Spatial Modelling and Analysis

Lecture 1
Spatial Data and Attribute Data

Lecturer: Dr. Tingneyuc Sekac, Bsc, Mphil, P.hd

Lecture Outline:

1. Introduction to Spatial Analysis and Modeling
2. Introduction – Spatial Data and Attribute Data
3. Attribute Data
4. Introduction - Attribute Table Join and Relates
5. Spatial Data
6. Expected Outcome
7. References

1. Introduction – Spatial Analysis and Modeling

- Spatial analysis is the set of all possible mathematical/statistical analysis with spatial datasets to address environmental queries and challenges in the GIS domain.

- With Spatial Modeling, mathematical analysis are re-purposed.

- The course intends to provide knowledge and skills necessary to investigate the spatial patterns, which result from social and physical processes operating on or near the Earth's surface.

- The focus is on understanding the essential theoretical and practical concepts of spatial analysis, including;

- measures of geographical data distribution,
- spatial autocorrelation and interpolation,
- to find and apply the best analytical tool for solving GIS based problem and to correctly and appropriately interpret and present outputs.

1.1 The Functions in Spatial Analysis and Modeling

- The Spatial Analysis and Modelling incorporates the functions of;

- ✓ Data input,
- ✓ Editing and verification,
- ✓ Data storage and database management,
- ✓ Data analysis,
- ✓ modeling and cartographic manipulation,
- ✓ Data output and presentation, User interface / interaction.

- The common analysis expected in this course are not limited to;

- ✓ Viewing, geo-coding,
- ✓ Spatial interpolation,
- ✓ Overlay analysis,
- ✓ 3D modeling and mapping using raster and vector data sets.
- ✓ Surface analysis/Raster data analysis
- ✓ Vector data analysis

2. Introduction - Spatial Data and Attribute Data

The GIS database contains:

1. Map data

- depicting location of geographical objects

2. Attribute data

- describing physical characteristics of each object.

2.1. Example

Analyzing Forestry Problems;

Physical characteristics:

Such as timber species and tree diameter and

Non-physical characteristics:

Such as estimated market value and management codes

During a GIS analysis, site (map) data is linked with situation (attribute) data for each mapped timber stand.

https://stylesatlife.com/articles/cardboard-box-crafts/

https://www.etsy.com/listing/287969483/zz0065-mural-wallpaper-canvas-diy?gpla=1&gao=1&

2.2 Spatial and Non-spatial data

Geographic database is a place where geographic data are stored.

This database can be considered as a collection of spatially referenced data that acts as a model of reality.

There are two important components of this geographic database:

1. its geographic position (Spatial)
2. its attributes or properties (Non-Spatial).

In other words, spatial data (where is it?) and attribute data (what is it?)

2.3 Data Analysis Platform

Using Various GIS Software, the attribute data are populated from each spatial data.

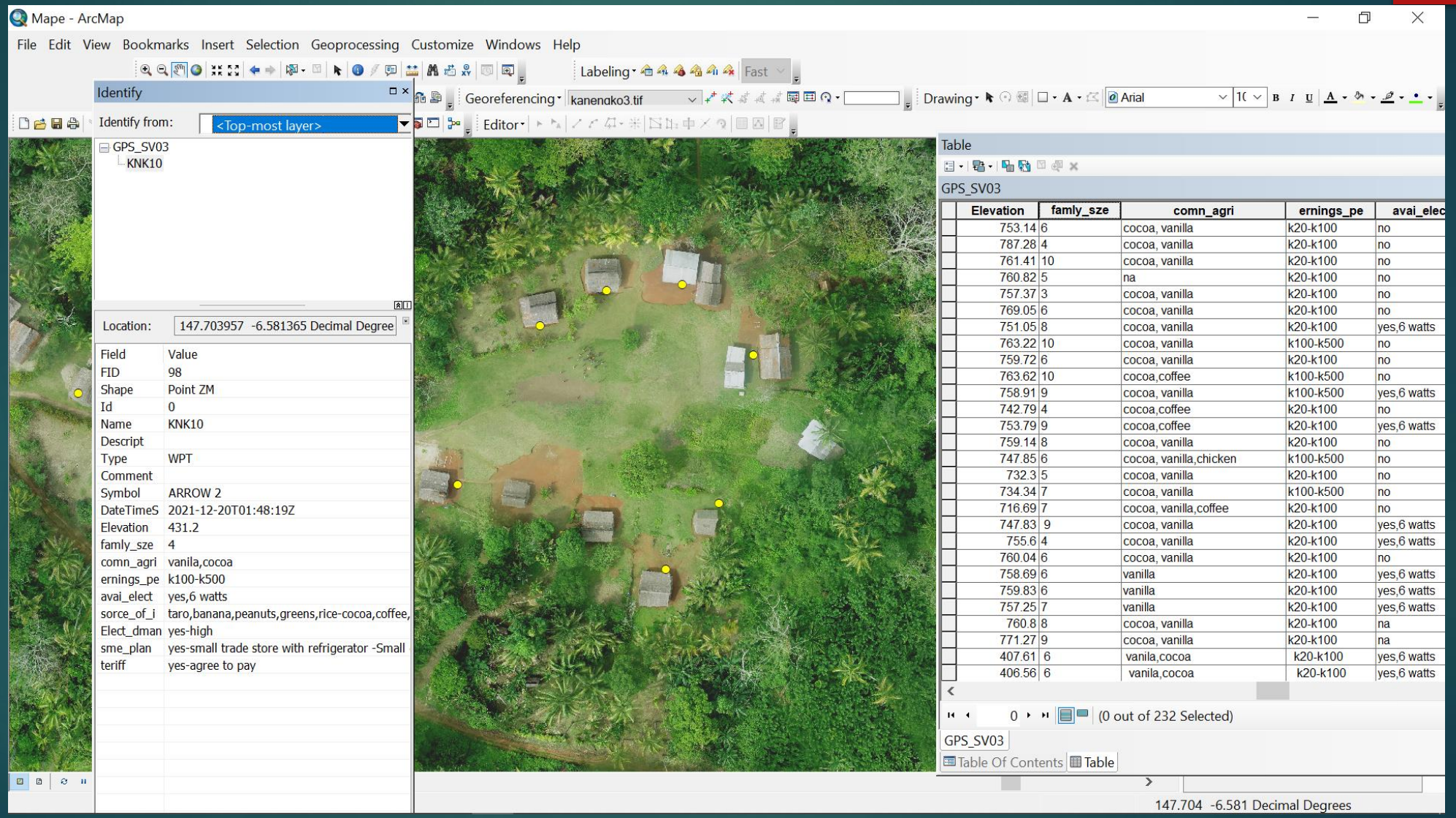
The Software use for Spatial analysis and Modeling;

- ArcGIS
- QGIS
- MapInfor
- Global Mapper
- R-Studio (GIS platform with the addition of external packages)
- Other

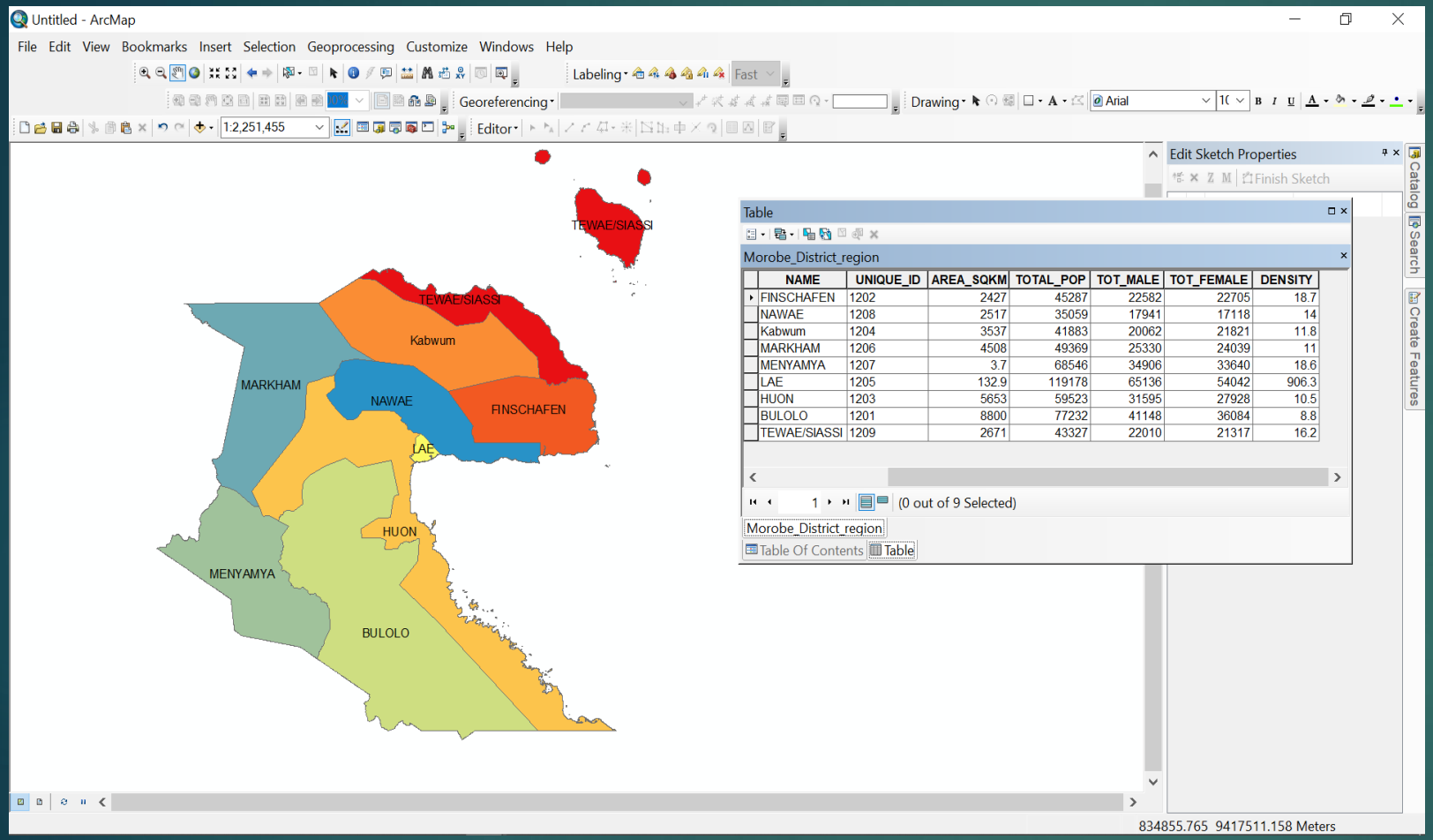
Specific information are extracted from spatial data to create attribute tables following the rule of attribute data types.

