Exercise – Geodatabases & Attribute Tables

Introduction

-If geodata is the fuel of a GIS,
then the geographic database is the framework that keeps a GIS together.

Remember!
Geodatabases are dealing with the second and third 'steps' of the GIS definition by Burrough (1986).
Geodata: Capture → Storing → Retrival → Transformation & Analysis → Presentation.

In the 'cradle days' of GIS, practically everybody was storing common geodata directly onto their own computers.

Naturally, this way of managing geodata resulted in considerable problems within an organization.

Imagine what happens when employees start adding/modifying/deleting data to the geodataset they keep locally.

-You will end up with a myriad of versions, practically one unique version for each one of the employees.

Not even the best routines to shuffle around the last version of a geodataset among everybody in the organization, could maintain the principle of *one* version – the latest update – for long.

DBMS

Consequently, without a central database management system (DBMS) it would be difficult to keep track of all the updates and changes of geodata.

This was an introduction to why a central database system, which always keeps the latest versions of a geodataset, is of tremendous value to an organization.
And, this is why the majority of the geodata at the IGN are kept on a GIS server.

Database

However, here, you are not going to deal with the complexities of a central database management system (DBMS).

Instead, you will focus on the database itself.

Without the theory and practical skills, you will learn during this exercise, you will unquestionably be less prepared for future GIS enterprises.

-Knowledge of databases and tables will surely add to your 'GIS confidence'.

Introduction

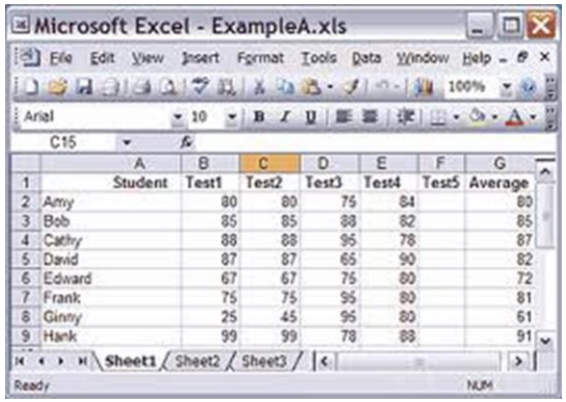
Attribute

Attribute Table

In this exercise you will continue working with the geodata you created during the 'Data Capture – Digitizing' exercise.
This time you will not be adding more points, lines and polygons to them.
Instead, you will extend their databases by adding *descriptive data* to each single geographic object.
Descriptive data are called *attributes*.
As a consequence, in ArcGIS Pro, a database of geodata is called an Attribute Table.
And, that is just what it is – a *table*. Just like a worksheet in MS Excel.
Remember, a database does not have to be more complicated than an old-school phonebook.
Thus, an Attribute Table of a feature class in ArcGIS Pro looks much like that (in a digital format, though), with each column describing a certain aspect (*e.g.* Name, Age, Date), that is relevant to that specific database (Fig. 1a-c).

DIGIT-1 ➔ ➔ ➔ ➔ ➔

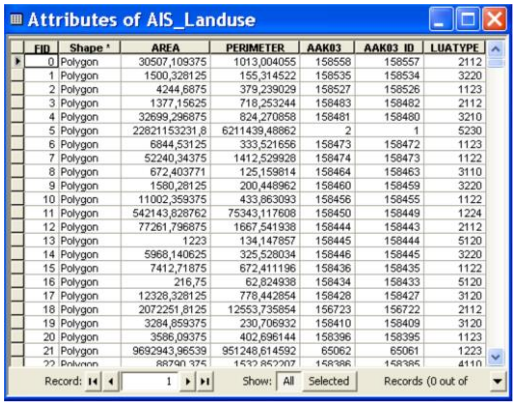
a)



	A	B	C	D	E	F	G
1	Student	Test1	Test2	Test3	Test4	Test5	Average
2	Amy	80	80	75	84		80
3	Bob	85	85	88	82		85
4	Cathy	88	88	95	78		87
5	David	87	87	65	90		82
6	Edward	67	67	75	80		72
7	Frank	75	75	95	80		81
8	Ginny	25	45	95	80		61
9	Hank	99	99	78	88		91

b)

c)



FID	Shape *	AREA	PERIMETER	AAK03	AAK03_ID	LUATYPE
0	Polygon	30507,109375	1013,004055	158558	158557	2112
1	Polygon	1500,328125	155,314522	158535	158534	3220
2	Polygon	4244,6875	379,239029	158527	158526	1123
3	Polygon	1377,15625	718,253244	158483	158482	2112
4	Polygon	32699,296875	824,270858	158481	158480	3210
5	Polygon	22821153231,8	6211439,48862	2	1	5230
6	Polygon	6844,53125	333,521656	158473	158472	1123
7	Polygon	52240,34375	1412,529928	158474	158473	1122
8	Polygon	672,403771	125,159814	158464	158463	3110
9	Polygon	1580,28125	200,448962	158460	158459	3220
10	Polygon	11002,359375	433,863093	158456	158455	1122
11	Polygon	542143,828762	75343,117608	158450	158449	1224
12	Polygon	77261,796875	1667,541938	158444	158443	2112
13	Polygon	1223	134,147857	158445	158444	5120
14	Polygon	5968,140625	325,528034	158446	158445	3220
15	Polygon	7412,71875	672,411196	158436	158435	1122
16	Polygon	216,75	62,824938	158434	158433	5120
17	Polygon	12328,328125	778,442854	158428	158427	3120
18	Polygon	2072251,8125	12553,735854	156723	156722	2112
19	Polygon	3284,859375	230,706932	158410	158409	3120
20	Polygon	3586,09375	402,696144	158396	158395	1123
21	Polygon	9692943,96539	951248,614592	65062	65061	1223

Fig. 1 Databases: a) An excel worksheet (digital), b) a phonebook (analog), and c) an Attribute Table in ArcGIS (digital).

Objective

A database makes it possible to select geodata of specific interest and to generate lists and statistics.

Aim:

In this exercise you will increase your comprehension of the 'backbone' of geodata – the databases. You will:

- Get insight into the building blocks of a geographical database, and learn to add and edit descriptive data.
- Learn several techniques to select geodata.
- Learn to derive simple statistics from the databases.

Exercise

1. Start a new ArcGIS Pro project (Name it and save it to a familiar location, *e.g.* your H drive).

2. You will have a look at the Attribute Tables of some of the geodata you have created so far.

Copy Feature Class (or Import/Export)

a) Copy the point feature class from the previous exercise (when you were digitizing) to this project geodatabase.

b) In the Contents pane, right-click the point map layer ➔ Attribute Table.

Row/Object/Record/Post

The Attribute Table opens (Fig 2).
At the moment it is not very informative.
We may conclude that the feature type is point.
And, that the database in fig. 2 contains 22 rows (which is the total number of stations of the original Copenhagen metro network).

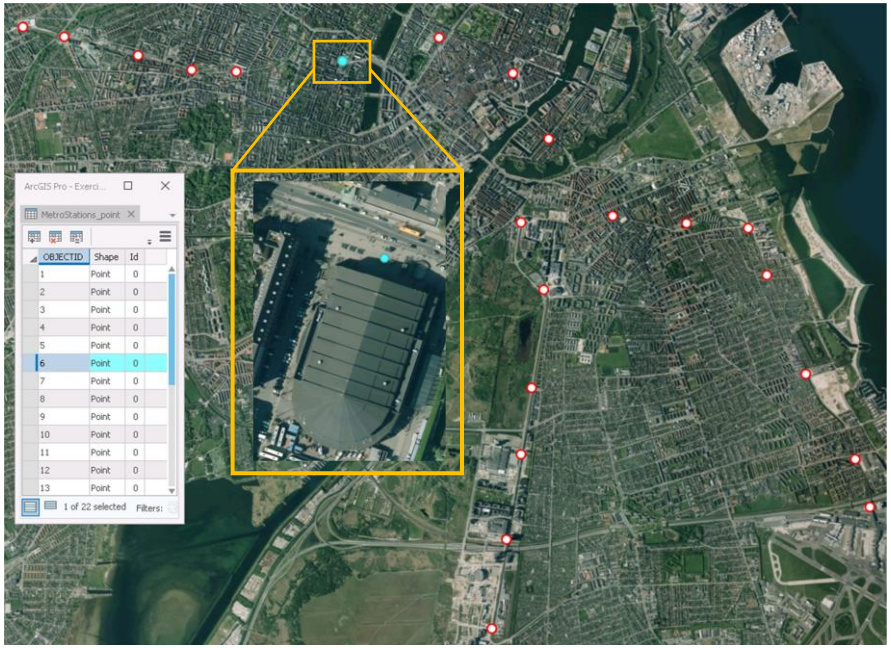


Fig. 2 The Attribute Table of the point feature class representing the metro stations in Copenhagen (Lines M1 and M2). The selected point (high-lighted in blue in the table and in the Map view) is the Forum metro station.

