

A test of ArcPro Network Analyst to perform route optimization

And site selection for a new depot reduce time cost of route

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Introduction

Last mile delivery is a well know concept in industries providing goods and services to clients. Last mile delivery is the end segment of a delivery route whether it be delivering good and services to customers/businesses or delivering commuters to places of work. An example would be commuters using trains/busses to get to a city center, but their place of work might still be out of walking distance. Many cities have started to introduce bike shares (Divvy Bikes in Chicago, or Capital Bikes in Washington D.C.), or car shares (Reach Now or Car To Go) as a means of Last Mile Delivery for Commuters. This concept is similar for delivery of goods to residential customers. Amazon Prime is one company that is responsible for changing the delivery expectation paradigm. According to Andre Pharand, global management consulting lead for the postal and parcel industry for Accenture, "[Amazon Prime] service has been growing 30% a year since 2011."(Kaplan, 2017). With more companies offering goods and services delivered it will become increasingly important for these companies to be efficient with time and cost to stay competitive with big companies. Furthermore, the study by Hajghasem and Abbas shojaie concludes that routing efficiency is the most significant factor in cost reduction during the delivery process (Hajghasem 2016).

This project examines the Last Mile Delivery problem using example data from a new farm-to-door grocery delivery company called The Local Milk Run. The Local Milk Run is unique in their business model in that all of their products are local to the area being served, so Last Mile Delivery is the only leg of the journey they deal with. The Local Milk Run uses a Google API in order to route pick-ups from vendors and deliveries to clients. This first stage of this project will test a sample route efficiency by using ArcPro Network Analyst and Esri's Network Dataset against the route produced by Google API. After that, a multi criteria site selection along with location allocation will be performed to attempt to increase delivery efficiency by increasing the number of supply depots as well as changing from the current depot location. Lastly, service area polygons will be produced to aid in choosing which new depot location should be considered first. We expect to find the routes created in ArcPro with the Esri's Network Dataset will be more efficient compared to the sample route. It is also likely that we will find significantly increased efficiency by adding more depots, and from the multi criteria site selection we will find the most ideal spots around Portland for these depots.

Introduction to ArcPro

ArcPro was used for all of the analysis in this project. As well as our final conclusions of the study we also expect to make some conclusions with our experiences using ArcPro.

Data and Methods

Part 1 Routes

For this study we used sample data from The Local Milk Run. We received a list of registered businesses (vendors), as well as a customer list of geographically fuzzed lat/long points to preserve customer confidentiality. We considered creating our own dataset for delivery locations but decided to use the fuzzed locations in order to preserve the approximate route times so we can more accurately compare results of an example route against a route we will create with ArcPro. We used Esri's Network Dataset that is available with ArcPro. In the USA they offer Predictive Traffic Service which their documentation describes as:

Predictive Traffic— Comprehensive street data with historical, live, and predictive traffic information is available. Viewing traffic or performing analyses in areas with predictive traffic data can take into account changing traffic conditions based on current, future, and past observations.

- ArcGIS REST API documentation, <https://developers.arcgis.com/rest/network/api-reference/network-coverage.htm>

The Network Dataset in the USA also includes traffic incidents and logistics attributes. Two sample routes from The Local Milk Run were used to create routes in ArcPro. Stops were imported using the sample route and given time per stop attribute, 3 minutes per delivery. The start time of the route was set to 8 AM (new feature in ArcPro) to keep consistent with the sample route from The Local Milk Run. The mode was set to "driving time" and the sequence was set to "preserve first and last stop", because the delivery truck has to start and end the day at the depot. No barriers were input.

Run

Import Stops

Mode: Driving Time

Sequence: Preserve First & Last Stop

Type: Custom Date & Time

Time: 8:00 AM

Date: 2/1/2018

Along Network

Directions

Analysis

Input Data

Travel Settings

Arrive/Depart Time

Output Geometry

Report

Geoprocessing

Add Locations

Parameters: Environment

Input Network Dataset Layer: Westside Found

Sub-List: Stop

Input Locations: Location

Field Mappings: Property

Name: Name

Field Name: Name

Default Value: Default Value

Sequence: Sequence

Time/Distance/Time: Time/Distance/Time

Service Area: 3000 Meters

Append to Existing Locations

Layer Properties: EastSide Route

General

Metadata

Source

Travel Mode

Name: Driving Time

Description: Models the movement of cars and other similar small automobiles, such as pickup trucks, and finds solutions that optimize travel time. Travel along one-way roads, avoids illegal turns, and follows other rules that are specific to cars. When you specify a start time, dynamic travel speeds based on traffic are used where it is available.

