ArcGIS Pro

Module 4 - Data Analysis

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Goals

- Learn some basic geospatial analysis through the use of various tools
- Solve a basic spatial problem using GIS

Calculating Distances

1 - Load your bikeways dataset

2 - click on various segments of lines from the "bikeways" dataset

3 - notice the various attributes



Calculating Distances

1 - right-click on the "bikeways" layer in the "Contents" pane and select"Attribute Table"



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Polyline 20111833	4492			736	0.000043	Strachan Ave	N	N	0	0	(D
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Calculating Distance

1 - with the "bikeways" attribute table open, click on the "Add" button to create a new field

3 - name the field "LineLength" with the alias "Line Length"

-ArcGIS Pro - Analysis 6 iii bikeways × 4 Field: 📰 Add 📰 Delete 📰 Calculate Selection: canadauz.svg HINUN TNOD Add Field X 200481 Add a new field in this table. 0 2000000 140503 U. light Number Format Domain Default Length 0 14134876 1413498 CZ. 0 0 0 0 0 20047161 1346057 Numeric P 110 \checkmark OE_FLAG_L OE_FLAG_L Text 2 1 OE_FLAG_R OE FLAG R Text 1 LONUML LONUML Long Numeric 1 HINUML HINUML Long Numeric LONUMR Numeric 1 LONUMR Long 1 HINUMR HINUMR Long Numeric FNODE FNODE Numeric 1 Long ~ TNODE TNODE Long Numeric 1 ONE WAY DI ONE WAY DI Short Numeric 20 1 DIR_CODE_D DIR_CODE_D Text 1 FCODE FCODE Long Numeric 100 1 FCODE DESC FCODE DESC Text \checkmark JURIS CODE 20 JURIS CODE Text Numeric OBJECTID OBJECTID \checkmark CP_TYPE CP_TYPE Text 50 1 RID RID Double Numeric 1 LineLength Line Length Double

4 - select "Double" as the "Data Type"

Calculating Distances

1 - right-click on the "Line Length" column and select "Calculate Geometry" Ξ

2 - in the "Geoprocessing" popup select "Length (geodesic)" in the "Property" column

3 - select "Kilometers" as the "Length Unit"

4 - click on "Run"

The column should now be populated with the line length of every segment of the bikeways layer.



Spatial Joins

1 - right-click on the "Neighborhoods" layer and select "Zoom to Layer"





Spatial Joins

1 - right-click on the resulting "NEIGHBORHOODS_spatial_Join" layer in the "Contents" pane and select "Attribute Table"

2 - examine the "Join_Count" column (this is the number of bikeway segments are in each neighbourhood"

3 - slide along the table until you find the "Line Length" field

4 - right-click on the column and select "Sort Descending"

Which Toronto Neighbourhood has the longest total KMs of bikeways?



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Spatial Joins method II

1 - right-click on the "bikeways" layer
and select "Joins and Relates" →
"Spatial Join"

2 - in the "Geoprocessing" popup, select "NEIGHBORHOODS_WGS84" in the "Join Features" option

3 - give the name "bikeways_SpatiaJoin" to the resulting joined layer

4 - Join Operation to "Join one to many" and Match option to "Within"

5 - click "Ok"



Spatial Joins method II

1 - right-click on the new joined layer "bikeways_SpatialJoin" and select // "Attribute Table"

Examine the attribute data. You will notice that the city wards data are now attached to each bike lane



Summarizing statistics

1 - in the new "bikeways SpatialJoin" attribute table, right-click on the "Line Length" column and select "Summarize"

2 - in the Geoprocessing popup, name your summary table "bikeways SpatialJoin Statist length"

3 - in the "Case field" option, select "AREA NAME"

4 - in the "Statistic Type", select "Sum"



^{5 -} note the name of the "Output Table"

Summarizing statistics

1 - right-click on the resulting table in the "Contents" pane and select "Open"

This table has one entry for each Toronto Neighbourhood. Each entry has the number of "bikeways" segments (FREQUENCY) within the Neighbourhood and a "SUM_LineLength", which is the total amount of Kilometres of "bikeways" are in that neighbourhood.