To this feature class we may add a lot of informative data (*e.g.* name, platform length).

Column/Field/Attribute

You will add the name of the stations in a new column.
(In case you have digitized something else for your point dataset you may choose some other descriptive data, as long as it is *text* data).

Add Field/Column/Attribute

3. Add a new field (Fig. 3).

Data Type: Text

The new column is added to the Attribute Table.
Check the header of that column. What does it say?

DIGIT-2a-b ➔ ➔ ➔ ➔ ➔

Not surprisingly, the cells of the new column are empty.
You will have to add the descriptive data by yourself.
There are various techniques to edit data in an Attribute Table.
In this exercise we are presenting them from difficult to easy, or should we say, from cumbersome to convenient.

Note! ➔ ➔ ➔ ➔ ➔ ➔ ➔

The Field Properties (Length = 40) means that a station name may not be longer than 40 characters.

Exercise

Edit Descriptive Data

Accuracy

No matter the technique, it is always imperative that the data you add are accurate.
Specifically, that the texts are spelt correctly and that the numbers are right.
Inaccuracy within the databases may have far-going consequences.
Imagine what would happen in a digital phonebook directory, if a person called 'Jonson' was misspelt as 'Ronson'.
You probably would not be able to search and find her/his telephone number there, you would have to look elsewhere.
Or, a nautical chart where the water depth is recorded as 20m instead of 2m …

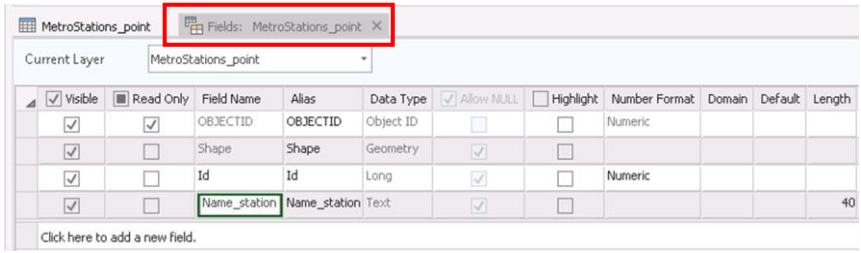


Fig. 3 The Fields tab (red rectangle).
Here you define the characteristics of a new column in the Attribute Table.

Editing manually

4. You will now start editing the Attribute Table by typing *text* for all your points (Fig. 4).

a) This is very straightforward, just click the text cell and start typing.

b) Remember to save your edits every now and then to secure that no entries are lost.

Tips! ➔ ➔ ➔ ➔ ➔ ➔ ➔ ➔
You may get help to find any names using the 'Topographic' or 'Imagery Hybrid' Basemaps. Also, the Locate tool is useful to find addresses and places.

Remember!
Descriptive data may be utilized as labels in a final map layout, just like in the first exercise.

You have now added some very valuable and useful descriptive data to your point geodata. – Congratulations.
Such data may be utilized to select or perform analysis on a subset of the database, for example, all the station names starting with the letter 'F'.

As you may have realized, this is the most cumbersome technique to add descriptive data.
However, sometimes it is necessary to construct a database like this – the hard way.
The good thing about it is that the database editor is a thinking human being.

She/He may realize that entering special characters (like the Danish letters å, æ, ø) will result in problems if the database is going to be implemented internationally.

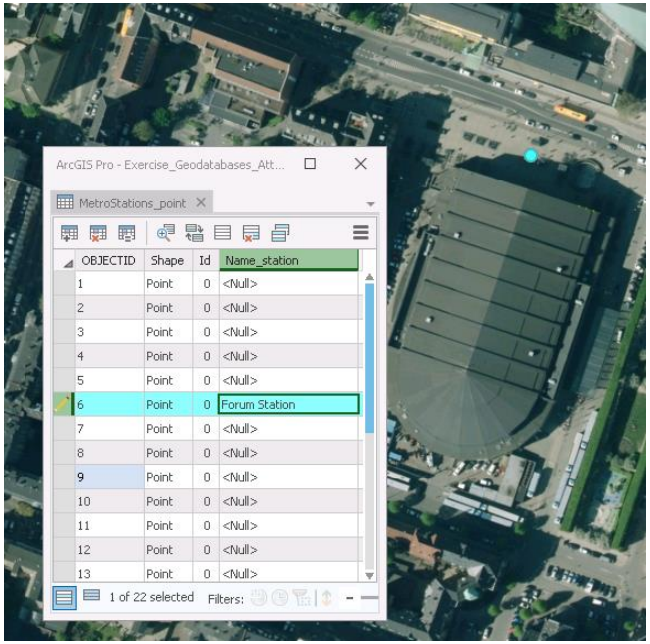


Fig. 4 Editing in an Attribute Table.

Exercise

A more automatic editing technique, on the other hand, would perhaps have 'translated' such special characters to something that ended up even odder.

Warning systems

The bad thing about editing by hand is that even the best database editor may have a bad day.
Fortunately, you may set up database 'warning systems', which are automatically detecting errors like mistyping.
You may for example restrict the possible outcomes of a column (*e.g.* terrain elevation in Denmark: -20m to 180m).
A data value entry beyond this interval would not be possible, and the database editor would be alerted instantly.

5. Next, you will add the *line* feature class, which you digitized in a previous exercise (Fig. 5).
When you open its Attribute Table, you will find that, besides the length of a line (which was generated automatically), descriptive data about the features are missing here too.

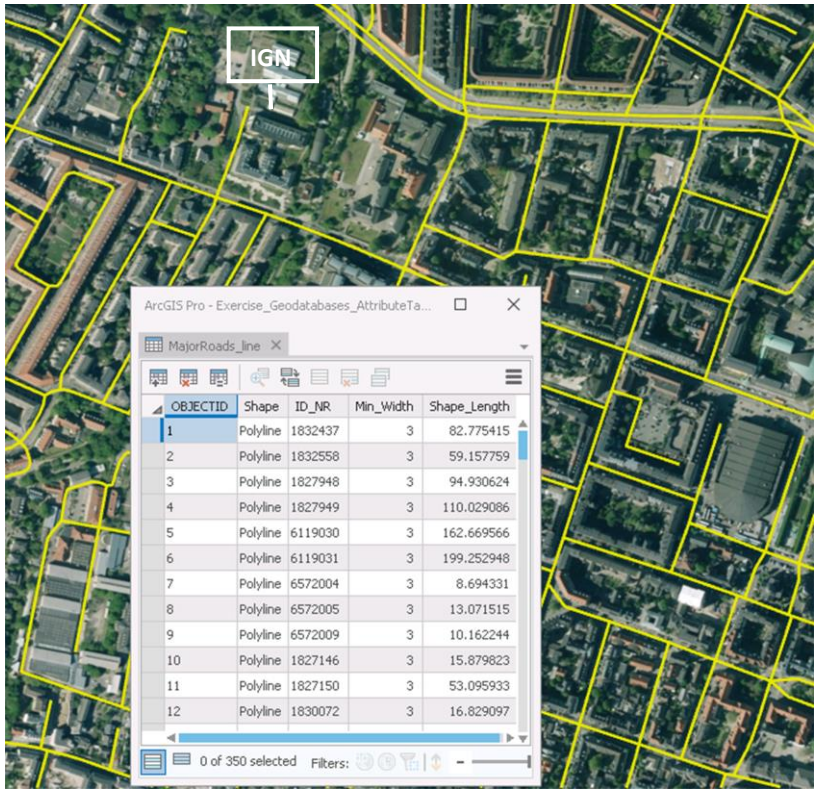


Fig. 5. The Attribute Table of the line feature class representing the major roads around the Frederiksberg Campus area.

6. To add descriptive data (*i.e.* attributes) is your next task.

a) Use your skills to add a new column to the Attribute Table.

b) Give the new field the following properties:

- Field Name: Type something suitable (*e.g. Min_Width*).
  This will indicate the minimum width of the major roads that were digitized.
  (In case you have digitized something else for your line dataset you may choose some other descriptive data, as long as it is *numerical*).

Data Type: Short (Integer)

- Data Type: Select **Short (**Integer) in the drop-down list.

