bands

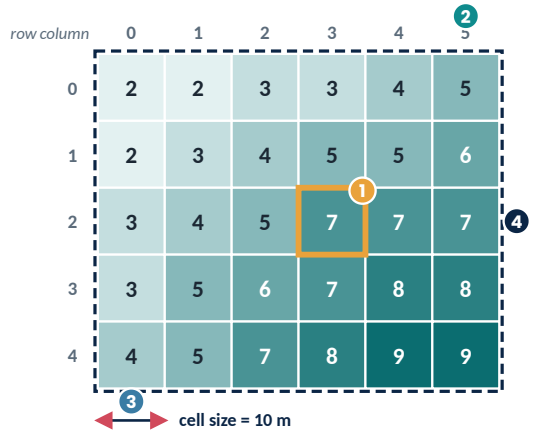
4.1 Raster data in plain English

Picture a sheet of graph paper. Each little square holds one number or one colour. Together the squares make a picture of the ground. That is a **raster**. In Esri's words, a raster is a matrix of cells, also called **pixels**, arranged in rows and columns, and each cell holds a value [1]. Aerial photographs, satellite images, digital pictures and scanned maps are all rasters [1].

Rasters are not only pictures. A cell can hold a measurement, such as height above sea level, or a code that means "forest". The picture-like look comes from drawing the values as colours.

4.2 The anatomy of a raster

Figure 4.1 shows a small raster. All cells have the same size [1]. A cell's position is given by its row and column numbers, which start at 0 [1]. The **extent** is the rectangle the whole grid covers, described by its top, bottom, left and right coordinates [1].



1 One cell
Row 2, column 3, value 7.
Every cell holds exactly one value.

2 Row and column numbers
Counted from 0. Here we start at the top-left corner.

3 Cell size (resolution)
Each cell is 10 m × 10 m on the ground.
All cells are the same size.

4 Extent
The rectangle the grid covers:
60 m wide × 50 m tall = 6 × 5 = 30 cells.

FIGURE 4.1 The anatomy of a raster. This invented raster has 6 columns and 5 rows. Counting starts at the top-left corner in this drawing.

4.3 Cell size and resolution

Cell size is the area on the ground that one cell represents. In a GIS, cell size and **spatial resolution** mean the same thing: a raster with 5 m × 5 m cells has a resolution of 5 m [2]. Smaller cells give more detail but also larger files and slower work [1, 2]. Esri notes that halving the cell size can need as much as four times the storage [1]. The next example shows why.

WORKED EXAMPLE How many cells?	
GIVEN	A block of ground 100 m wide and 80 m tall. Compare cells of 20 m and 10 m.
REQUIRED	The columns, rows and total cells for each cell size, and how the total changes.
FORMULA	columns = width ÷ cell size. rows = height ÷ cell size. cells = columns × rows.
STEP 1	20 m cells: 100 ÷ 20 = 5 columns. 80 ÷ 20 = 4 rows. 5 × 4 = **20 cells**.
STEP 2	10 m cells: 100 ÷ 10 = 10 columns. 80 ÷ 10 = 8 rows. 10 × 8 = **80 cells**.
STEP 3	Compare: 80 ÷ 20 = 4.
ANSWER	**20 cells at 20 m and 80 cells at 10 m.** Halving the cell size gave four times as many cells.
CHECK	Both rasters must cover the same area. 20 cells × (20 × 20 = 400 m²) = 8,000 m². 80 cells × (10 × 10 = 100 m²) = 8,000 m². And 100 × 80 = 8,000 m². All three agree.

Cell size also decides what can be seen. Esri notes that if a cell is larger than a road's width, the road may not appear [1]. Figure 4.2 shows this with an invented 6 m road and a pond.

