Introduction to GIS:
Layers, Data, and Spatial Questions

- Build shared vocabulary for thinking spatially and asking geographic questions
- For students, educators, and early-career analysts: no GIS background needed
- GIS captures, stores, checks, manages, analyzes, and displays location-based information
- Roadmap: layers, vector and raster data, data quality, projections, spatial questions
- Outcomes: recognize GIS workflows, read maps critically, frame a spatial question



Why Location Matters:
Spatial Thinking Foundations

Location, distance, direction, shape, and pattern: building blocks of spatial reasoning

Spatial thinking combines concepts of space, tools of representation, and reasoning

It serves description, analysis, and inference—not just locating things

Everyday examples: school catchment planning, service coverage, environmental monitoring

Beginner trap: maps are arguments built from choices, not neutral pictures



Maps as Arguments: Reading Layers Critically

- A map is a stack of layers: a basemap plus data layers on top
- Drawing order follows the contents pane; bottom layers draw first and below
- Selection, generalization, classification, and symbols decide what appears
- Ask critical questions: what is included, excluded, and assumed
- Habit: ask who made the map, for what purpose, at what scale



The GIS Layer Stack: Basemaps and Feature Layers

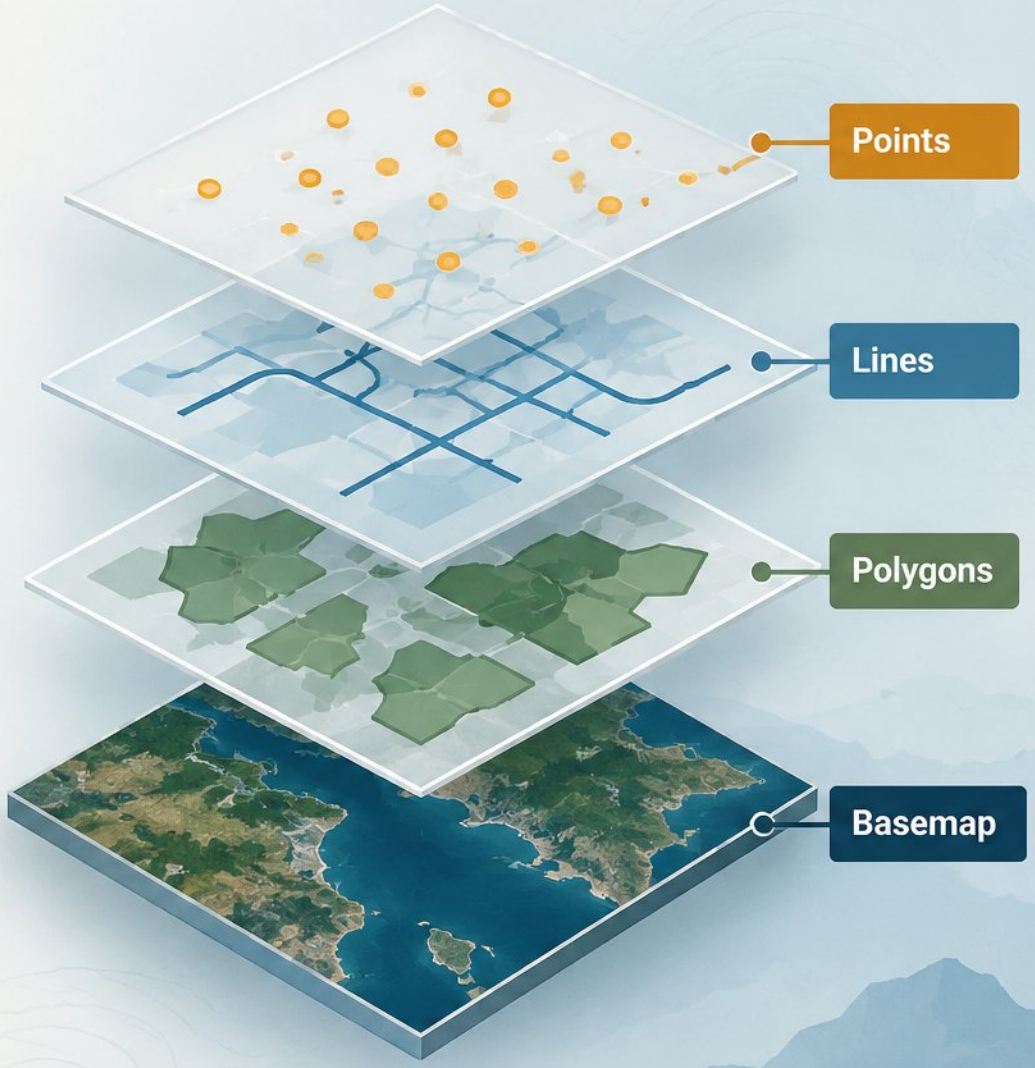
Layer: a reference to geographic data whose properties and attributes control drawing