Note!
Please use the Save button to save the edits.
Ctrl + S will save the Project (but not the edits).

c) Click Save.
The new field/column is added to the Attribute Table.

Exercise

Data Types

Data Type: Float or Double
are allowing decimal numbers

DIGIT-3 ➔ ➔ ➔ ➔ ➔

Data Type: Long (Integer)

<NULL> (=No Data)

[*Editing by Calculate Field*]

Calculate Field tool

DIGIT-4 ➔ ➔ ➔ ➔ ➔

'Short' (Integer) is a numerical data type. This means that only numbers may be entered.
Integers indicate that only whole numbers are allowed, no decimals (*e.g.* 0, 1, 2…).
Short Integers means that only short (small) numerical values are allowed,
usually from 0 to about 65 000 (if negative whole numbers are excluded).
Why is this important?
Why not just define that *any* type of numerical values is allowed?
There are several answers to this question; One is storage space.
Each cell of a database 'consumes' space on the hard drive/server.
Thus, a column with a Short (Integer) data type consumes considerably less
compared to one with the Long (Integer) data type.
Even cells with no data entry (*i.e.* empty/NULL) are consuming space!
This is usually not a problem for small databases,
but consider a national database covering all buildings in a country…

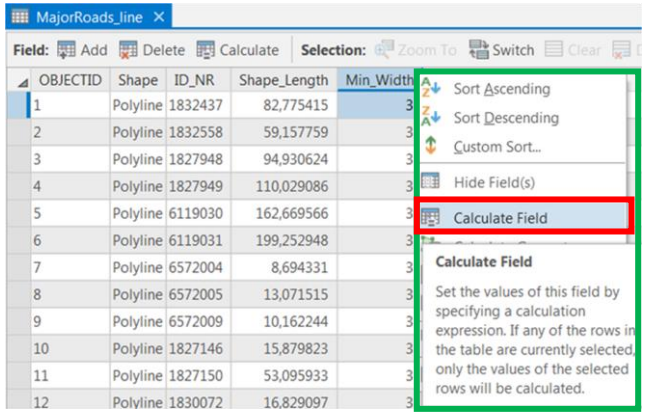


Fig. 6. How to open the Calculate Field tool.

7. You will now start entering data to the cells of the new column.
This time you will not be typing them in by hand.
Instead, you will be using a faster technique.
This technique is very efficient for entering the same data entry
into many rows simultaneously – by use of the Calculate Field tool (Fig. 6-7).

The Calculate Field tool is exactly what it says – a calculator of a field.
And, since you right-clicked a particular field/column, the results of any
calculations will end up in this column (and not elsewhere in the database).

Then, what if you would not like all cells to get the same value?
But still would like to use a quicker technique than typing by hand?
If the descriptive data you would like to enter *vary* (*e.g.* width = 1m, 3m or 6m),
be patient, we have a solution for you.
We will soon present a third data editing technique, which enables the entry
of varying descriptive data, fast and efficiently.

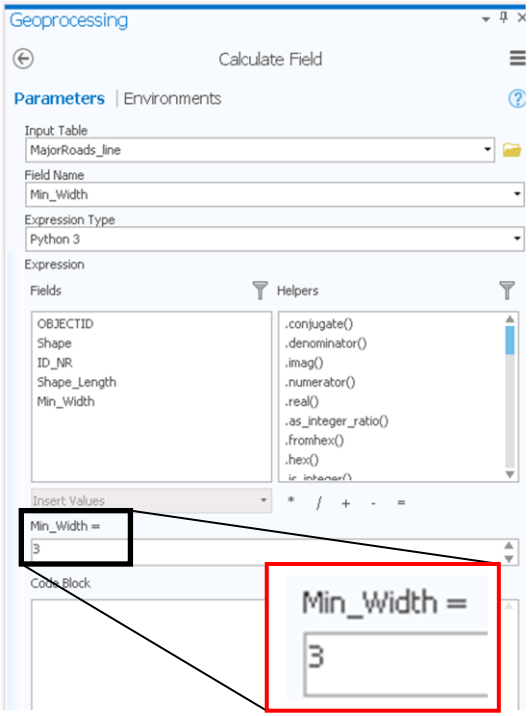


Fig. 7. The Calculate Field tool.
Enter '3' into the numerical field *Min_Width*.

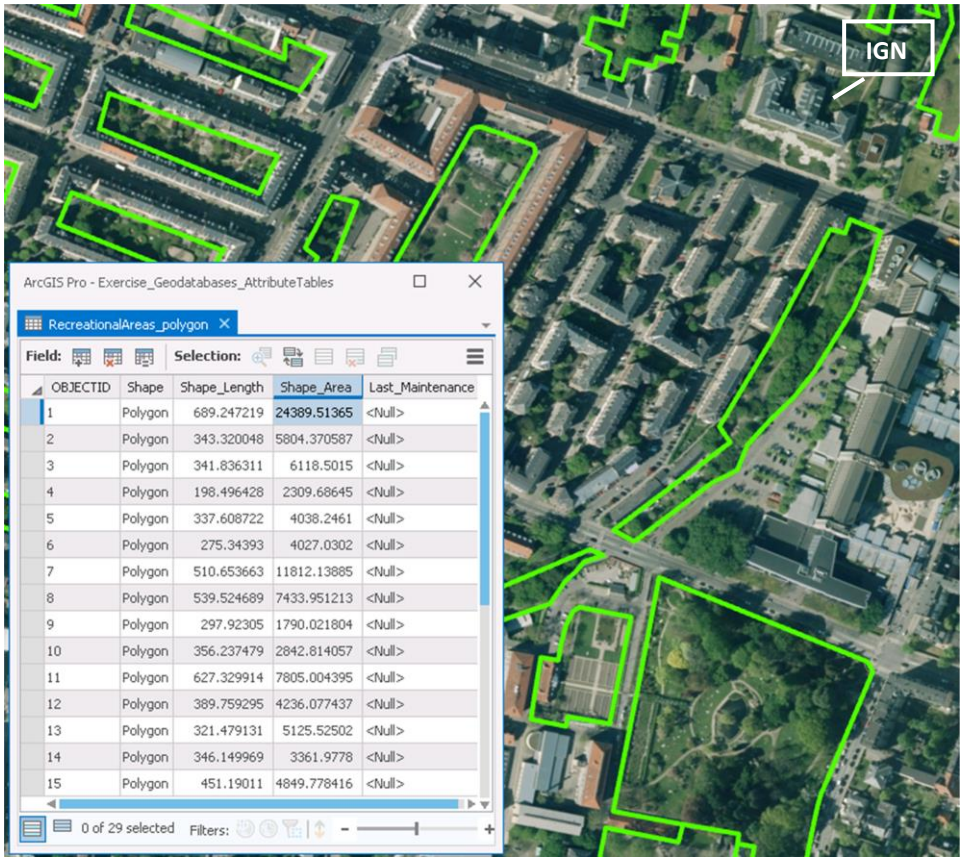
Exercise

Notice!
The polygons in figure 8
have been made transparent.

8. Next, you will add the *polygon* feature class you digitized in a previous exercise (Fig. 8).

When creating a new polygon feature class, two fields with desciptive data are generated automatically: *Shape_Length* and *Shape_Area*. Those fields will contain the perimeter length and the area size of the digitized polygons (the values will be generated automatically).

Besides those, as you open the Attribute Table, you will find that descriptive data are missing.



OBJECTID	Shape	Shape_Length	Shape_Area	Last_Maintenance
1	Polygon	689.247219	24389.51365	<Null>
2	Polygon	343.320048	5804.370587	<Null>
3	Polygon	341.836311	6118.5015	<Null>
4	Polygon	198.496428	2309.68645	<Null>
5	Polygon	337.608722	4038.2461	<Null>
6	Polygon	275.34393	4027.0302	<Null>
7	Polygon	510.653663	11812.13885	<Null>
8	Polygon	539.524689	7433.951213	<Null>
9	Polygon	297.92305	1790.021804	<Null>
10	Polygon	356.237479	2842.814057	<Null>
11	Polygon	627.329914	7805.004395	<Null>
12	Polygon	389.759295	4236.077437	<Null>
13	Polygon	321.479131	5125.52502	<Null>
14	Polygon	346.149969	3361.9778	<Null>
15	Polygon	451.19011	4849.778416	<Null>

Fig. 8 The Attribute Table of the digitized polygon feature class. The newly-added field/column (*Last_Maintenance*) has <Null> entries.