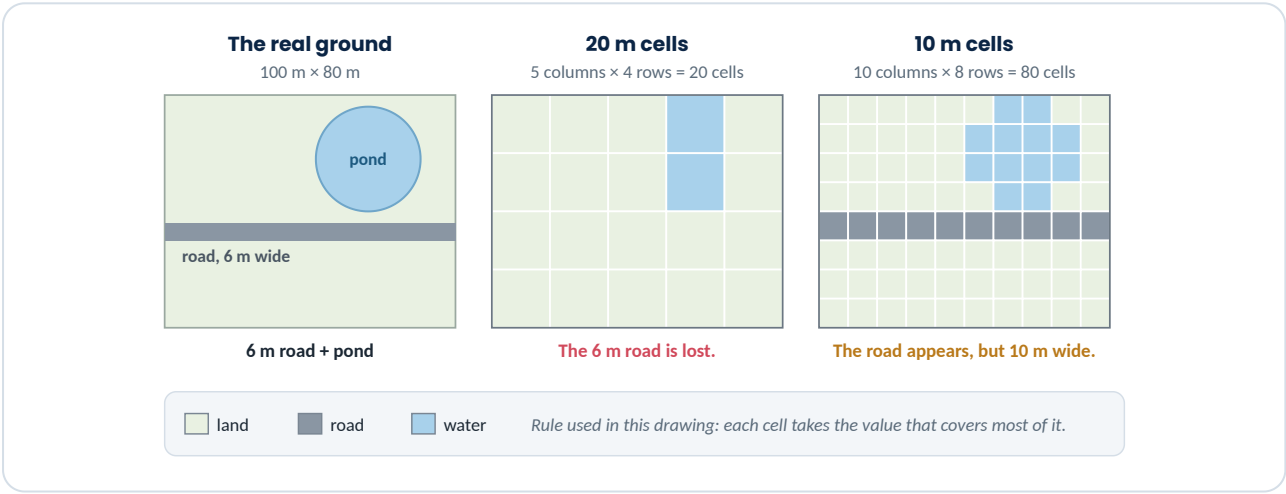


FIGURE 4.2 The same ground at two cell sizes. At 20 m the road disappears. At 10 m it appears, but looks 10 m wide. A raster cannot show detail smaller than one cell.

> **IMPORTANT** Smaller cells do not always add detail
>
> You can resample a raster to a smaller cell size, but this adds no real detail [2]. Esri also reminds users that results are only as accurate as the least accurate dataset used. A 30 m land-cover raster does not become more detailed by combining it with a 10 m elevation raster [2].

4.4 Discrete and continuous rasters

Raster values come in two main kinds. **Discrete** (thematic) rasters hold categories, such as land use or soil type [1]. They usually store whole numbers, where each number is a class code [1]. **Continuous** rasters hold measurements that change across the surface, such as elevation or temperature [1]. Esri describes continuous data as phenomena where every location has a value, such as elevation measured from sea level [3]. Continuous values are often floating-point numbers [1]. Figure 4.3 shows one of each.

A raster of categories usually has a **raster attribute table**. It has a Value field, which lists each unique cell value, and a Count field, which gives the number of cells with that value. NoData cells are not counted [11]. Table 4.1 shows the table for Figure 4.3A. Because every cell covers the same area, **Count × cell area** gives the area of each class. Here each cell is 30 m × 30 m, so one cell covers 900 m².

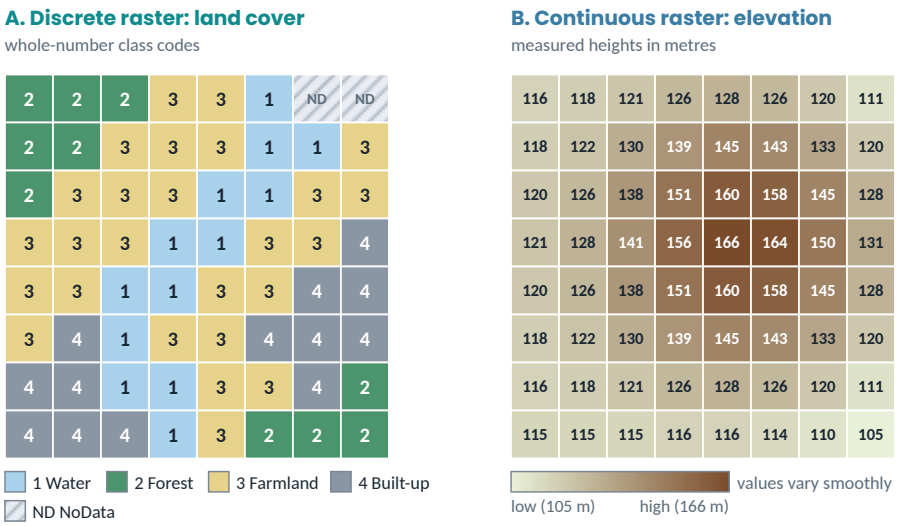


FIGURE 4.3 A discrete raster and a continuous raster. Both are 8 × 8 cells with invented values. ND marks NoData cells.

