**GIS--OR GEOGRAPHIC INFORMATION SYSTEMS--IS A TOOL** for coordinating data you can map. It can assist you when making location decisions and thinking about how space impacts variables on the landscape. Today we will use GIS to screen an area for the viability of a recycling market.

HERE'S OUR SCENARIO. As innovators we have discovered a new insulation technology that demands cleaner waste streams of recycled paper and certain plastics. We know the City of Chicago's Blue Cart Program contracts with different waste hauler providers to collect residential recyclables for six zones in the City[1] (see image at right).

Currently Chicago's residential recycling program asks its residents to put all qualified recyclables into one large blue bin that is picked up in alleys or curbsides. The waste stream is mixed and collected in trucks that compact the recyclables. Recyclables are eventually driven to a sorting center outside the Chicago city limits[2]. Incredibly, this program was finally expanded to include the whole city--a total of 600,000 residential buildings with 1 to 4 dwelling units--as recently as 2013.
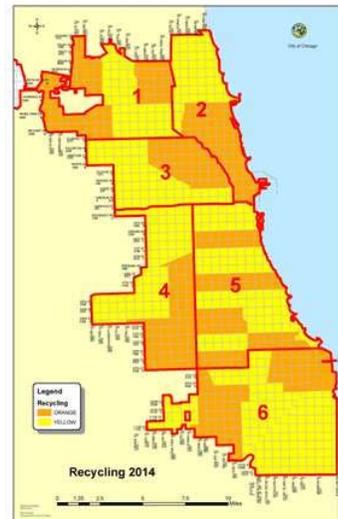
Waste is inevitable even in recycling[3]. Even with advances in mechanical separation of single-stream recycling collection (as used in Chicago), glass shards and food waste (grease and food particles on paper) pollute otherwise recyclable materials.

Your boss wonders if we could get *more and cleaner paper and plastic recyclables* if instead of Blue Carts, we could collect material from drop off sites. Chicago manages 37 drop off sites. We are interested in experimenting in one recycling zone (Area 3) to see if we can convince residents to drop off their waste. We also want to know the *fuel energy impact* on recycling this way.

Your boss learned that he has 10 minutes to speak with the Mayor of Chicago this afternoon at 1 p.m. You have been given the task to calculate the fuel energy costs of collecting recyclables using the Blue Cart method verses using drop off sites. (So much for your lunch!) If costs are competitive, then the project has merit to proceed and your boss will lobby strongly.

What do you do? (a) Cry. (b) Start networking on Linked-In. (c) Turn to GIS.

We will use GIS to do some back-of-the-envelope calculations. In the process we will find adequate data, record our assumptions, and give your boss the results.

COLLECTING DATA. Lucky for us, the City of Chicago maintains a Data Portal https://data.cityofchicago.org/
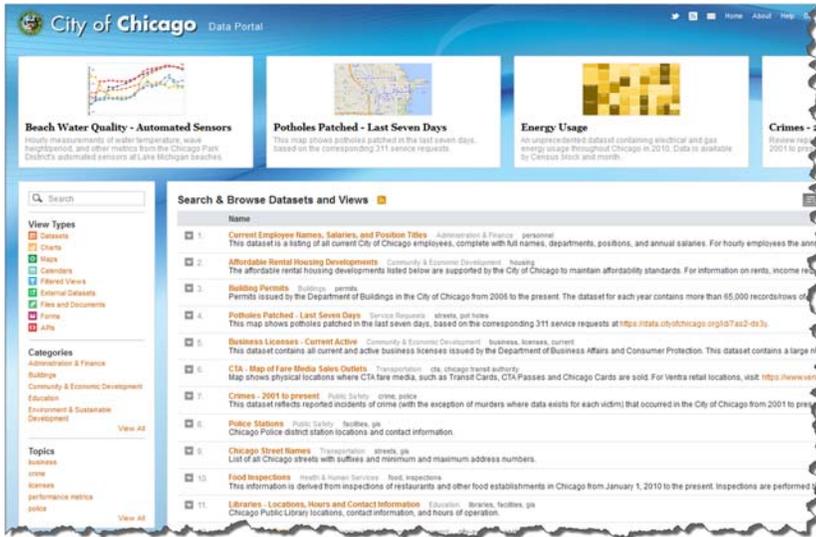
At this site we will download the data we think we need for this project: Chicago boundary, Blue Cart Zones, Chicago streets, Census block geography, current locations of recycling drop off sites.