https://geography.wisc.edu/gis/1001-2/

2.4. ArcGIS platform to analysis and visual spatial and attribute data



3. Attribute Data

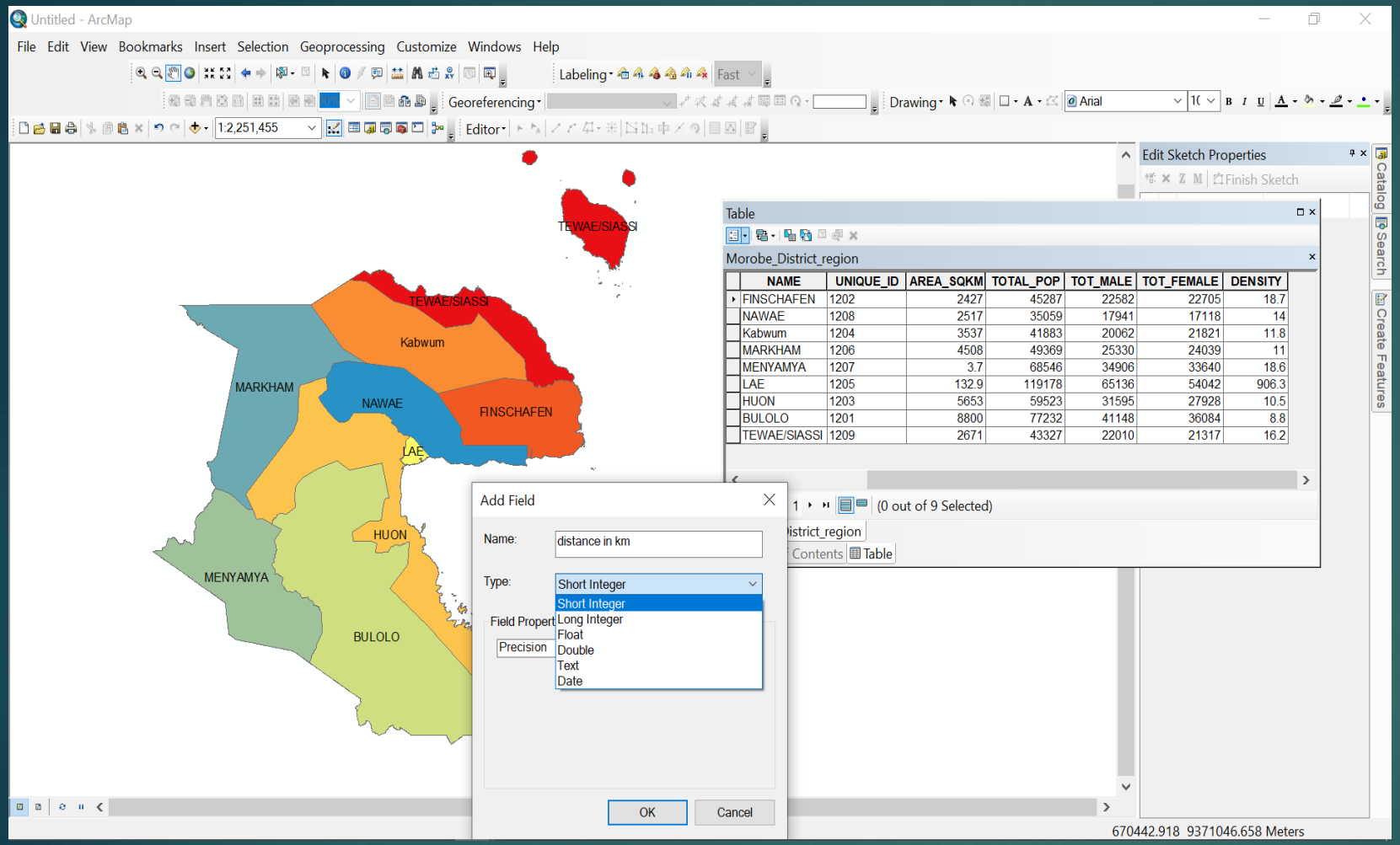


NAME	UNIQUE_ID	AREA_SQKM	TOTAL_POP	TOT_MALE	TOT_FEMALE	DENSITY
FINSCHAFEN	1202	2427	45287	22582	22705	18.7
NAWAE	1208	2517	35059	17941	17118	14
Kabwum	1204	3537	41883	20062	21821	11.8
MARKHAM	1206	4508	49369	25330	24039	11
MENYAMYA	1207	3.7	68546	34906	33640	18.6
LAE	1205	132.9	119178	65136	54042	906.3
HUON	1203	5653	59523	31595	27928	10.5
BULOLO	1201	8800	77232	41148	36084	8.8
TEWAE/SIASSI	1209	2671	43327	22010	21317	16.2

The attributes refer to the properties of spatial entities. They are often referred to as non-spatial data since they do not in themselves represent location information.

Attribute data is information appended in tabular format to spatial features. Attribute data can contain information about the ‘what’, ‘where’, and ‘why’.

3.1 Attribute Data Type



Attribute data can be store as one of five different field types in a table or database.

1. Character (text)
2. Integer (numeric)
3. Floating (numeric)
4. Date
5. Binary Large Object (BLOB)

3.2. Attribute Data Types- Specification

3.2.1 Character Data (Text)

- ✓ The character property (or string) is for text based values such as the name of a street or descriptive values

such as the condition of a street.

- ✓ Character attribute data is stored as a series of alphanumeric symbols.

3.2.2. Numeric Data

Integer and floating are numerical values.

- ✓ Within the integer type, there is a further division between short and long integer values.

- ✓ As would be expected, short integers store numeric values without fractional values for a shorter range

than long integers.

- ✓ Floating point attribute values store numeric values with fractional values. Therefore,

floating point values are for numeric values with decimal points.

Source: Dempsey, 2013

3.2.3. Date/Time Data

Date fields contains date and time values.

3.2. 4. BLOB Data

BLOB stands for binary large object and this attribute type is used for storing information such images, multimedia, or bits of code in a field. This field stores object linking and embedding (OLE) which are objects created in other applications such as images and multimedia and linked from the BLOB field