TABLE 4.1 Raster attribute table for Figure 4.3A. The counts total 62 cells. Adding the 2 NoData cells gives all 64 cells of the 8 × 8 grid.

Value	Class	Count	Area (m²) = Count × 900
1	Water	13	13 × 900 = 11,700
2	Forest	10	10 × 900 = 9,000
3	Farmland	26	26 × 900 = 23,400
4	Built-up	13	13 × 900 = 11,700
ND	NoData	2 (not counted)	unknown

4.5 NoData and bands

NoData marks cells with no information, for example ground hidden by cloud in a satellite image (an illustrative case). NoData is not zero. Zero is a real value, and NoData means “unknown” [1].

A raster can have one band or many [13]. A **band** is a single grid of cell values. An elevation raster has one band: each cell stores a height [13]. Satellite imagery has several bands. Each band covers the same area but records a different measurement [13]. Any three bands can be shown together as red, green and blue to make a colour image [13].

CHECK YOUR UNDERSTANDING

1. A raster has 12 columns and 8 rows. How many cells does it have?
2. A raster has 5 m × 5 m cells. What is its resolution?
3. Which of these is usually continuous: land use, soil class, elevation, temperature?

CHAPTER SUMMARY

- A raster is a grid of equal cells in rows and columns. Each cell holds one value.
- Cell size is the same as resolution. Halving it can give four times as many cells.
- A raster cannot show detail smaller than one cell, and resampling to smaller cells adds no real detail.
- Discrete rasters hold categories. Continuous rasters hold measurements.
- NoData means unknown, not zero. A raster can have one band or many.

CHAPTER 5

Vector or Raster?

A side-by-side comparison and a simple method for choosing the right data type.

IN THIS CHAPTER

- Vector and raster side by side
- A decision flowchart
- Using both together
- Converting, and its limits

5.1 Vector and raster side by side

Neither type is better. Each is a different model of the world. Table 5.1 compares them.

TABLE 5.1 Vector data and raster data compared

Aspect	Vector	Raster
Stores	Features as points, lines and polygons made of coordinates	A grid of equal cells, each with a value
Best for	Separate objects with clear boundaries, such as parcels, roads and wells [3]	Images and surfaces where every location has a value, such as photographs, elevation and temperature [1, 3]
Detail depends on	How carefully the vertices were captured	Cell size: smaller cells give more detail [2]
Edges	Sharp; they follow the stored boundary	Stepped, because cells are square
Attributes	One record per feature, with many fields	One value per cell (per band). A raster of categories may have a table with Value and Count [11]
Typical measures	Position, length, perimeter, area	The value of a cell; counts and areas of classes
Size grows with	The number of features and vertices	The number of cells: area ÷ cell size²

5.2 Choosing: a simple decision method

Start with one question: **is it a thing, or is it a surface?** A thing, such as a parcel or a well, has edges. A surface, such as elevation or temperature, exists everywhere and changes gradually. Figure 5.1 turns this into a flowchart.

> **TECHNICAL NOTE** The flowchart is a guide
>
> Some things fit both models. Land cover can be drawn as polygons or stored as a classified raster. Elevation can be shown as contour lines (vector), as a raster, or as a TIN (Chapter 6). Choose by the question you need to answer and the tools you will use.