From the US Census Bureau's website, we will get the count of households by census block from the 2010 decennial census.

Even luckier for you, you have a pal who already pre-processed most of this data (for a couple of beers, of course!). All you have to do is finish data processing and hand your boss some figures and become a GIS superhero.

NOW FOR THE EXERCISE.

Go to xxxxxxxxxxxxxxxx to download the work your very best friend did for you. She created what is called a "map package" in ArcGIS parlance. We will continue to use ArcGIS Desktop (version 10.1) to complete our work.

HERE ARE OUR BROAD TASKS:

A. We will first take a look at the original data your friend downloaded.
B. Next we will focus on Area 3. Often, we get more data than we need for our work. In this step we eliminate what we do not need.
C. We will run tools and processes to calculate the number of vehicle miles.
D. We will use Excel to do a few back-of-the-envelope calculations.

A. EXAMINE OUR DATA:

1. To open the map package double-click on the file you downloaded.

You should be looking at an ArcGIS map document.
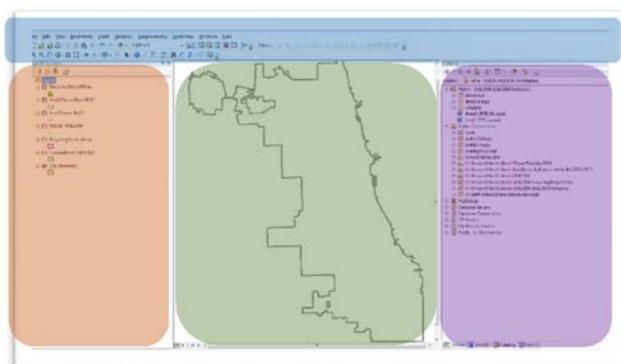
There are 4 major areas of this interface.
Blue: Some menus and toolbars
Orange: The Table Of Contents (TOC) pane
Green: The map canvas
Purple: Additional panes like Catalog, Search

2. We will spend some time toggling layers in the TOC on and off and examining our data.

> **Knowledge nugget:**
> It is critical whenever using new data to become familiar with it. The best scenario is to have full documentation, sometimes called *metadata*. *Data dictionaries* define the content of attributes or variables associated with mapped features. It is not everything you need to know, but it is better than nothing.

Sometimes you don't get much information about the data at all. In this case, there isn't much information, but your best friend has worked with these data before, so she can tell you something about them.

name of layer in TOC	definition
City_Boundary	Chicago boundary
RecyclingServiceAreas	Blue Cart Zones
TRANS_2008APRIL	Chicago streets
RecyclingDropoffSites	Current locations of recycling drop off sites maintained by Chicago
CensusBlockTIGER2010	Census block geography

B. FOCUS ON AREA 3:

3. We are interested in only recycling Area 3 from the **RecyclingServiceAreas** layer.
We will see how to "select" it. Selecting data temporarily constricts the data. This is useful and using this technique, we will create layers in the TOC that are limited to Area 3.

4. Bring in **Area3RecyclingBndry**.
Your friend already extracted the Area 3 Zone from **RecyclingServiceAreas.**
You may need to resymbolize it:
    Make the Fill Color *NO color* and the Outline Width *2*.
We will use this layer to select from streets and census blocks to create the two layers we need.

5. Select just the streets in Area 3.
This type of selection--called *Select By Location*--is unique to GIS.

> **Knowledge nugget:**
> The power of GIS software allows us to use the locations of features in ways our brains do.
> GIS allows us to "see" and select features that are related to other features by *proximity*, *containment*, and *adjacency*. We cannot easily do this with other technology.

From the Selection Menu > *Select By Location*
    Selection method: **Select Features From**
   Target Layer: **TRANS_2008APRIL**
    Source layer: **Area3RecyclingBndry**
    Spatial selection method: **Intersect The Source Layer Feature**

Open the attribute table of **TRANS_2008APRIL** and see there are **8535 out of 55,681** selected records**.**

> **Knowledge nugget:**
> Keep your eye on the number of records and selected records in each layer ALL THE TIME.