Basemap: foundational layer providing visual and geographic context; draws first

Feature layers: points, lines, or polygons used for querying, editing, and analysis

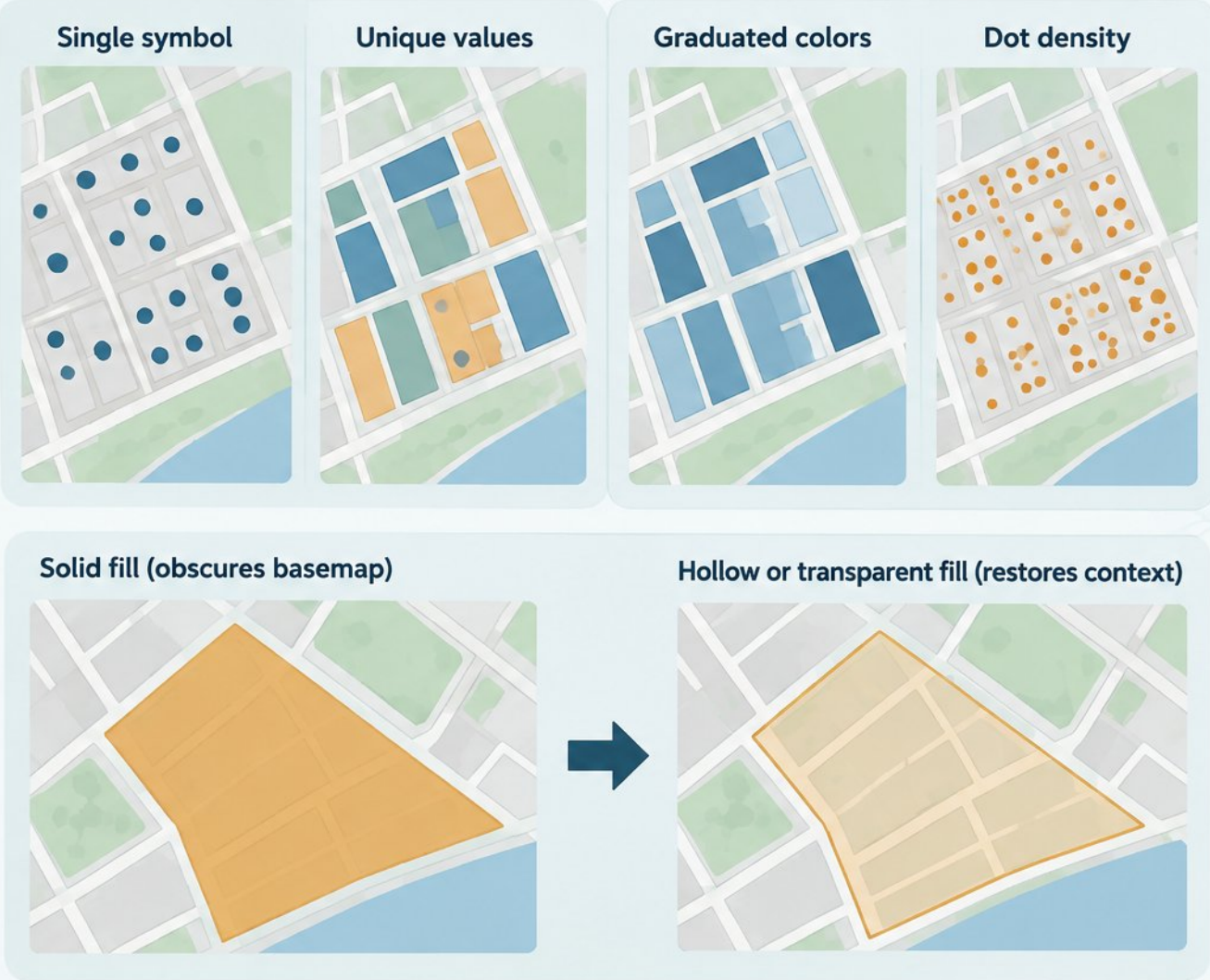
Typical stacking: imagery and tile layers first, then polygons, lines, and points