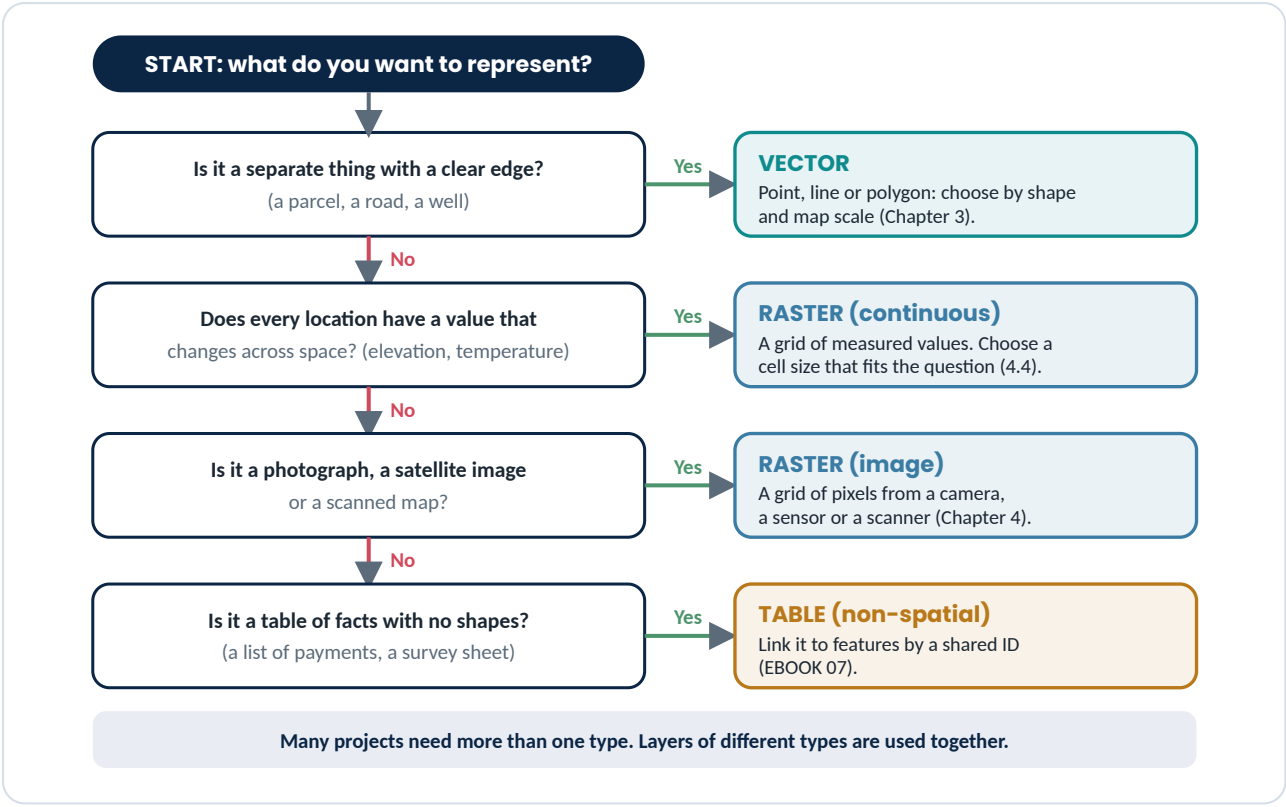


FIGURE 5.1 Which data type fits? Follow the red arrows down when the answer is No. Follow the green arrows right when the answer is Yes.

5.3 Using both together

REAL-WORLD EXAMPLE Illustrative: a flood-risk check

Problem. A council wants to know which parcels lie on low ground.

Data. An elevation raster (continuous), parcel polygons with a ParcelID and LandUse (vector with attributes), and a road line layer.

How GIS helps. ArcMap has tools that read raster values at vector features. Later eBooks teach them. Each parcel gets a ground-height value in its attribute table.

Output. A list of parcels to check, and a map. This scenario is invented. It is not a documented case study.

5.4 Converting between types

A raster can be turned into polygons, and polygons into a raster. Each conversion changes the data. Going to larger cells loses detail. Going to smaller cells adds none [2]. Before any conversion, keep a copy of the original data.

CHECK YOUR UNDERSTANDING

1. Choose vector or raster for each: land parcels, a rainfall surface, an aerial photograph, bus routes.
2. Why might land cover be stored either as polygons or as a raster?

CHAPTER SUMMARY

- Vector and raster are two models. Neither is better in every case.
- Ask: is it a thing or a surface? Things suit vector. Surfaces and images suit raster.
- Many projects use both. Layers of different types can be combined.
- Converting between types changes the data. Keep the original.

CHAPTER 6

Other Data Types and Data in ArcMap

TINs, CAD files, tables and web services, and where to look at your data in ArcMap 10.8.2.

IN THIS CHAPTER

- Other data types you will meet
- How ArcMap treats outside data
- An optional hands-on exploration

6.1 Other data types you will meet

Vector and raster cover most GIS data, but not all. Table 6.1 lists other types that you will see. The descriptions follow Esri's help pages.

TABLE 6.1 Other data types

Type	What it is	Remark
TIN	A surface model built from nodes, edges and triangles. Each node has a height value [6].	An alternative to a raster for surfaces. EBOOK 06 stays with rasters.
CAD files	Drawings from CAD programs. ArcGIS can work with DWG, DXF and DGN files [7].	Survey and design drawings are often brought into a GIS.
Tables	Excel and text files are among the data sources ArcGIS can read [7].	Rows with no shapes. They can be linked to features by a shared ID.
Web services	Data served over the internet, such as OGC WMS and WCS services and ArcGIS Server services [7].	Check the source and date, as for any data.
Geodatabases	Personal, file and enterprise geodatabases [7].	EBOOK 05 explains them.