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Expressway		_	▲ OBJECTID	AREA_NAME	FREQUENCY	SUM_LineLength
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🕂 Major Railwa	14	Create Cł	iart 🕨	Banbury-Don Mills (4	28	3.034035
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- Minor Arteria	+=	Dicelay V	/ Data	Bay Street Corridor (7	13	1.614285
- Minor Arteria	XY		T Data	Bayview Village (52)	9	1.355025
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Summarizing statistics

1 - right-click on the "SUM_LineLength" column and select ______" "Sort Descending"

You can see that the "Rouge (131)" neighbourhood has the most kilometres of bikeways in Toronto

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23	Danforth East York (59)	65	6.284881		Calculate Geometry
36	High Park-Swansea (41	4.946701	ullu	Statistics
29	Edenbridge-Humber	36	4.889906	2	Summarize
98	Woburn (137)	38	4.823141	P.	Fields
91	Waterfront Commun	71	4.104392		

Charts

1 - right-click on the new summary table once again in the "Contents" pane and select "Create Chart" \rightarrow "Bar Chart"

2 - under "Category or Date", select "AREA_NAME" and under "Aggregation", select "Sum"



Charts

1 - click on "Data Labels"

2 - in the newly created chart, click on the "Axes" option and select "Rotate chart"





1 - in Windows, navigate to the
"ArcGISWorkshop" → "data" →
"Neighbourhood_Profiles" folder and double-click on the file
"2016_neighbourhood_profiles.csv"

2 - right-click on the "NEIGHBORHOODS_WGS84" layer in the "Contents" pane and select "Attribute Table"

3 - compare the two. What might be some of the issues here?*

*Hint - the spreadsheet file has the neighbourhoods listed in individual columns. The GIS file has the neighbourhoods all in one column





1 - click the first cell (A1) at the top-left of the table

2 - while holding down the shift key, click the last cell (EO2384)

3 - click on "Copy"



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	2351 1	.447 1	,539 3,1	31 2,291	867	2,532	7,149	4,106	4,603	4,188	2,855	1,640	3,785	6,023	2,061	2,639	8,114	1,231	842	1,642	970	1,045	4,426	1,969
	2352 5	,540 3	,635 6,8	5,885	2,765	6,260	15,080	10,130	11,980	10,515	7,045	4,220	9,595	17,185	6,120	6,760	19,565	3,805	2,465	4,670	3,065	3,000	11,320	4,895
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	2365 12	,734 2	,575 2,7	5,863	6,081	3,181	7,884	2,728	2,317	2,770	2,631	2,740	2,837	5,557	5,347	4,150	2,403	5,643	4,331	6,635	12,435	16,766	2,227	3,244
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	2377 12	,595 7	,115 8,9	8,875	2,955	9,970	17,595	17,475	20,390	13,660	9,970	7,305	17 830	20,140	7,870	13,920	30,665	7,605	4,690	7,930	5,785	5,660	14,720	9,125
	2378 7	,625 2	,435 9,8	6,635	3,535	6,365	45,930	8,050	10,945	11,225	6,560	3,285	8,385	27,855	8,070	7,020	19,235	3,920	2,710	4,700	5,450	6,195	11,400	4,290
	2379 5	,405 1	,470 5,0	4,215	1,775	4,215	21,170	5,835	6,195	6,300	4,325	2,390	5,585	12,880	4,305	4,740	11,975	2,920	2,100	3,355	3,020	3,895	6,435	2,940
	2380 2	,215	960 4,7	2,415	1,765	2,150	24,770	2,210	4,745	4,910	2,235	890	2,805	14,980	3,765	2,270	7,260	985	620	1,350	2,425	2,310	4,965	1,345
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1 - delete the first three lines, and the fifth line of the spreadsheet

2 - you will notice that our spreadsheet now has the neighbourhood identifiers in columns