Notice the map and the table both have cyan-colored records. This special color means these records and corresponding features are selected.
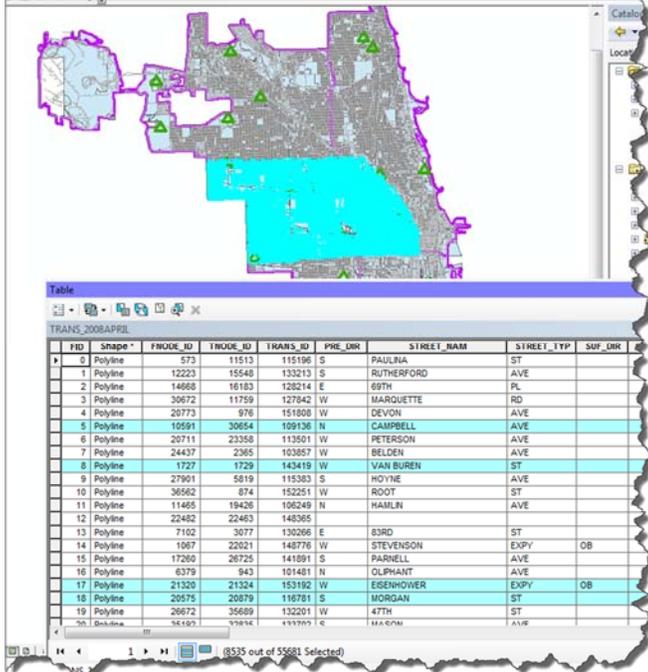
Normally we would export these records to a new layer. But that has already been done for us.

First clear the selection by clicking this box:

Next bring in the layer **Area3Streets**
Make sure you can see the new layer.
You may wish to uncheck some other layers to aid visibility.

6. Zoom to your new street layer.
In the TOC, Right click on the layer **Area3Streets** > *Zoom To Layer*

If you are familiar with Chicago, you will notice there are some expressways (Kennedy and Eisenhower) in this area in addition to the on/off ramps associated with these expressways.
Because we are routing waste removal trucks, we will eliminate these expressways.
We have done that for you by selecting streets with certain attributes for expressways.

To see the result, bring in the **Area3StreetsNoX** layer.
If you position the two street layers carefully, you will see the 2nd file has fewer street segments.
The attribute tables tell the same story, but with record counts.

name of layer in TOC	number of records
Area3Streets	8535
Area3StreetsNoX	7972

6. Select just the Census blocks in Area 3.
We would do another *Select By Location* as we did in the previous step. In the interest of time, we will bring in the layer that has been selected and exported for us called **Area3CensusBlock2010**
How many records? **7534**

> **Knowledge nugget:**
> Every Census block in the United States has a unique 15-digit code assigned to it which is a combination of several codes "concatenated" together: State, County, Tract, Block

Census blocks are the gateway to Census information like the *number of households* within. This important statistic will indicate how many car recycling trips originate from that block.
We ultimately want to derive a distance from each household to the nearest recycling center.
One way to do this is to convert Census block *polygons* to Census block *centroid points*.

7. Create Census block centroids.
Find the Search pane in the group of panes at the right of the interface. Search for the tool *Feature To Point*

Again, in the interest of time, we may not complete the tool interface, but understand that for each Census block, this tool will create a point and keep all the attribute information for it.
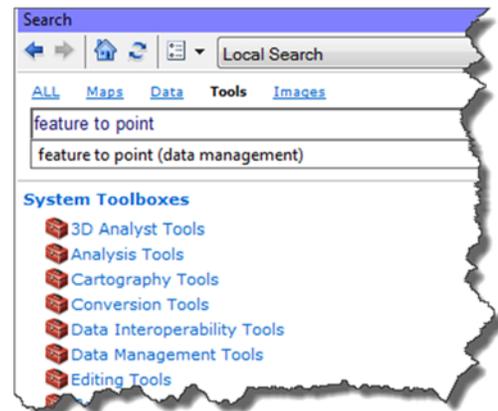
8. Bring in **Area3CensusBlock2010PtsHH** layer to see the results of the *Feature To Point* tool on the Census block polygons.
How many records? **7534**

9. Attach the number of households to each Census block.
Again, in the interest of time, we previously downloaded SF1 tables of information from the 2010 Decennial Census from the American FactFinder website of the US Census Bureau.

We downloaded all the Census block data for numbers of households (occupied housing units) for Chicago, and then attached them to the Census block point file.
If there is time, we will do this.
[If not, we used another tool called *Join* to put tabular data onto the points file.]