6.2 How ArcMap treats outside data

ArcGIS can work with many data sources besides its own geodatabases, including file-based data, database data and web services [7]. Esri says that most external data sources are used in ArcGIS as either feature classes or raster data sources [7]. This is one more reason to learn vector and raster well: almost everything you meet falls into one of the two.

The status of ArcMap 10.8.2 was explained in EBOOK 01, Section 7.2. The ideas in this eBook apply to every GIS.

6.3 Try it: a guided exploration (optional)

This exercise lets you see data types in a real ArcMap window. You need ArcMap 10.8.2 and a map document with at least one vector layer and one raster layer. If you have none, you can skip this section.

STEP-BY-STEP Look at vector and raster data

1. Open the map document. In the Table of Contents, note which layers are vector (symbols are points, lines or filled shapes) and which are raster (a picture or a colour ramp).
2. Right-click a vector layer and choose **Open Attribute Table**. You can also select the layer and press Ctrl+T [8]. Read the field names. Find the column that holds a unique ID for each record [4, 5].
3. Click a record in the table. The matching feature is highlighted on the map [16].
4. Choose the **Identify** tool on the Tools toolbar and click a feature. The Identify window lists the feature's attributes [10].
5. Right-click a raster layer, choose **Properties** and open the **Source** tab. Find the number of columns and rows, the number of bands, the cell size and the pixel type [14].
6. Optional: with the Identify tool, click a raster cell. An Esri tip describes the Identify window as reporting a single pixel value per click [15].

Expected result: a vector layer opens a table with one row per feature, and selecting a row highlights its shape. A raster layer shows cell size and band information, but no row for each cell.

What it means: you have just seen the difference between the two types. Vector features carry records. Raster cells carry values, and the raster properties describe the grid.

CHECK YOUR UNDERSTANDING

1. Name two data types that are neither vector nor raster.
2. What do you expect to find on the Source tab of a raster layer?
3. How do you open a vector layer's attribute table in ArcMap?

CHAPTER SUMMARY

- TINs, CAD files, tables, web services and geodatabases are other data types you will meet.
- ArcGIS uses most outside data as feature classes or raster data sources.
- Open Attribute Table shows a vector layer's records. The Source tab of a raster shows its grid information.
- The Identify tool reads attributes for a feature, or a pixel value for a raster.

CHAPTER 7

Common Mistakes and Misunderstandings

Seven mistakes that beginners often make, why they happen, and how to avoid them.

Most mistakes about data types come from a wrong picture in the mind, not a wrong button. Table 7.1 lists seven common ones. Each links back to a section where the idea was explained.

TABLE 7.1 Seven common beginner mistakes

Mistake	Why it happens	What goes wrong	How to avoid it
1. "A raster is just a picture."	Photographs are the best-known rasters.	You overlook elevation, temperature and class maps, which are rasters too.	A raster is a grid of values. Colours only show them (Section 4.1).
2. "Smaller cells are always better."	More detail sounds better.	Files get larger and work slows. Resampling adds no real detail [2].	Match the cell size to the question and the source data (Section 4.3).
3. "Vector is exact, raster is rough."	Vector lines look sharp.	Both are models. Vector accuracy depends on capture. Raster detail depends on cell size.	Ask about source, date, scale and cell size (Section 5.4).
4. Storing numbers as text.	The values look like numbers.	Sorting is wrong and sums are impossible.	Choose the field type by what you will do with the value (Section 2.4).
5. Doing sums with class codes.	Land-use codes are numbers.	The average of codes 1 and 3 is 2, which means nothing.	Use codes to count and group, not to calculate (Section 4.4).
6. Mixing shapes in one feature class.	Points and polygons are both "features".	A feature class holds one geometry type [4].	Use one feature class per geometry type (Section 3.4).
7. "A shapefile is one file."	ArcGIS shows it as one item [12].	Parts can be left behind when files are copied by hand.	Keep all parts together. EBOOK 04 explains how.

PRO TIP A four-question check

Before you use a dataset, ask: (1) Is it a thing or a surface? (2) If a thing, is it a point, a line or a polygon? (3) If a surface or an image, what is the cell size? (4) Which fields hold the facts, and what type is each?