9. You will add descriptive data (*i.e.* attributes).

Use your skills

Use your skills to add a new column to the Attribute Table.

On the Fields tab:

- Field Name: Type something suitable (*e.g. Last_Maintenance*).

  This will indicate the last time a recreational area was maintained (*e.g.* when the lawns were mowed). This would be useful info to the management office of the public areas.

(In case you have digitized something else for your polygon dataset you may choose some other descriptive data, as long as it is *a date*).

Data Type: Date

- Data Type: Select **Date** in the drop-down list.

<Null> = no record/empty
<Null> ≠ zero

As you may have noticed, all the cells of the new field are automatically filled by *<Null>* (Fig. 8).
It is important to realize that 'null' is different from '0' (zero).
'Null' means empty/no record, whereas 'zero' is a factual value.

Exercise

Selecting features

Your next task is to enter data into the cells of the new column.
This time we will introduce a fast technique to enter the same data to some of the rows, but not to all of them.
This technique requires that you are selecting the polygons that are going to receive the same data entry.

We will start by showing how you may select features in ArcGIS Pro.
There are numerous techniques. We will show you two procedures now (and a third a bit later).

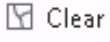
Select in Map view

10. The first technique is to select features directly in the Map view.

Select Features tool 

a) On the Map ribbon, select the Select Features tool  (Fig. 9).

b) Use the Select Features tool to click directly on a polygon to select it.

Clear Selected Features 

Notice that as you are selecting a polygon, the outline is highlighted in blue.
Also notice that the same polygon object is highlighted in blue in the Attribute Table.

Select more than one feature

c) To select several polygons, you may click-and-drag the mouse to define a rectangle. The polygons within this area are selected.
Or, you may select an additional polygon by clicking on it, pressing the SHIFT key simultaneously.

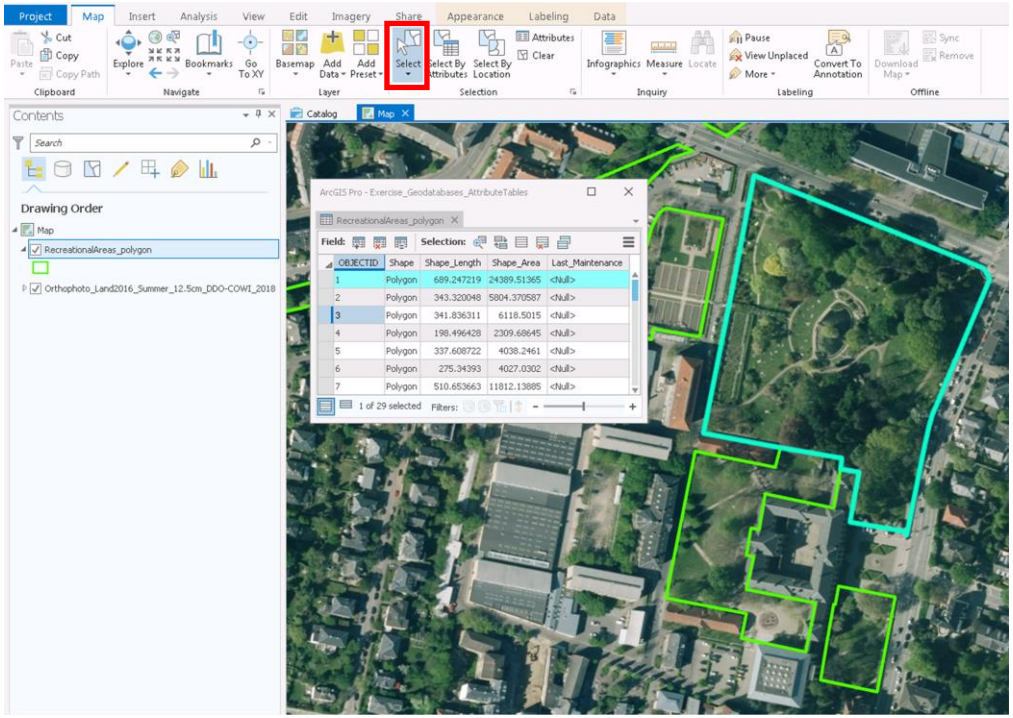


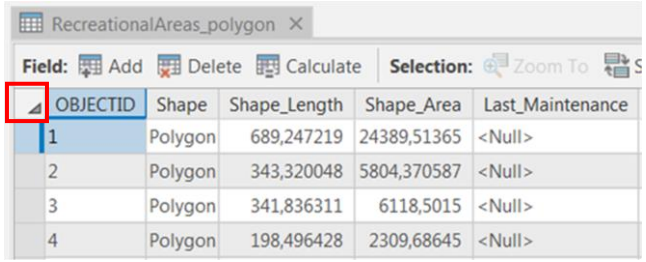
Fig. 9. Selecting features.
The recreational area polygon was selected using the Select Feature tool (indicated by a red box on the Map ribbon).
The selected object is highlighted in blue in the Map view and in the Attribute Table.

Exercise

Select in Attribute Table

A second technique to select features is by utilizing the Attribute Table.

11. Once you know how to select rows, you will learn to enter descriptive data into the selected rows of the Attribute Table (Fig. 10).



OBJECTID	Shape	Shape_Length	Shape_Area	Last_Maintenance
1	Polygon	689,247219	24389,51365	<Null>
2	Polygon	343,320048	5804,370587	<Null>
3	Polygon	341,836311	6118,5015	<Null>
4	Polygon	198,496428	2309,68645	<Null>

Fig. 10 The Attribute Table.
Any selected rows are unselected by clicking the left uppermost square (red square).

12. Select a few features and then use the Calculate Field tool once again to fill out the empty/null cells in the *Last_Maintenance* field (Fig. 11).

The *Last_Maintenance* field is of the Date data type.
Since ArcGIS Pro is an American product, the date is set up to be formatted the American way (M/D/Y).
That is, the date 6. April 2018 would correspond to the following syntax in the Calculate Field tool:

M/D/Y = month/day/year (American date format)

"4/6/2018"

D/M/Y (date format used in most parts of the world)

This may seem a bit awkward to non-Americans, who are more accustomed to the D/M/Y format.

Here is an alternative way you may enter the date:

"04-06-2018"

The complete wording in the Calculate Field tool will be:

Troubleshoot! ➔ ➔ ➔ ➔ ➔
You need to obey this exact syntax.

Last_Maintenance = "04-06-2018" ,

indicating the most recent date the selected park areas in the Frederiksberg area were maintained.

Notice!
In the Attribute Table, the Date format will end up in the original American style: 04-06-2018

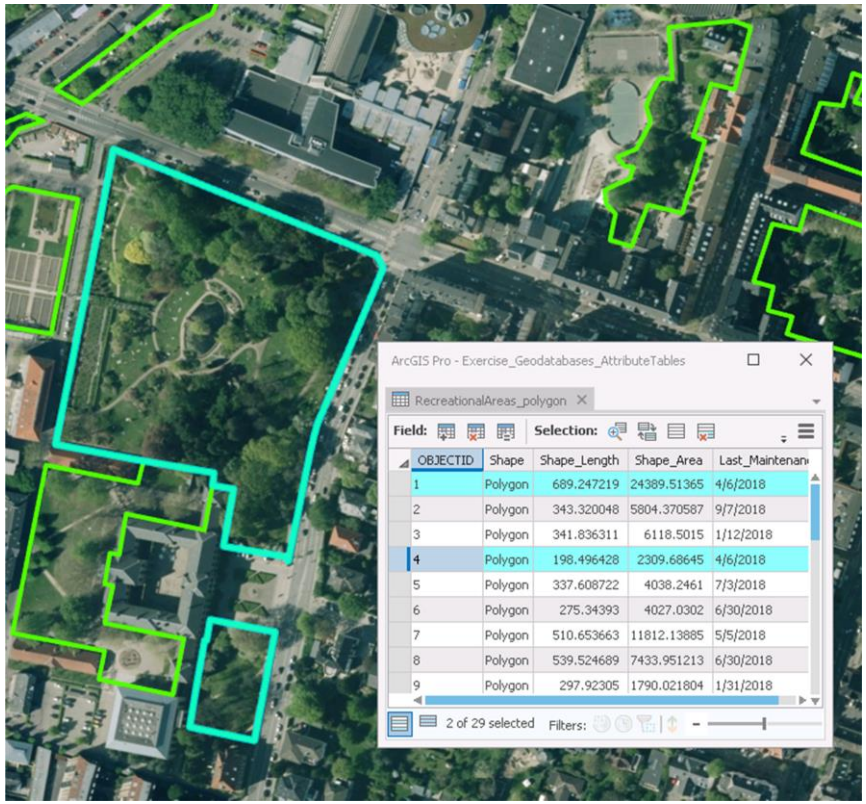


Fig. 11. Editing data into the Attribute Table using the Calculate Field tool.
Data are only added to the selected rows of the *'Last_Maintenance'* field.