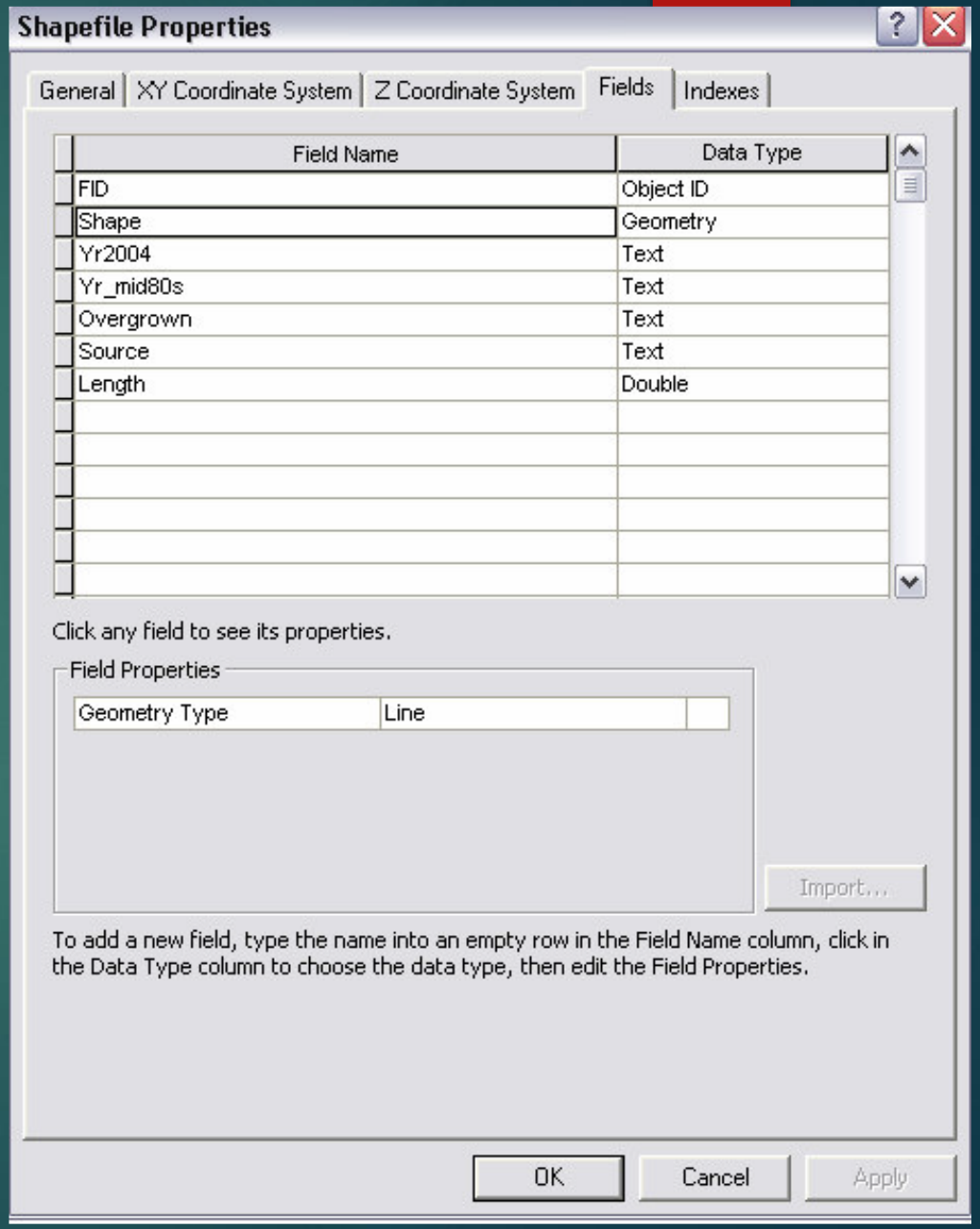
Source: Dempsey, 2013

3.3. Attribute Field properties

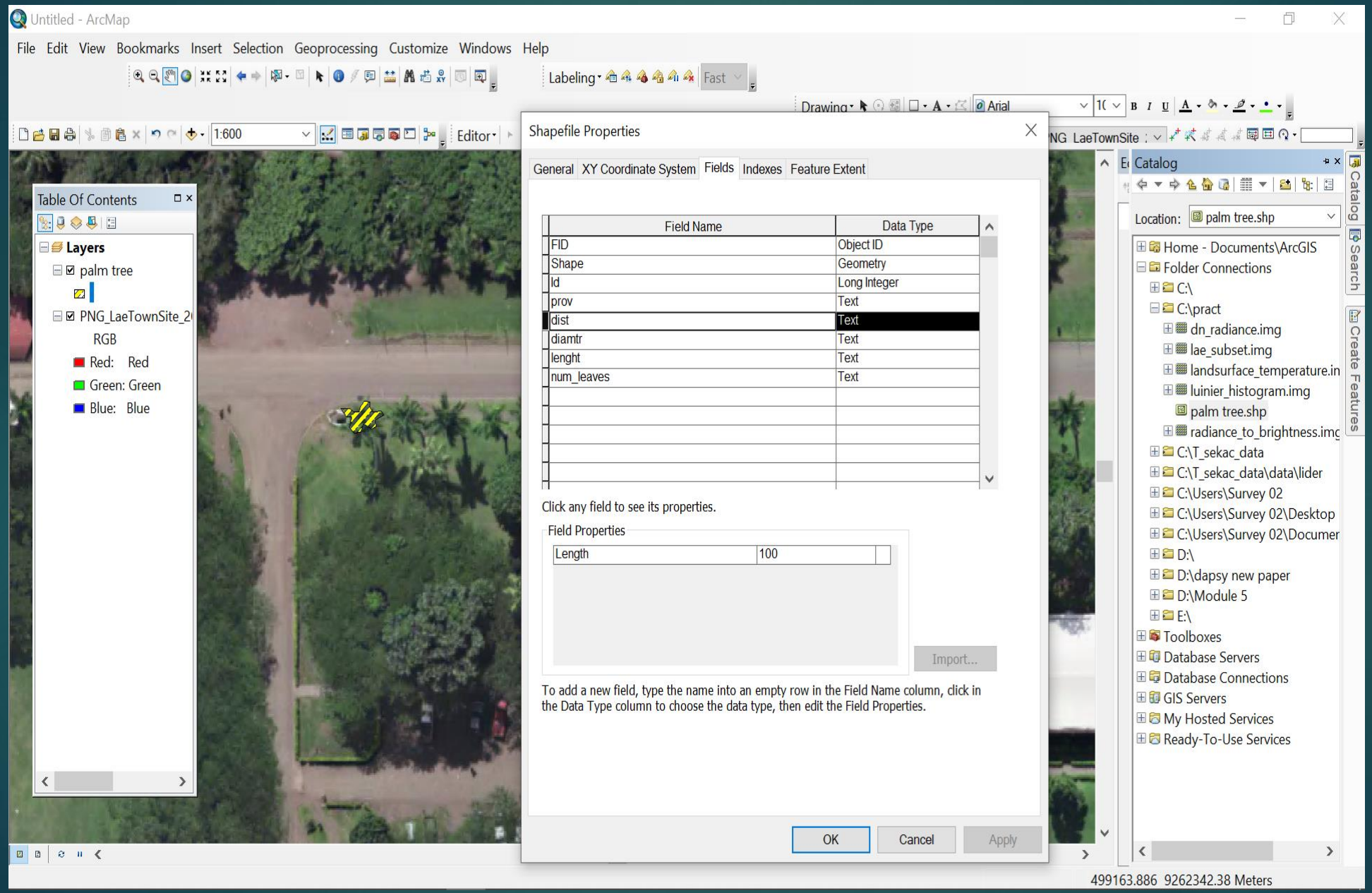
When creating a new table or feature class number of fields are specified to be included in an attribute table through a properties dialog box.

Figure here provides an example based on the ArcMap user interface of what this type of dialog box looks like.

You can also specify settings for fields, such as the field type and the maximum size of the data that can be stored in the field.



3.3.1 ArcGIS Display of Field properties



4. Introduction - Attribute Table Join and Relates

- ✓ Most database design guidelines promote organizing your database into multiple tables—each focused on a specific topic—instead of one large table containing all the necessary fields.

- ✓ Having multiple tables prevents duplicating information in the database because you store the information only once in one table.

- ✓ When you need information that isn't in the current table, you can link the two tables together.

  For example, you might obtain data;

- from other departments in your organization,
- purchase commercially available data,
- download data from the Internet.

- ✓ If this information is stored in a table, such as a dBASE, INFO, or geodatabase table, you can associate it with your geographic features and display the data on your map.

Source: ESRI, 2008

4.1 Join and Relates

ArcMap provides two methods to associate data stored in tables with geographic features:

1. **Joins**
2. **relates**.

Joins are used for 1-to-1 relationships, or many-to-1 relationships between the attribute table and an external table.

Relates are used for 1-to-many relationships, or many-to-many relationships between the attribute table and an external table.

When you join two tables, you append the attributes from one onto the other based on a field common to both.

Relating tables defines a relationship between two tables—also based on a common field—but doesn't append the attributes of one to the other; instead, you can access the related data when necessary.

Source: ESRI, 2008

4.2 Example: Join and Relates

Source: GISGeography 2022

4.3. One to One

There are four types of relationships possible between records within tables in a relational database:

one-to-one – One record in the first table is related to one (and only one) in the second table. For example, the attribute data for a series of water quality sampling stations could be stored in a related table. There would be the same number of stations as records in the attribute table with a relationship established through a station identifier attribute common to both tables.

US_Cities.shp

NAME
San Francisco
Houston
Miami
Chicago
New York

1-1 Relationship

NFL_Team.xlsx

CITY	NFL_Team
San Francisco	49ers
Houston	Texans
Miami	Dolphins
Chicago	Bears
New York	Jets

US_Cities.shp

NAME
San Francisco
Houston
Miami
Chicago
New York

Join Table

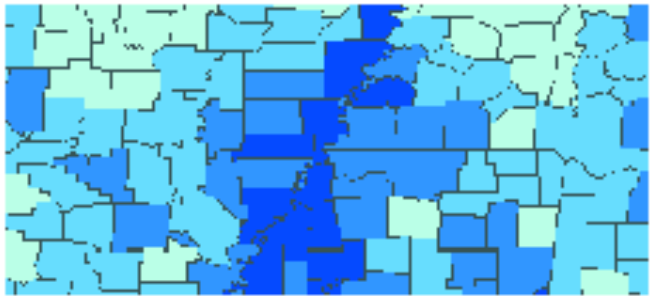
NAME	NFL_Team
San Francisco	49ers
Houston	Texans
Miami	Dolphins
Chicago	Bears
New York	Jets

NFL_Team.xlsx

CITY	NFL_Team
San Francisco	49ers
Houston	Texans
Miami	Dolphins
Chicago	Bears
New York	Jets