CHAPTER SUMMARY

- Most beginner mistakes come from wrong ideas, not wrong clicks.
- Remember: a raster is values, not just a picture; cell size is a choice; vector and raster are both models; field types follow use; class codes are labels.

CHAPTER 8

Practice, Review and Next Steps

Try the exercises on your own first. Worked answers are in Appendix A.

IN THIS CHAPTER

- Six exercises, from easy to challenging
- Review questions
- What comes next in Module 1

8.1 Practice exercises

PRACTICE TASK **Exercise 1 | Easy**

Say whether each item is **spatial** data or **attribute** data: (a) the coordinates of a well; (b) the name of a school; (c) the outline of a lake; (d) the number of students in a school; (e) the date a pipe was installed; (f) the route of a road; (g) the surface type of a road; (h) the shape of a parcel.

PRACTICE TASK **Exercise 2 | Easy**

Choose a field type for each: (a) number of floors in a building (1 to 60); (b) population of a city (up to 12,000,000); (c) a land-use code such as “RES”; (d) a pipe diameter in metres, such as 0.25; (e) the date a pipe was installed; (f) a post code such as “00501”.

PRACTICE TASK **Exercise 3 | Moderate**

A raster covers 600 m × 400 m. (a) How many columns, rows and cells does it have with 10 m cells? (b) How many cells with 5 m cells? (c) How many times more cells is that? Check your answer with areas.

PRACTICE TASK **Exercise 4 | Moderate**

A water main is drawn as a line with vertices (0, 0), (120, 0), (120, 50) and (200, 110), in metres. Calculate its length.

PRACTICE TASK **Exercise 5 | Challenge**

Figure 8.1 shows a land-cover raster with 20 m × 20 m cells. Build its raster attribute table: give the Count for values 1, 2 and 3, and the number of NoData cells. Then calculate the area of each class in square metres.

PRACTICE TASK **Exercise 6 | Challenge**

A council wants to choose a site for a new public park. (a) List four layers you would collect. (b) For each, say whether it is vector (point, line or polygon) or raster, and whether it is a thing or a surface. (c) For each vector layer, name two fields you would want, with a field type for each.

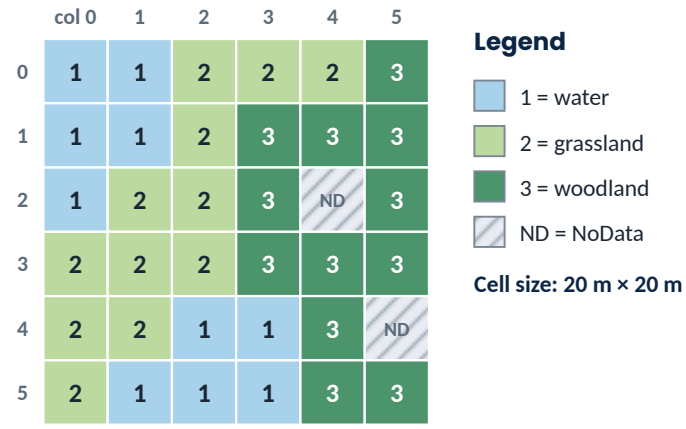


FIGURE 8.1 Data for Exercise 5. Invented values. ND marks NoData cells. Row and column numbers start at 0.

8.2 Review questions

1. What two questions does every GIS dataset answer? Which kind of data answers each?
2. Are vector data and raster data both spatial data? Explain.
3. Name the three vector shapes and give one use for each.
4. What does a raster cell hold? What are rows, columns and extent?
5. What is cell size? What happens to the number of cells if the cell size is halved?
6. What is the difference between a discrete raster and a continuous raster?
7. Give two other data types besides vector and raster.

8.3 What comes next

This is EBOOK 02 of 10 in Module 1. EBOOK 03, **Understanding Vector Geometry**, studies points, polylines and polygons in depth: what each represents, how to choose between them, and how scale changes the answer.



Appendices

Answers, glossary and references.

Appendix A Answers and Worked Solutions

Try each question yourself before you read the answer.

A.1 Check your understanding

Chapter 1

1. The pin's position is spatial data. The name and the number of students are attribute data.
2. False. Vector and raster are both ways of storing spatial data.

Chapter 2

1. A row is a record. A column is a field.
2. Short integer for the number of floors (a small whole number). Text for P-101, because it contains a letter and a dash.
3. No. Each feature has exactly one record.