13. You may now continue to enter different dates in the remaining empty cells.

Exercise

You will now be introduced to yet another technique to add data into an Attribute Table. This is the fourth technique.
As we explained earlier, the techniques presented are in order from cumbersome to convenient.
Consequently, this is the swiftest way to increase the amount of descriptive data to the Attribute Table.
Actually, you may add several fields/columns of data simultaneously.
This is done by *attaching* a whole separate table to your Attribute Table.
The table to attach may come in various file formats, for example as *.xls/.xlsx* (MS Excel) or as *.dbf*.

Join Tables

Key

Both keys also have to be of the same data type (e.g. numeric).

The technique is a so-called *join* operation.
For a join operation to work, one important condition has to be fulfilled – a common key.

A key is a field/column in both tables with data that 'correspond to' one another.
For example, the personal identification number (ID no. or CPR no.) in one registry would match uniquely to the ID no. of the same individual in another registry.

Example:

In the example here beside are two tables (Fig. 12).
Both are containing numerals, but in two languages.

By using the common key of the two tables (the ID columns) you may match the two tables.

The match does not have to be perfectly complete for a join operation to take place.

For example, in figure 12, the row containing the **ID=2** is present in the 'English' table, but absent in the 'French' table.

The join between these two tables will work anyway.
However, the end result will differ depending on the conditions you chose for your join operation.
(We will have a look at this in a moment).

English_Text	English_ID
One	1
Two	2
Three	3
Four	4
Five	5
Six	6

French_ID	French_Text
1	Un
3	Trois
4	Quatre
5	Cinq
6	Six
7	Sept
8	Huit

**Fig. 12 Two tables, one containing numerals in English and the other in French.
One table may be joined to the other using a common key (the ID columns).
The result will be a simple English-French dictionary of numerals.
However, since the tables lack some data the dictionary will be incomplete.**

Exercise

Receiving vs. Supplying table

You will learn how to complete a join operation between two tables in a moment.
But first, it is always important to recognize which table is going to *receive* data (target) from the other table.
This is simply because the table *supplying* data will be unaffected by the join operation.
(Accordingly, there is no mutual exchange of data between tables; No data will be joined to the supplying table).

14. In this case, the *supply* of data originates from an Excel worksheet.

    a) From the ***I:/SCIENCE-IGN-CGD-UVMAT/GIS_course/Exercises/ArcGIS_Pro/Exercise_Geodatabases_AttributeTables/*** folder, **copy** the *Non_maintained_area.xlsx* file.

    b) Save it to the H/T drive.

Add Table

    c) Add the *Non_maintained_area.xlsx* file from where you saved the copy.
    Notice that you will have to add a specific worksheet of the Excel file (Fig. 13).

    The Excel file is added, and turns up as *Sheet1$* in the Contents pane.

    Also notice that when you have added the table to ArcGIS Pro,
    the Contents pane changes appearance slightly.
    When a table is added to ArcGIS Pro, a sub-header ('Standalone Tables')
    is added automatically (Fig. 14, **blue** rectangle).

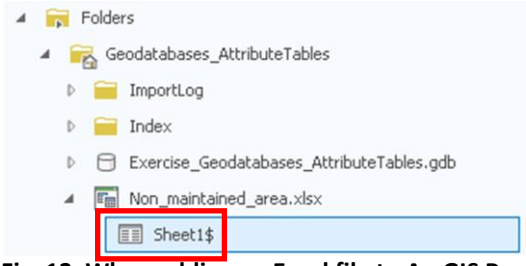


Fig. 13. When adding an Excel file to ArcGIS Pro you will need to specify the worksheet.

You will have a brief look at the newly-added Excel table.

15. In the Contents pane, right-click the *Sheet1$* layer ➔ Open.

    The *Non_maintained_areas.xlsx* file is made up of three fields/columns
    (see Fig. 15, next page):

    - *ID*
    - *Area _non_green*
    - *Name_area_calculation*

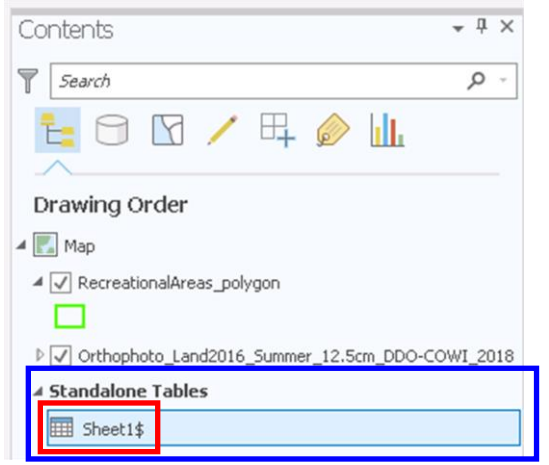


Fig. 14. When adding a data table to ArcGIS Pro, a sub-header called Standalone Tables (blue rectangle) is added automatically to the Contents pane.

Exercise

The *Non_maintained_area.xlsx* file contains descriptive data of recreational areas (Fig. 15):
(These areas relate to the polygons in the *Recreational_Areas* geodata)

- The ***Area_non_green*** column stands for the measured area of a park, which are constituted by paths, parking lots etc.
  This data can be useful to the park administrative office when planning the time to manage the green areas only of a park.
  The data type is numerical.

- The ***Name_area_calculation*** column represents the person/employee, who measured the non-green areas.
  The data type is text.

- The ***ID*** column represents the ID number of the recreational areas.
  This data type is numerical.

Sheet1$

Field: Add Delete Calculate Select

ID	Area_non_green	Name_area_calculation
1	377.41	Anne Poulsen
2	0	Preben Elkjaer
3	412.87	Kevin Murdoch
4	208.62	Trine Vesterager
6	305.96	Muhammar Al Ayadi
7	156.77	Anne Poulsen

Fig. 15 The table of the *Non_maintained_area.xlsx* file.

Common key

Let´s say the ID numbers of the Excel table corresponds to the OBJECTID numbers of the park areas in your *RecreationalAreas_polygon* feature class.
Consequently, we would have a common key***!!!***
And, since these two columns are of numerical data type, we may use them for a join operation.

Join tables

As you may have figured out, the Attribute Table of the *RecreationalAreas_polygon* feature class will *receive* the descriptive data columns from the Excel file:

Target and Source

- **Target:** *RecreationalAreas_polygon* (Attribute Table of a feature class)
- **Source:** Excel worksheet (plain table)

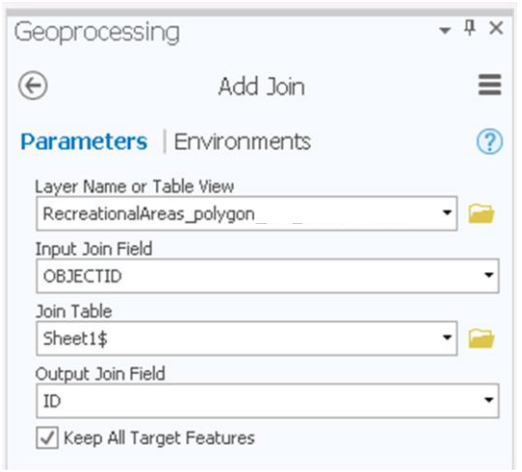


Fig. 16. The Add Join tool.

16. You will now perform a join with the data of the Excel table to the Attribute Table of the Recreational Areas polygon geodata (Fig. 16).

Voila!
The columns from the Excel table are automatically adjoined to the Attribute Table of the polygon layer (Fig. 17).
As you probably realize, this is a very efficient method to enter additional descriptive data (attributes) into your table.

RecreationalAreas_polygon

Field: Add Delete Calculate Selection: Zoom To Switch Clear Delete Copy

OBJECTID	Shape	Shape_Length	Shape_Area	Last_Maintenance	ID	Area_non_green	Name_area_calculation
1	Polygon	689.247219	24389.51365	4/6/2018	1	377.41	Anne Poulsen
2	Polygon	343.320048	5804.370587	9/7/2018	2	0	Preben Elkjaer
3	Polygon	341.836311	6118.5015	1/12/2018	3	412.87	Kevin Murdoch
4	Polygon	198.496428	2309.68645	4/6/2018	4	208.62	Trine Vesterager
5	Polygon	337.608722	4038.2461	7/3/2018	<Null>	<Null>	<Null>
6	Polygon	255.524995	3255.755409	6/30/2018	6	305.96	Muhammar Al Ayadi

Fig. 17. The Attribute Table after the Join operation.
The join is temporary, and there are some <Null> values.