3 - close the spreadsheet (you can save it if you wish, but a saved version has already been created for you in the same folder called "2016_neighbourhood_profiles_transp osed.xlsx" \

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1 - In ArcGIS Pro, turn on the "Catalog" pane under the "View" menu

2 - in the "Catalog" pane, navigate to the "Neighbourhood_Profiles" folder

3 - expand the

"2016_neighbourhood_profiles_transp osed.xlsx" spreadsheet and select and drag into the map, the tab named "_2016_neighbourhood_profiles_tra\$"

4 - right-click on

"_2016_neighbourhood_profiles_tra\$" in the "Contents" pane and click on "Open"

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1 - right-click on the / "NEIGHBORHOODS_WGS84" layer and select "Attribute Table" and compare the geography columns between this table and the spreadsheet

2 - notice that there are similar fields, but no common fields. "AREA_S_CD" in the boundary file is a text field. "Neighbourghood_Number" in the spreadsheet is a number field. ArcGIS Pro will not match these together despite having the same number. The column with the names of the neighbourhoods would not work either because they are not written the same way

Fie	ld:	Add	🛛 Delete 🕎 C	alculate	Selection: 🐙 Zoom To 📑 Switch
4	FID	Shape	AREA_S_CD ·	AREA_N	NAME
	41	Polygon	001	West Hu	umber-Clairville (1)
	98	Polygon	002	Mount	Olive-Silverstone-Jamestown (2)
	7	Polygon	003	Thistlet	own-Beaumond Heights (3)
	103	Polygon	004	Rexdale	-Kipling (4)
/	78	Polygon	005	Elms-O	d Rexdale (5)
	44	Polygon	006	Kingsvie	ew Village-The Westway (6)
	110	Polygon	007	Willowr	idge-Martingrove-Richview (7)
	58	Polygon	008	Humbe	r Heights-Westmount (8)
	64	Polygon	009	Edenbri	dge-Humber Valley (9)
	30	Polygon	010	Princess	-Rosethorn (10)
	82	Polygon	011	Eringate	e-Centennial-West Deane (11)
	125	Polygon	012	Marklar	nd Wood (12)

Open Table (Ctrl+T)

Open the attribute table for this

Copy

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Attribute Table

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Design

Drawing Order

✓ Topographic

Map

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	Mount Olive-Silverstone-Jamestown	2	NIA
_	Thistletown-Beaumond Heights	3	NIA
	Rexdale-Kipling	4	No Designation
	Elms-Old Rexdale	5	NIA
	Kingsview Village-The Westway	6	NIA
	Willowridge-Martingrove-Richview	7	No Designation
	Humber Heights-Westmount	8	Emerging Neighbou
	Edenbridge-Humber Valley	9	No Designation
	Princess-Rosethorn	10	No Designation
	Eringate-Centennial-West Deane	11	No Designation
	Markland Wood	12	No Designation
	Etobicoke West Mall	13	No Designation
	Islington-City Centre West	14	No Designation
	Kingsway South	15	No Designation
	Stonegate-Queensway	16	No Designation

There are many ways to tackle this problem, but in this case we will create a new numeric field for our neirghbourhood ID in our shapefile

1 - in the "NEIGHBORHOODS_WGS84" / attribute table, click on the "Add Field" icon

2 - name your field "ID" and select "Double" as the "Data Type"

3 - under	the	"Fields"	menu,	click	on
"Save"					

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. .

2 - double-click on the "AREA_S_CD" field to populate the "ID =" box to read "!AREA_S_CD!" This operation will convert our text field to a numeric field.

3 - click on Run

FID	Shape	AREA_S_CD ·	AREA_NAME	ID	22.272	(2) Y		1		
41	Polygon	001	West Humber-Clairvi	0 24	Sort Ascend	ding				
98	Polygon	002	Mount Olive-Silverst	0 A+	Sort Descer	nding	Ge	eoprocessing		* ⊕
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103	Polygon	004	Rexdale-Kipling (4)	0	Hide Field(s)		-) Calcul	ate rielu	-
78	Polygon	005	Elms-Old Rexdale (5)	0		-,	Pa	arameters Environmen	ts	0
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110	Polygon	007	Willowridge-Marting	0	Calculate G	Calculat		NEIGHBORHOODS_WGS84	<u> </u>	-
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Our two tables now contain matching columns and we can now join the two

layers.