Chapter 3

1. (a) point; (b) line; (c) polygon.
2. A feature class holds one geometry type only [4]. Use one feature class for wells and another for parcels.
3. dx = 60, dy = 80. d = $\sqrt{(60^2 + 80^2)} = \sqrt{(3{,}600 + 6{,}400)} = \sqrt{10{,}000} = 100$ m.

Chapter 4

1. 12 × 8 = 96 cells.
2. 5 m.
3. Elevation and temperature are usually continuous. Land use and soil class are categories.

Chapter 5

1. Land parcels: vector (polygons). Rainfall surface: raster. Aerial photograph: raster. Bus routes: vector (lines).
2. A land-cover map can be drawn as polygons with clear boundaries, or stored as a grid where each cell holds a class code. Which is better depends on the question and the tools.

Chapter 6

1. For example a TIN and a CAD file (or a table, or a web service).
2. The number of columns and rows, the number of bands, the cell size and the pixel type [14].
3. Right-click the layer and choose Open Attribute Table [8].

A.2 Practice exercises

Exercise 1

Spatial: (a), (c), (f), (h). Attribute: (b), (d), (e), (g).

Exercise 2

(a) Short integer. (b) Long integer, because 12,000,000 is larger than 32,767. (c) Text. (d) Float or Double. (e) Date. (f) Text, because a number would lose the leading zeros.

Exercise 3

(a) 600 ÷ 10 = 60 columns. 400 ÷ 10 = 40 rows. 60 × 40 = 2,400 cells. (b) 600 ÷ 5 = 120 columns. 400 ÷ 5 = 80 rows. 120 × 80 = 9,600 cells. (c) 9,600 ÷ 2,400 = 4 times. Check: 9,600 × 25 m^2 = 240,000 m^2 = 600 × 400.

Exercise 4

Segment 1: 120 m. Segment 2: 50 m. Segment 3: dx = 80, dy = 60, d = $\sqrt{(6{,}400 + 3{,}600)} = \sqrt{10{,}000} = 100$ m. Length = 120 + 50 + 100 = **270 m**.

Exercise 5	Counts: value 1 = 10, value 2 = 12, value 3 = 12, NoData = 2. Total = 36 cells. Each cell is 20 × 20 = 400 m². Areas: water 10 × 400 = 4,000 m²; grassland 12 × 400 = 4,800 m²; woodland 12 × 400 = 4,800 m². The area of the NoData cells is unknown.
Exercise 6	Example answer. Roads: vector lines (fields: RoadName as Text, RoadClass as Text). Existing parks: vector polygons (ParkName as Text, Area_m2 as Double). Schools: vector points (SchoolName as Text, Students as Long integer). Elevation: raster, continuous surface. Flood zones: vector polygons. Roads, parks and schools are things. Elevation is a surface. Other sensible answers are fine. Check that every layer has a data type and every field has a suitable field type.

Appendix B Glossary

Attribute data	Data that say what a feature is like. They are kept in a table.
Attribute table	A table of attribute data. Each row is a record. Each column is a field.
Band	One grid of cell values in a raster. A raster can have one band or many.
Cell (pixel)	One square of a raster grid. It holds one value.
Cell size	The width and height of one raster cell on the ground. Also called resolution.
Continuous data	Data where every location has a value that changes across space, such as elevation.
Discrete data	Data for objects with clear boundaries, such as parcels. Also, raster cells that hold categories.
Extent	The rectangle a dataset covers: its top, bottom, left and right coordinates.
Feature	One real-world thing stored in a GIS, such as one well or one road.
Feature class	A collection of features with the same geometry type and the same attribute fields.
Field	A column in a table. It holds one property of every feature.
Non-spatial data	Data with no shapes or locations of their own, such as a table of payments.
NoData	A raster value that marks a cell with missing information. It is not zero.
Point, polyline, polygon	The three vector shapes: a point (one pair of coordinates), a polyline (connected coordinates) and a polygon (a closed outline).
Raster	Data stored as a grid of cells, each with a value.
Record	A row in an attribute table. It describes one feature.
Shapefile	A simple file format for vector features. It is made of several files.
Spatial data	Data that say where a feature is and what shape it has.
TIN	A surface model made of triangles joined between points that have height values.
Vector	Data stored as points, lines and polygons made from coordinates.

Appendix C References and Further Learning

Sources that were actually consulted, and suggestions for further reading.