Troubleshoot ➔ ➔ ➔ ➔ ➔

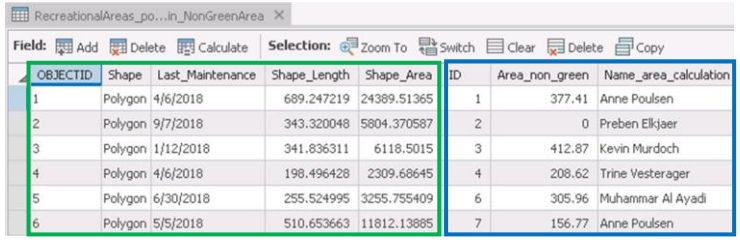
Even if you have digitized some other type of polygon objects you may use the Excel table for the join operation.
The table will be used to illustrate a join, but also a few other functionalities.

Exercise

Copy Features tool

DIGIT-5 ➔ ➔ ➔ ➔ ➔

17. Use the Copy Features tool to make a copy of the Recreational Areas polygon geodata, so that the temporarily joined data (from the Excel table) will become permanently added to the Attribute Table.


RecreationalAreas_po...in_NonGreenArea

Field: Add Delete Calculate | Selection: Zoom To Switch Clear Delete Copy

OBJECTID	Shape	Last_Maintenance	Shape_Length	Shape_Area	ID	Area_non_green	Name_area_calculation
1	Polygon	4/6/2018	689.247219	24389.51365	1	377.41	Anne Poulsen
2	Polygon	9/7/2018	343.320048	5804.370587	2	0	Preben Elkjaer
3	Polygon	1/12/2018	341.836311	6118.5015	3	412.87	Kevin Murdoch
4	Polygon	4/6/2018	198.496428	2309.68645	4	208.62	Trine Vesterager
5	Polygon	6/30/2018	255.524995	3255.755409	6	305.96	Muhammar Al Ayadi
6	Polygon	5/5/2018	510.653663	11812.13885	7	156.77	Anne Poulsen

Fig. 18. The Attribute Table after the Copy Features operation. The original fields (green) and the joined fields (blue).

18. a) Open the Attribute Table of the newly-generated copy of the Recreational Areas polygon geodata (Fig. 18).

Notice that there does not seem to be any *<Null>* values in the Attribute Table any longer. How can this be?

Actually, they have not disappeared from the Attribute Table of the geodata copy.
Instead, the records with *<Null>* values from the join have been positioned at the bottom of the Attribute Table.
For example, a feature which received *<Null>* values from the Excel table, may receive a completely new OBJECTID.
And, so will all the polygon features beneath in the Attribute Table. This does not seem very logical!

DIGIT-6 ➔ ➔ ➔ ➔ ➔

b) Scroll down to discover them.
This is a bit of a quirk in ArcGIS Pro, since it makes it unnecessarily hard to keep track of the features and their IDs.

In a previous exercise we informed you that a feature class created inside a geodatabase (.gdb) is a bit special.
When you have started to digitize lines or polygons to such a feature class, some new fields will be added automatically:

Perimeter = Circumference

* Line feature class – a *Shape_Length* field with the length of the digitized line.
* Polygon feature class – a *Shape_Length* field with the polygon perimeter length.
  – a *Shape_Area* field with the polygon area size (Fig. 18).

Calculate area (or length)

As mentioned above, this automatic function is true for feature classes inside a geodatabase (.gdb) in ArcGIS.
This is not necessarily true for another type of vector geodata, like a shapefile (or using another GIS software).
Consequently, it would be a good idea to show how you may add such important numeric data 'manually' too.

Hint! ➔ ➔ ➔ ➔ ➔ ➔ ➔
Check out page 6, above.

To insert area data into the polygon map layer Attribute Table, you will first need to do… What?
Yes, you will have to add a new field to the Attribute Table (unless you are willing to overwrite data in an existing).

19. Use your skills to add a new field.

- You may for example name it 'Total_area'.
- The data type should obviously be numeric, and in this case a data type that allows for decimal numbers.

Exercise

Calculate Geometry

19. Fill the new '*Total_area*' field with polygon area size measurements using the Calculate Geometry Attributes tool (Fig. 19).

    The '*Total_area*' column is almost instantly filled with the area calculations in square meters.

Currently you have both data on the measurements of:

- The total area of the park polygons, and
- The area of their non-green surfaces.

Earlier we discussed that the area of only the green surfaces of a park could be of interest to the park area planners (in order to estimate the time expenditure to manage lawns, trees, flowerbeds etc).
Using the already calculated fields we may now easily derive this kind of data.
Once again you will make use of the Calculate Field tool.

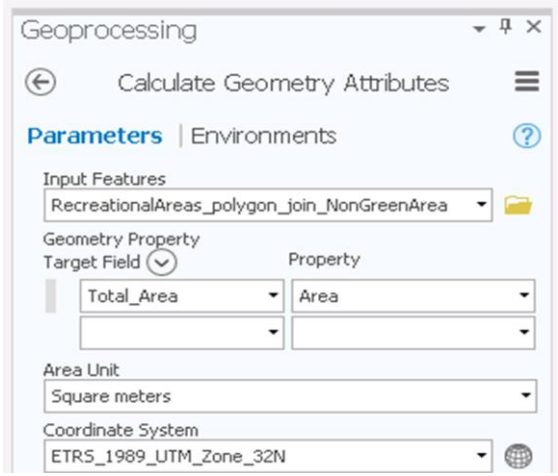


Fig. 19 The Calculate Geometry Attributes tool. Using this tool the length of lines, area and perimeter of polygons etc may be calculated.

20. You will put the result of the green area calculations in a new field. Use your skills to generate a new field of the same data type as in step 19. You may call the column '*Green_area*'.

Calculate Field – using data from other fields

As you experienced earlier (page 6) the Calculate Field tool may be used to add/edit data directly into a field (column) of the Attribute Table.

21. Now, you will conduct the calculation of the '*Green_area*' field, however, using data from other fields of the same Attribute Table.

Mathematical Operators

*	/	+	-	=

Green area =
Total area – Non-green area

The outcome of the mathematical operation you have constructed should look like this:
(or similar depending on the exact field names you have been using)

Green_area = Total_Area – Sheet1_Area_non_green

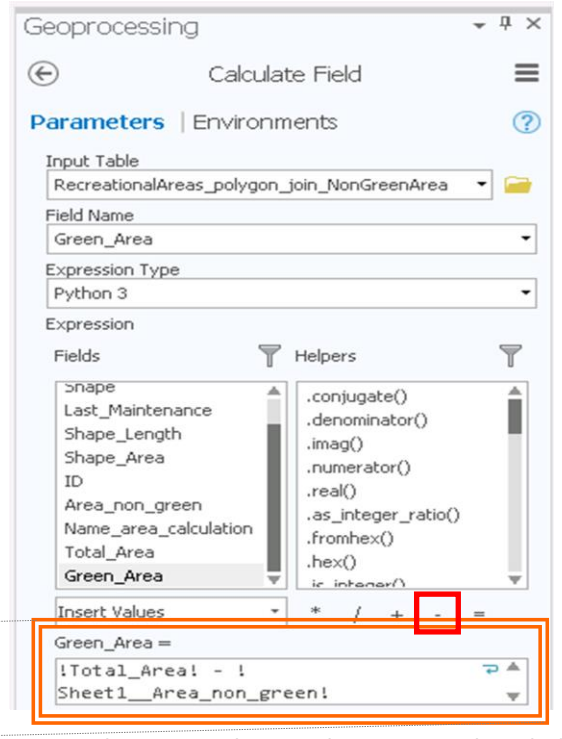


Fig. 20 Conducting a mathematical operation in the Calculate Field tool in order to add data into a field/column.