ArcGIS Pro - Analysis		rsis				
NEIG	HBORHO	ODS_WGS84 ×	🖷 Fields: NEIGHBOR	HODS_WGS84 (Mag2)		
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41	Polygon	001	West Humber-Clairvi	West Humber-Clairvi	1	
98	Polygon	002	Mount Olive-Silverst	Mount Olive-Silverst	2	
7	Polygon	003	Thistletown-Beaumo	Thistletown-Beaumo	3	
103	Polygon	004	Rexdale-Kipling (4)	Rexdale-Kipling	4	
78	Polygon	005	Elms-Old Rexdale (5)	Elms-Old Rexdale	5	
44	Polygon	006	Kingsview Village-Th	Kingsview Village-Th	6	
110	Polygon	007	Willowridge-Marting	Willowridge-Marting	7	
58	Polygon	008	Humber Heights-We	Humber Heights-We	8	
64	Polygon	009	Edenbridge-Humber	Edenbridge-Humber	9	
30	Polygon	010	Princess-Rosethorn (Princess-Rosethorn	10	
82	Polygon	011	Eringate-Centennial	Eringate-Centennial	11	
125	Polygon	012	Markland Wood (12)	Markland Wood	12	
32	Polygon	013	Etobicoke West Mall	Etobicoke West Mall	13	
11	Polygon	014	Islington-City Centre	Islington-City Centre	14	
52	Polygon	015	Kingsway South (15)	Kingsway South	15	
4	Polygon	016	Stonegate-Queensw	Stonegate-Queensway	16	

NEIGHBORHOODS_WGS84	16_neighbourhood_profiles_tra\$	K 🖷 Fields: NEIGHBC	ORHOODS_WGS84
Field: Add Delete Calculate	Selection: 🐙 Zoom To 📲 Sw	vitch 📃 Clear 戻 Dele	ete 🗐 Copy
⊿ Characteristic	Neighbourhood_Number •	TSNS2020_Designatic	Population_2016
West Humber-Clairville	1	No Designation	33312
Mount Olive-Silverstone-Jamestown	2	NIA	32954
Thistletown-Beaumond Heights	3	NIA	10360
Rexdale-Kipling	4	No Designation	10529
Elms-Old Rexdale	5	NIA	9456
Kingsview Village-The Westway	6	NIA	22000
Willowridge-Martingrove-Richview	7	No Designation	22156
Humber Heights-Westmount	8	Emerging Neighbour	10948
Edenbridge-Humber Valley	9	No Designation	15535
Princess-Rosethorn	10	No Designation	11051
Eringate-Centennial-West Deane	11	No Designation	18588
Markland Wood	12	No Designation	10554
Etobicoke West Mall	13	No Designation	11848
Islington-City Centre West	14	No Designation	43965
Kingsway South	15	No Designation	9271
Stonegate-Queensway	16	No Designation	25051

1 - right-click on the "NEIGHBORHOODS_WGS84" layer in the "Contents" pane and select "Joins and Relates" → "Add Join"

2 - select "ID" field as the "Input Join Field" from the "NEIGHBORHOODS_WGS84" table, and select the "Neighbourhood_Number" from the

"Join Table",

"2016_neighbourhood_profiles_tra\$"

3 - Click on "Run"



1 - open the "NEIGHBORHOODS_WGS84" "Attribute Table". You will notice that now all the data from the spreadsheet are now available for each of the Toronto neighbourhoods.

Now let's map some of these variables.