Type: Type

Time: Custom Date & Time

Not Using Time

Today

Current Date & Time

Day of Week

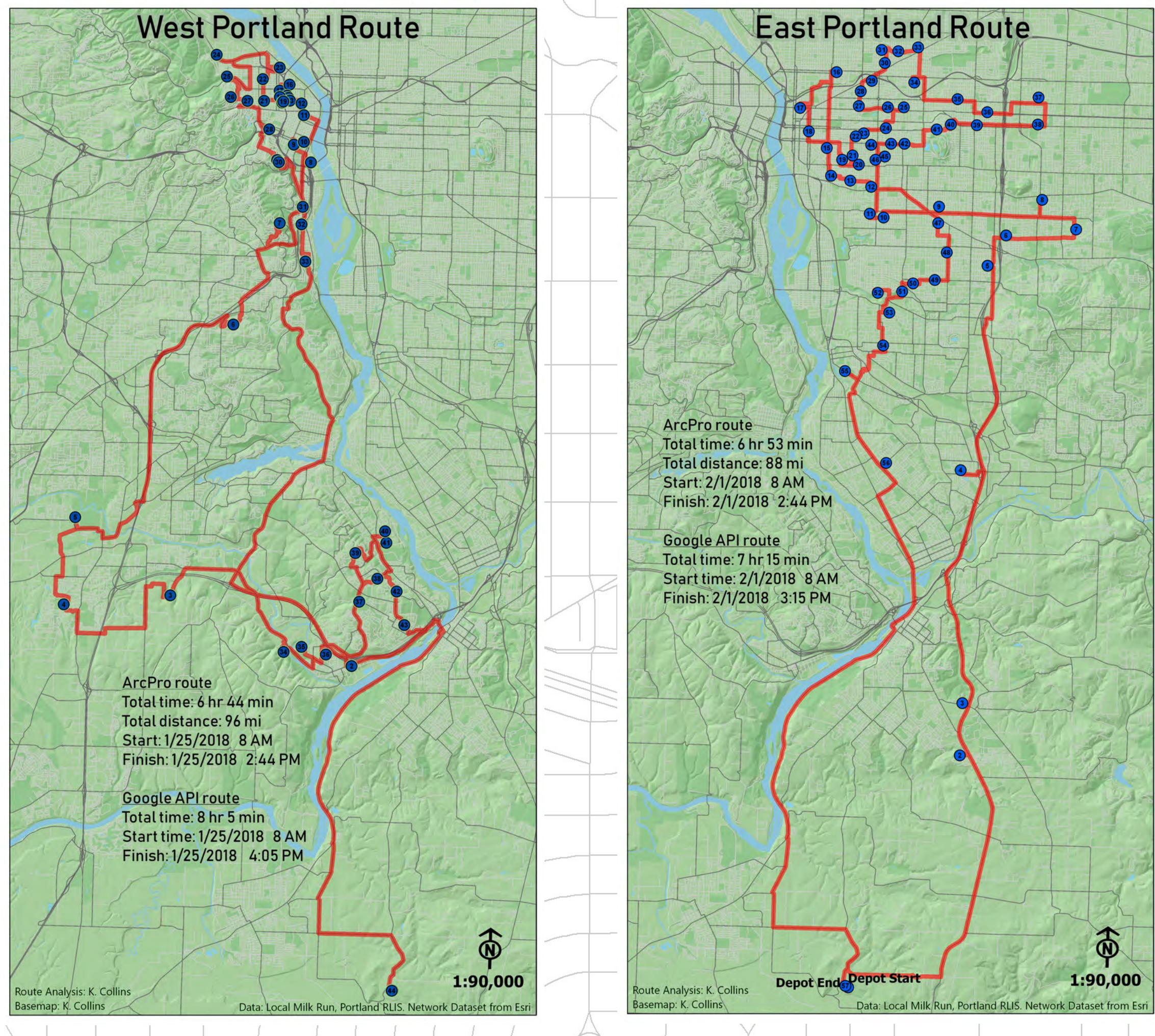
Route optimization options in ArcPro



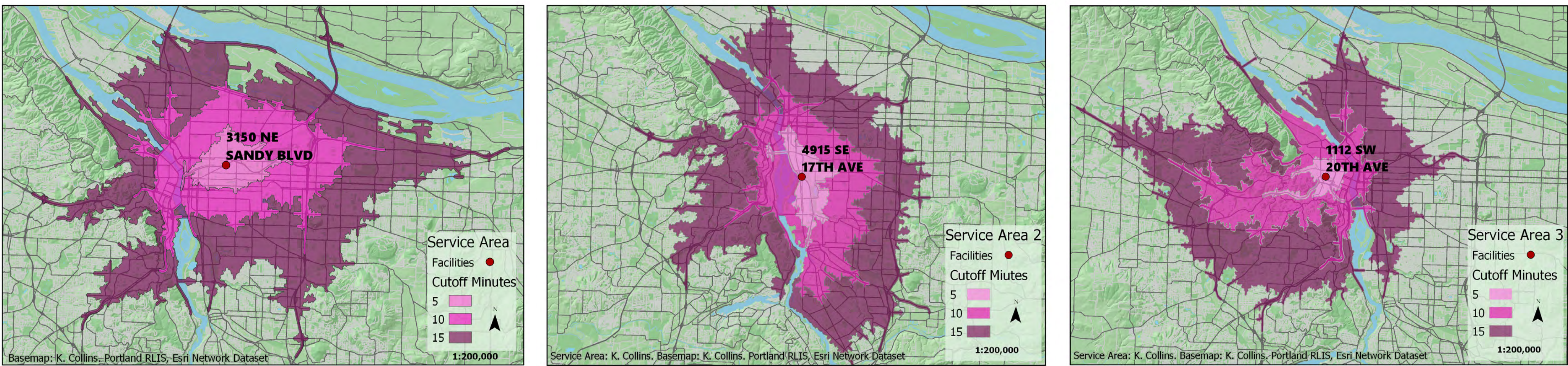
Creative solutions to the last mile delivery problem

Route Results

The routes created in ArcPro were quicker than the sample routes. The time for the route in East Portland was 22 minutes faster, and the route for West Portland was 1 hour and 16 minutes faster. While it seems that ArcPro has outperformed Google API routes, there are a few things to keep in mind. The data we used was geographically masked to preserve client confidentiality, so this could have some impact on route time. There is a possibility that the results of the masking could be responsible for the faster routes. Another possibility is unusual traffic on delivery day making the actual sample route much slower. Or possibly the delivery driver's lunch break is taken into account for the actual route. In our analysis we didn't account for breaks throughout the day. There needs to be further analysis and comparison (preferably within the company so masking is unnecessary) to assess the efficiency of ArcPro.



Part 3 Service Area Polygons of Selected Depots



Run

Import Facilities

Mode: Driving Time

Direction: Away from Facilities

Type: Not Using Time

Cutoffs: 5, 10, 15

Date:

Standard Precision

Dissolve

Rings

Polygons

Output Geometry

Since the Local Milk Run will most likely be adding new depots one at a time rather than multiple at once we decided to make service area polygons to show potential reach of different depots. 3 of the possible 7 depots were chosen based on their location being closer to the edge of the city as specified by the Local Milk Run. These results could be useful for deciding to how best serve current customers or for gaining new customers.

A critique of ArcPro by Phillip Stout
After working in the ArcPro Environment for the entirety of this project I have found that it is really worthwhile to switch over. There are a lot of differences between ArcMap and ArcPro on the surface which at first can delay the project you are working on. But once you get past these, the new interface makes everything flow a lot smoother.
A summary of some of the changes are:
The symbology interface has changed a lot to make it quicker to alter symbols/colors and the breakdown of your map. This interface has been moved to its' own interface instead of being accessed through the properties tab. More importantly this interface has been moved to a sidebar where the catalog plane might be on ArcMap, this allows you to make quick changes to the map and tweak variables as they come up with ease.
The process for calculating new fields has changed slightly as well. One can add many new fields at once now and calculate new fields very quickly when doing things for many fields. This would be very useful when doing things like areal interpolation which require many fields calculations. On top of this ArcPro has added options for how you write the expression to calculate these fields, i.e SQL vs Python. Unfortunately the SQL script requires access to an enterprise server. As such Python is the default. If you are not familiar with the difference between the two you can run into complications. I actually crashed my computer trying to calculate fields for a big dataset with the incorrect script.
For definition queries in the model builder SQL is still used however and ArcPro has added a new UI for writing the function.

