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December 10th, 2016

Denver Neighborhoods

A Spatial Analysis of the Housing Market

1. Introduction

Earlier this spring Colorado's 5280 Magazine publish an article titled The 25 Best Places to Live in Denver Right Now. Neighborhoods presented at the top of the list were Congress Park, Hilltop, University Park, Cherry Creek and Washington Park. Anyone around Denver would contend that these areas are indeed a wonderful place to live, but come with a jaw-dropping price tag. Per the Denver Post, Colorado has become a "millennial magnate" with Denver ranking third, behind Chicago and Dallas, for younger individuals and couples moving to the city. What does this mean? Well, much higher cost of living most of all. This project will look various spatial features in Denver County by varying neighborhoods. As the average person moving to Denver would unlikely be considering neighborhoods like Cheery Creek due to financial restrictions, let's prose the question of the best places to live for a younger demographic. We will look at factors like rent prices (maybe instead of ownership), entertainment (theaters, bowling alleys, museums, etc.), recreation (parks, golf-courses, etc.) public transportation (both bus and train), restaurants, bars/pubs and other amenities. In essence, the process is just one large optimization problem. Given various constraints (usually money) what is the best way to optimize a choice of home given a set of preferences. This problem is very much in line with what many Denverites are facing now.

2. Defining the Problem

There were many different approaches to such a problem. Throughout the entire process, however, I considered price as the main priority. In other words, I was aiming to minimize price while keeping in mind various "preferences". I choose to define "preferences" as the accessibility to various community entities, like parks, entertainment and light rail stations. I also referenced statistical information about each neighborhood, like crime. In the end, the problem became a pursuit of minimization; minimizing cost of living, the distance to various neighborhood conveniences and crime.

3. Data

The initial process of gathering data wasn't as difficult as anticipated. Denver Open Data Catalog is an online open source database equipped with geospatial data ranging from abandoned railroad lines to marijuana facilities in Denver County. This was my main source of information. I also used US census data for demographic information under the American Neighborhood Survey 2015. This was a great layer to import into ArcGIS because the shape file recognized neighborhoods as polygons rather than just an attribute. See Appendix A for a map of Denver County neighborhoods. Although not a shapefile, I downloaded a tab delimited file from Zillow providing monthly rental cost by neighborhood over time. Data.opencolorado was another great source. See the table below for specifics regarding data, file type and source.

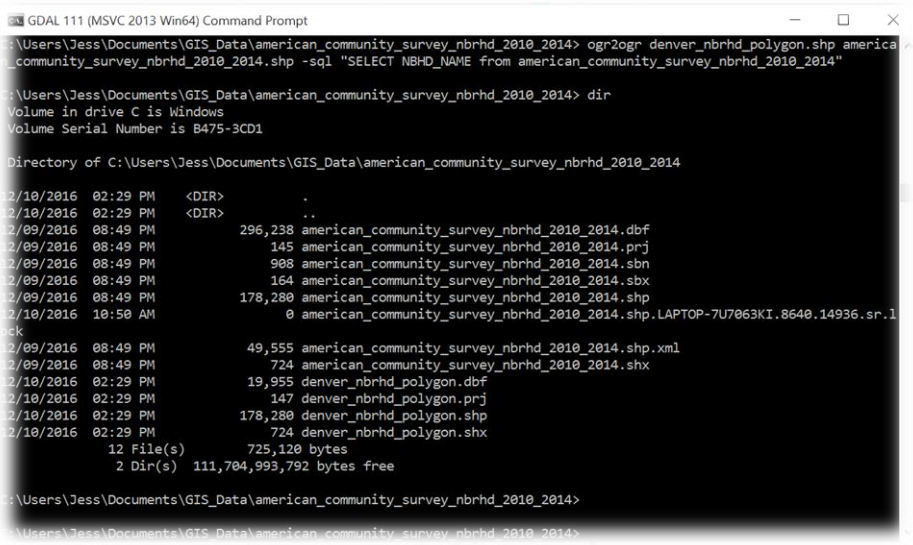
Data	File	Source
Med Monthly Rental Cost by Ngbhd	Tab delimited	Zillow
Crime (Incidents)	Shape (Point)	Denver Open Data Catalog
Light Rail Stations	Shape (Point)	RTD
Land Use (parcels)	Shape (Polygon)	Data.opencolorado
Major Roads and Highways	Shape (Line)	Denver Open Data Catalog
Food Stores	Shape (Point)	Denver Open Data Catalog
Bars/Pubs	Shape (Point)	Denver Open Data Catalog
Ngbhd Demographics	Shape (Polygon)	US Census
Counties (Denver and Surrounding)	Shape (Polygon)	Denver Open Data Catalog