2 - right-click on the "NEIGHBORHOODS_WGS84" layer and select "Symbology"

1 - in the "Symbology" popup window, select "Graduated Colors" under — "Primary symbology"

2 - select "Population_2016" as the "Field"

3 - select "<u>Natural Breaks (Jenks)</u>" as "Method"

4 - choose a "Color scheme" -

5 - Examine the resulting map

nary symbology					
le Symbol			-		
nbolize your layer using one symbol					
Single Symbol Draw using single symbol.	Symbology - NEIGHBOURHOODS_UTM6			- Ţ >	
nbolize your layer by category		<u>ин</u> /			
Unique Values Draw categories using unique values of one or multiple fields.		Ξ			
bolize your layer by quantity	Primary symbology				
Draw quantities using graduated colors.	Graduated Col				
Graduated Symbols	oradated con			-	
Unclassed Colors	Field	Population_2016		• 🗙	
Draw quantities using an unclassed color gradient.	Normalization	<none></none>			
 Propertional Symbols Draw quantities using proportional symbols. 	Method Natural Breaks (Jenks) Classes 5				
Dot Density Draw quantities using dot density.				•	
bolize your layer using symbol attributes	Color scheme				
Dictionary Draw features using a symbol dictionary and rule set.	·				
	Classes				
	Classes Hist	ogram Scales			
				More *	
	Symbol	Upper value 🔺	Label		
		≤ 13154.0	≤13154		
		≤ 18675.0	≤18675		
		≤ 26274.0	≤26274		
		< 36635.0	<36625		
		5 30023.0	530023		
		≤ 65913.0	≤65913		

31

Since we have not "normalized" our data, what does is this map really _____expressing since we are comparing just population numbers?



1 - Normalize your data using the field "Land Area"

2 - This now gives us population density

3 - "Natural Breaks" group data into natural groups within the data range.
Using this method, features are divided into classes where there are relatively large differences in values.
Since the least populated neighbourhood in Toronto is about
10% of the most populated one, this is a good starting point to classify our data.



1 - change the number of "Classes" to "7"

You can see that this provides a little more precision to demonstrate where the highest densities are located.

2 - Return the "Classes" to "5"



1 - Change the "Method" for classification to "Quantile"

Quantile distributes evenly the number of features (or entries in the attribute table) within the number of classes regardless of the jumps in values. Best suited for linear data, this is not a particularly good choice for Toronto's big differences in population and density across all of its geography.



1 - Change the "Method" for classification to "<u>Equal Interval</u>"

Equal Interval divides the attribute data into equal sub-ranges. For example, if you have values ranging from 0 to 100 and you specify 5 ranges, values will vary from 0-25, 26-50, 51-75 and 76-100. Unlike quantiles, the number of features within a class will differ. Because the density of Toronto's population is mostly in the southern core, most values end up displayed in few classification colours.



1 - return your map to "Single Symbol" classification under the "Primary symbology" option

2 - right-click on the "NEIGHBORHOODS_WGS84" layer in the "Contents" pane and select "Copy"

Graduated symbols show quantitative differences between mapped features by varying the size of symbols. Data are classified into ranges that are each assigned a symbol size to represent the range. See

https://pro.arcgis.com/en/pro-app/latest/help/mappi ng/layer-properties/graduated-symbols.htm







1 - in the "Symbology" popup window, select "Graduated Symbols". <u>Graduated Symbols</u> show quantitative differences between features by varying the size of the symbols.

2 - use "Population_2016 for the "Field" and normalize by "area" and play around with different classification "Methods"; "Natural Breaks", "Quantile" and "Equal Interval" and with different "Classes" 5, 6 or 7.



Graduate colors do not work well with raw population numbers. However, graduated symbols do work well with raw populations.

1 - change the "Normalization" to your symbology for your "Graduated Symbols" to "<None>"



1 - change the "Symbology" of the second copy of "NEIGHBORHOODS_WGS84" to "Graduated Colors" with the 2016 population normalized by area using the "Natural Breaks (Jenks)" "Method"

Our resulting map is interesting because it allows for displaying both full population numbers and the population density at the same time.





Proportional Symbols

1 - Return to "Single Symbol" for the second neighbourhood layer and change the "Primary symbology" to "Proportional Symbols" on the other

Proportional Symbols are used to show relative differences in quantities among features. Unlike graduated symbols, proportional symbols represent quantitative values as a series of unclassed symbols, sized according to each specific value.