Shape	FID	County
Polygon	1	Atoka
Polygon	2	Kiowa
Polygon	3	Nowata

County	Rain	Total
Atoka	1.80	10.16
Kiowa	2.34	13.67
Nowata	1.62	11.90

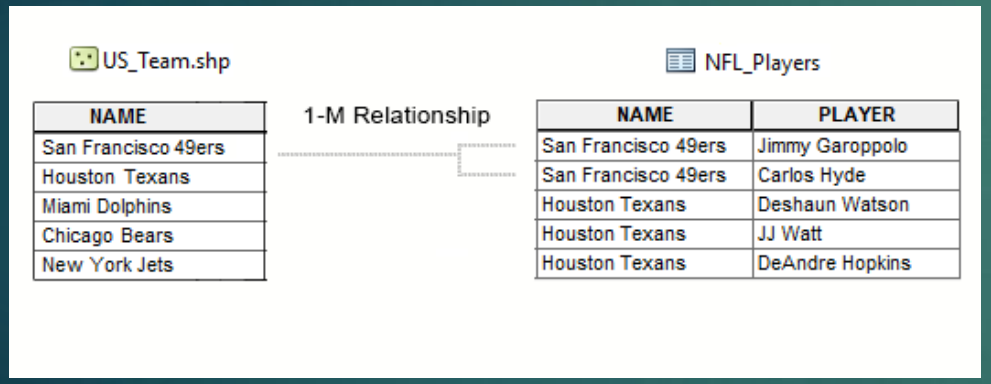


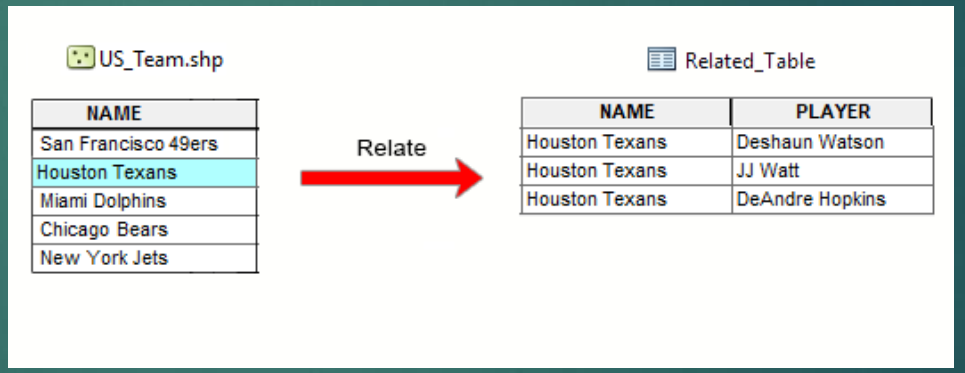
Source: Blyth and Cake, Module 1 (2007) and GIS Geography, 2022

4.4. One to Many

one-to-many – One record in a table is related to many records in another table. When one record has multiple matching IDs in another table, this is a one-to-many relationship (1-M). And it's best to use "relate" for 1-M relationships.

For example, let's say we have a list of football teams and players. There are multiple players per team and each team is unique. So this means that it's 1-M.





A **table relate** creates an entirely new table. So when you select the record(s) in one table, it will create a temporary table based on all the matching unique IDs.

For example, if we select the Houston Texans, only those players on that team will show up in a new table.

FID	Shape	ER_NAME
1	Point	St. Vincent
2	Point	Seattle Grace
3	Point	County General
4	Point	Princeton–Plainsboro
5	Point	All Saints

FID	INJURY	HOSPITAL
1	Femur Break	St Vincent
2	TBI	St Vincent
3	Autoimmune	Princeton-Plainsboro
4	Overdose	All Saints
5	Laceration	All Saints

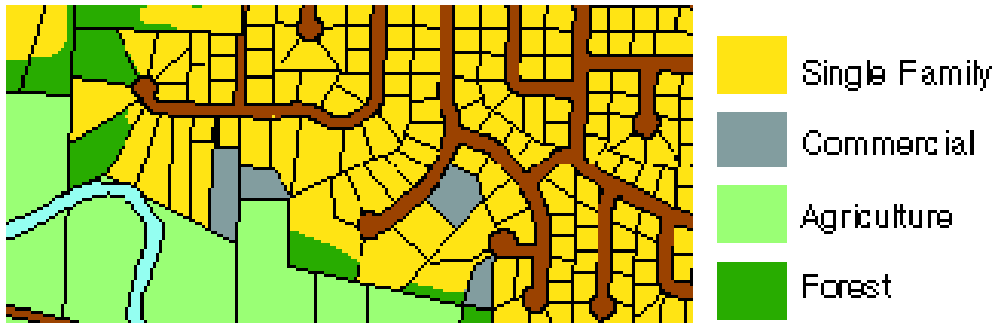
Source: GISGeography, 2022

4.5. Many to One

many-to-one – Many records in a table may be related to one record in another table. For example, a land use dataset might have hundreds of land use polygons with twenty possible land use classes stored in a separate look-up table.

Shape	FID	LU_Code
Polygon	1	2
Polygon	2	1
Polygon	3	1

LU-Code	Description
1	Single Family
2	Agriculture
3	Commercial



FID	Shape	COVER_CODE
1	Polygon	1
2	Polygon	2
3	Polygon	1
4	Polygon	2
5	Polygon	1

FID	COVER_CODE	COVER_TYPE
1	1	Grass
2	2	Forest
3	3	Water

Source: Blyth and Cake, Module 1 (2007) and ESRI,2008

4.6. Many to Many

many-to-many – Many records in a table may be related to many records in another table. For example, many vegetable types might be grown on a single farm and these types of vegetables may be grown on more than one farm (spatial base).

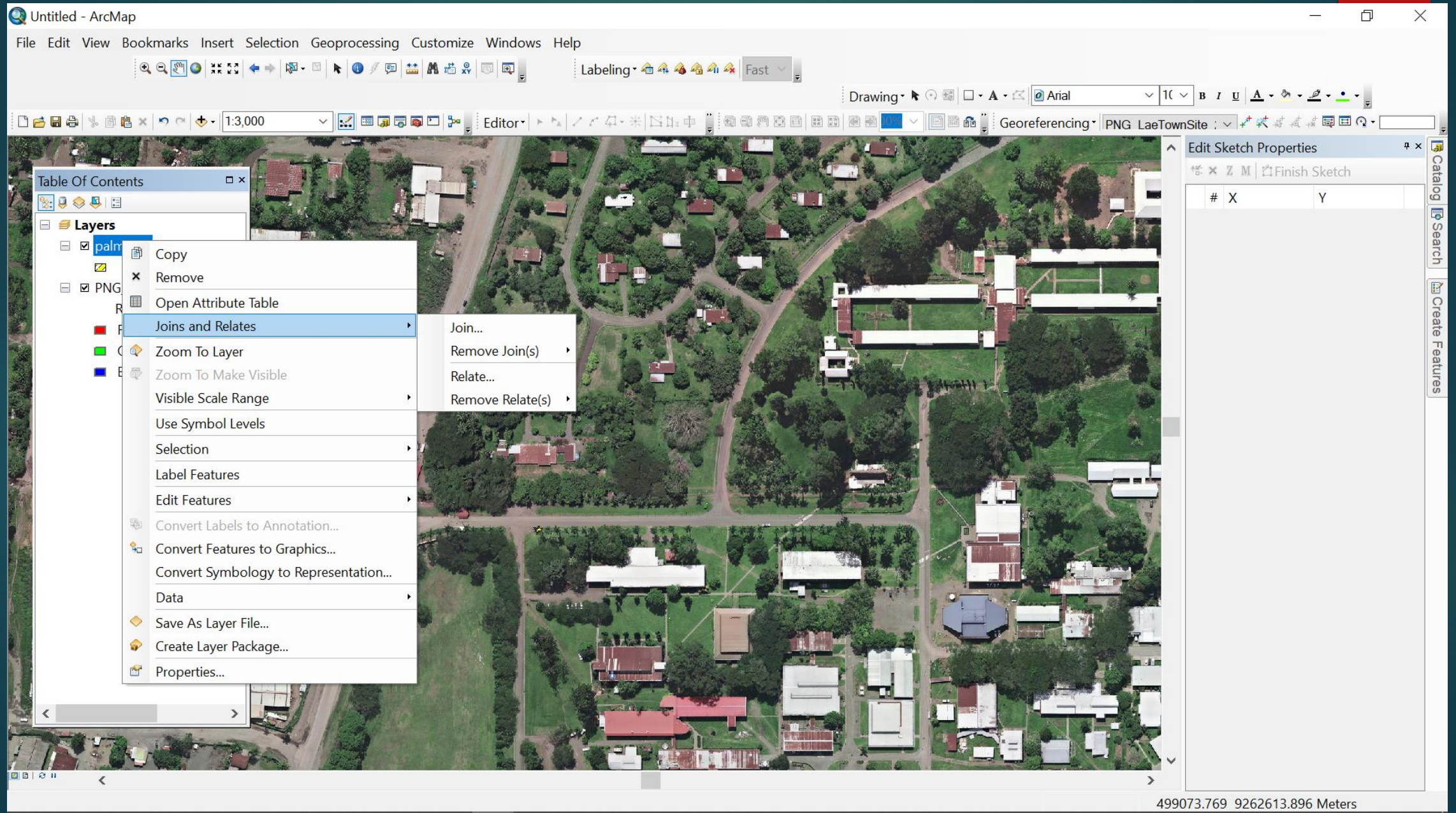
Non-Spatial

FID	STDNT_NUM
1	s12345
2	s09876
3	s45678
4	s69538
5	s58726
6	s31974

FID	CLASS_CODE	STDNT_NUM
1	GIS 101	s12345
2	GIS 101	s09876
3	GIS 210	s45678
4	GIS 210	s58726
5	GIS 210	s31974
6	GIS 212	s31974
7	GIS 212	s12345

Blyth and Cake, Module 1 (2007)