4. Analysis Tools

4.1 Initial Clean-up

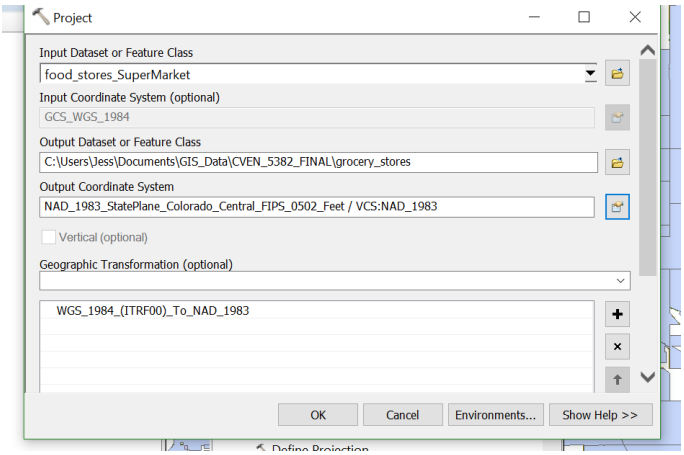
Firstly, the importance of establishing consistent geographic coordinate system (GCS) and/or projection coordinate system (PCS) among all datasets is essential. There is an observation in the industry; data preparation consumes 80% of GIS projects. Outside of simply finding your data, common preparations include integrity checking (what is the source and timestamp?), compatibility among entire dataset (GCS, projections and datums), understanding definitions among sources (i.e. possible differences in how neighborhood boundaries are defined), filtering unneeded information as well as identifying missing data.

One beneficial data development software I used throughout this project was GDAL. For example, the American Community Survey Neighborhood shape file was the only file that digitally contained the polygon feature for Denver neighborhoods. Most of the analysis operations were based the neighborhood polygons, (joins, relates, distances, etc.). However, this file contained dozens id fields; many of which were unneeded. Here, I simply created a polygon layer of neighborhoods where the only field that was maintained was obviously “NBHD_NAME”. That way, user-operations in ArcMap completed much faster as less data was involved. Deleting individual column fields in the attribute table within an ArcMap session would have taken significantly more time.



As shape files were gathered just from a few sources, there were only a handful of coordinate/ projection systems to consider. I was working under the GCS of WGS_1984, making transformations on-the-fly as needed, until I came to preform spatial geometries computations, like calculating area and

distance. These types of procedures only make sense when geometries live in a two-dimensional domain. Therefore, I needed to attached a projection to my data as well (via **Project** tool in the geoprocessing toolbox). I decided to use the local State Plane Colorado Central Projection (EPSG:2232) as the data was solely for Denver County. I accepted the default method of transformation. Here, it was important to understand the difference between a coordinate system and a projected coordinate system as well as how to choose the best system for your particular area of study.



