

So you want to use GIS in your research...

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Overview

- What is GIS and what can it do?
- GIS data
 - Raster & Vector layers
 - Attributes
 - Structured & semi-structured data
- Finding GIS data
- Selecting a GIS software
- GIS project tips

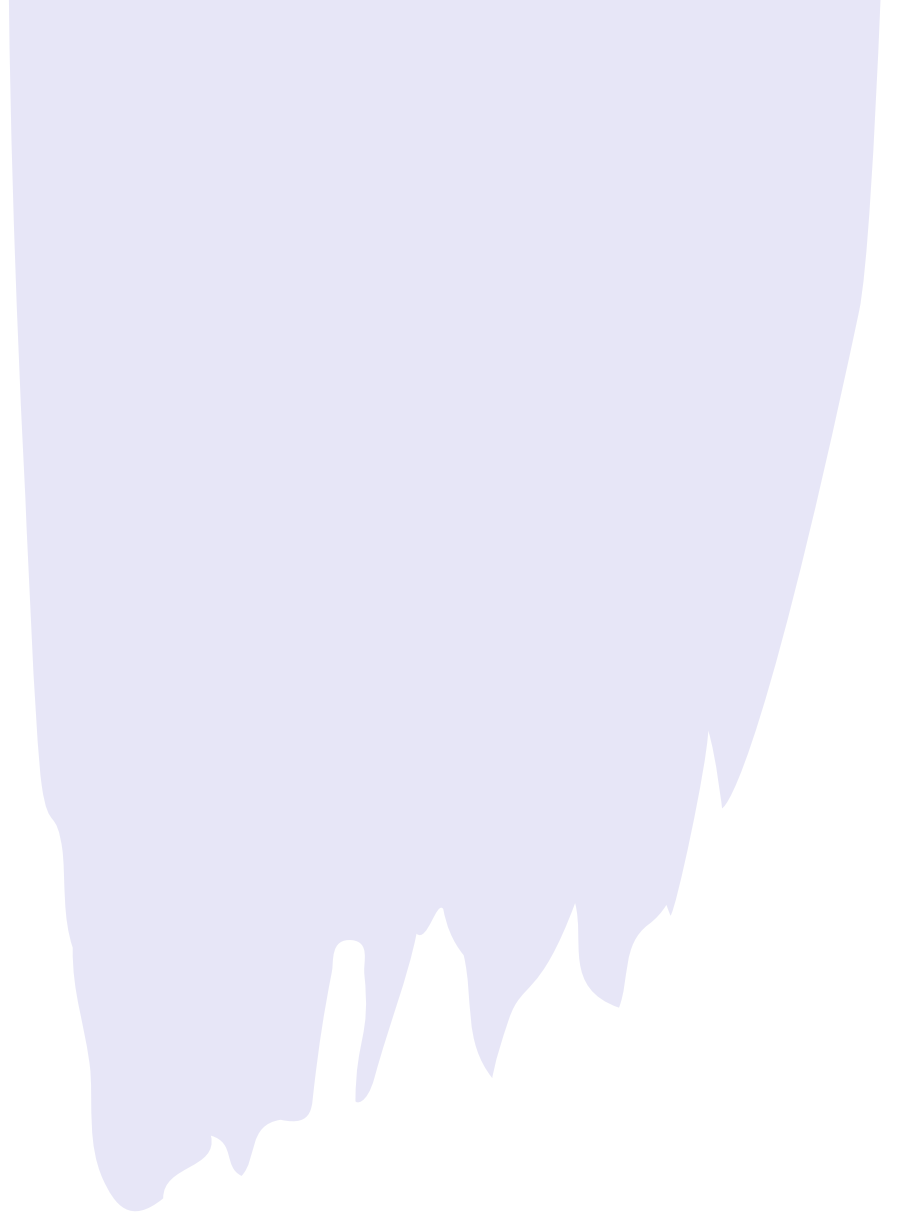
Before we start

GIS has a lot of terminology and technical quirks, so can be frustrating. That's normal!

We often say that it's not a learning *curve*, but a *brick wall*.

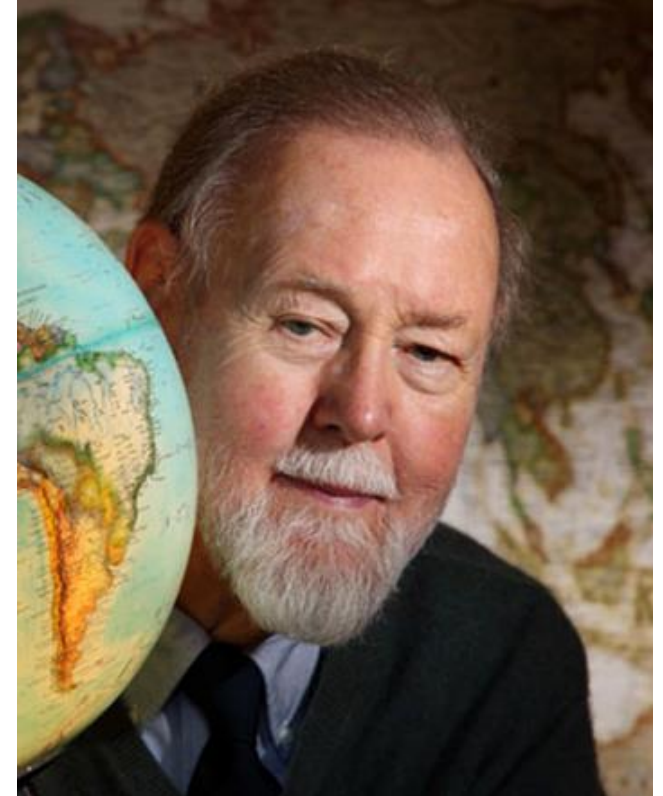


What is GIS?



What is GIS?

- GIS = Geographic Information System
- Invented in the 1960s by Roger Tomlinson at Natural Resources Canada



Source: <https://commons.wikimedia.org/wiki/File:RogerGlobe.jpg>

What is GIS?

- There are 3 main components to a GIS:
 - Visual representation as layers (map)
 - Table (data)
 - Analysis tools (software)
- **These 3 components are directly linked**
 - What happens in the table (underlying data) is represented visually in the map layer.
 - If you do analysis (e.g. querying, filtering a selection) in the table, the changes are represented and visualized in the layer.

MyProject2 - Ottawa_Road_Network - ArcGIS Pro

Project | Map | Insert | Analysis | View | Edit | Imagery | Share | View | Appearance | Labeling | Data | rebeccabartlett_Carleton_U (GIS Services at Carleton University Library)

Clipboard: Cut, Copy, Paste, Copy Path

Navigate: Explore, Bookmarks, Go To XY

Layer: Basemap, Add Data, Add Preset

Selection: Select, Select By Attributes, Select By Location

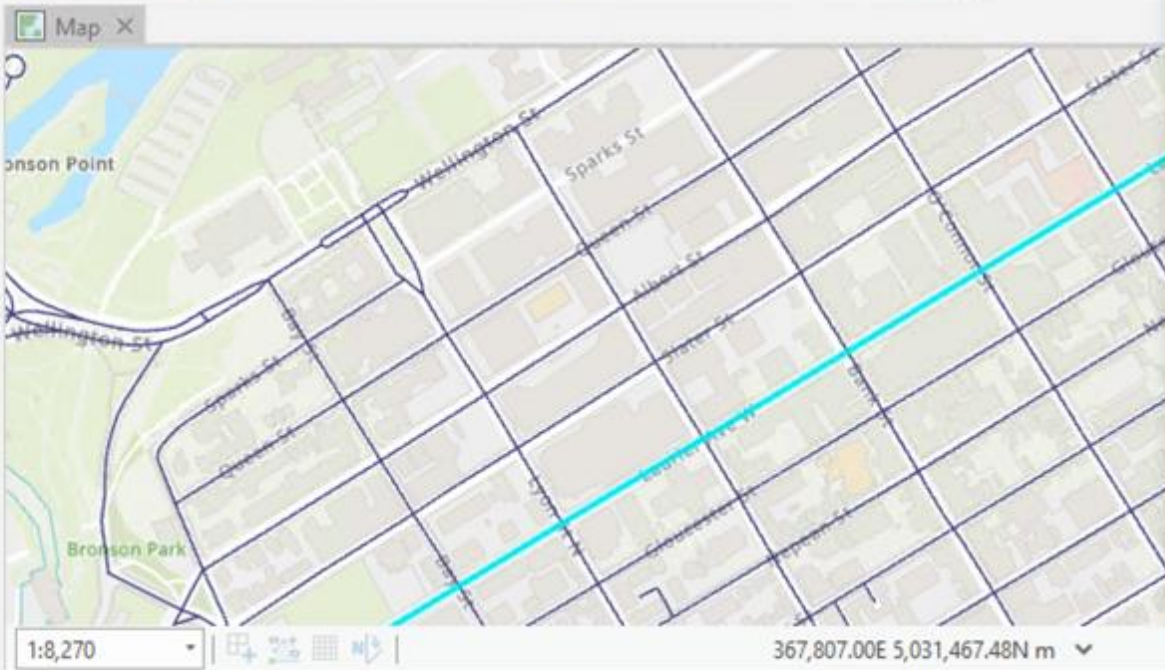
Inquiry: Attributes, Clear, Infographics, Measure, Locate

Contents

Search

Drawing Order

- Map
 - Ottawa_Road_Network
 - World Topographic Map
 - World Hillshade



Pop-up

Ottawa_Road_Network (1)

LAURIER

Ottawa_Road_Network - LAURIER

STREET	LAURIER AVE W
ADD_RANGE	399 - 440
ADD_ID	232913
FROMLEFT	410
TOLEFT	440
FROMRIGHT	399
TORIGHT	433
PREDIR	
PRETYPE	
STREETNAME	LAURIER
SUFTYPE	AVE
367,235.97E 5,031,117.43N m	

Geoprocessing | Pop-up

Ottawa_Road_Network

Field: Selection: Highlighted:

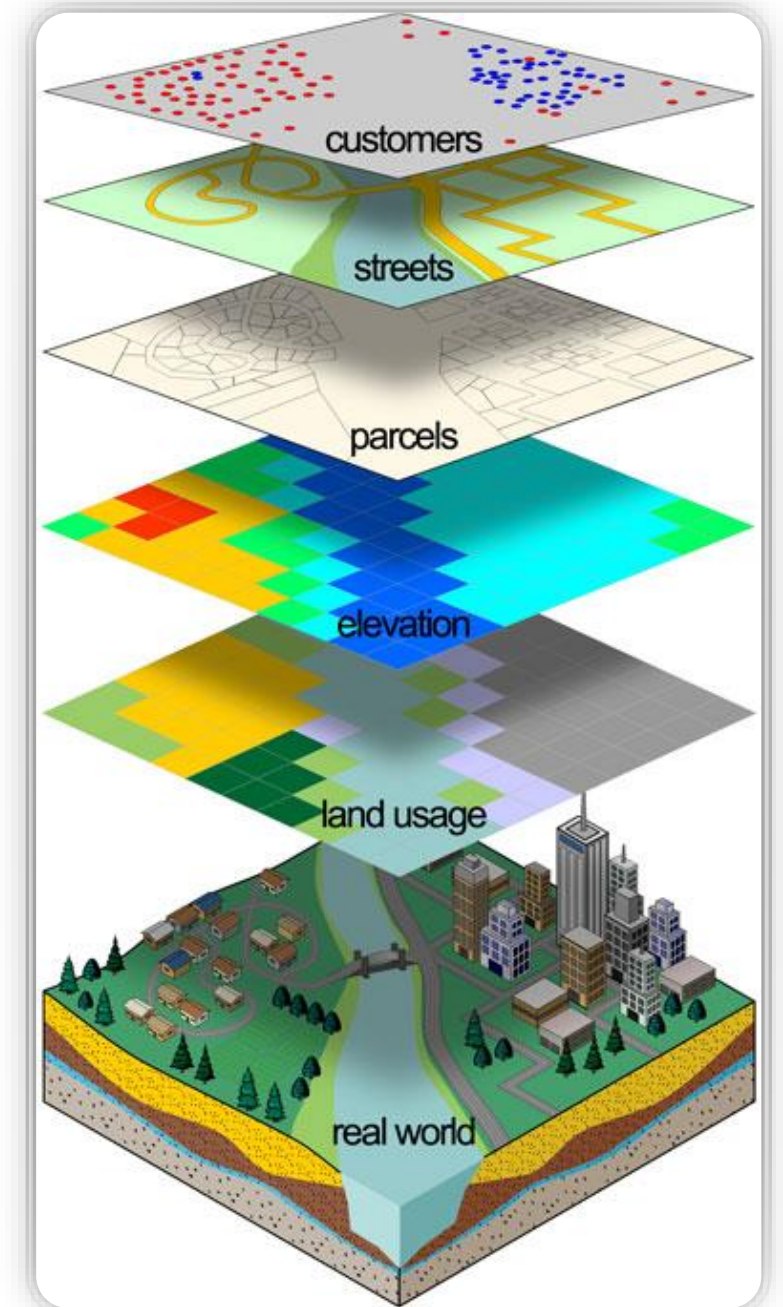
FID	Shape	UID	STREET	ADD_RANGE	ADD_ID	FROMLEFT	TOLEFT	FROMRIGHT	TORIGHT	PREDIR	PRETYPE	S
16704	Polyline	C4F2A395-E54C-4698...	LAURIER AVE W	133 - 170	232913	140	170	133	169			LA
16705	Polyline	46F3ABC5-A208-455...	LAURIER AVE W	190 - 251	232913	190	250	191	251			LA
16706	Polyline	90538BA9-FB1A-407...	LAURIER AVE W	257 - 300	232913	300	300	257	299			LA
16707	Polyline	6D3FCD77-0D31-48D...	LAURIER AVE W	301 - 380	232913	318	380	301	365			LA
16708	Polyline	E2CFE167-CE7E-4875...	LAURIER AVE W	399 - 440	232913	410	440	399	433			LA
16709	Polyline	A908ADF1-6C00-484...	LAURIER AVE W	445 - 475	232913	450	470	445	475			LA

66 of 43,335 selected

Filters: 100%

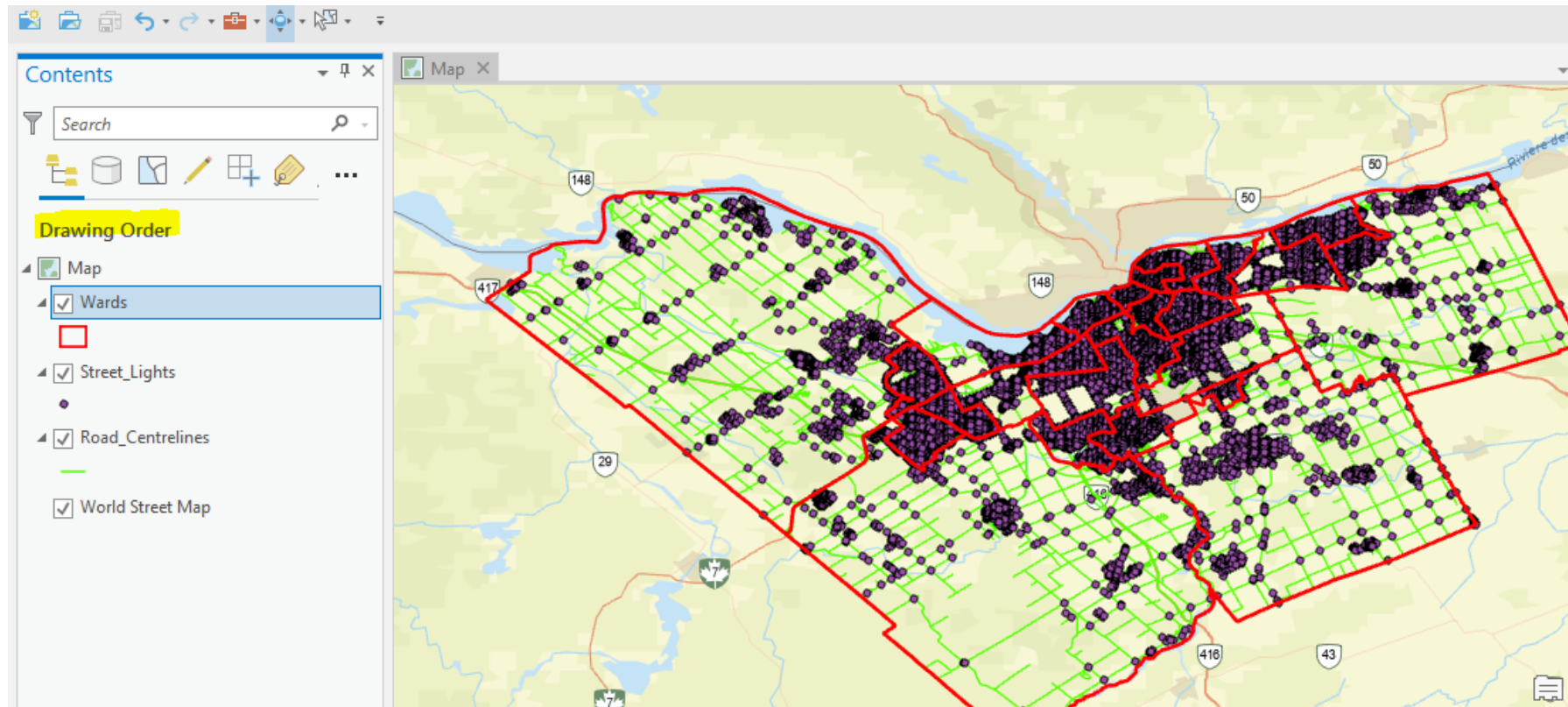
What is GIS: GIS layers

- Each GIS dataset is a *layer* when used in GIS software
- Layers can be stacked on top of one another to create a map or to perform analysis
- It is important to note that there is a hierarchy to the layer drawing order
 - If you place a polygon layer with a colour fill on top of a point layer, your points may not show up



What is GIS: GIS layers

- Layer order or drawing order is important to take note of

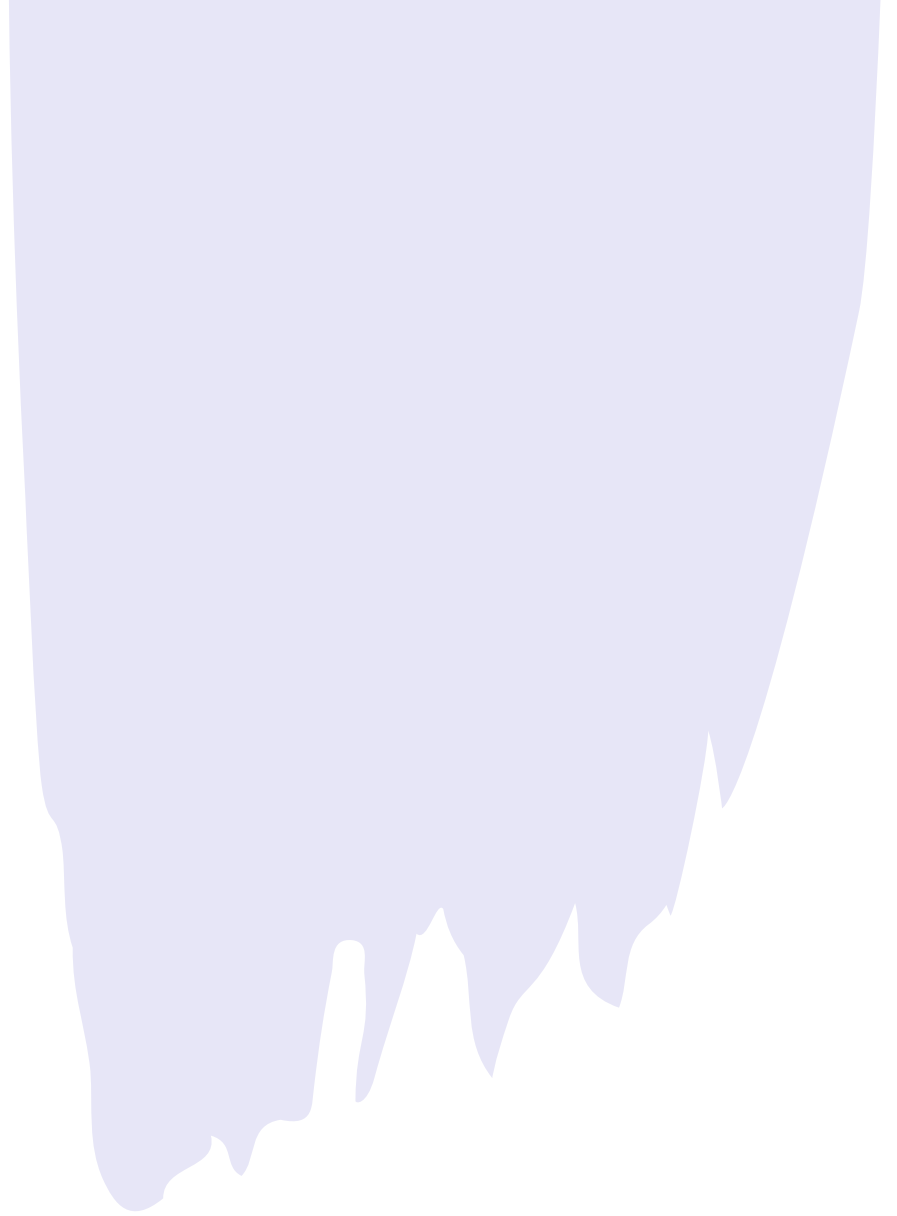


What can GIS do?

- It can help solve spatial questions or problems. For example:
 - Where should we build a new social service center so that it serves the most people in need?
 - What is the topology or surficial geology of the location where a new build will take place?
 - What percentage of an area has tree canopy?
 - How can we visualize changing patterns in sea ice?

But...how?!