Feature layer items may contain sublayers with different geometry types, added individually



Symbology, Order, and Transparency: How Layers Communicate

- Primary methods: single symbol, unique values, graduated colors and symbols, proportional symbols, dot density, charts, heat maps
- Symbols are defined by shape, size, color, spacing, and transparency
- Layer order and transparency control what stands out and what gets hidden
- A solid fill can obscure the basemap; hollow or transparent fills restore context
- Match method to data: categories use unique values, quantities use graduated or proportional symbols



Two Ways to Represent the World: Vector and Raster

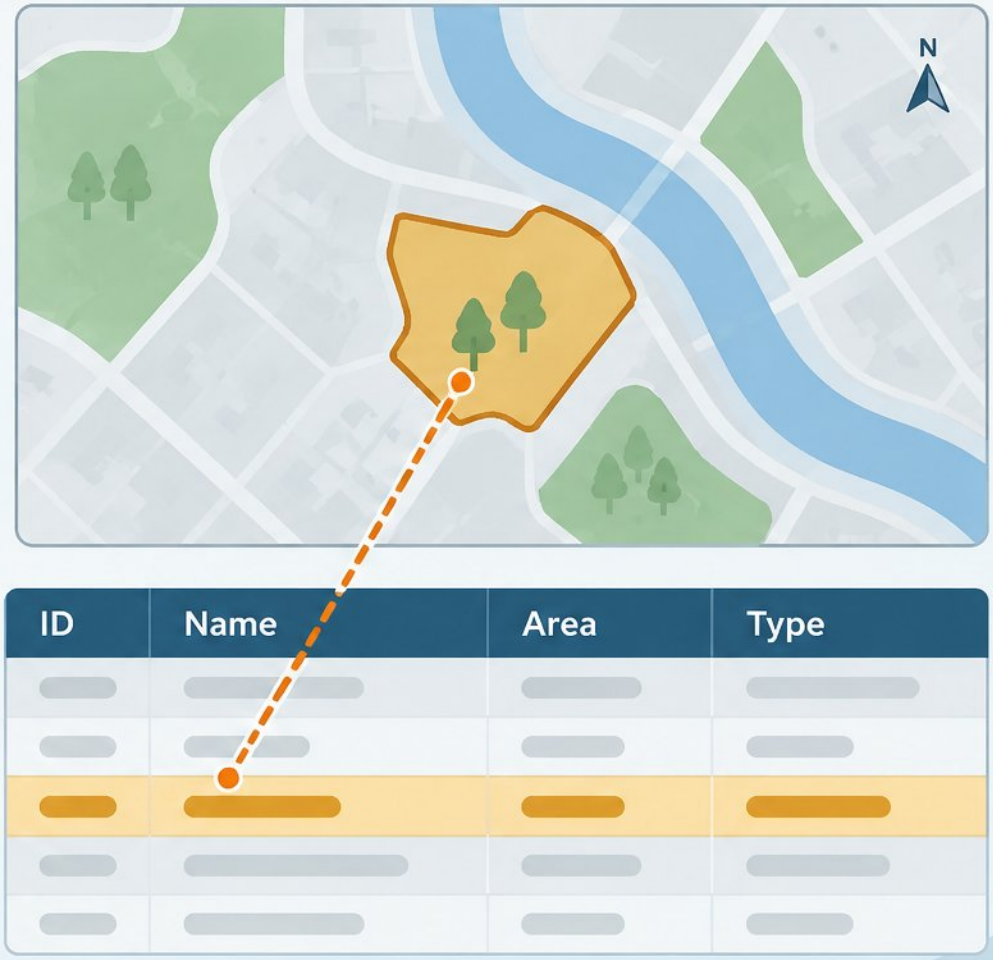




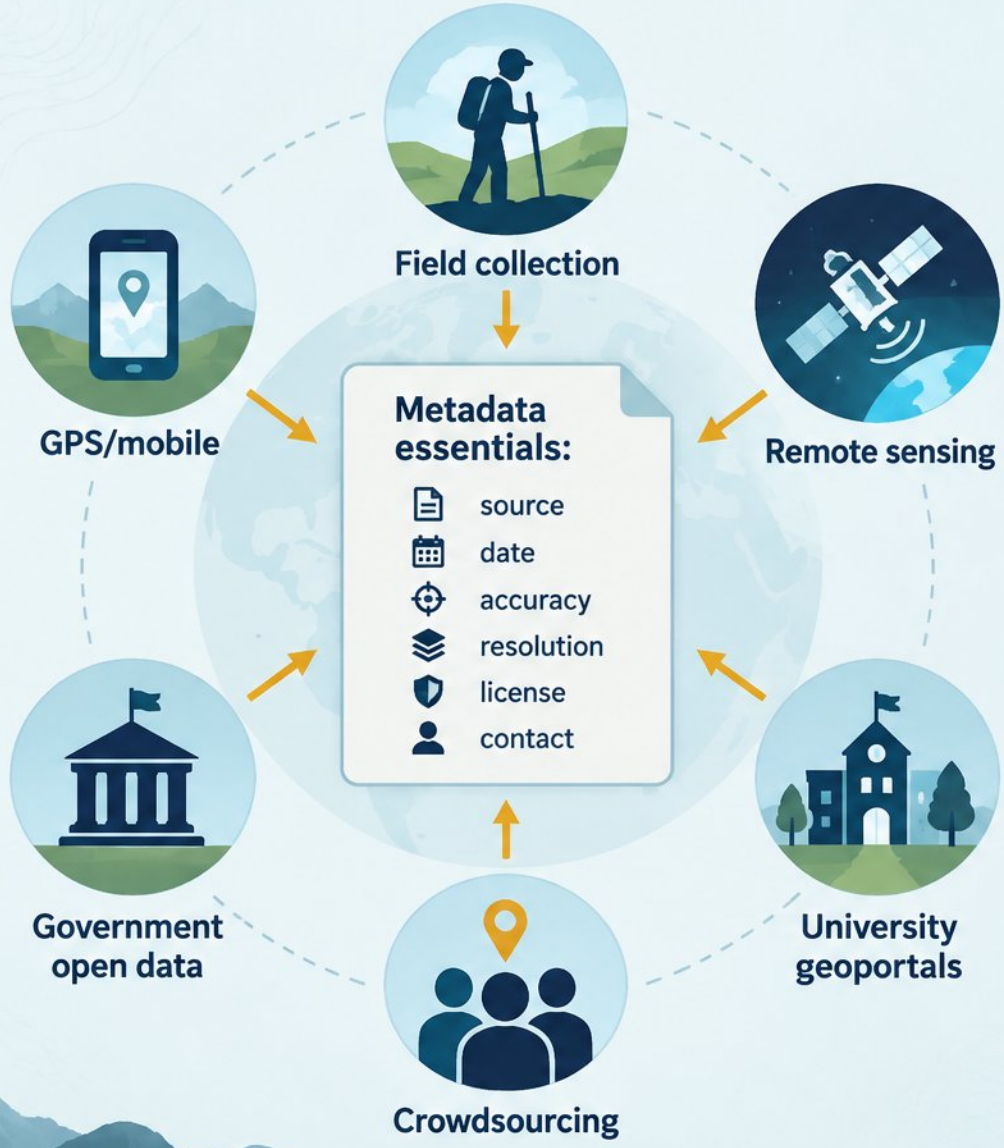
- **Vector:** discrete points, lines, and polygons built from vertices, with linked attribute tables
- **Raster:** a grid of cells, each holding a value; resolution defines cell size
- **Match the model to the phenomenon:** discrete features vs. continuous fields (elevation, temperature)
- **Trade-offs** in precision, file size, processing speed, and visual clarity; neither model is universally better
- **Mixed pixel problem:** coarse cells may contain more than one real-world category