4.2 Spatial Tools and Functions

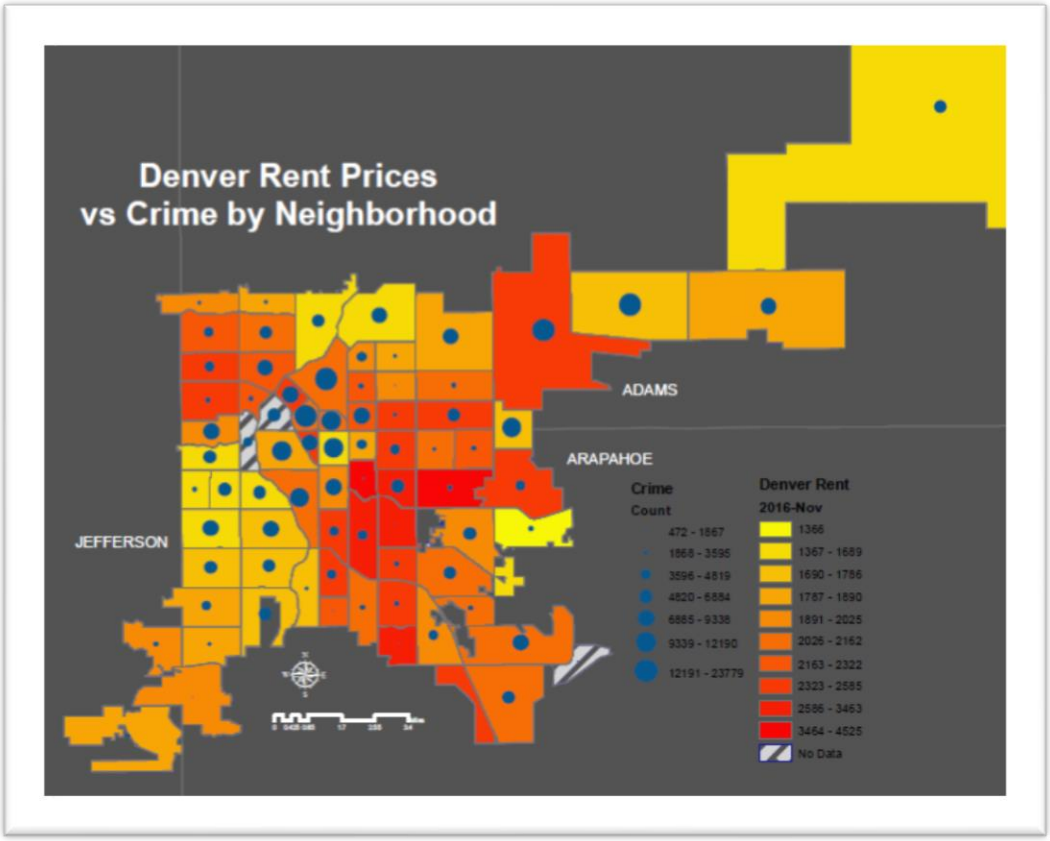
Many files contained information outside of Denver. The **Clip** function grabbed data only within the polygon of Denver. Another key function used was the **Spatial Join**. The crime point layer listed the neighborhood where the crime occurred only as an attribute. Because I had a polygon neighborhood layer, I was then able to consider how many crimes occurred in a neighborhood by selecting the *sum* option. Other join operations included the **Distance Spatial Join** (how far it the nearest light rail station from a neighborhood?) and the **Attribute Join** (joined an excel file with average monthly rental with a polygon layer base on the common class "neighborhood"). I also performed **Attribute Queries** to filter out unwanted information within ArcMap when it was appropriate. For example, the liquor license layer included every single facility that owed a license, like retail and special events. Of course, I was only interested in fields that included strings like 'BAR', 'TAVERN' or 'PUB'. Similarly, I disregarded non-major food stores, like 7-11 and Walgreens, in the food stores layer as well as measly traffic incidences from the crime layer. Lastly, the **Split** function divided a feature class into many based on a specified field (land parcel data).