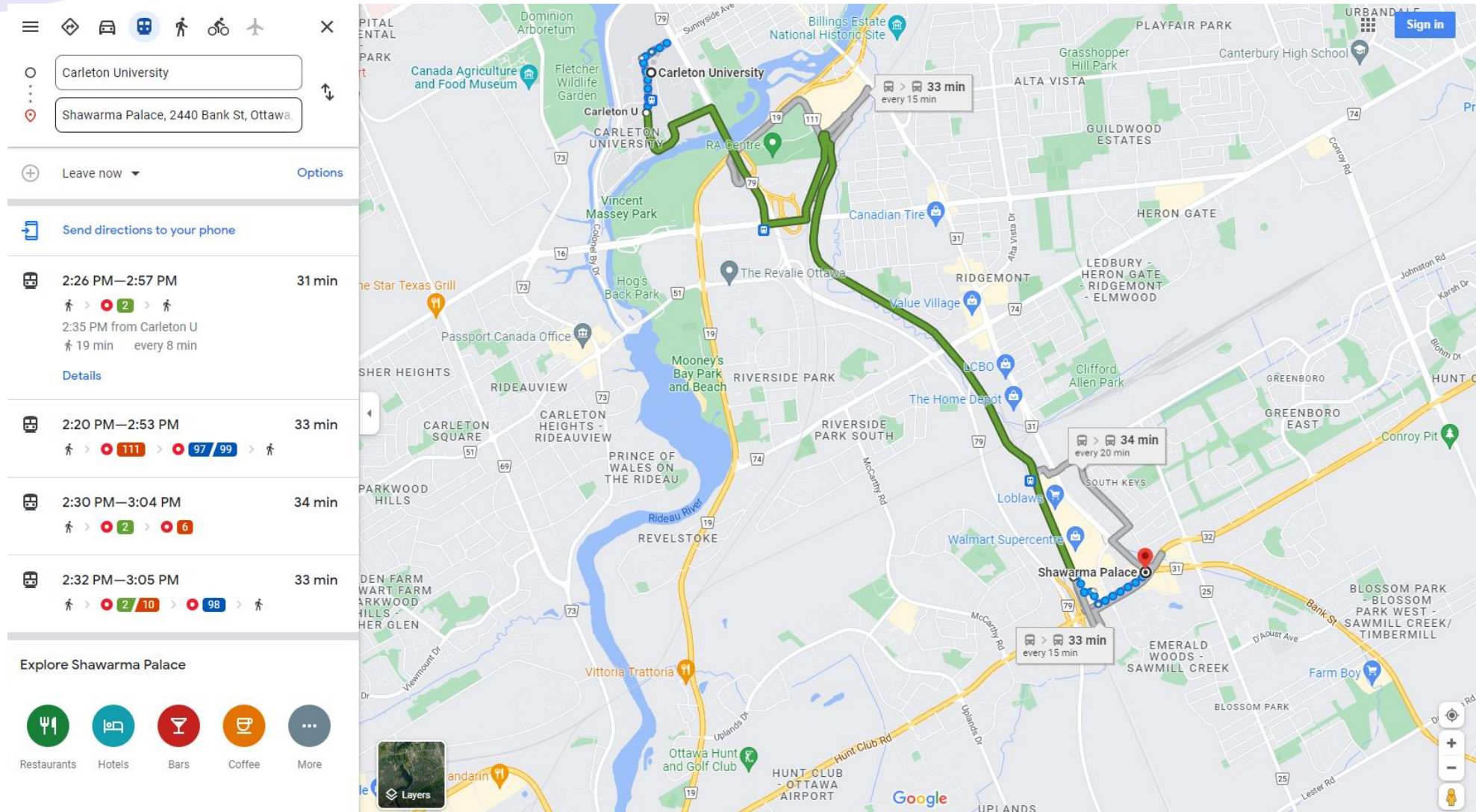
Spatial analysis!



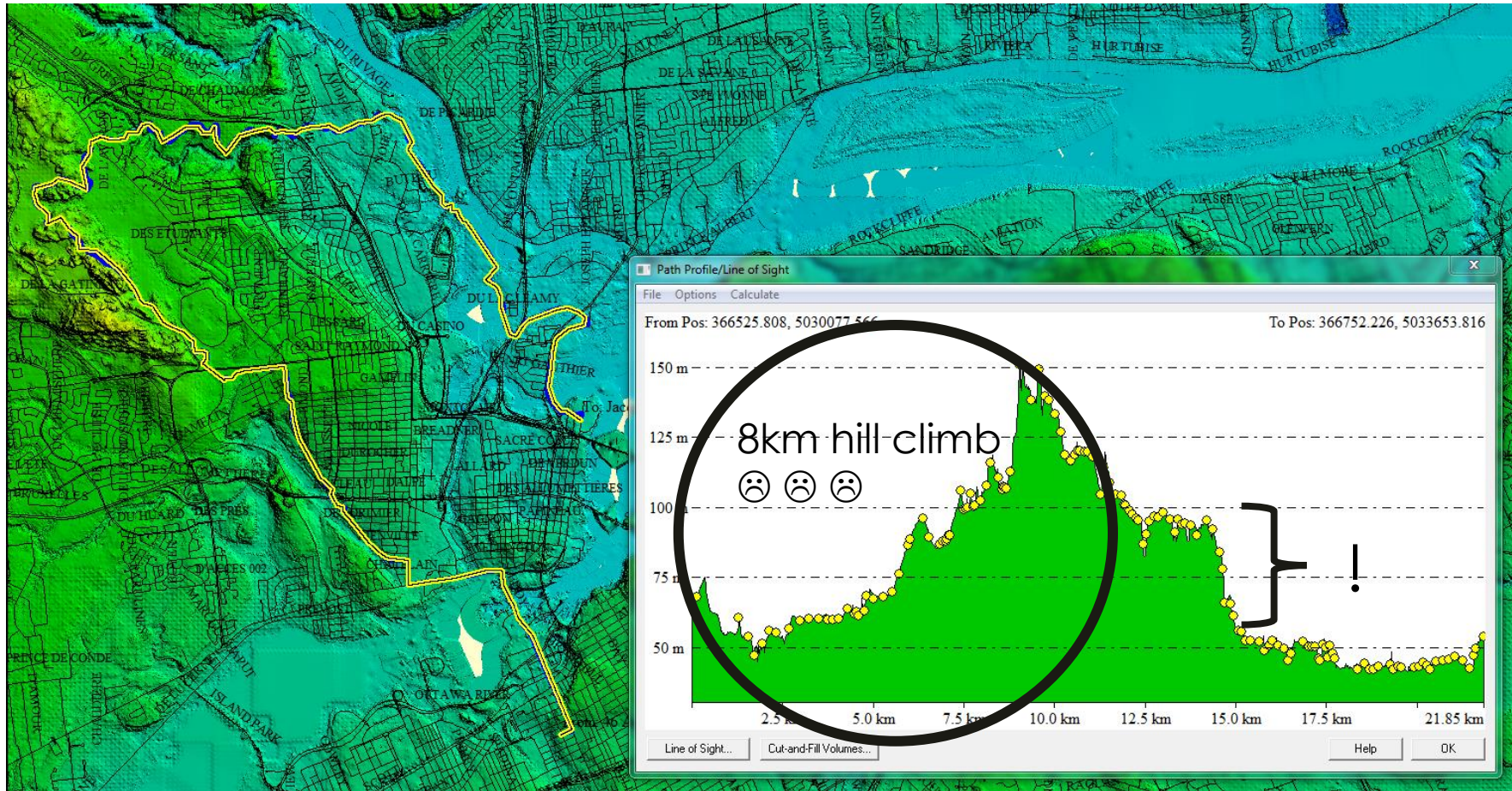
Spatial Analysis: What is it?

- Uses geospatial data to study entities using their geographic or topological properties
- Can identify relationships between different entities, or combine entities to create new information
 - What's the fastest route from Carleton to Shawarma Palace by public transit?
 - How many people live within 5km of Ottawa hospitals?
 - If moose prefer marshes and areas more than 1km away from roads, where are their ideal habitats?

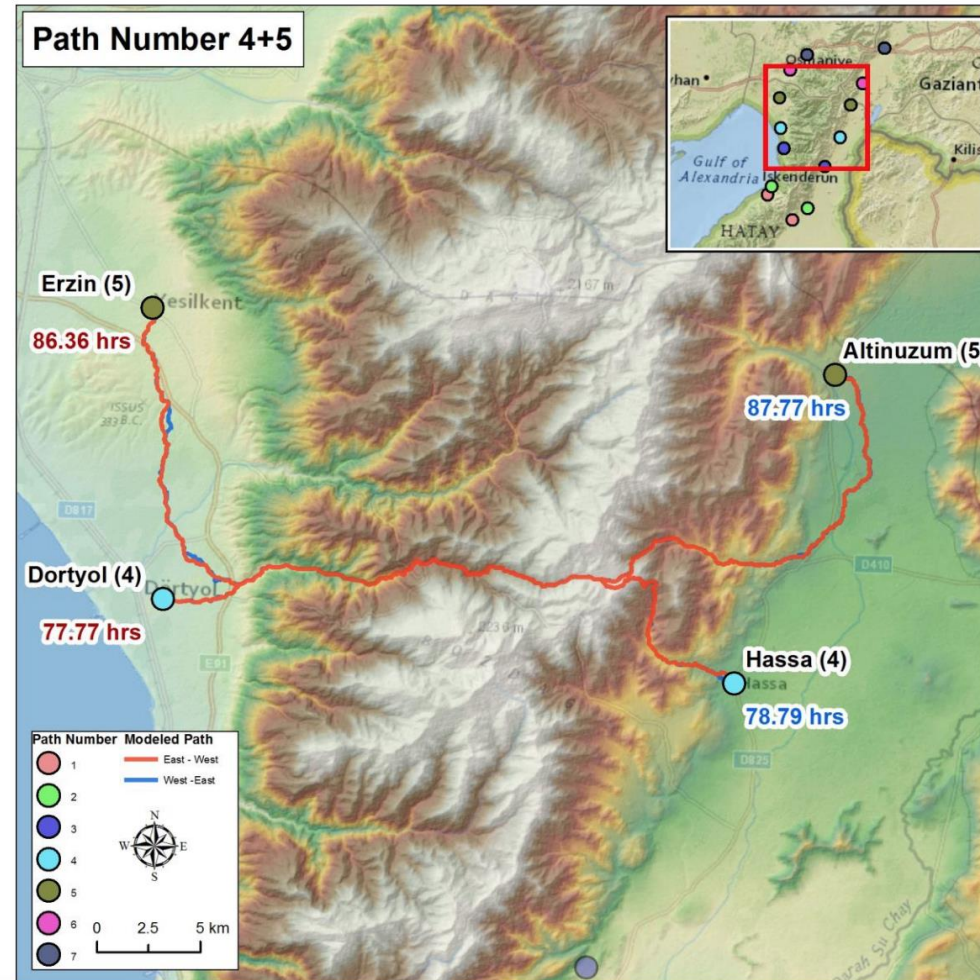
Spatial Analysis: Shawarma Palace via transit