To see the extract of the American FactFinder file, bring in **ChicagoBlockHH_2010SF1.dbf**
This is a .dbf data file with **46,324 records** (the number of 2010 Census blocks in Chicago).
Open the table to see the information.

C. CALCULATE VEHICLE MILES:

10. Calculate the lengths of all the street segments.
Our assumption is that recycling trucks eventually travel the distance of all streets in the area.
Open the attribute table for **Area3StreetsNoX**

William "Max" Dieber, Director; Nina Savar, GIS Coordinator
Urban Data Visualization Laboratory, UIC
maxdbr@uic.edu • nsavar@uic.edu
www.uic.edu/cuppa/udv

Scroll all the way to the right.
The last two fields are called *RoadFt* and *RoadMi*. We calculated for you the length of each road segment in feet and in miles.
You will repeat the calculation.

From the *Table Options* button (upper left button) > *Add Field...*
  Name: **RoadMile**
  Type: **Double**
A new attribute field at the right side of the table is added.
To populate the field with the length of the street segments:
  Right click on the field header **RoadMile**
  Calculate Geometry...
  Click YES to calculate outside an edit session
  In the popup: Property = **Length** and Units = **Miles US [mi]**
Click OK.

11. Calculate the distances from each Census block point to the nearest Recycling Center.
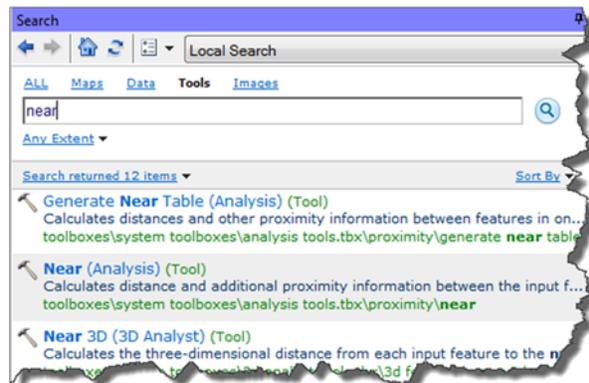To do this we need another tool.
In the Search pane, search for "near".

You get several options.

We want the tool **Generate Near Table**.
This tool creates a table of distances (as the crow flies) from each Census block point to the nearest recycling center.

Complete the tool interface:
  Input Features: **Area3CensusBlock2010PtsHH**
  Near Features: **RecyclingDropoffSites**
  Output Table: **area3blkptdropoff**
  Leave the remaining defaults.

12. Open the new table **area3blkptdropoff**
How many records? **7534**
[Do you see a pattern that all Census block files have the same number of records?]

13. Add these distance to the Census blocks.
These distances are in feet.
They need to be "joined" to the Census block they belong to.
In the interest of time, we did this for you.
Bring in the layer **Area3CensusBlock2010PtsHHDist**
Open its attribute table.

Scroll all the way to the right.
The last 7 columns are the result of the *Join* plus the addition of two new fields: **HHallDist, HHhafDist**

> **HHallDist** and **HHhafDist** are the distances in US Miles, weighted by the number of households in the block times 2 for the round trip.

If you were to repeat this, you would first add a new field, Type = Double, for the total number of households.
    Right click on the new field header > *Field Calculator...*
    Construct a calculation:
      ([NEAR_DIST]/5280) * [hshld2010] * 2

D. DO QUICK DISTANCE CALCULATIONS:

14. We will use Excel to do our final calculations.
Open Excel.
Create a framework like this:

	A	B	C	D
1		**BlueBin**	**DropOff All**	**DropOff Half**
2	miles			
3	MPG	2.8	20	20
4	gallons			
5	cost/gal	$ 4.50	$ 3.50	$ 3.50
6	cost			

In this worksheet we are expressing our assumptions.

Assumptions:
Blue Cart trucks will drive all the streets once to collect all recyclables.
We will not include miles traveled to/from recycling sorting center.
Autos will drive to and from recycle center.
All households will participate in drop-off recycling.
Half of all households will participate in drop-off recycling.
Residential auto fleet gets on average about 20 miles per gallon.
Trash trucks get about 2.8 miles/gallon[4].
Cost of diesel fuel in Chicago-- about $4.50[5].
Cost of regular gas in Chicagoland -- about $3.50[6].