Methods

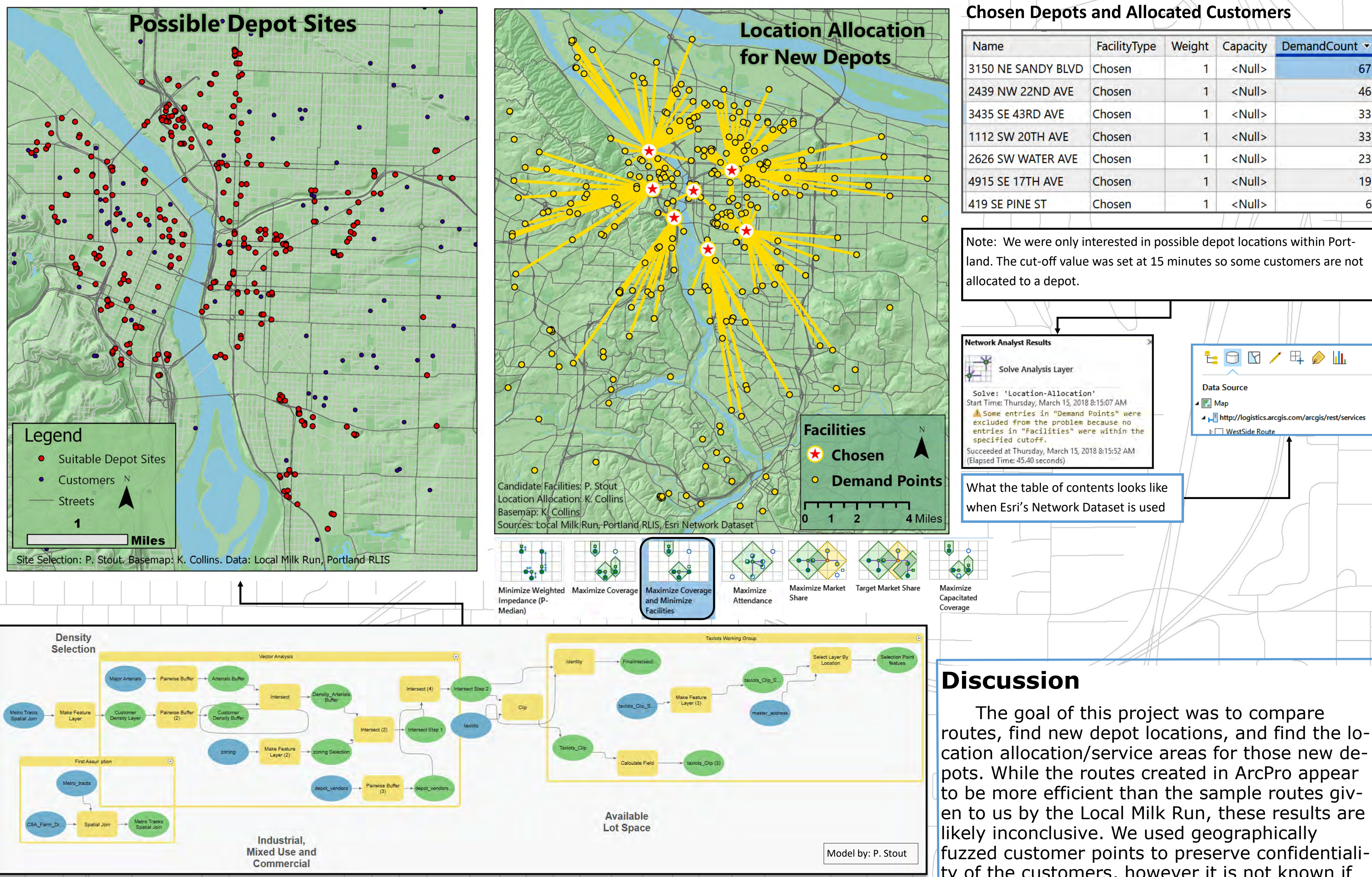
Part 2 Site Selection and Location Allocation