Spatial Analysis: Prepare for a bike ride



Spatial Analysis: Bronze Age travel routes across Amanus Mountains in Türkiye



Spatial Analysis: Google Maps but in Ancient Rome

ORBIS The Stanford Geospatial Network Model of the Roman World

About Tutorial Walter Scheidel
Elijah Meeks

Route Network Flow

FROM: Lugdunum

TO: Carthago

DEPARTING: MONTH SEASON

❄️ 🌱 ☀️ 🍃

PRIORITY: Fastest Cheapest Shortest

NETWORK MODES

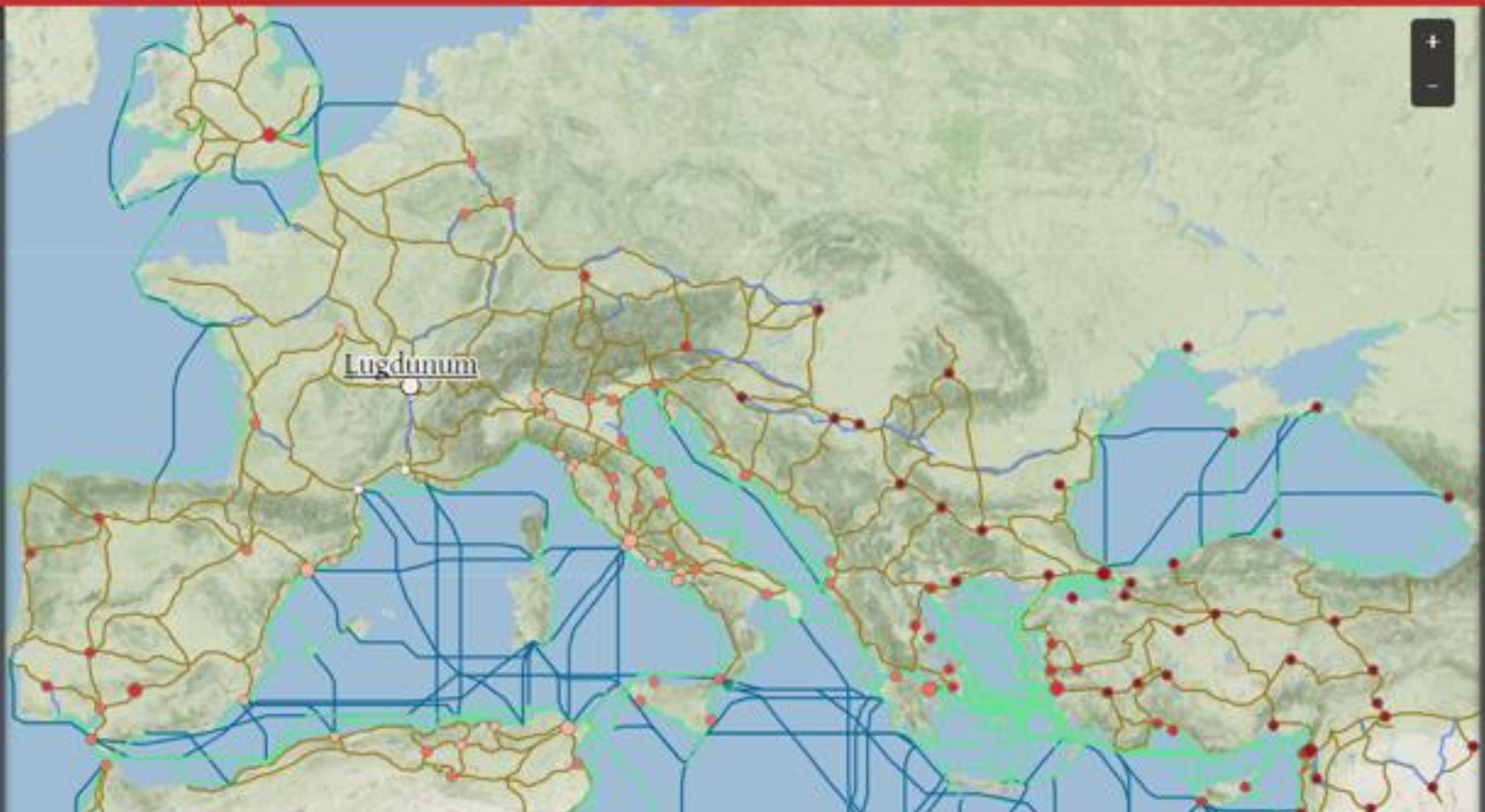
Road Coastal Sea
 River Open Sea
 High Resolution

MODE TRANSFER COST

ROAD: Foot (30km/day) 0

RIVER: Civilian 0

SEA: Fast 0



DISPLAY

Terrain
 Sites
 Names
 Paths
 Regions
 All Sites

Select Sites
Reset Map
Cluster
History
Export SVG
Path Coloring

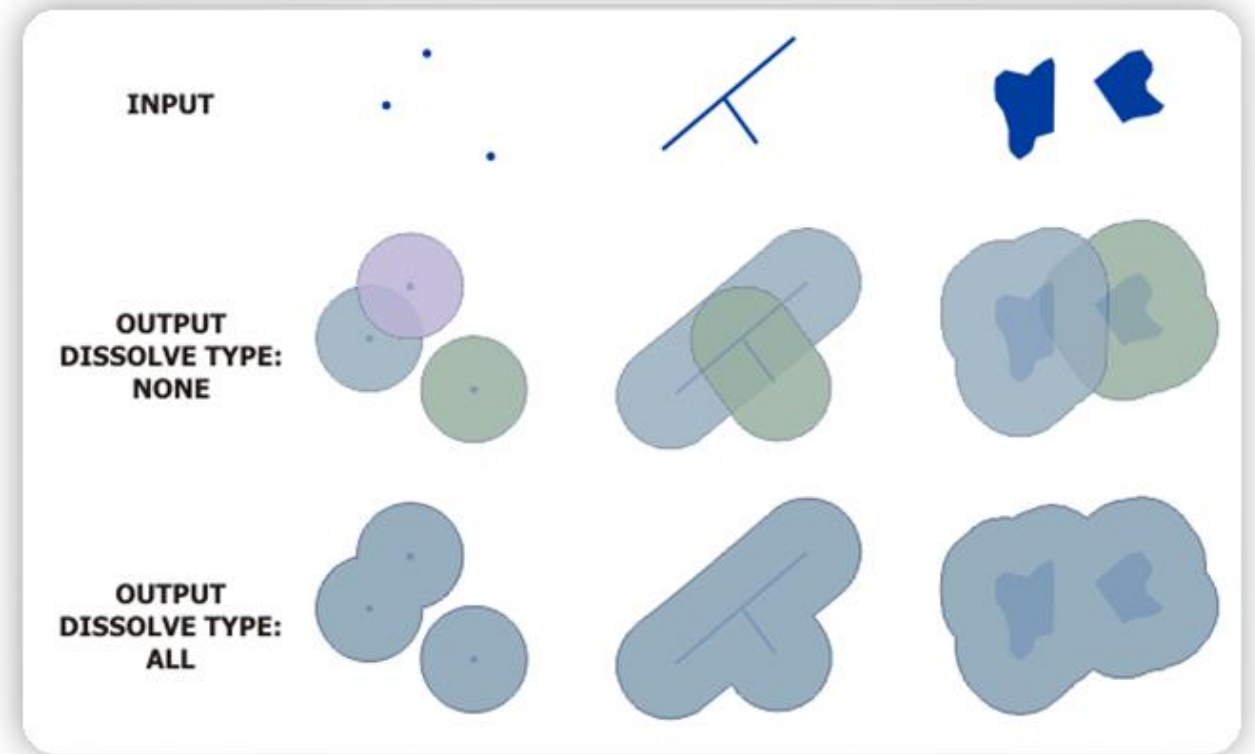
Tweet

31K
Like
Share

Source: <http://orbis.stanford.edu/>

Spatial Analysis: Buffer

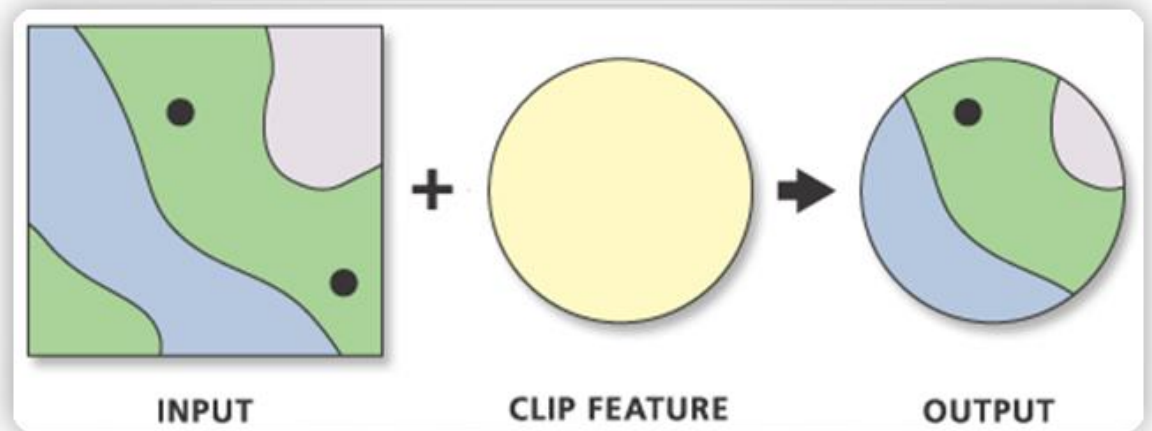
- A buffer creates an area around an entity at a specified distance
 - e.g. a 5km-diameter circle around a hospital



Source: <https://desktop.arcgis.com/en/arcmap/latest/tools/analysis-toolbox/buffer.htm>

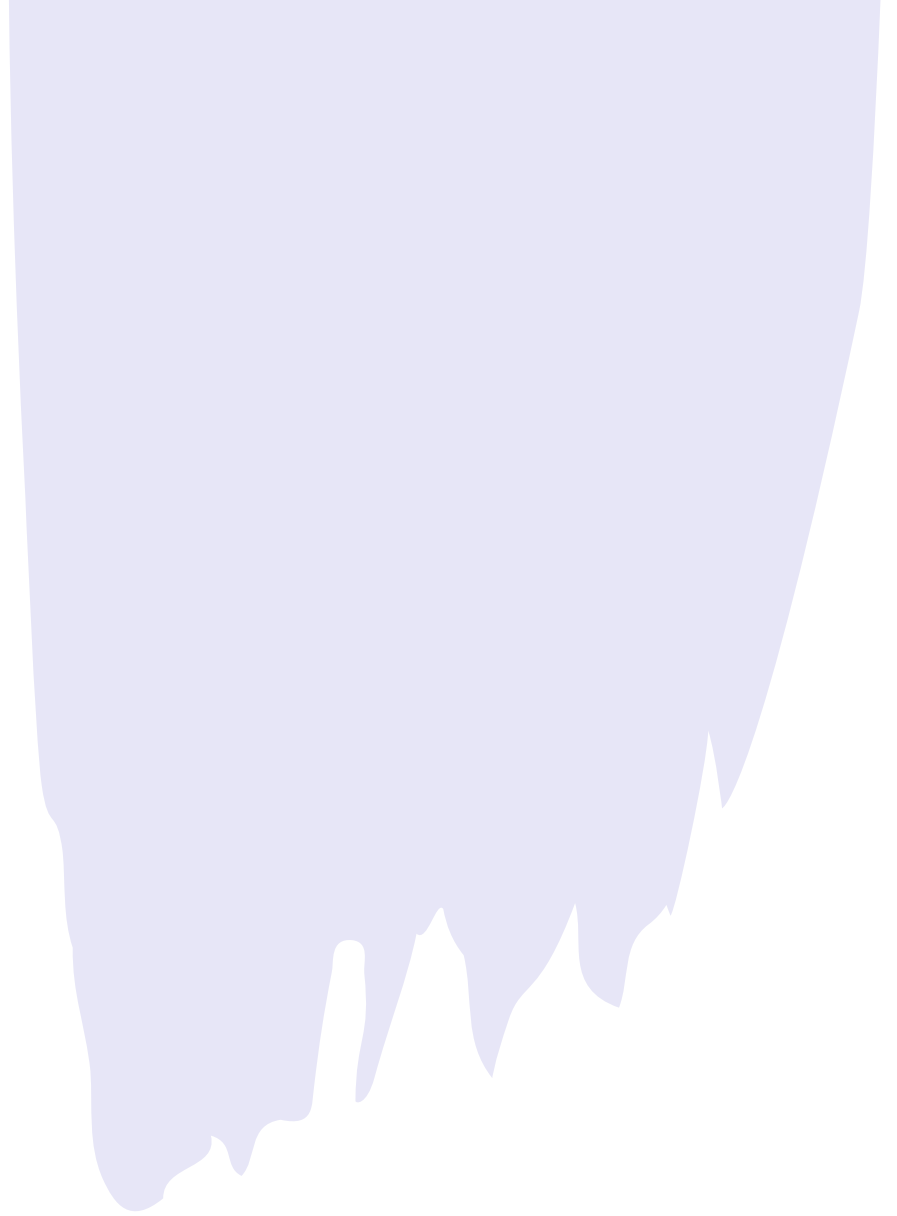
Spatial Analysis: Clip

- Clipping uses a polygon to cut out all the entities that fall within that polygon
 - e.g. all the homes within that 5km hospital buffer