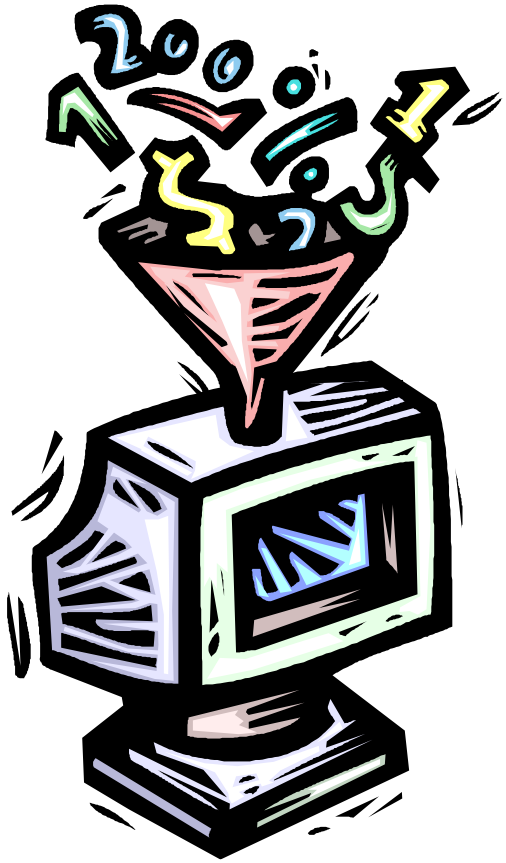
Exercise

The result of the calculations appears in the '*Green_area*' column.
(Do not despair if your green areas happen to end up with *negative* areas sizes.
This is because the non-green areas of the Excel sheet were not made to correspond to the polygons you have digitized.)

Hint! ➔ ➔ ➔ ➔ ➔ ➔ ➔
Use the division operator.

If you happen to be interested in some other type of derivative data – Just go ahead!
For example, it could be interesting to find out the *proportion* of green area within each park area polygon.

Now you have learnt how to generate new data in the database using its existing data.



-So, what's all this nonsense about adding data to tables here and there? What´s the use?!

Well, as you probably have heard a few times by now, data are the *fuel* that propels analyses and presentations.

Without meaningful descriptive data any project would come to a standstill.

Consequently, access to high-quality data is seldom a problem. Deficiency is.

That is true for GIS (and for any science, for that matter).

Just to show you the usefulness of the data you have added/edited/adjoined we will present a few functions.

Perhaps you have come across one or two of them earlier in the series of exercises, but they are worth repeating.

In a subsequent exercise you will be introduced to GIS analysis.

Exercise

The first purpose of the data in an Attribute Table, which we are going to present, is an old goody.
You saw this application of attributes already in the introductory exercise (Map Comprehension) – ***Labels***.

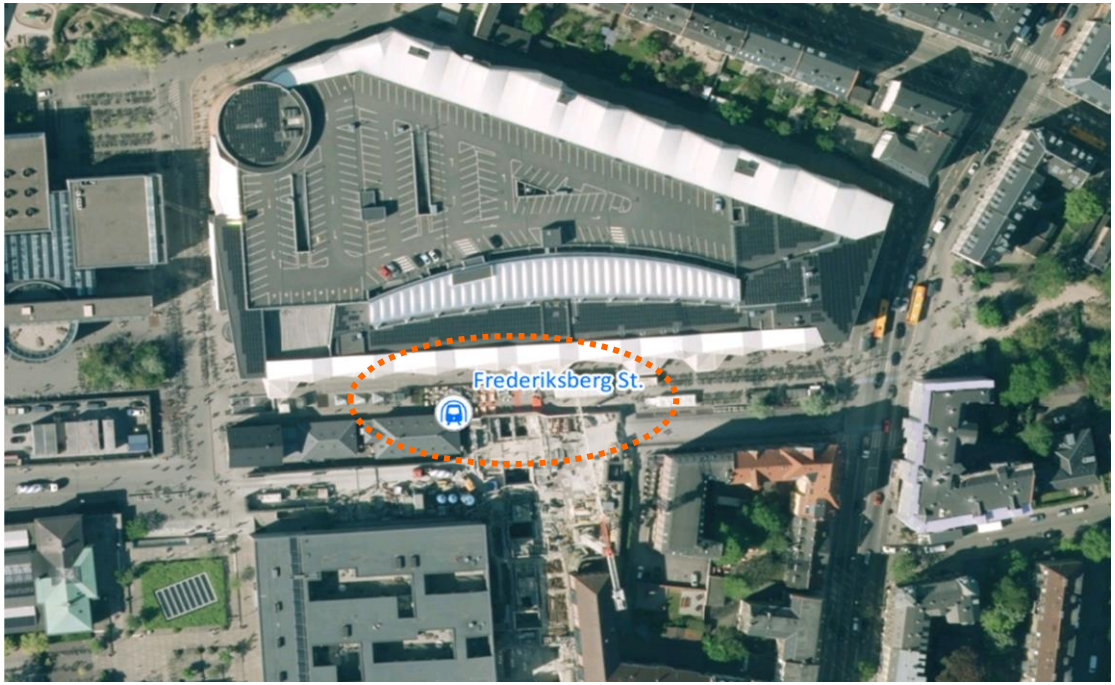


Fig. 21 A label of the *MetroStations_point* map layer shown on a recent orthophoto background image.

Label

In the example above the *MetroStations_point* map layer has been labelled (Fig. 21).

22. Use your skills to display labels.
    (You may use any of the geodata you have digitized so far).

Import Symbology Style

Tip!
You may import more symbols.

Another common purpose of the data in an Attribute Table is to generate some general ***descriptive statistics***.

Descriptive Statistics - general

23. Generate some general descriptive statistics for one of your geodata layers.

Exercise

You may also use the data in an Attribute Table to quickly generate grouped/summary ***descriptive statistics***.

The output of grouped/summary descriptive statistics is saved to a new database file.

Descriptive Statistics – grouped/summary

You will return to the Attribute Table of the recreational areas polygon geodata (the one with permanently joined data).
Let's say the park area administrative office wants to know how large green area is managed per day.
To find out you may sum the maintained green areas with respect to date.

24. Open the Attribute Table of the recreational areas polygon map layer.
    Then, generate the grouped/summary descriptive statistics requested by the park area administrative office (Fig. 22).

25. In the Contents pane: Open the newly-generated table.

    (In this example the table is called *Sum_GreenArea_per_Date*)
    From the table you may conclude that in total the largest green area was managed '4/6/2018' (Fig. 23).
    You may also conclude that two park areas were managed on that particular date.

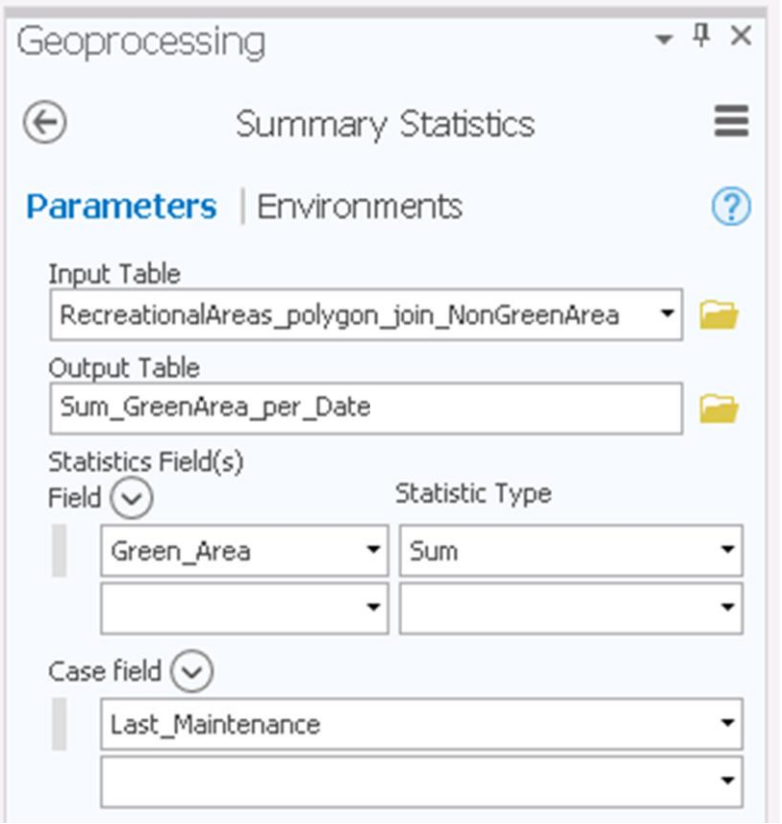
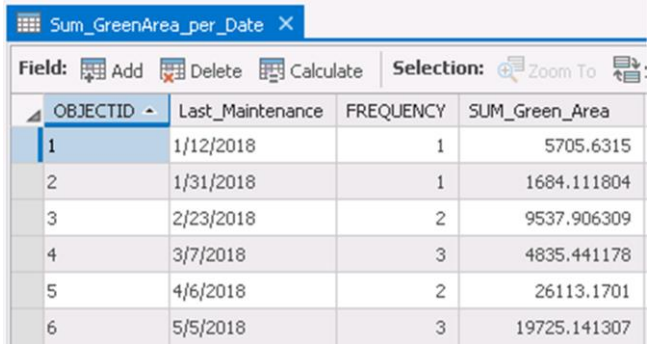


Fig. 22 The Summarize Statistics tool offers a range of statistics. The generated descriptive statistics may be saved as a standalone table inside or outside a geodatabase (*.gdb*).