4.7. ArcGIS Demo on Join and Relates



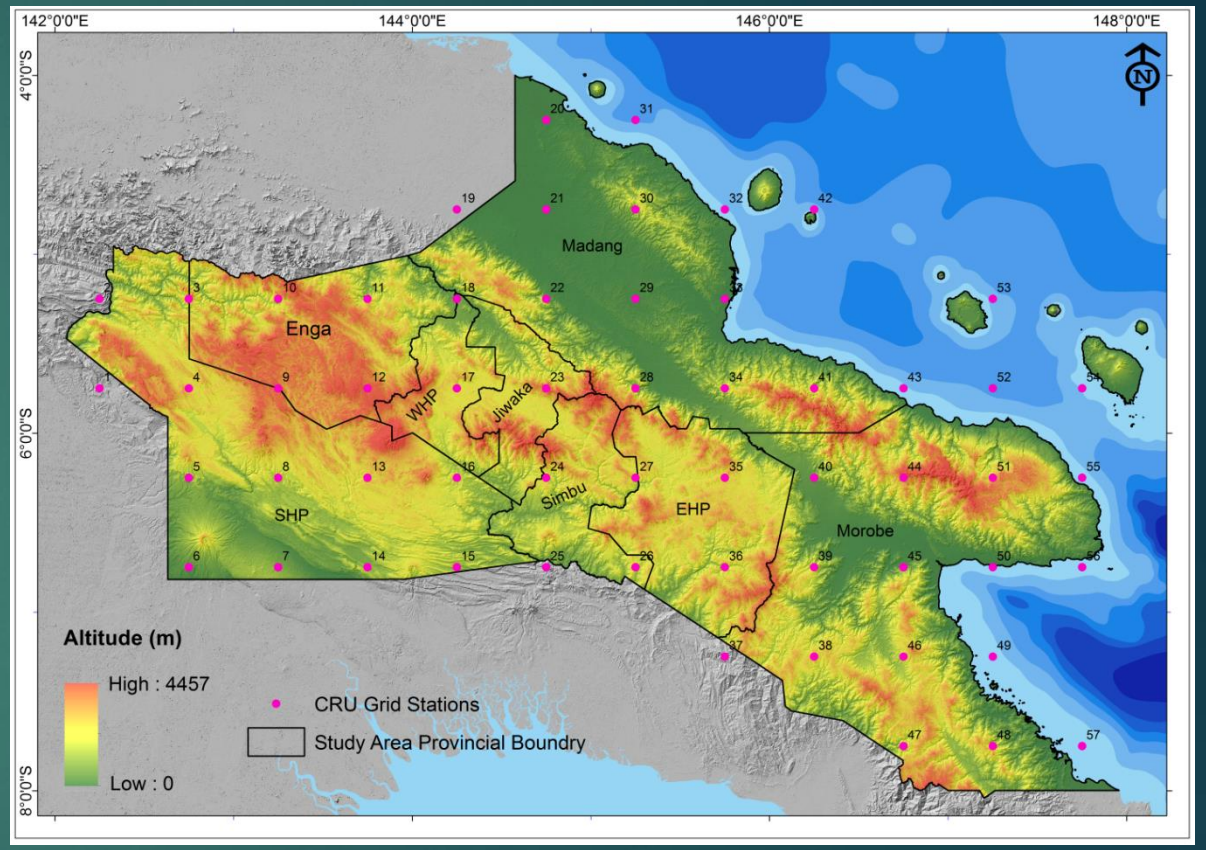
5. Spatial Data

5.1. Spatial Data and Coordinate System

Each geographical features are address to be spatial data since location information (X, y coordinates) are attached to it.

To specify the position in an absolute way a coordinate system is used.

For small areas, the simplest coordinate system is the regular square grid. For larger areas, certain approved cartographic projections are commonly used.



Source: T. Sekac, 2020

5.2. Coordinate System

Internationally there are many different coordinate systems in use.

However, the two most commonly used global coordinate system are;

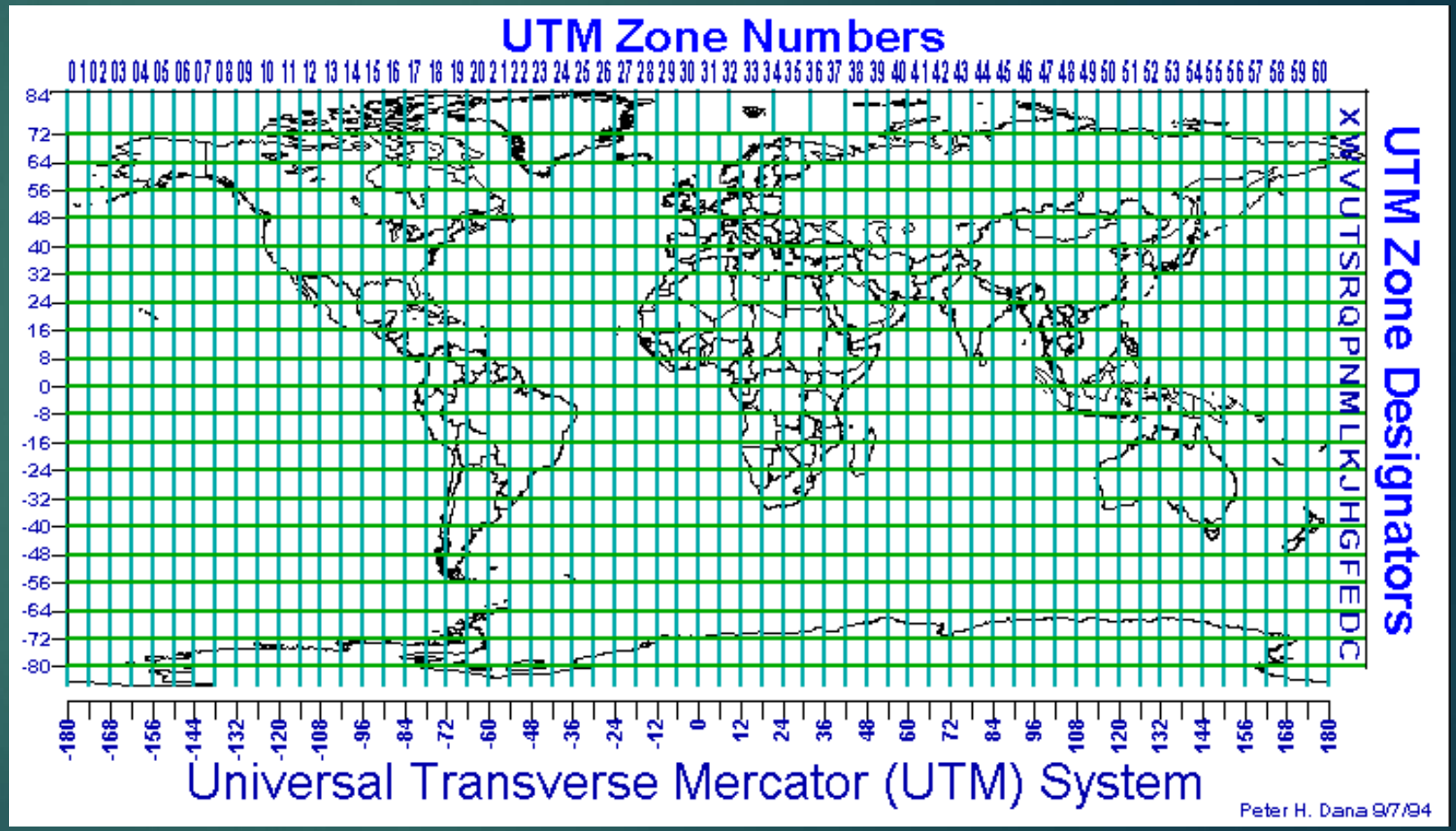
1. UTM Coordinate System

2. Geographic (Latitude/Longitude) coordinate system

These are the coordinate system that defines geographic phenomena to its correct location.

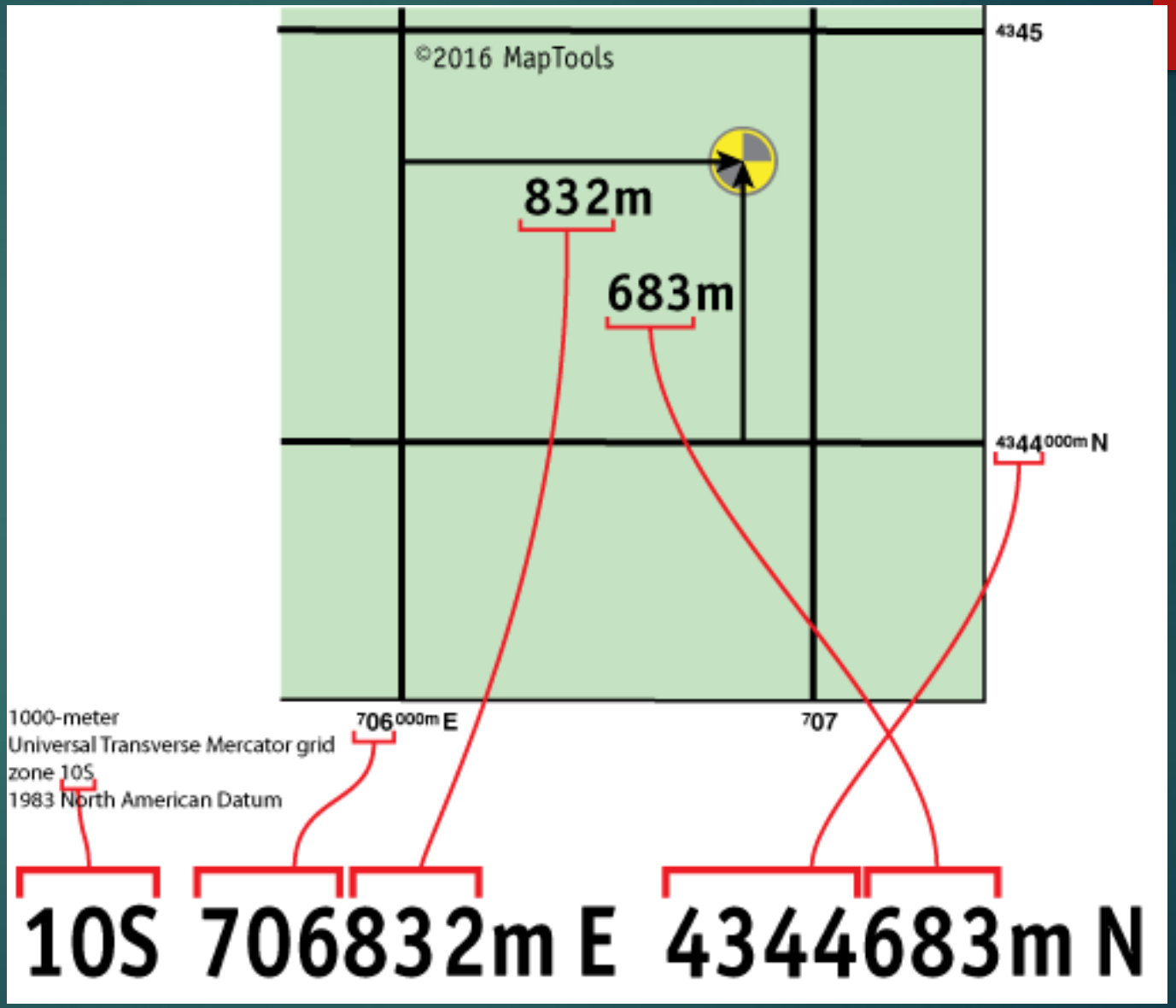
5.3. Universal Transverse Mercator (UTM) Coordinate System