Source: <https://desktop.arcgis.com/en/arcmap/latest/tools/analysis-toolbox/clip.htm>

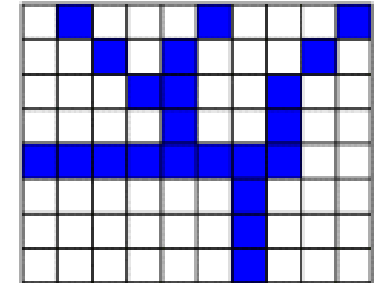
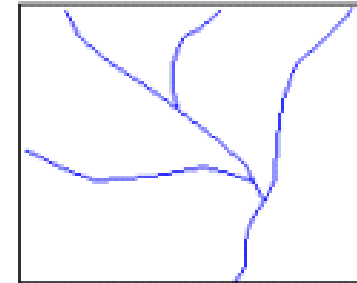
GIS Data



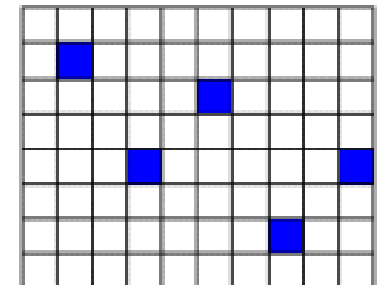
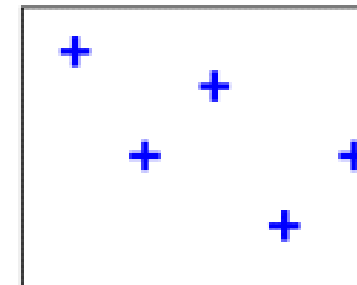
GIS Data: Two types of layers

- Vector: points, lines, and polygon geometries
 - File types include DWG, shapefiles, Google Earth KML
- Raster: continuous grids made up of pixels
 - File types include TIFF & JPEG
 - Air photos are raster files

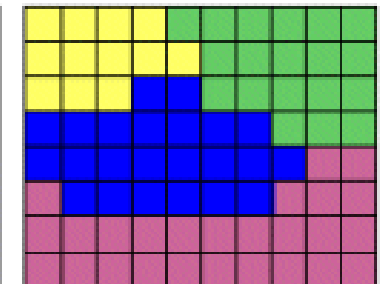
Lines



Points

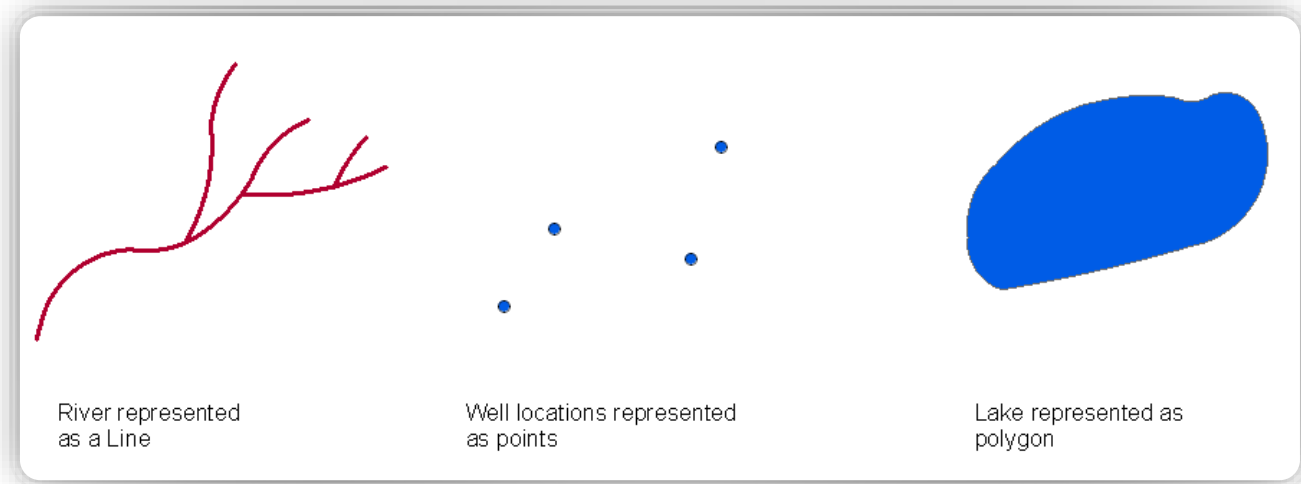


Polygons

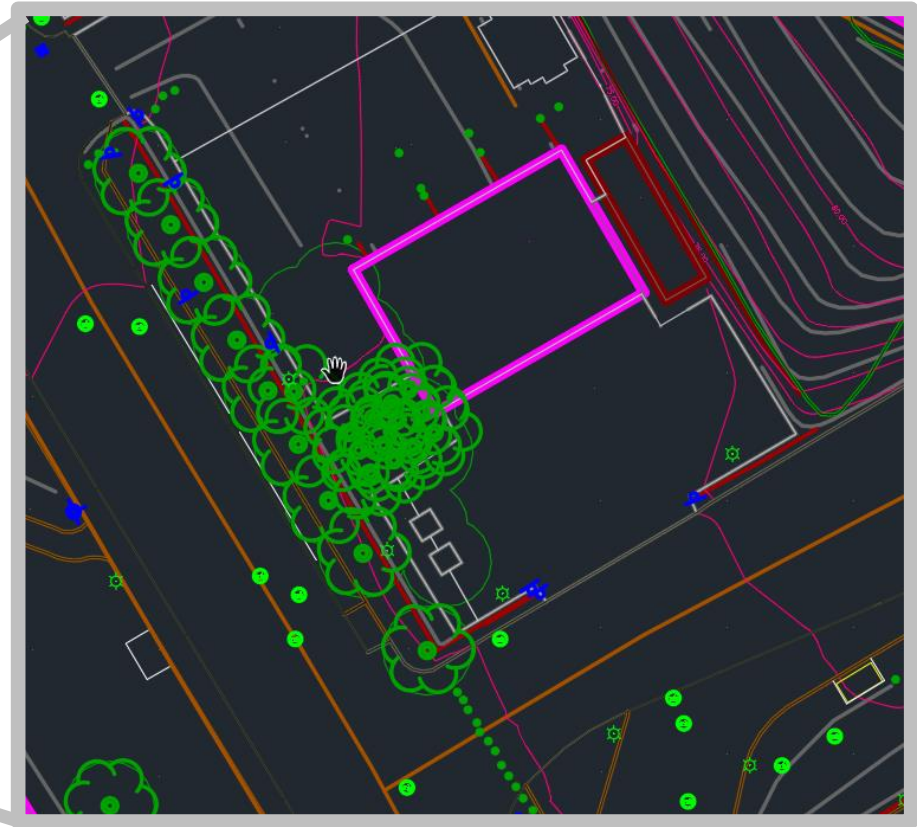
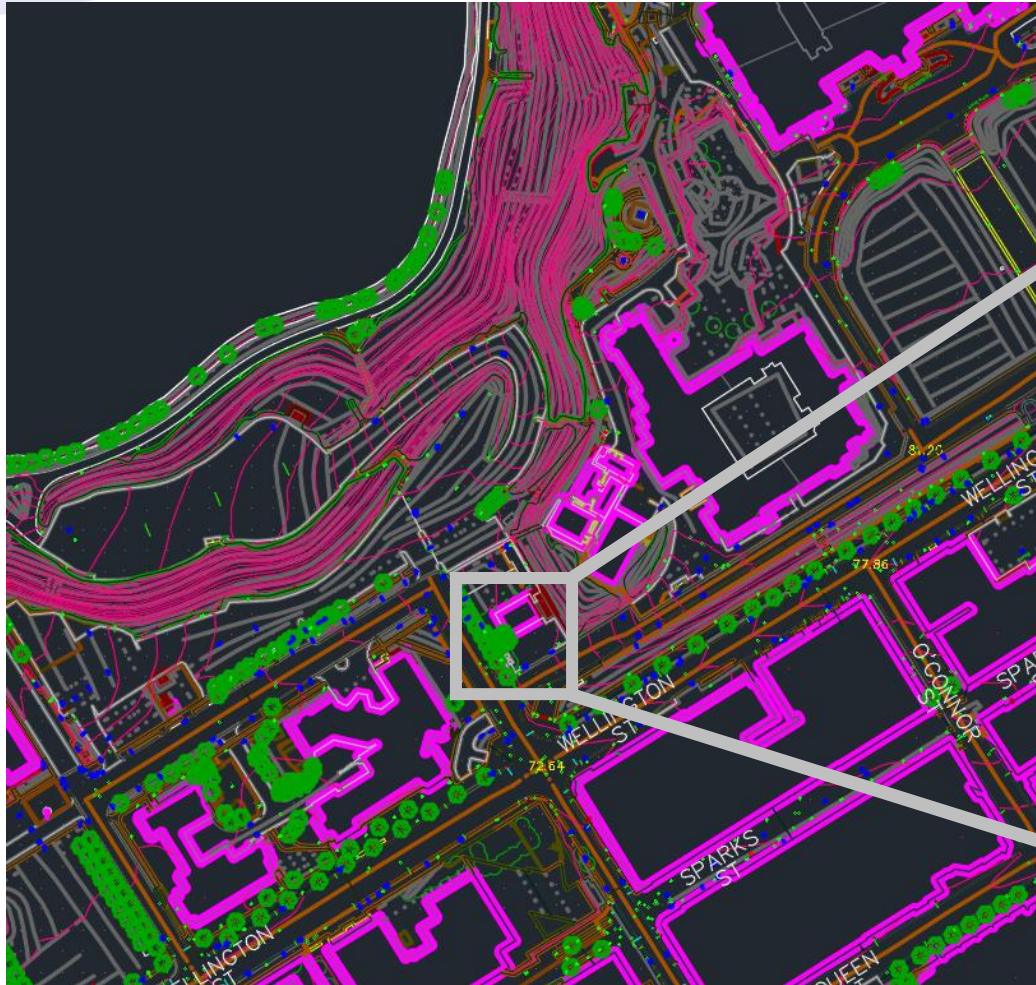


GIS Data: Vector layers

- **Vector** - Geographical features often expressed as types of geometry.
 - Points, Polylines & Polygons
 - Common file formats
 - Esri Shapefile (shp)
 - AutoCAD Drawing (dwg)
 - Google Earth (kml)
 - OpenStreetMap (osm)



Vector data: Ottawa 1:1000 topographic data



Source: Ottawa 1:1000 topographic data, tile 367031A.dwg; <https://carleton-u.maps.arcgis.com/apps/PublicInformation/index.html?appid=d572e8f92e21414483f293c667ae0c9e>

Vector data: Ottawa tree survey

Ottawa

Tree Inventory

Private Member
City of Ottawa

Summary

Dynamic map showing over 150,000 trees around the City of Ottawa.