Attributes and the Link Between Geometry and Data

- Attribute tables hold the descriptive information that makes spatial data analyzable
- A unique identifier links each geometry to its record, keeping map and table in sync
- Vector handles many attributes per feature; raster usually needs one layer per attribute
- Attribute and spatial queries combine: parks over 10 ha within 1 km of a river
- Rich attributes enable filtering, classification, labeling, and thematic mapping



Where Data Comes From: Sources and Metadata



- Six main sources: field collection, GPS/mobile, remote sensing, government open data, crowdsourcing, university geoportals
- Metadata essentials: source, date, accuracy, resolution, license, contact
- Free to download is not always free to reuse—always read the license
- Example starting points: Natural Earth, OpenStreetMap, national statistical agencies, city open data portals
- Lineage documents sources and processing steps, supporting trust and reproducibility

How Good Is the Data? Quality and Fitness for Purpose

- Five quality dimensions: positional and attribute accuracy, logical consistency, completeness, currency
- Accuracy is closeness to truth; precision is consistency across repeated measurements
- A precise measurement can still be inaccurate, and vice versa
- Fitness for use: good enough for one question, unsuitable for another
- Pre-analysis checks: completeness, consistency, currency, spatial coverage
- Ground-truth samples and reported error make uncertainty visible



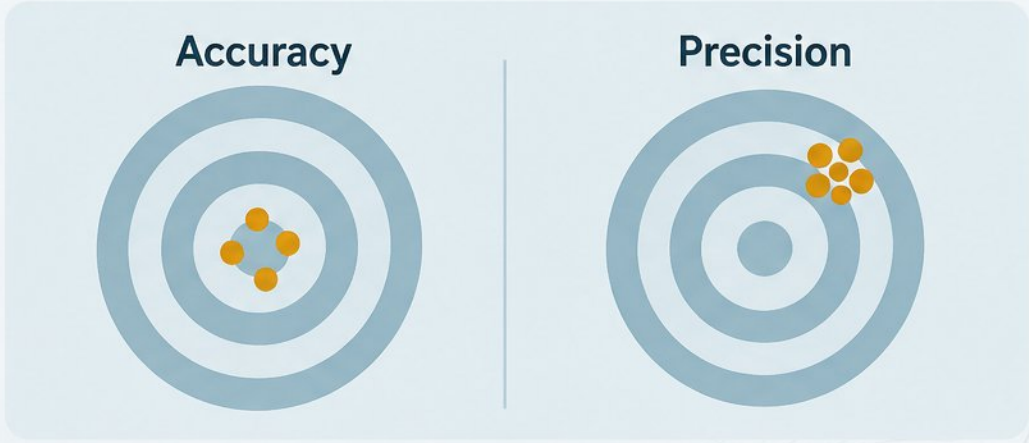
Positional accuracy

Attribute accuracy

Logical consistency

Completeness

Currency

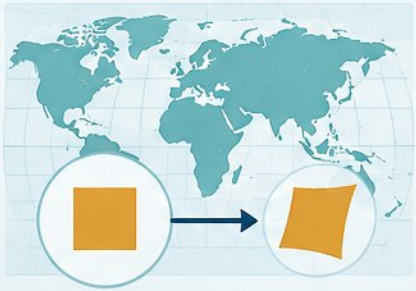


Coordinate Systems, Projections, and Scale

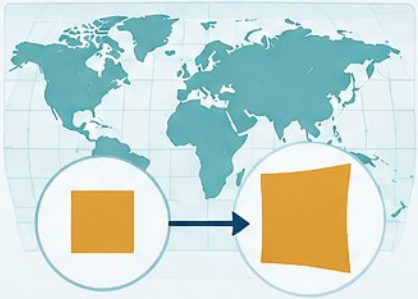
- Geographic coordinates use latitude and longitude; projected coordinates use planar x and y
- Every flat map distorts shape, area, distance, or direction—never all four
- Match projection to purpose: conformal for angles, equal area for area, equidistant for distance
- On-the-fly reprojection suits display, not analysis or editing
- Watch for misaligned layers, odd units, and drifting measurements



Shape



Area



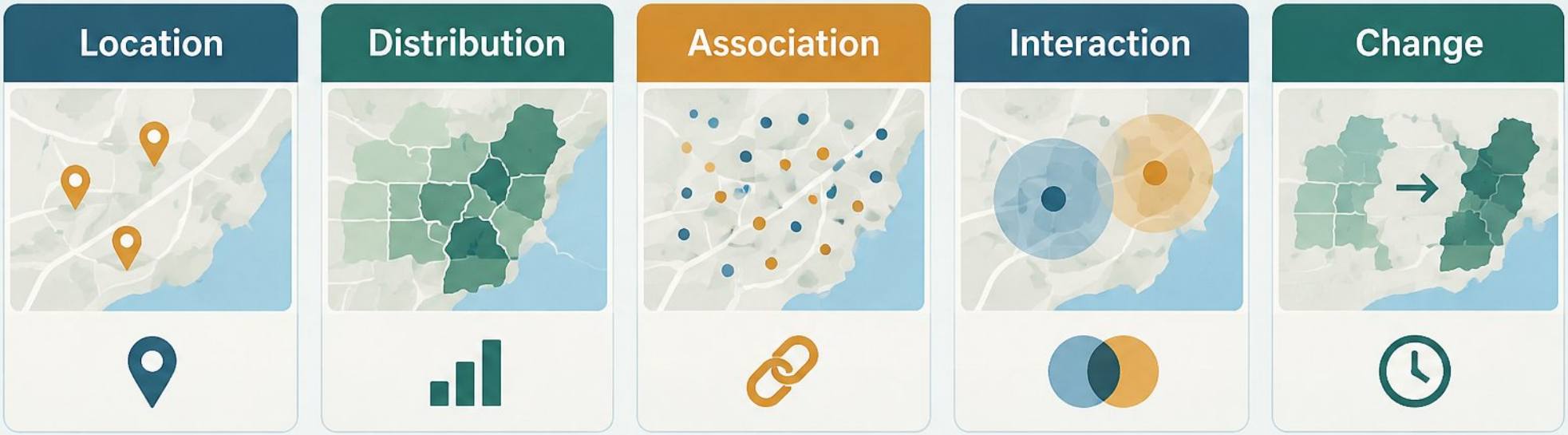
Distance



Direction



Asking Spatial Questions That Data Can Answer



- Five question families: location, distribution, association, interaction, change
- Make questions testable: specify place, time, and measure
- Overlay asks what is on top of what; buffers ask what is near what
- Spatial joins and summary statistics connect layers and quantify patterns
- Define study area and scale before analyzing; work the neighborhood accessibility example