- UTM projection is used to define horizontal, positions world-wide by dividing the surface of the Earth into 60 zones, each mapped by the Transverse Mercator projection with a central meridian in the center of the zone.
- UTM zone numbers designate 6 degree longitudinal strips extending from 80 degrees South latitude to 84 degrees North latitude.
- UTM zone characters designate 8 degree zones extending north and south from the equator



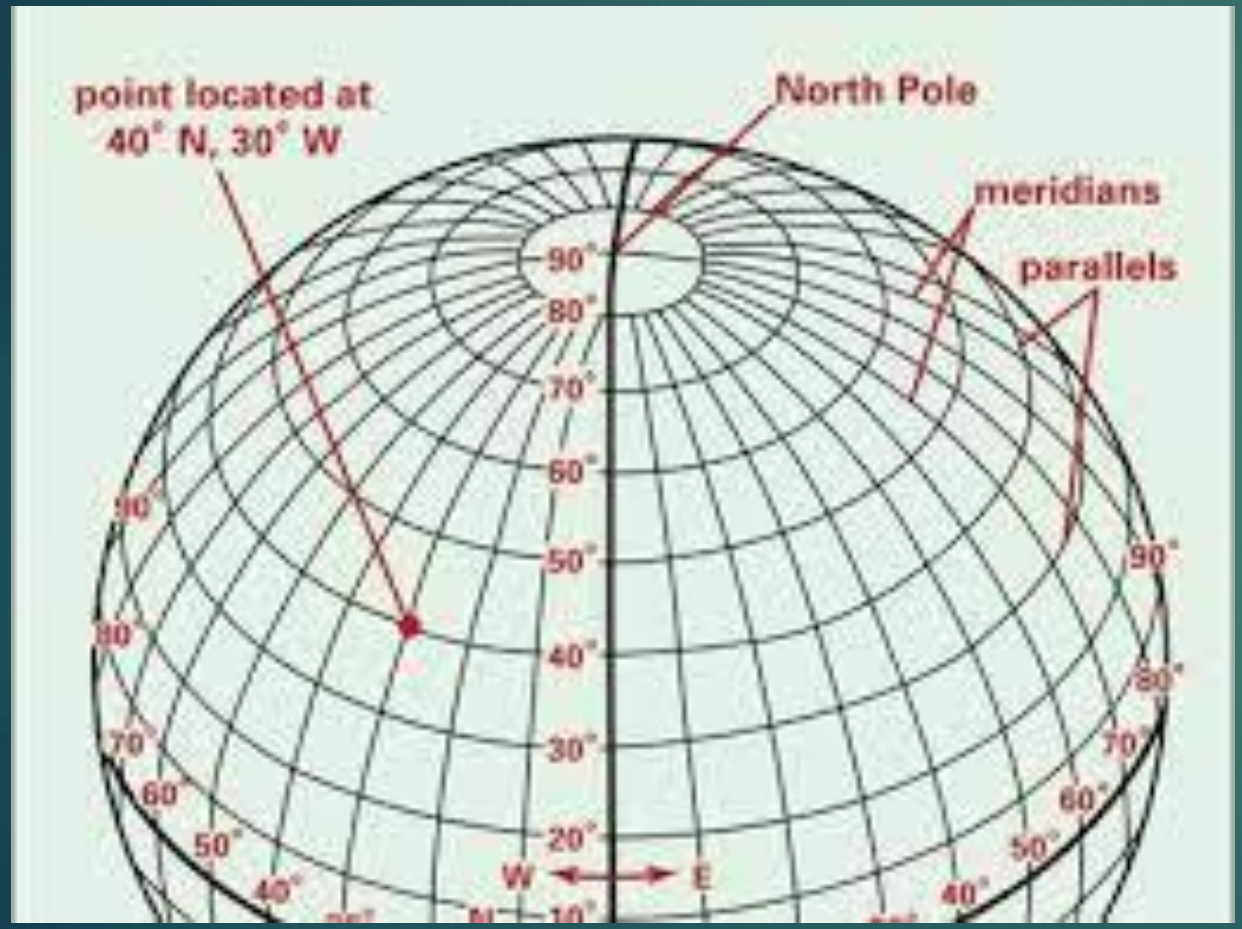
Phillipps. G.P, 2002

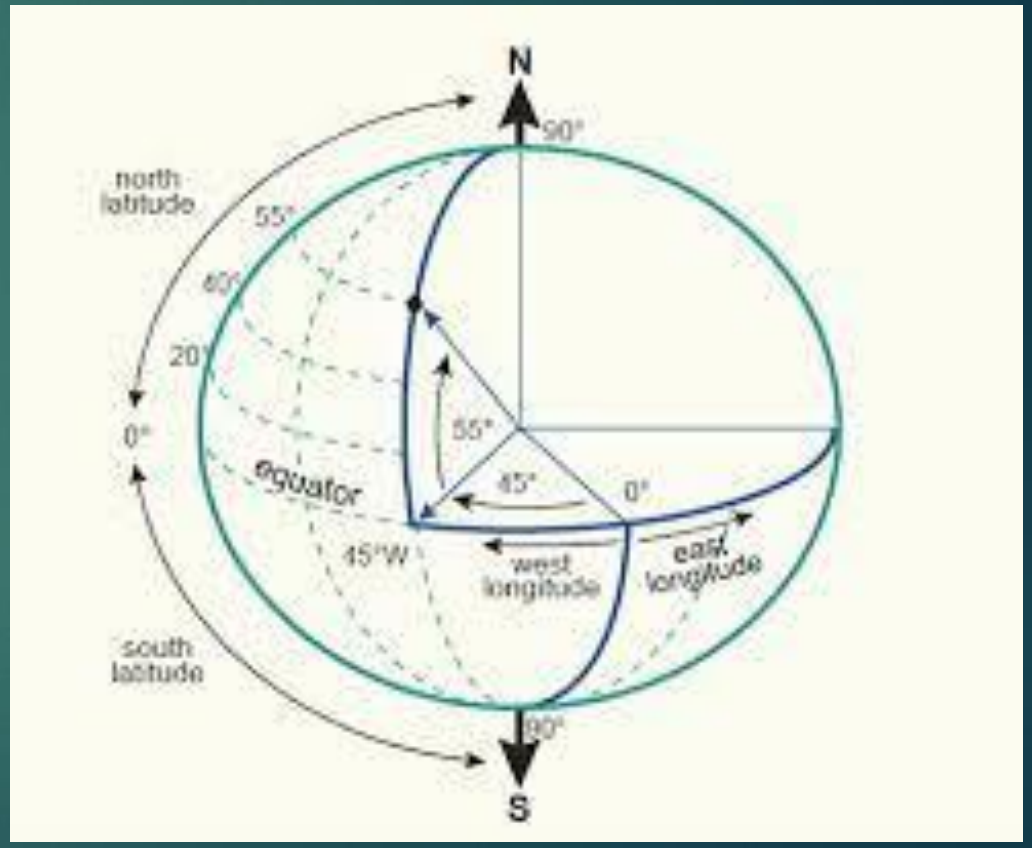
5.3.1. UTM Coordinate System



https://www.maptools.com/tutorials/utm/quick_guide

5.4. Geographic (Latitude/Longitude) coordinate system





https://kartoweb.itc.nl/geometrics/Coordinate%20systems/coordsys.html

5.5. Spatial data Representation

Geographic object can be shown by FOUR type of representation viz., points, lines, areas, and continuous surfaces.