[View Full Details](#)

[Download](#)

Details

- Dataset**
Feature Layer
- February 13, 2021**
Info Updated
- February 13, 2021**
Data Updated
- May 17, 2018**
Published

[I want to use this](#)

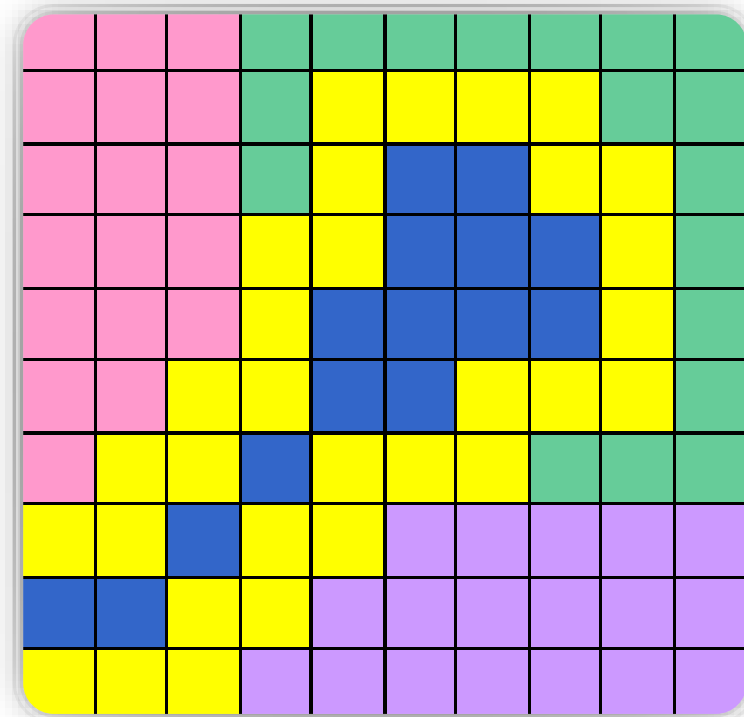
286,509 records

Map showing tree locations (blue dots) around the City of Ottawa, including streets like av. Riverdale Ave., av. Windsor Ave., av. Belmont Ave., and prom. Riverside Dr.

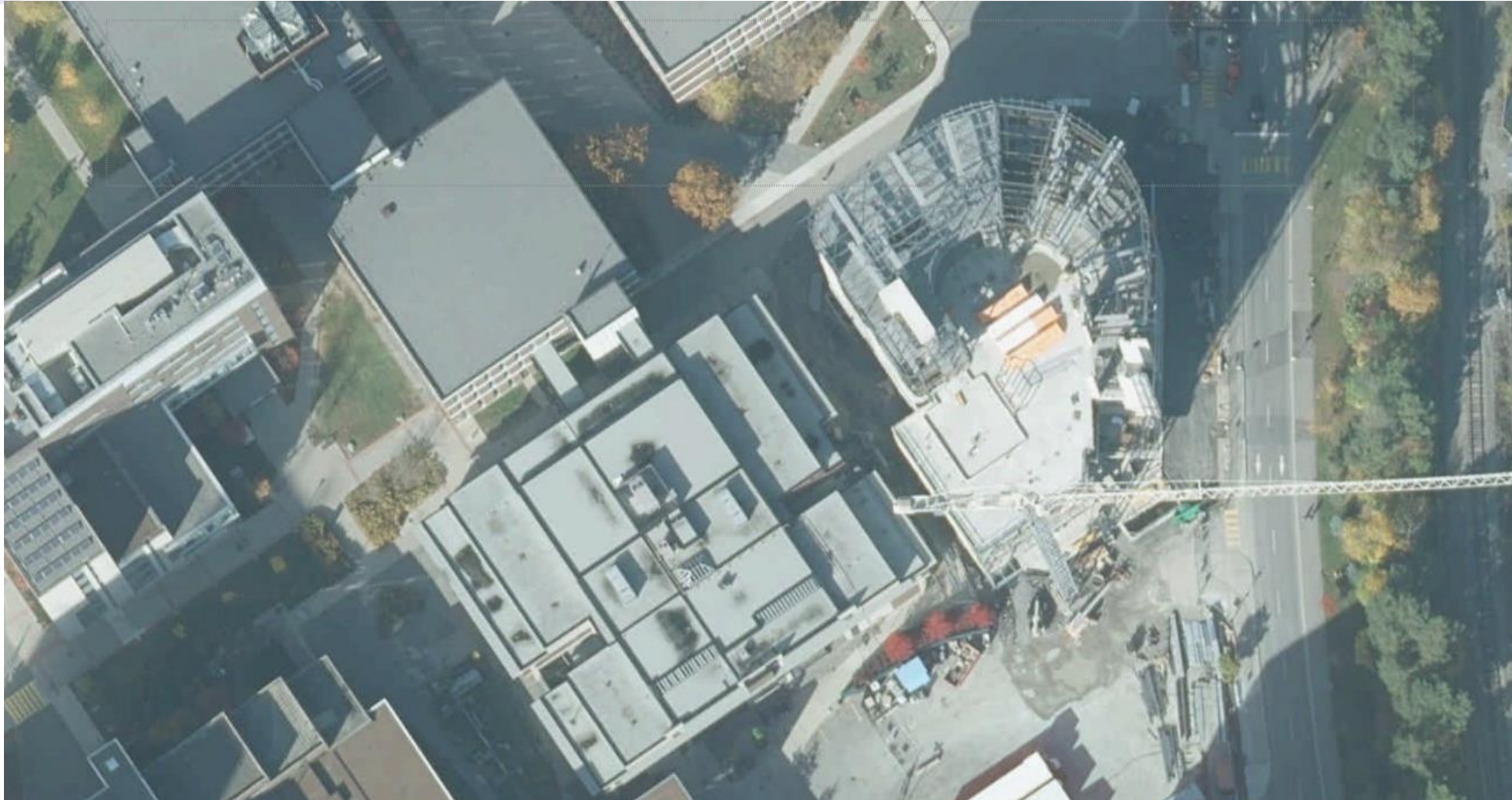
Source: <https://open.ottawa.ca/datasets/tree-inventory/explore?location=45.393315%2C-75.675664%2C8.00>

GIS Data: Raster layers

- **Raster** - Type of digital image represented by reducible and enlargeable grids or pixels.
 - Air photos, satellite images, Digital Elevation Models (DEMs)
 - Various file formats:
 - GeoTiff
 - JPEG
 - JPEG2000
 - MrSID



Raster layer: Air photo



Source: 2019 DRAPE imagery, Land Information Ontario; https://geo.scholarsportal.info/#r/details/_uri@=2799205642

GIS Data: Attributes

- Attributes are what describe a specific feature such as:
 - Lines representing roads could have the road name, speed limit, direction, address range, etc.
 - Points representing trees could include species and circumference attributes
 - Areas representing building footprints could include address, business names (if relevant), property owner, etc.

GIS Data: Attributes

The screenshot displays the Ottawa GIS web application interface. On the left, a 'Filters' panel is active, showing a list of attribute filters for 'Road Centrelines'. The 'Filter as map moves' toggle is turned on. Below the filters, a table displays the attributes for a selected road segment.

Filters
Road Centrelines

Filter as map moves

Select attribute filters (42)

- TMP/OP Classification (1 to 10) 129
- Sub Classification (15 values) 11
- Road Ownership (5 values) 11
- Flow Direction of One Way Streets (2 values) 11
- Data Collection Method (2 values) 11
- Grade Separated (4 values) 11
- Road Land Use Code (4 values) 11
- Owner 1 ID (12 values) 11
- Owner 2 ID (12 values) 11

Filtering 1,302 of 28,543 records

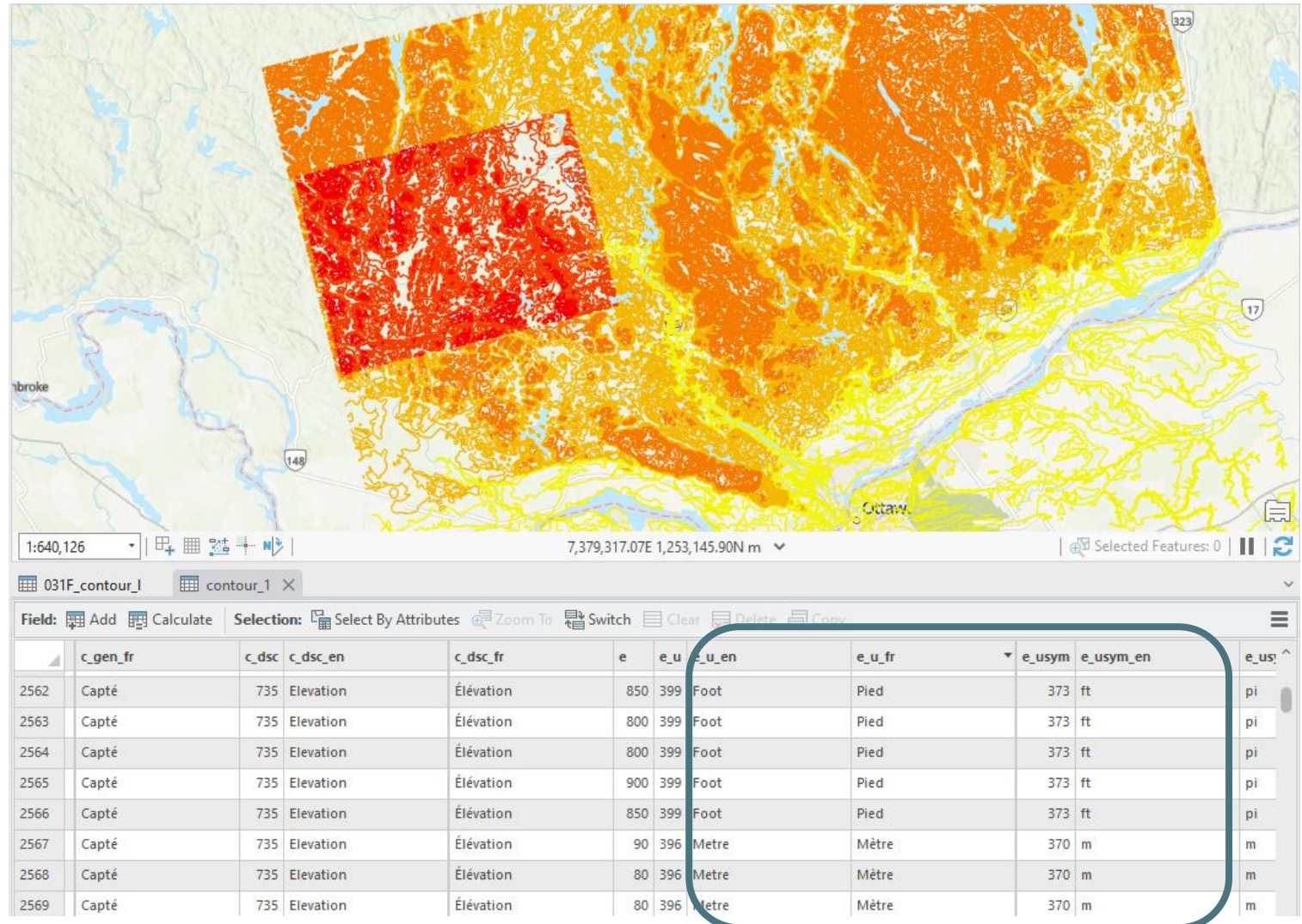
Full Road Name: SPARKS ST

Road Centrelines / Lignes médianes de route	
OBJECTID	8023
SUBTYPE	5
SUBCLASS	LOCAL
OWNERSHIP	PUBLIC
FLOW	null
COLLECTION_METHOD	null
GRADE_SEPARATED	NO
ROAD_LAND_USE_CODE	null
OWNER_1_CODE	null
OWNER_2_CODE	null
OWNER_2_SIDE	null