The next phase to this project is a multi-criteria site selection for possible depot locations around the edge of Portland city limits. Since The Local Milk Run is a unique delivery service only offering local and regional goods we took certain criteria into consideration when performing the site selection. These criteria are:

- Distance from Arterial Streets (easy access in and out of city)
- Zoned industrial, mixed use, or commercial
- Proximity to vendors
- Population density
- Proximity to existing CSA drop-offs

We picked these criteria based on recommendations from The Local Milk Run, as well as our own criteria. The Local Milk Run needs a space zoned industrial, mixed use, and commercial. They would also like to be near an arterial for easy access in and out of the city for farmers and vendors. We made 2 logistical assumptions in our chosen criteria: Population density because this service will want to reach as many customers as possible, and proximity to existing CSA drop-off locations because it is very likely that customers who participate in a CSA will be interested in the service offered by The Local Milk Run. This assumption could be validated by the Local Milk Run by simply heading out to the CSA drop-off locations and surveying customers to gauge interest.

Once the site selection was completed we used these locations to perform location allocation to test what locations would reach the maximum number of customers. This study assumes that all of these new depots will contain the same products so delivery can occur from depot to customer to another depot to more customers and so on. This is different than the current route in that there will not be intermediate vendor stops on the route unless a depot needs to restock



Discussion

The goal of this project was to compare routes, find new depot locations, and find the location allocation/service areas for those new depots. While the routes created in ArcPro appear to be more efficient than the sample routes given to us by the Local Milk Run, these results are likely inconclusive. We used geographically fuzzed customer points to preserve confidentiality of the customers, however it is not known if this significantly changed the route time. It is possible through random geographic masking

that multiple customer points could end up closer to a main road or in places where it would make the route seem faster. In order for the Local Milk Run to accurately compare routing solutions it is recommended that they try ArcPro and decide if the cost is worth the time saved. As for the site selection, many suitable places for possible new depots were found. As you can see from the model workflow the suitable polygons were converted to points, then a spatial join was used to append the street address/current owner to these point features. This would make it very convenient for the Local Milk Run to find the correct address and owner if they would like to take a look at the property. The Location Allocation analysis is useful in that out of 7 possible depot sites it shows how many customers are associated with each one. However, since we don't know if the Local Milk Run will expand and add multiple depots at once or one at a time these allocations might not be the most illuminating. That is where the Service Area Polygon analysis becomes relevant. 3 out of the 7 locations were chosen and polygons were generated to show the reach of these locations. These could be used as a reference during expansion to capture most of the current customer base or target areas of prospective customers.

And in general the modelbuilder UI is a little bit easier to use and includes new logical arguments which can be within the model.
Data Management
ArcPro changes the interface again for data management, and gives the catalog window an entire page. But the biggest change comes in the scope of the file format. Arcpro files are organized in what they call "Projects" these contain a default geodatabase they set up for you, a default toolbox and a map by default. The strength in this new format is in creating lots of maps with similar data, within the project you can create many maps in a way similar to data frames in ArcMap. You can then also create multiple different layouts at the same time with these maps.
Of all the changes I think the new data management features are the most powerful and have the most benefit to the casual GIS user.
I did run into some issues using ArcPro's spatial Join interface which is similar to ArcMaps but was returning me invalid results, so I did perform my spatial joins in ArcMap. In general ArcPro is faster and easier to use than Arcmap once you learn where your tools are. And the added benefits from Arcpro such as 3-D mapping, data management and generally being able to run faster make it a very worthwhile investment of your time. Another powerful feature of ArcPro I neglected to mention earlier is the integration of ArcPro and ESRI's Webmap. On top of all the new features for making maps after you are finished you can publish your map directly to your ESRI online account for use on that platform.

Data Sources:
The Local Milk Run, Portland RLIS, US Census Bureau, Portland Open Maps
References:
Esri ArcGIS documentation
Hajghasem, Mahtab, and Amir Abbas Shojaie. "Optimal Routing in Supply Chain Aimed at Minimizing Vehicle Cost and Supply." *Procedia Economics and Finance*, vol. 36, 2016, pp. 353–362.
Kaplan, Deborah Abrams. (2017, May 22). 9 Trends in Last Mile Delivery. <https://www.supplychaininsider.com/news/last-mile-supply-chain-trends-tech-growth-443904/>
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