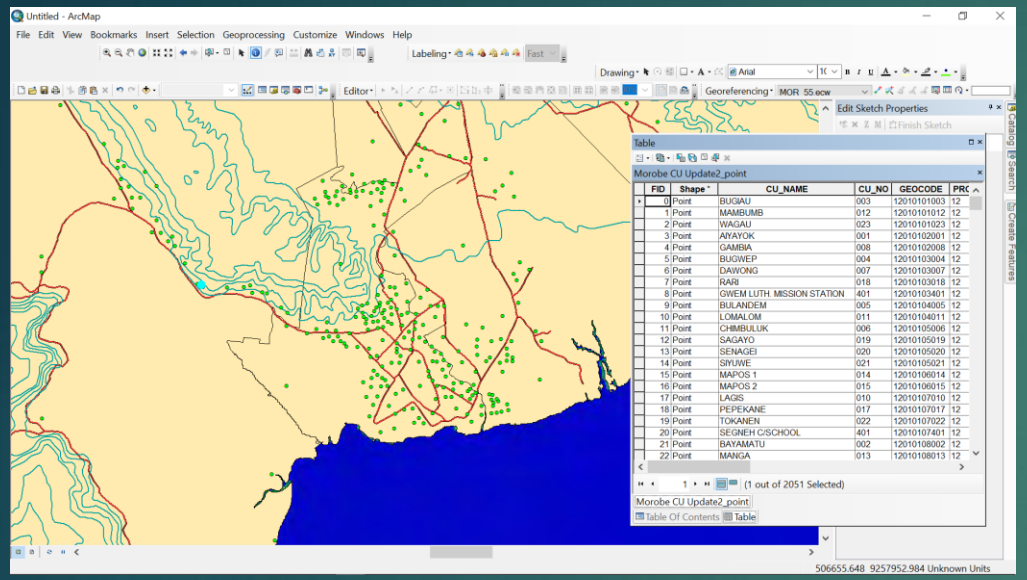
1. Point Data: Points are the simplest type of spatial data. They are-zero dimensional objects with only a position in space but no length.

2. Line Data: Lines (also termed segments or arcs) are one-dimensional spatial objects. Besides having a position in space, they also have a length.

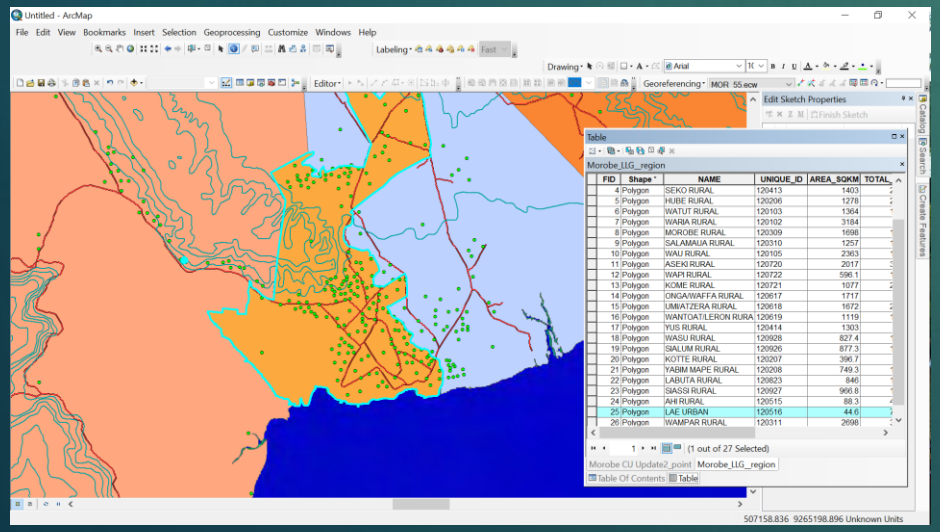
3. Area Data: Areas (also termed polygons) are two-dimensional spatial objects with not only a position in space and a length but also a width (in other words they have an area).

4. Continuous Surface: Continuous surfaces are three-dimensional spatial objects with not only a position in space, a length and a width, but also a depth or height (in other words they have a volume). These spatial objects have not been discussed further because most GIS do not include real volumetric spatial data.

5.5.1. Vector Data/Vector Representation



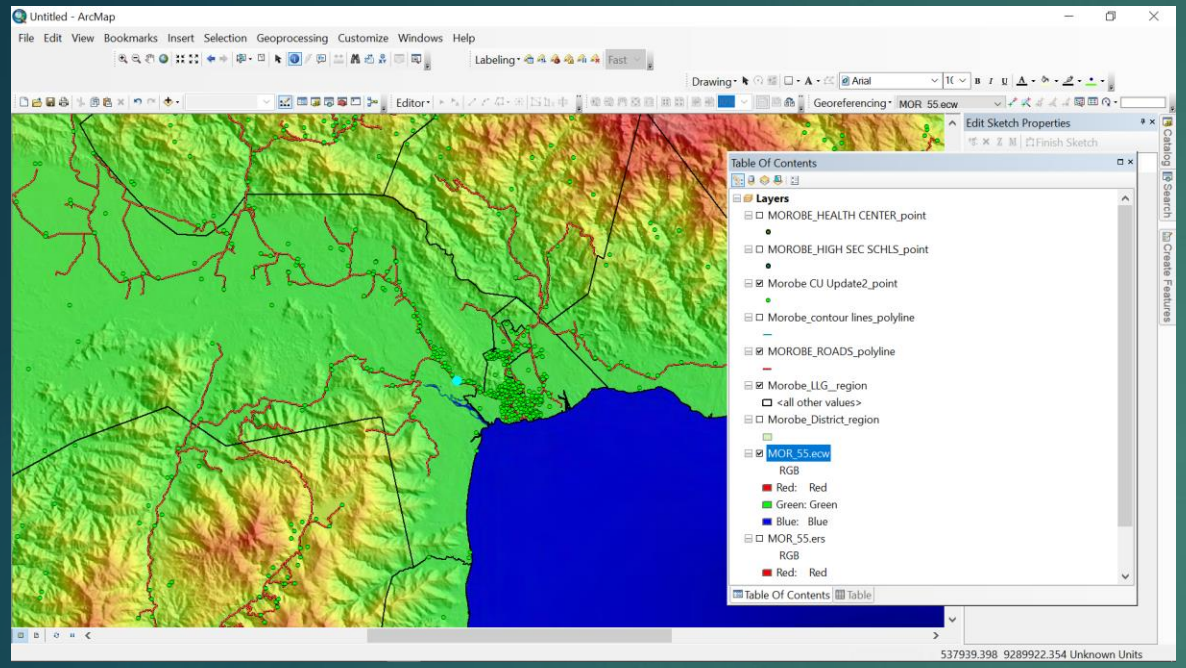
X & Y Locations represents **points**



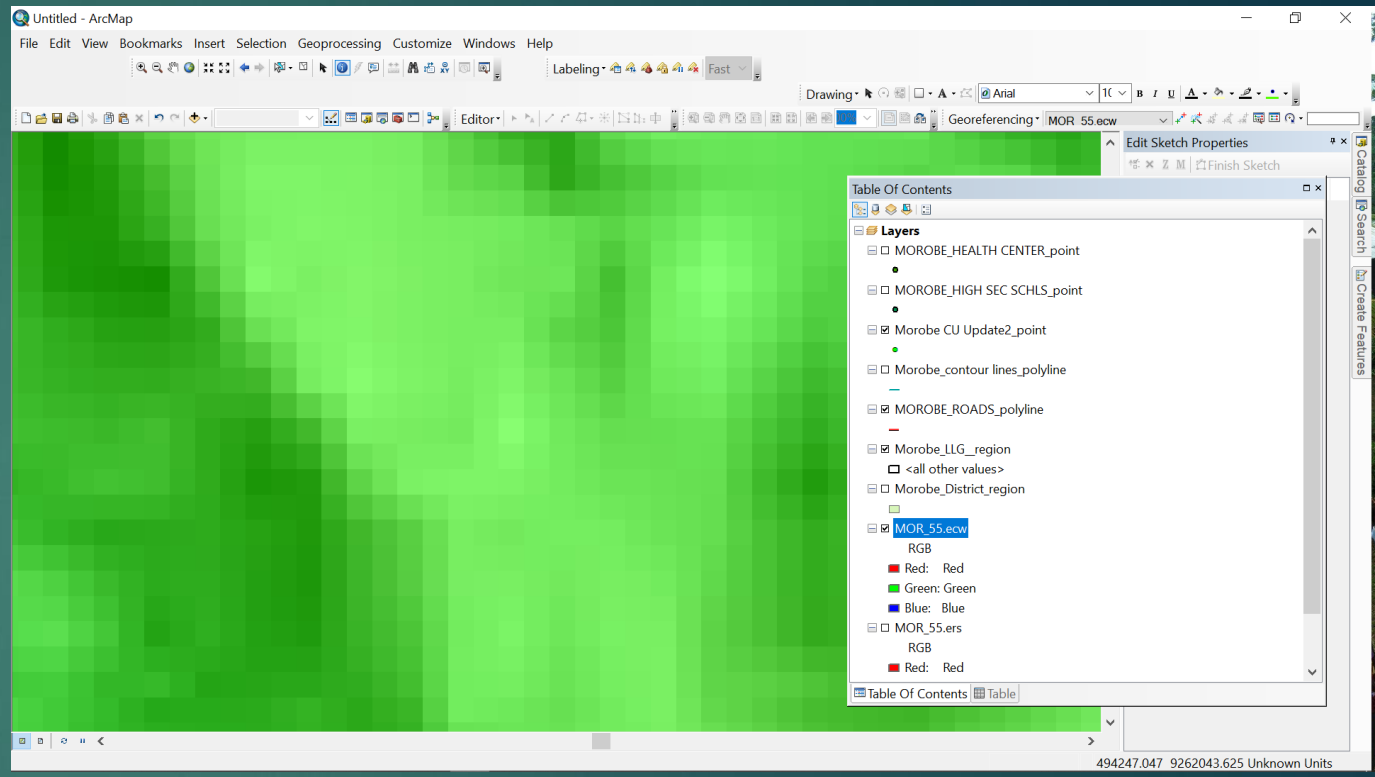
Connecting points/ X & Y Locations forms a **line**

Connected points, lines connected to each other contain attribute information forms a polygon.

