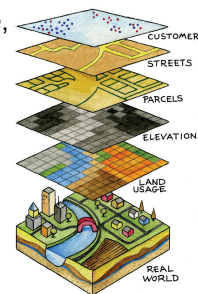


**GIS** (Geographic Information System) is a collection of hardware, tools, data, and people used to curate, manage, and analyze geographic information.

A **GIS** is built by **humans** with **collections** of **data** organized as **layers** with a **toolset** and stored on hardware to meet some specific **purpose**; often to make a map or perform an analysis.

**Maps** are **models** of the Earth's surface, **not representations**. **Scale** is very important.



**Tool Sets** are collections of computer programs for organization, display, and analysis of GIS data.\*



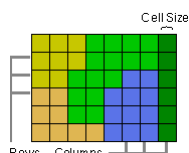
Common: ESRI suite (ArcGIS Pro, ArcGIS Online, ArcCatalog) <https://www.esri.com/> and/or Quantum GIS (QGIS) <https://qgis.org/>

Advanced: Python (<https://www.python.org/>) and R (<https://www.r-project.org/>) with the Geospatial Data Abstraction Libraries (GDAL) <https://gdal.org/index.html>



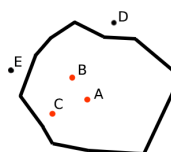
\* Tool sets and data are separate: data is not stored inside the toolset project and must be well organized.

There are two **Common Data Structures** used in GIS, rasters or grids of cells and vectors as discrete features.

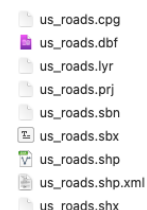


**Raster:** A grid of cells where each cell represents a lat/lon and/or x/y coordinate. The numeric cell value can represent one attribute, elevation or temperature, for example.

**Vector:** A collection of points that can be organized into point, line, or polygon features. Each feature can have attribute values that can be numbers, text, or logical.



**Common File Formats** for GIS data are grouped by the type of data structure, there are more than listed below.\*



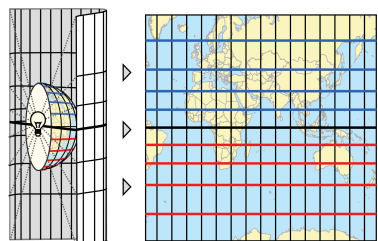
**Raster:** geotiff (.tiff, .tif), jpg (.jpg), ESRI grid (as several files in a folder), ERDAS grid (.img)

**Vector:** shapefile (.shp with .sbn, .dbf, .shx, .sbx, .prj), geojson (.json), geodatabase (.gdb as a folder), google earth (.kml, .kmz), autocad (.dxf, .dwg)

\* Often GIS data are organized as collections of files with the same name and different extensions, for example the .xml extension is reserved for any metadata associated with the actual GIS data file(s).

All GIS data use **Coordinate Reference Systems (CRS)** to describe location as coordinates on the Earth's surface.

All GIS data uses one of several **spherical coordinate reference systems** as latitude/longitude in angular degrees for the Earth's surface. These are **geographical CRS**. The two most common spherical CRS in North America are **WGS 84** (global data) and **NAD 86** (North American data).



GIS data can also be **projected into Cartesian coordinates**

(based on x and y) that use measurable units like feet or meters.

Two common groups of projected CRS in North America are the

**Universal Transverse Mercator (UTM)** and the **State Plane** systems. Projected data must still reference an underlying spherical CRS. As examples the standard projection for online maps in meters is the **WGS84 Web Mercator** and a common projection for Miami, FL in feet is the **NAD86 State Plane Florida East**.



All coordinate reference systems have **EPSG** codes as commonly used identifiers (European Petroleum Survey Group). As examples, WGS 84 is EPSG **4326**, NAD 86 is EPSG **4269**, the WGS 84 Web Mercator is EPSG **3857**, and the NAD 83 State Plane Florida East (feet) is EPSG 2236.

**GIS project** file extensions are different for each software toolset: as examples ArcGIS Pro is **.aprx** and QGIS is **.qgz**. The project does **\*NOT\*** contain the GIS data, but instead links the files in the file system with metadata that describes symbology, layer order, labeling, and other visualization information. When copying GIS projects, make sure to copy all the data files as well. Project files are often not included in the data curation process.

## Common GIS Data Types

.XML	Metadata (all formats and structures)*
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*\*often accompanies the actual data file(s) and can be in one of several schemas\**

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### Tabular (must have columns with x/y or lat/lon coordinates with a known CRS)

.CSV	Comma Separated Values
.XLS .XLSX	Excel

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### Vector (points, lines, or polygons)

.SHP .DBF .SHX .SBX .SBN .PRJ .XML .CPG .QMD	Shapefile
.GEOJSON .JSON	Geographic JavaScript Object Notation (GeoJSON)
.GML	Geography Markup Language
.KML .KMZ	Google Keyhole Markup Language
.GPX	GPS eXchange Format
.OSM	OpenStreetMap

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### Raster (remote sensed data or continuous surface data)

.TIF .TIFF .OVR .TFW	GeoTIFF
.IMG	ERDAS Imagine
.NC	Network Common Data Form (NetCDF)
.ADF	Esri Grid (legacy, inside folder on disk)
.JPG .JP2	jpeg, jpeg2000
.ASC	American Standard Code for Information Interchange ASCII Grid

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### Database (holding both raster and vector data structures)

.GDB	Esri File Geodatabase (folder on disk) **
.GPKG	Open Geospatial Consortium (OGC) GeoPackage
.SQLITE	SpatialLite
.SQL	postGIS (SQL loaded on database server)

*\*\*raster layers can only be opened by ESRI products\*\**

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### Project Files (no actual data, but instead metadata that points to data files)

.QGS, .QGZ (compressed, version 3.0 and higher)	QGIS
.APRX, .PPKX (compressed)	ArcGIS Pro
.MXD	Legacy ESRI files (ArcMap) - Map Exchange Document

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## GIS Metadata

### Essential metadata for geospatial data

- Geographic Coordinate System (CRS - coordinate system and/or projection)
- Point location, bounding coordinates, or gazetteer name
- Lineage/process steps (is the data derived or collected and descriptions for either process)

### Additional Metadata Elements for Vector and Raster Data Structures

#### Vector

- Data dictionary
- Recommended scale (or scale of digitization)

#### Raster

- Pixel size
- Band information
- Look up tables (if categorized)

### GIS Metadata Resources

Open Geospatial Consortium Metadata Standards

<https://www.ogc.org/standards/>

DCAT-US Schema v1.1 (Project Open Data Metadata Schema)

<https://resources.data.gov/resources/dcat-us/>

USGS Metadata Creation Guidelines

<https://www.usgs.gov/data-management/metadata-creation>

FGDC Content Standard for Digital Geospatial Metadata (legacy)

<https://www.fgdc.gov/metadata/csdgm-standard>