15. Now let's complete the Excel table by getting the *mileages* from our GIS layers.
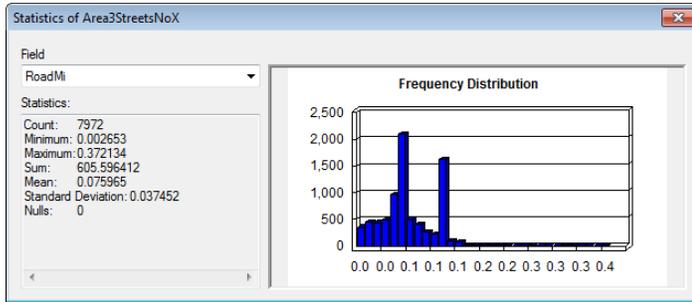Open the **Area3StreetsNoX** layer.
This is the layer of all the streets with our calculation of segment length.
    Scroll all the way to the right.
    Right click on the field **RoadMi**.
    Click *Statistics...*

Copy the number to the right of "Sum:"
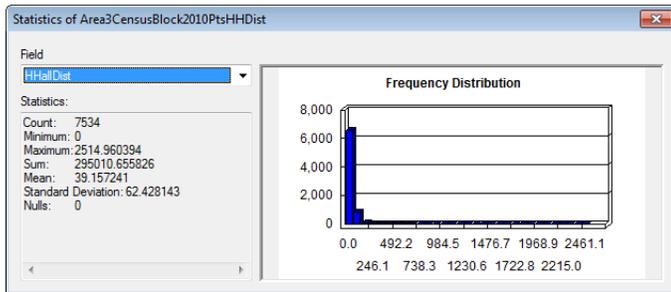Paste it into your Excel worksheet in cell B2.

Close the table.

Open the **Area3CensusBlock2010PtsHHDist** layer.
This is the layer of all Census block points with our calculation of distance to nearest drop off center.
    Scroll all the way to the right.
    Right click on the field **HHallDist**. [this is the distance traveled if all households recycled]
    Click *Statistics...*

Copy the number to the right of "Sum:"
Paste it into your Excel worksheet in cell C2.

Repeat for field **HHhafDist**.

16. Complete the spreadsheet.

	A	B	C	D
1		**BlueBin**	**DropOff All**	**DropOff Half**
2	miles	605.5964	295010.6	147505.3
3	MPG	2.8	20	20
4	gallons	216.2844	14750.53	7375.265
5	cost/gal	$ 4.50	$ 3.50	$ 3.50
6	cost	$ 973.28	$ 51,626.86	$ 25,813.43
7				

17. What will you advise your boss?
What other assumptions can you make for or against the collection of a cleaner recyclable waste stream?

Resources

[1] City of Chicago, Streets & Sanitation, Blue Cart Schedule and Maps.
http://www.cityofchicago.org/city/en/depts/streets/supp_info/recycling1/blue_cart_schedulesandmaps.html, accessed 14 Aug 2014.

[2] Why Can't Chicago Recycle? by Mick Dumke, 22 July 2010, Chicago Reader. http://www.chicagoreader.com/chicago/chicago-recycling-blue-carts-service/Content?oid=2135422, accessed 14 Aug 2014.

[3] Is what we're recycling actually getting recycled? by Josh Clark, circa 2008, HowStuffWorks,
http://science.howstuffworks.com/environmental/conservation/issues/recycling-reality.htm, accessed 14 Aug 2014.

[4] Greening Garbage Trucks: Trends in Alternative Fuel Use, 2002-2005, by James S. Cannon, 2006.
http://www.informinc.org/reportpdfs/st/GGTUPDATEFINAL.pdf, accessed 9 Aug 2014.

[5] ChicagoGasPrices.com, http://www.chicagogasprices.com/GasPriceSearch.aspx, accessed 14 Aug 2014.

[6] ibid.

Other resources

[7] City of Chicago Recycling: Blue Carts, Chicago Recycling Coalition, http://www.chicagorecycling.org/bluecarts.htm, accessed 14 Aug 2014

[8] Taking out the trash: Recycling in Chicago has a long way to go, by Rachel Cromidas, RedEye, April 21, 2014,
http://articles.redeyechicago.com/2014-04-21/news/49297402_1_trash-collection-blue-cart-program-recycling-bins, accessed 14 Aug 2014