5.5.2. Raster or Surface.



Raster: Row and column matrix represent geographic space.

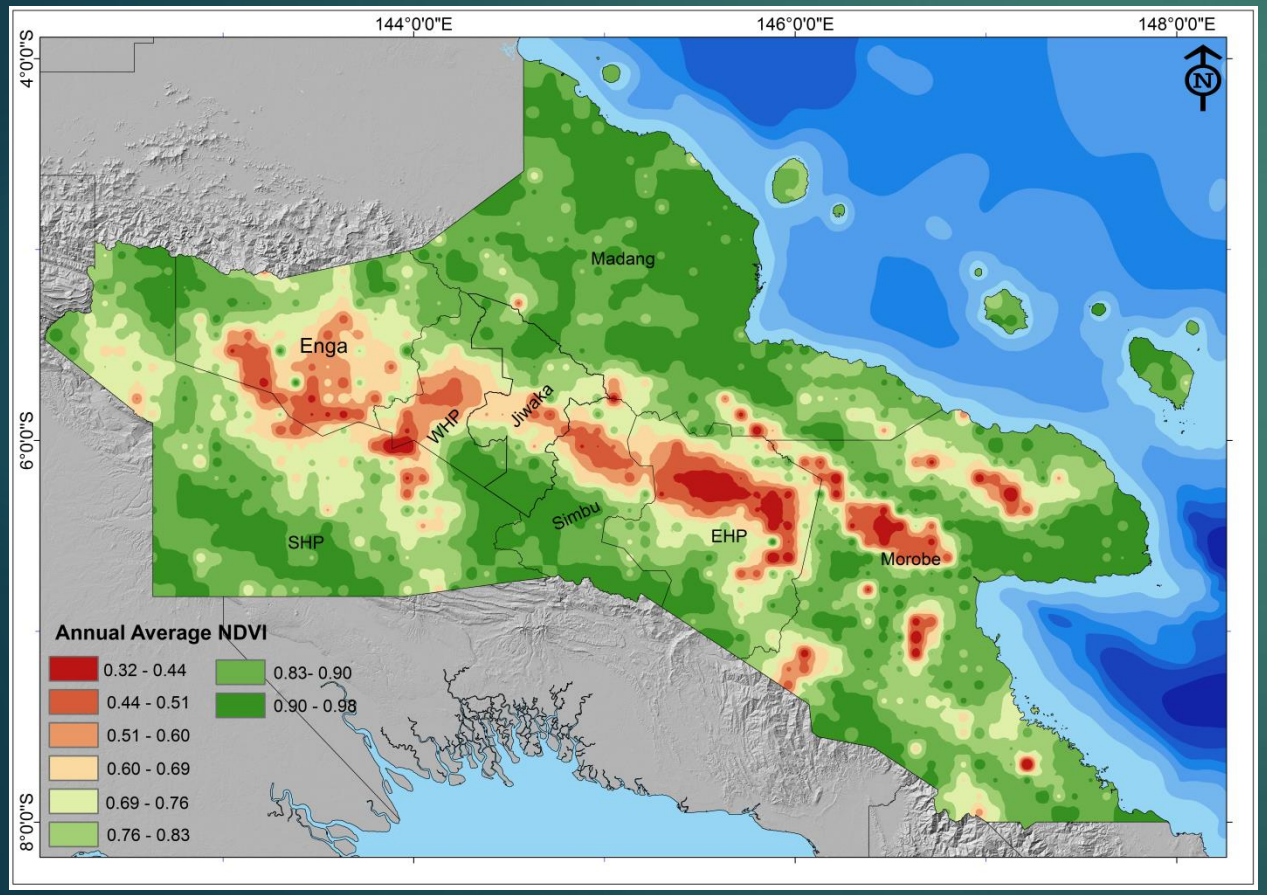


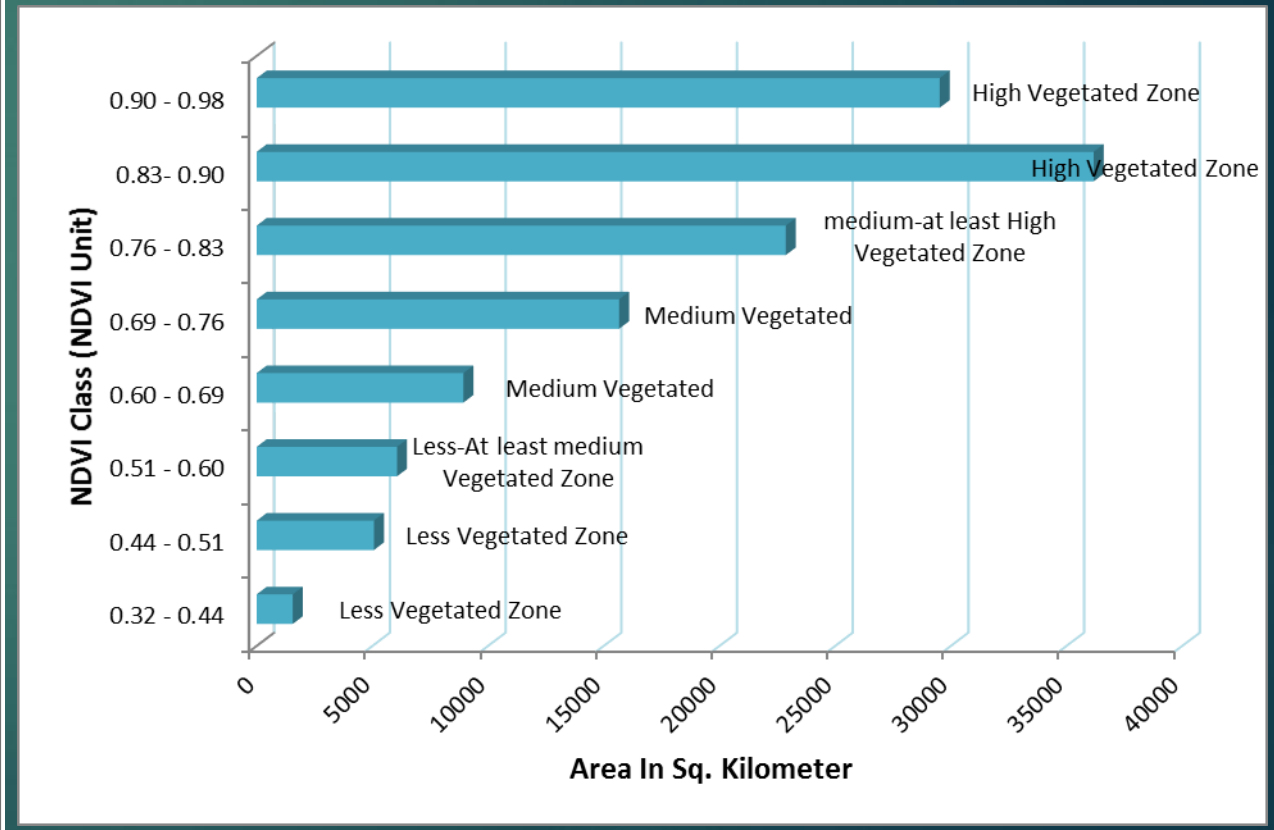
Example of Row and column matrix when zoom in

6. The Expected Results

When Arranging Spatial and attribute data, the end results assist in planning and decision making

Example: Annual mean Natural differential Vegetation index





T.Sekac, 2021/2022

7. References

Blyth, A and Cake, D., Module 1 (2007). Training material „Spatial analysis and modeling“ (GII-07)

Knippers, R., (2009). 2. Coordinate System. Retrieve from;
https://kartoweb.itc.nl/geometrics/Coordinate%20systems/coordsys.html

GISGeography (2022). Relate vs Join: **Cardinality for Attribute Tables in ArcGIS.**
Retrieve from: https://gisgeography.com/relate-vs-join-attribute-tables-arcgis/

Phillipps, P.G (2002). Introduction to Geographic Information Systems (GIS) (Power Point Presentation)
Retrieve from: file:///C:/Users/Survey%2002/Downloads/gis-basics-surfaces%20(1).pdf

ESRI, (2008). About joining and relating tables. Retrieve from: http://webhelp.esri.com
/arcgisdesktop/9.2/index.cfm?TopicName=About_joining_and_
relating_tables#:~:text=ArcMap%20provides%20two%20methods%20to,a%20field
%20common%20to%20both.

Dempsey, C., (2013). Attribute Data Types for GIS. Retrieve from:
https://www.gislounge.com/attribute-data-types-gis/

7. References……..cont……..

The Esri Guide to GIS Analysis (three (3) volumes). Mitchel, A. Redlands, CA, Esri Press. (2005-2020).

2020. Volume 1: Geographic Patterns and Relationships, 2nd Edition - 13: 9781589485792 (print), 9781589485808 (e-book).

2005. Volume 2: Spatial Measurements and Statistics, 1st Edition, ISBN-13: 9781589485792 (print), 9781589485808 (e-book).

2012. Volume 3: Modeling Suitability, Movement, and Interaction, 1st Edition, ISBN-13: 9781589481169 (print), 9781589482951 (e-book).

2. . Geographic Information Analysis, O'Sullivan, D. and Unwin D. J., 2nd Edition
New York, John Wiley & Sons, (2010). ISBN-13: 978-0- 470-28857-3 (print), 978-0-470-54909-4 (e-book)