Source: screenshot of Road Centrelines from <https://open.ottawa.ca/datasets/road-centrelines/explore?location=45.416302%2C-75.697275%2C6.00>

GIS Data: Attributes

- Natural Resources Canada contours in Quebec where one section is measured in feet and rest is measured in metres



GIS Data: data structure

- **Structured data** is comprised of clearly defined data types whose pattern makes them easily searchable
- **Unstructured data** – “everything else” – is comprised of data that is usually not as easily searchable, including formats like audio, video, and social media postings.
- To make things even more clear, there is also occasionally **semi-structured data**

Structured vs. semi-structured data

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
OBJECTID	OBJECT_ID	DESCR	RANK	SP_EVID	CSP_EVID	LOC_CLS	BUS_EFF_DT	ACCURACY	SYS_AREA	SYS_LEN	EFF_DATE	Shape_Le	ORIG_FID	POINT_X	POINT_Y
1	69941860	Black Bear Den Si	Very High	Y	Yes	Upland I	2009-11-30	Within 20 metres	163.985	52.298	2010-01-27	0.000563	0	-78.1307	45.32994
2	1050126561	Black Bear Den Si	High	Y	Yes	Upland I	1998-04-14	RE Reliable (to 100m)	1252	0	2003-12-04	0.001384	1	-78.1229	45.82831
3	1050126562	Black Bear Den Si	High	Y	Yes	Shoreline	1998-04-14	RE Reliable (to 100m)	1252	0	2003-12-04	0.001383	2	-78.0956	45.81529
4	1050126563	Black Bear Den Si	High	Y	Yes	Upland I	1998-04-14	RE Reliable (to 100m)	1252	0	2003-12-04	0.001383	3	-78.1094	45.81319
5	1050126564	Black Bear Den Si	High	Y	Yes	Upland I	1998-04-14	RE Reliable (to 100m)	1252	0	2003-12-04	0.001382	4	-78.1583	45.74214
6	1050126565	Black Bear Den Si	High	Y	Yes	Upland I	1998-04-14	RE Reliable (to 100m)	1252	0	2003-12-04	0.001382	5	-78.2066	45.73629
7	1050126566	Black Bear Den Si	High	Y	Yes	Upland I	1998-04-14	RE Reliable (to 100m)	1252	0	2003-12-04	0.001382	6	-78.0465	45.72376
8	1050126567	Black Bear Den Si	High	Y	Yes	Shoreline	1998-04-14	RE Reliable (to 100m)	1252	0	2003-12-04	0.001382	7	-78.0479	45.72364
9	1050126568	Black Bear Den Si	High	Y	Yes	Upland I	1998-04-14	RE Reliable (to 100m)	1252	0	2003-12-04	0.001382	8	-78.0469	45.72313
10	1050126569	Black Bear Den Si	High	Y	Yes	Upland I	1998-04-14	RE Reliable (to 100m)	1252	0	2003-12-04	0.001382	9	-78.3004	45.72603
11	1050126570	Black Bear Den Si	High	Y	Yes	Upland I	1998-04-14	RE Reliable (to 100m)	1252	0	2003-12-04	0.001382	10	-78.0944	45.69782
12	1050126571	Black Bear Den Si	High	Y	Yes	Shoreline	1998-04-14	RE Reliable (to 100m)	1252	0	2003-12-04	0.001381	11	-78.3386	45.65983
13	1050126572	Black Bear Den Si	High	Y	Yes	Upland I	1998-04-14	RE Reliable (to 100m)	1252	0	2003-12-04	0.00138	12	-78.3255	45.58012
14	1050847495	Black Bear Den Si		Y	Yes		2001-01-18	Within 20 metres	555.781	0	2004-02-27	0.001194	13	-78.8975	45.71812
15	1050847496	Black Bear Den Si		Y	Yes		2001-01-18	Within 20 metres	1256.5	0	2004-02-27	0.001385	14	-78.9016	45.70781

		Ottawa, City [Census subdivision], Ontario				Ontario [Province]			
Topic	Characteristics	Note	Total	Flag_Total Male	Flag_Male Female	Flag_Fem.Total	Flag_Total Male	Flag_Male Female	Flag_Female
Counts (unless otherwise specified)									
Population and dwellings	Population; 2016	1	934243		...	...	13448494	...	...
Population and dwellings	Population; 2011	1	883391		...	...	12851821	...	...
Population and dwellings	Population percentage change; 2011 t		5.8		...	...	4.6	...	...
Population and dwellings	Total private dwellings	2	395985		...	...	5598391	...	...
Population and dwellings	Private dwellings occupied	3	373756		...	...	5169174	...	...
Population and dwellings	Population density per square kilome		334.8		...	...	14.8	...	...
Population and dwellings	Land area in square kilometres		2790.3		...	...	908699.3	...	...
Age characteristics	Total - Age groups and aver	4	934245	453875	480365	13448495	6559390	6889105	
Age characteristics	0 to 14 years		155680	79185	76490	2207970	1131615	1076350	
Age characteristics	0 to 4 years		48870	24800	24070	697360	357300	340055	
Age characteristics	5 to 9 years		53715	27365	26350	756085	387320	368765	
Age characteristics	10 to 14 years		53095	27020	26075	754530	387000	367530	

- GIS data needs to be structured to work correctly in GIS software.

GIS data may not start as structured or even semi-structured data

- **Any data with a geographic component can be mapped**
 - Address, town, country, latitude-longitude coordinates, etc.
 - That information can come from just about anywhere



Source: [Wikipedia](#)



San Diego Fireworks 2012, LOUD and up close

CHAPTER I

JONATHAN HARKER'S JOURNAL

(Kept in shorthand.)

3 May. *Bistritz*.—Left Munich at 8:35 P. M., on 1st May, arriving at Vienna early next morning; should have arrived at 6:46, but train was an hour late. Buda-Pesth seems a wonderful place, from the glimpse which I got of it from the train and the little I could walk through the streets. I feared to go very far from the station, as we had arrived late and would start as near the correct time as possible. The impression I had was that we were leaving the West and entering the East; the most western of splendid bridges over the Danube, which is here of noble width and depth, took us among the traditions of Turkish rule.

<https://www.gutenberg.org/cache/epub/345/pg345-images.html>

...but it will need to end up as structured data to work in GIS software

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
OBJECTID	OBJECT_ID	DESCR	RANK	SP_EVID	CSP_EVID	LOC_CLS	BUS_EFF_DT	ACCURACY	SYS_AREA	SYS_LEN	EFF_DATE	Shape_Len	ORIG_FID	POINT_X	POINT_Y
1	69941860	Black Bear Den S	Very High	Y	Yes	Upland I	2009-11-30	Within 20 metres	163.985	52.298	2010-01-27	0.000563	0	-78.1307	45.32994
2	1050126561	Black Bear Den S	High	Y	Yes	Upland I	1998-04-14	RE Reliable (to 100m)	1252	0	2003-12-04	0.001384	1	-78.1229	45.82831
3	1050126562	Black Bear Den S	High	Y	Yes	Shoreline	1998-04-14	RE Reliable (to 100m)	1252	0	2003-12-04	0.001383	2	-78.0956	45.81529
4	1050126563	Black Bear Den S	High	Y	Yes	Upland I	1998-04-14	RE Reliable (to 100m)	1252	0	2003-12-04	0.001383	3	-78.1094	45.81319
5	1050126564	Black Bear Den S	High	Y	Yes	Upland I	1998-04-14	RE Reliable (to 100m)	1252	0	2003-12-04	0.001382	4	-78.1583	45.74214
6	1050126565	Black Bear Den S	High	Y	Yes	Upland I	1998-04-14	RE Reliable (to 100m)	1252	0	2003-12-04	0.001382	5	-78.2066	45.73629
7	1050126566	Black Bear Den S	High	Y	Yes	Upland I	1998-04-14	RE Reliable (to 100m)	1252	0	2003-12-04	0.001382	6	-78.0465	45.72376
8	1050126567	Black Bear Den S	High	Y	Yes	Shoreline	1998-04-14	RE Reliable (to 100m)	1252	0	2003-12-04	0.001382	7	-78.0479	45.72364
9	1050126568	Black Bear Den S	High	Y	Yes	Upland I	1998-04-14	RE Reliable (to 100m)	1252	0	2003-12-04	0.001382	8	-78.0469	45.72313
10	1050126569	Black Bear Den S	High	Y	Yes	Upland I	1998-04-14	RE Reliable (to 100m)	1252	0	2003-12-04	0.001382	9	-78.3004	45.72603
11	1050126570	Black Bear Den S	High	Y	Yes	Upland I	1998-04-14	RE Reliable (to 100m)	1252	0	2003-12-04	0.001382	10	-78.0944	45.69782
12	1050126571	Black Bear Den S	High	Y	Yes	Shoreline	1998-04-14	RE Reliable (to 100m)	1252	0	2003-12-04	0.001381	11	-78.3386	45.65983
13	1050126572	Black Bear Den S	High	Y	Yes	Upland I	1998-04-14	RE Reliable (to 100m)	1252	0	2003-12-04	0.00138	12	-78.3255	45.58012
14	1050847495	Black Bear Den S		Y	Yes		2001-01-18	Within 20 metres	555.781	0	2004-02-27	0.001194	13	-78.8975	45.71812
15	1050847496	Black Bear Den S		Y	Yes		2001-01-18	Within 20 metres	1256.5	0	2004-02-27	0.001385	14	-78.9016	45.70781

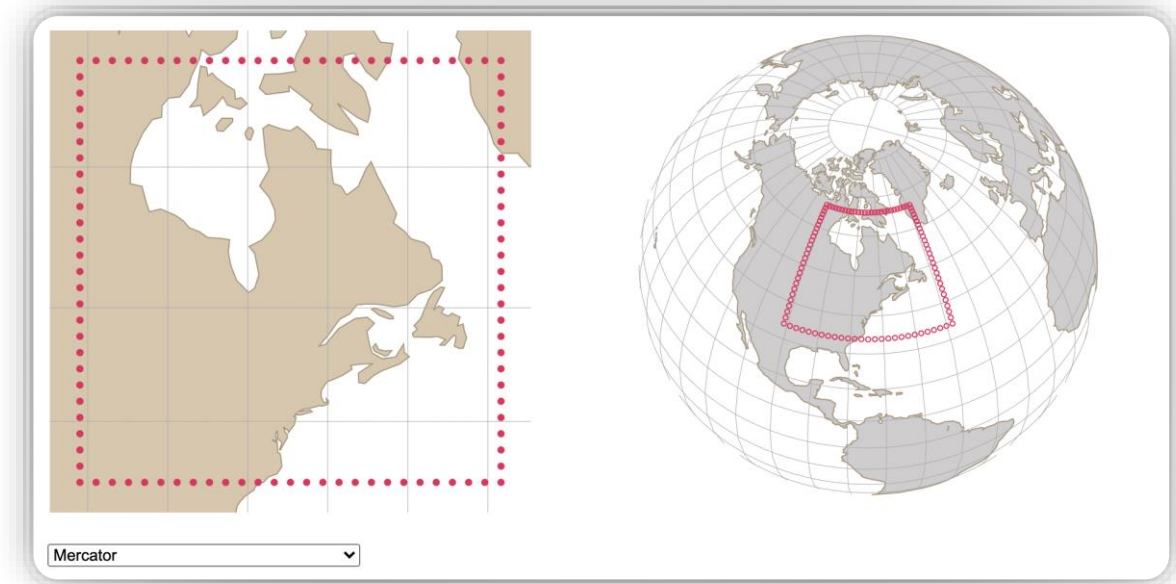
GIS Data: Coordinate systems and projections