OBJECTID	Last_Maintenance	FREQUENCY	SUM_Green_Area
1	1/12/2018	1	5705.6315
2	1/31/2018	1	1684.111804
3	2/23/2018	2	9537.906309
4	3/7/2018	3	4835.441178
5	4/6/2018	2	26113.1701
6	5/5/2018	3	19725.141307

Fig. 23 A table containing grouped statistics generated from a summarize operation using the Summary Statistics tool.

Exercise

Select By Query

Query =
To search and request data from a database.

*SQL = **Structured Query Language***
A database computer language designed for managing data in relational databases.

Select By Attributes

Troubleshoot ➔ ➔ ➔ ➔
You may select an area size and date of your own choice.

Operator >

SQL query

Boolean operator And

Operator =

A third common purpose of the data in an Attribute Table is to **query for selected objects** in the database.
This is also the third technique to select features we will present to you.

As a reminder – Earlier in this exercise you were introduced to the following two techniques to select features:
- Directly in the Map View (page 8).
- In the Attribute Table by selecting rows (page 9).

The third technique is also making use of the Attribute Table.
But, instead of selecting rows in the Attribute Table by clicking on them physically, you will query the table using SQL.

SQL is a computer language that is used to make queries, in order to search and request data from a relational database.
It has found wide use because it is straightforward, easy to learn, and the queries are built up by regular English words.

26. You will carry out a few SQL queries using the database of the recreational areas polygon map layer.

An SQL query will be formulated using various input parameters of the Select Layer By Attribute tool (Fig. 24, red box).

Query A

The park area administrative office would like to study the parks with a green area larger than 4 000 m^2.
The whole SQL query should be interpreted to this:

(From the map layer) RecreationalAreas… (make a) New Selection (of all the records/rows)(where the field) Green_Area > 4000 (m^2)

The next query will be based on the first query.
That is, you will modify the present selection and 'boil it down' even further, in order to make the selection narrower.

Query B

The administrative office now wants more precise information.
Of the park areas selected in Query A:
Which were maintained a certain date (*e.g.* 2/23/2018)?

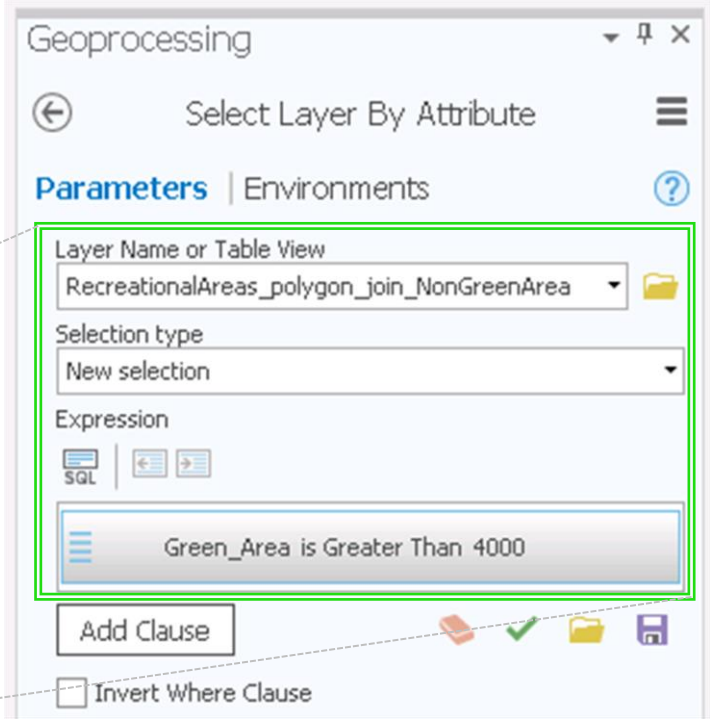


Fig. 24. The Select Layer By Attributes tool. An SQL query to select the recreational areas polygons larger than 4000 m^2.

Exercise

Wildcard character

The next and last example is a query using a so-called 'wildcard' characters.
A wildcard character query is very useful, for example when you are uncertain of the spelling of a term.
Wildcard characters vary between search applications (One may use a '*****' symbol, another a '**?**' or a '**_**').
For example, if you are looking for an address, but cannot remember if it was Kings *Road*, or Kings *Street*.
Then in a search application, you may use a wildcard character to search for all records starting with Kings (Kings*****).

'Begins/Ends with'
'Contains the text'
'Includes the value'

Here, in ArcGIS Pro the wildcard character is 'disguised'. Instead of using a symbol, the Select By Layer Attribute tool will use wildcard input parameters like 'Begins/Ends with', 'Contains the text' or 'Includes the value'.

27. Erase the previous query from the Select Layer By Attributes tool.

Query C

The park area administrative office wants information on the park areas measured by a colleague called Sonja.
It just takes a moment for you to realize that a query where you have typed the name 'Sonja' will not work. Why?
Because the '*Name_area_calculation*' field only has full names.
A simple query on the first name will not result in any hits.
The search engine expects a text string with both a first and a family name.
Only if the full name were separated into two columns – one with the first name, and a second with the family name – a simple query on 'Sonja' had been possible (using the column with the first names of employees).
But, don´t despair! With a 'wildcard search' it is possible to track down 'Sonja' from the available column.

To select the 'Sonja' records (Fig. 25):

i) In the Selection Type: Choose '*New Selection*' from the drop-down list.

ii) In the Expression section ➔ Click the Add Clause button:

- Select Field: 'Name_area_calculation'
- Select: 'Begins with'
- Type: 'Sonja'

iii) Click Add ➔ Click Run (in the bottom right corner).

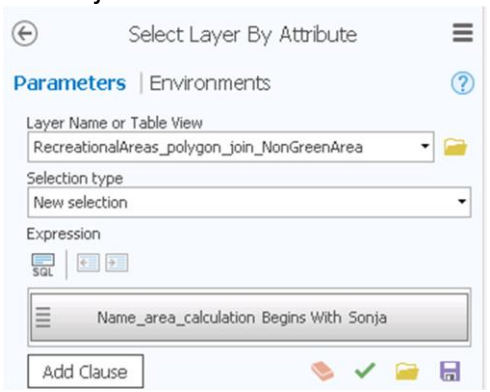


Fig. 25 The Select Layer By Attribute tool with a 'wildcard' SQL query.

Note!
Make sure you are typing ➔➔

Hint!
Have another look in the 'Name_area_calculation' field.
DIGIT-7 ➔➔➔➔➔

This query text tells us that we are looking for the rows in the '*Name_area_calculation*' field that begins with 'Sonja' (in the Attribute Table of the *recreational areas* polygon map layer).

However, the query does not result in any hits. Why? What went wrong? Try to figure it out yourself.

Exercise

During this exercise you have learnt to handle databases (tables) in ArcGIS Pro.
You have learnt to *add*, *edit* and *join* data in tables. And, you have utilized the data to *extract statistics*.
You have also learnt several techniques to *select* geodata – from the point-and-click on the screen to using SQL queries.

If you already had previous experience from other types of tables (*e.g.* an Excel worksheet) you have probably realized by now, that database tables resemble one another to a large extent.
This is always a good thing to know when you are introduced to a completely new software.

Zoom To Selection

Before ending this exercise session we will present a very handy function – Zoom To Selected.
Whenever you have selected a few features, you may zoom in directly to the extent of them.

You will use the result from the wildcard search above (the one with the successful query of 'Sonia').

28. In the Main menu:
    Right-click the *RecreationalAreas…* map layer
    ➔ choose Selection
    ➔ Zoom To Selection.

    The Map view zooms automatically to the extent of the selected feature (Fig. 26)
    (*i.e.* the park areas maintained by Sonia Morgenstern).

Fig. 26 The Zoom To Selection function.
The Map view zooms in automatically to the geographic extent of the selected features.

Thanks for your attention!