From Question to Map: A Simple Analysis Workflow



- Six stages: define, gather, check, analyze, visualize, interpret
- Document decisions and assumptions so results are reproducible
- Watch for wrong projections, mismatched units, over-aggregation, and data bias
- Report uncertainty and limitations alongside findings
- Start with QGIS, Google Earth Pro, or ArcGIS Online

Practice Activity: Read a Map, Ask a Question

Part 1:
Identify layers, data types, sources, and symbology in a sample map

Part 2:
Write one spatial question; select the layers and tools to answer it

Part 3:
Discuss assumptions, data limitations, and projection choices with peers

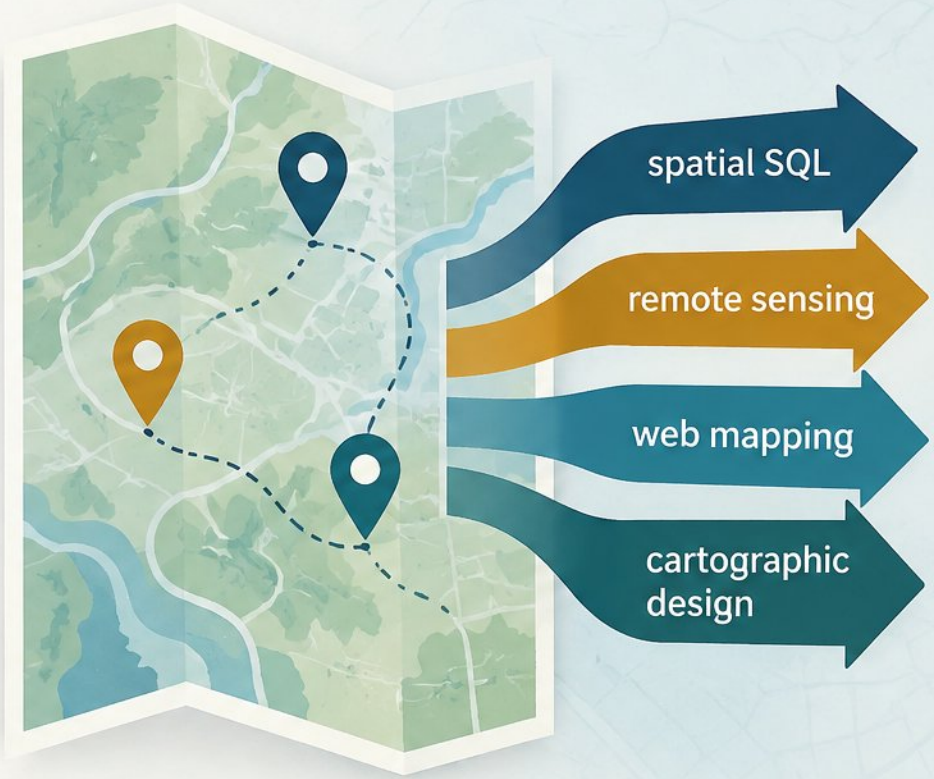
Self-check:
Use the checklist for spatial reasoning and data quality

Debrief:
Spot where beginners go wrong and how to close the gaps



Key Takeaways and Next Steps

- Layers organize spatial data; data models shape what can be analyzed
- Data quality and projections are analytical decisions, not technical footnotes
- Good GIS begins with a clear spatial question
- Next topics: spatial SQL, remote sensing, web mapping, and cartographic design
- Practice with QGIS tutorials, open curricula, and free dataset catalogs
- Start free: QGIS is open source; Google Earth Pro suits quick visualization





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