Source: https://krygier.owu.edu/krygier.html/geog_222/geog_222_lo/geog_222_lo13_gr/orangepeel.jpg

GIS Data: Coordinate systems and projections

- There will always – *always* – be distortion in at least one of the following ways:
 - Area
 - Shape
 - Distance
 - Direction
- See the distortion:
<https://blocks.roadtolarissa.com/enjalot/bd552e711b8325c64729>

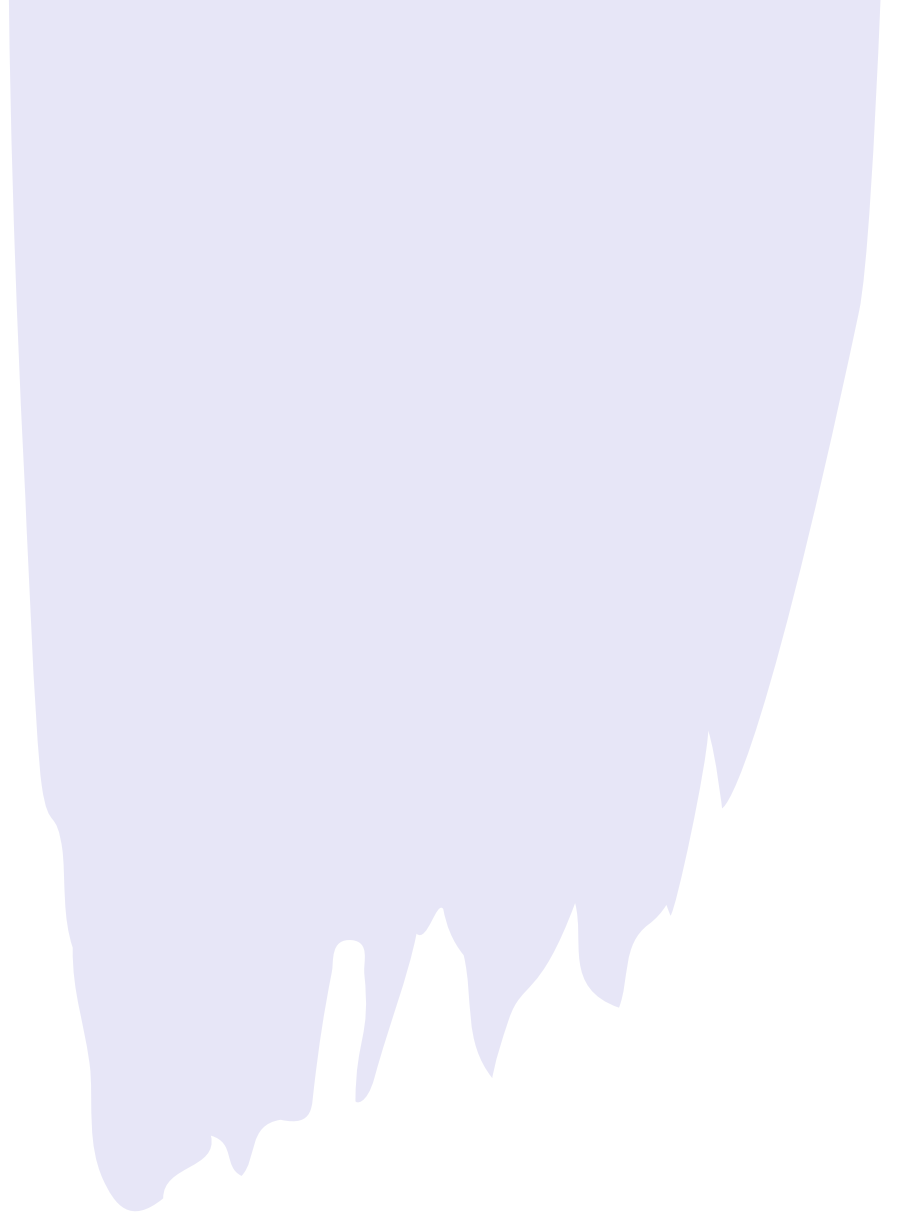


Source: <https://blocks.roadtolarissa.com/enjalot/bd552e711b8325c64729>

GIS data in summary

- GIS data can be vector (points, lines, polygons) or raster (pixelated surface).
- Attributes – and the attribute table – are where details about different features are.
- Data can be structured, semi-structured, or unstructured
 - GIS software needs structured data to work properly
- Coordinate systems & projections can impact measurements due to distortion

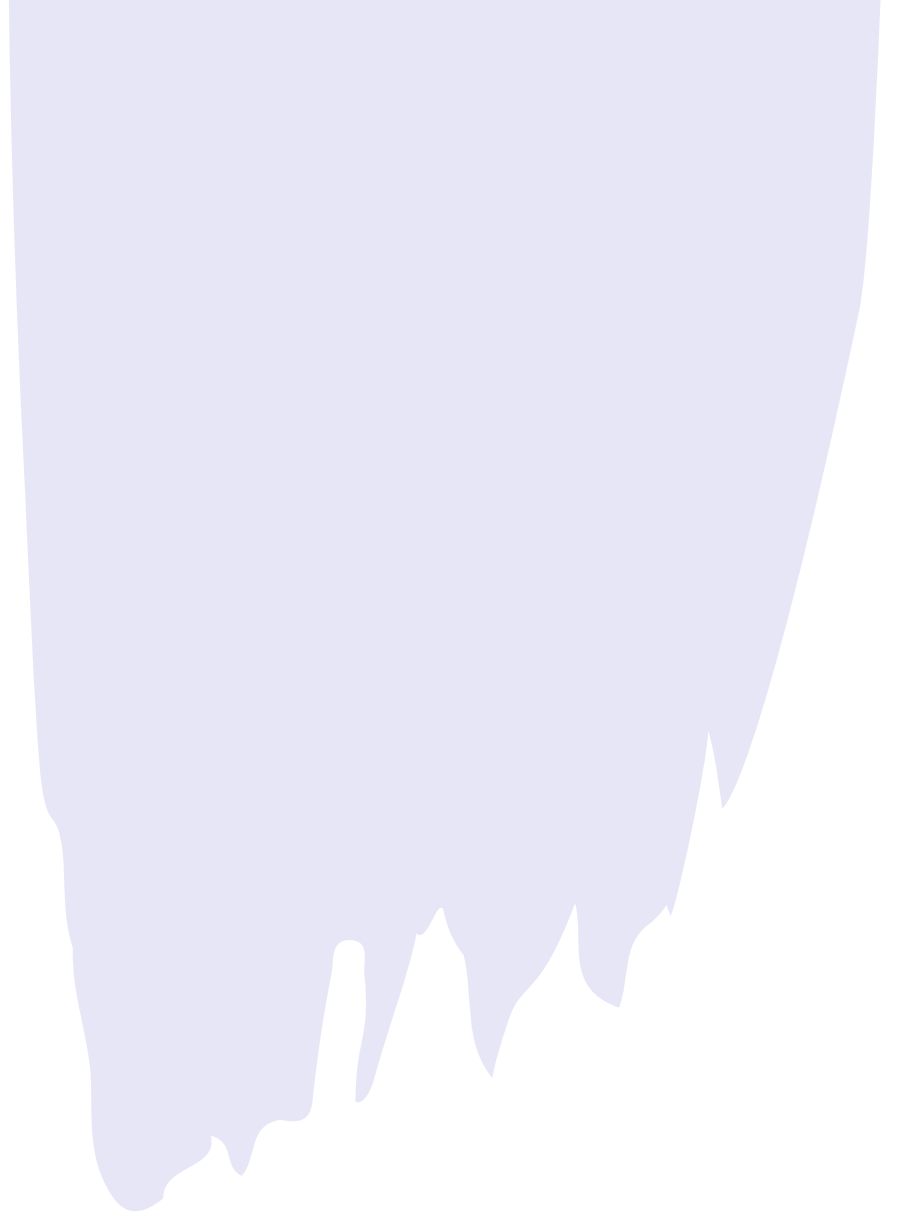
Finding GIS data



GIS Data: How do I find it? ([link](#))

1. Determine your **area(s) of interest**
2. Figure out **what kind of data** you want to find about that area
 - E.g.: road network, geology, air photos, provincial boundaries
3. Think about who (government, organization, etc.) cares enough to collect the data you want
 - Ask yourself “who cares?” and start there – Municipal, Federal, organization, etc.
4. Your search should include the following resources:
 - A **data portal** for the government(s) or organization(s) you've determined may collect the data
 - The [Carleton Library's GIS search](#)
 - **Google** (be specific and use terms like *GIS* or *shapefile* as keywords)
5. Still can't find anything? We'll help: GIS@carleton.ca
 - That said, sometimes the data just doesn't exist

Selecting GIS software



GIS software: which one should you choose?

<https://library.carleton.ca/guides/help/gis-software>

- There is no “one size fits all” answer
- Depends on several factors:
 - What is your final output going to be?
 - Interactive or static map? Print or digital?
 - What kind of analysis will you be doing?
 - Do you have a Windows or Mac computer?
 - Desktop ArcGIS products are Windows-only, but QGIS is Mac compatible
 - Will you need further GIS training?
 - ArcGIS products have a lot of online training/tutorials, as does QGIS

Project management tips

<https://library.carleton.ca/guides/help/gis-project-tips>

- **Keep all data files together** in one project folder
 - When saving your map project, make sure it is saved in the same folder as the data (makes it easy to zip everything up and share it if needed)
 - If you move your data from one folder location to another, the GIS software may not be able to find the path to the data and consequently will not display the data layers
- **Keep raw data saved and untouched** in a separate folder and save copies of it or any newly created files in a "working data" folder
- When saving data files or layers, **don't use spaces or characters in the file names**. Try using underscore for spaces or CamelCase

GIS services

<https://library.carleton.ca/find/gis>

- New 1st floor computer lab!
- [GIS workstations](#) – all computers in library & remote option
 - Currently 3-hour daily time limit per user
 - GIS software packages (ArcGIS, Global Mapper, Google Earth Pro, QGIS)
 - DWG TrueView
- [Free student editions of ArcGIS software](#) (Windows only, not Mac compatible)
 - We recommend ArcGIS Pro for new users, QGIS for Macs
 - [Which GIS software should I choose?](#)
- [GIS Help Guides](#) – includes sections for Architecture & Civil Engineering
 - [GIS Project Tips](#) may also be helpful
- Responsive via email: gis@carleton.ca

Future GIS Trajectories sessions

All Thursdays, 2-4pm, computer lab 103

- Feb 8, [Make an online map with Google My Maps](#)
- Feb 15, [Introduction to ArcGIS Online](#)
- More to come after Reading Week...
 - ArcGIS Pro – introduction + intermediate (2 different sessions)
 - Field Maps
 - Mapping census data in QGIS
 - Planet.com imagery

Questions?

DON'T HESITATE TO EMAIL US AT
GIS@CARLETON.CA