C.1 Sources consulted

The pages below were read in November 2026 with a page-fetching tool that returns a summary of each page. Statements were checked against those summaries. Web pages can change. Pages from earlier help versions are marked, because the 10.8 versions were not opened.

[1] Esri. *What is raster data?* (ArcGIS Desktop help). https://desktop.arcgis.com/en/arcmap/latest/manage-data/raster-and-images/what-is-raster-data.htm

[2] Esri. *Cell size of raster data* (ArcGIS Desktop 10.5 help; the 10.8 page was not opened). https://desktop.arcgis.com/en/arcmap/10.5/manage-data/raster-and-images/cell-size-of-raster-data.htm

[3] Esri. *Discrete and continuous data* (ArcGIS Desktop 10.5 help; the 10.8 page was not opened). https://desktop.arcgis.com/en/arcmap/10.5/manage-data/raster-and-images/discrete-and-continuous-data.htm

[4] Esri. *Feature class basics* (ArcGIS Desktop help). https://desktop.arcgis.com/en/arcmap/latest/manage-data/geodatabases/feature-class-basics.htm

[5] Esri. *ArcGIS field data types* (ArcGIS Desktop help). https://desktop.arcgis.com/en/arcmap/latest/manage-data/tables/arcgis-field-data-types.htm

[6] Esri. *TIN-based surface concepts* (ArcGIS Desktop 3D Analyst help). https://desktop.arcgis.com/en/arcmap/latest/extensions/3d-analyst/tin-based-surface-concepts.htm

[7] Esri. *About geographic data formats* (ArcGIS Desktop help). https://desktop.arcgis.com/en/arcmap/latest/manage-data/datatypes/about-geographic-data-formats.htm

[8] Esri. *Viewing tables in ArcMap* (ArcGIS Desktop help). https://desktop.arcgis.com/en/arcmap/latest/manage-data/tables/viewing-tables-in-arcmap.htm

[9] Esri. *A quick tour of tables and attribute information* (ArcGIS Desktop 10.7 help; the 10.8 page was not opened). https://desktop.arcgis.com/en/arcmap/10.7/manage-data/tables/a-quick-tour-of-tables-and-attribute-information.htm

[10] Esri. *Identifying features* (ArcGIS Desktop help). https://desktop.arcgis.com/en/arcmap/latest/map/working-with-layers/identifying-features.htm

[11] Esri. *Raster dataset attribute tables* (ArcGIS Desktop 10.5 help; the 10.8 page was not opened). https://desktop.arcgis.com/en/arcmap/10.5/manage-data/raster-and-images/raster-dataset-attribute-tables.htm

[12] Esri. *What is a shapefile?* (ArcGIS Desktop help). https://desktop.arcgis.com/en/arcmap/latest/manage-data/shapefiles/what-is-a-shapefile.htm

[13] Esri. *Raster bands* (ArcGIS Desktop help). https://desktop.arcgis.com/en/arcmap/latest/manage-data/raster-and-images/raster-bands.htm

[14] Esri. *Raster dataset properties* (ArcGIS Desktop 10.5 help; the 10.8 page was not opened). https://desktop.arcgis.com/en/arcmap/10.5/manage-data/raster-and-images/raster-dataset-properties.htm

[15] Esri ArcWatch. *Explore Raster Data Using the Pixel Inspector* (tip, November 2011; used only for its note on the Identify window). https://www.esri.com/news/arcwatch/1111/tip.html

[16] Esri. *Selecting records in tables* (ArcGIS Desktop 10.6 help; the 10.8 page was not opened). https://desktop.arcgis.com/en/arcmap/10.6/manage-data/tables/selecting-records-in-tables.htm

C.2 Suggested further reading (not consulted for this edition)

These suggestions come from general knowledge of the field and were not used to check facts in this eBook.

- The ArcGIS Desktop documentation at https://desktop.arcgis.com/, the official help pages for ArcMap 10.8.
- Esri's product life-cycle pages on support.esri.com, the official source for ArcMap support dates.
- EBOOK 01, *Introduction to GIS*, to revise the basics, and EBOOK 03 as your next step.

EBOOK 02 COMPLETE

You now know what a GIS is made of.

You can tell spatial data from attribute data, vector from raster, and discrete from continuous. You can count cells, measure a polygon and choose a field type.

NEXT IN MODULE 1

EBOOK 03: Understanding Vector Geometry

Points, polylines and polygons in depth: what each represents and when to use it.

CADGISTools

ArcMap 10.8.2 Learning Series | www.cadgistools.com