Dot Density

1 - change the "Primary Symbology" to "Dot Density" and select "Population_2016" as the Field to represent

2 - Change around the values for the "Dot Size" and the "Dot Value". "Dot Value" in this case means the number of people the dots represent.



Discussion

In your estimation, which better represents the population density of the City of Toronto? Graduated Colours, Graduated Symbols, Proportional Symbols or Dot Density?



Graduated Colours

Proportional Symbols



Graduated Symbols

Dot Density

Solving Problems with GIS

Problem: how do we find an ideal location to set up a new bicycle shop in Toronto where there are no established stores, but within a short distance of bicycle traffic in Toronto?

1 - In a new map, start by loading the "BICYCLE_SHOP_WGS84.shp" shapefile from the "bike_shops" folder





Erase

Our buffer represents areas we do not want to build a new bike shop in since the areas are already serviced. We need to "erase" these from our possible locations.

1 - in the "Geoprocessing" window search box, type "erase"

2 - click on the "Erase" toolbox



Erase

1 - your "Input Features" are the "NEIGHBOURHOODS_WGS84" layer from which we want to erase the buffer we just created "Bike_shop_buffer"

2 - provide a name from the resulting neighbourhoods "Output Feature Class" "NEIGHBOURHOODS_Erase_Buffers"

3 - click on "Run"



Box Grove

Cherryw

Buffering Lines

We now want to find areas that are within 1KM of our "bikeways" features created earlier. To accomplish this, we will create a new buffer, but we will not delete from this one, we will instead "clip" out our city layer from our resulting buffer.

1 - in the "Geoprocessing" popup, search for the "buffer" tool again, but this time build a buffer of 1 km around all bikeways features

2 - name your "Output Feature Class", "bikeways_Buffer"



Clipping

Our new buffer represents areas that are of good potential because they are close to bikeways. But we need to combine these results with what we erased earlier so we can get closer precision to finding potential sites.

1 - search for the "Clip" tool

2 - clip out of the "NEIGHBOURHOOD_Erase_Buffers" layer, the new "bikeways_Buffer"

The results now show areas that do not have a bike shop within 1km but that are within 1km of a bikeway feature.



Select by Location or Intersect

1 - add the "ADDRESS_POINT_WGS84.shp" shapefile to your map

This layer represents all address locations in the city. The addresses contain "land use" categories* for each location. Let's search for commercial locations that fall within our ideal areas identified.

*Note that as of the summer of 2021, this data has been "washed" out of the dataset



Select by location or Intersect

1 - under the "Map" menu, click <u>"Select</u> by Location"

2 - in the "Geoprocessing" popup, make sure your "Input Feature Layer" is set to "ADDRESS_POINT_WGS84"

3 - select "Completely within" under the "Relationship"

3 - under "Selecting Features" select "NEIGHBORHOODS_Erase_Buffers

This query will be looking for addresses that fall complete within our buffered, erased, and clipped layer "NEIGHBORHOODS_Erase_Buffers_"





Select by Attribute

Now we want to find only "Commercial" locations within the addresses found within our ideal area.

1 - Under the "Map" menu, click on "Select by Attributes"

2 - in the "Geoprocessing" popup, make sure you are querying the "ADDRESS_POINT_WGS84" layer and that your "Selection Type" is "Add to the current selection"





Select by Attributes

Let's create a new layer from these results.



Site Selection

1 - right-click on the "ADDRESS_POINT_WGS84" layer, select "Data" → "Export Features"

2 - provide a name for the resulting export feature



Site locations

1 - label your current bicycle shops byright-clicking the layer in the"Contents" pane and selecting "Label"

2 - zoom into your map



Site selection

Now it's just a matter of refining your searches by finding out which of these locations are for rent or for sale!

One could of course add new queries into the equation by looking at population numbers and income ranges, bike rack locations (available from the city) etc.



End of Module 4