5. Results

5.1 Rent vs. Crime

One of the most informative maps created displays a color ramp of rent cost by neighborhood as well as crime incidents as a proportional symbol. Note that there was no housing data for Auraria, Kennedy and Sun Valley neighborhoods. Map A shows a vague indirect relationship between these two parameters. Although devoid of any concrete statistical analysis, we can see a general tend; as rent price increases, crime decreases. This is to be expected. However, this relationship begins to deteriorate as neighborhoods are closer and closer to downtown. These areas have high crime and high tent prices. Neighborhoods west of Sante Fe have among the lowest rental prices, yet have relatively low crime as well. Areas like Cherry Creek, Speer and Wash Park are among the highest priced housing, yet the lowest among crime. While neighborhoods like Capitol Hill and East Colfax are just the contrary. I was expecting the association between rent and crime to be a little stronger. There are many other variables to consider. Although time series data is not the focus of this project, see Appendix B for a display of rental prices over time (2010-2016).

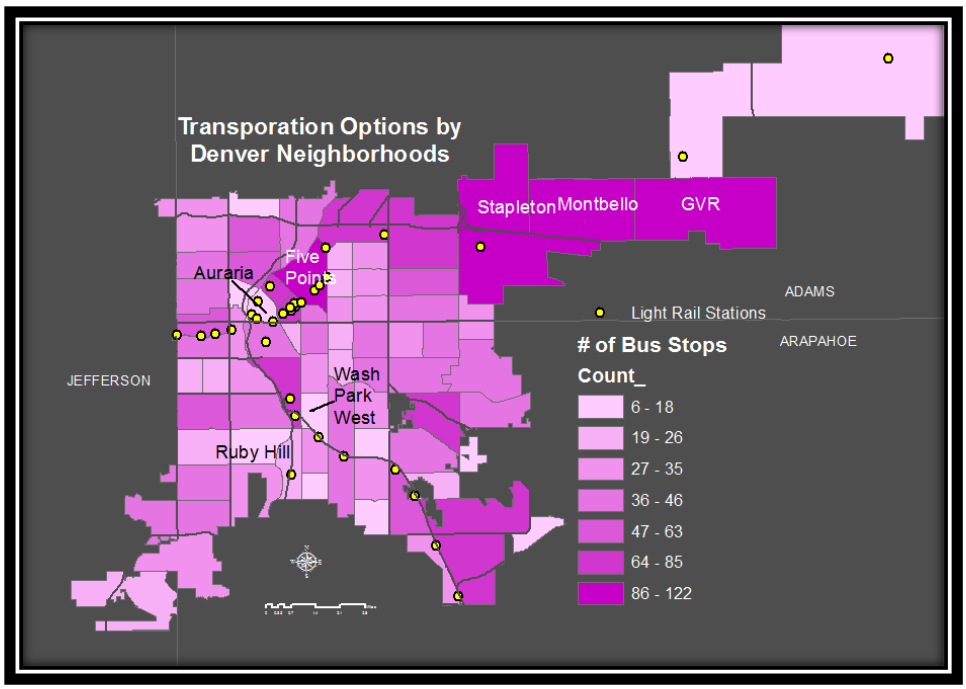
Snap Shot:
Most Expensive Areas: Country Club, Hilltop and Belcaro
Least Expensive Areas: Windsor, Capitol Hill and DIA
Most Crime: Five Points, CBD and Stapleton
Least Crime: Wellshire, Indian Creek and Kennedy



Map A

5.2 Public Transportation

Map B displays public transportation options by neighborhood. The color ramp shows the number of bus stops in each neighborhood and the yellow circle represents RTD Light Rail Stations. Larger neighborhoods are likely to have more bus stops by default. I was surprised that inner-city neighborhoods didn't have more bus stops than neighborhoods living in the outskirts. Again, this could have been a consequence of neighborhood area. Table 1 shows the number of bus stops for the top 10 neighborhoods. Note that I believe the first 3 listed are present simply due to area. To the right we see neighborhoods with at least one light rail station present.



Map B

Montbello	122
Gateway - Green Valley Ranch	115
Stapleton	100
Five Points	97
Hampden	85
CBD	84
Hampden South	82
Elyria Swansea	75
Washington Virginia Vale	71
Union Station	71

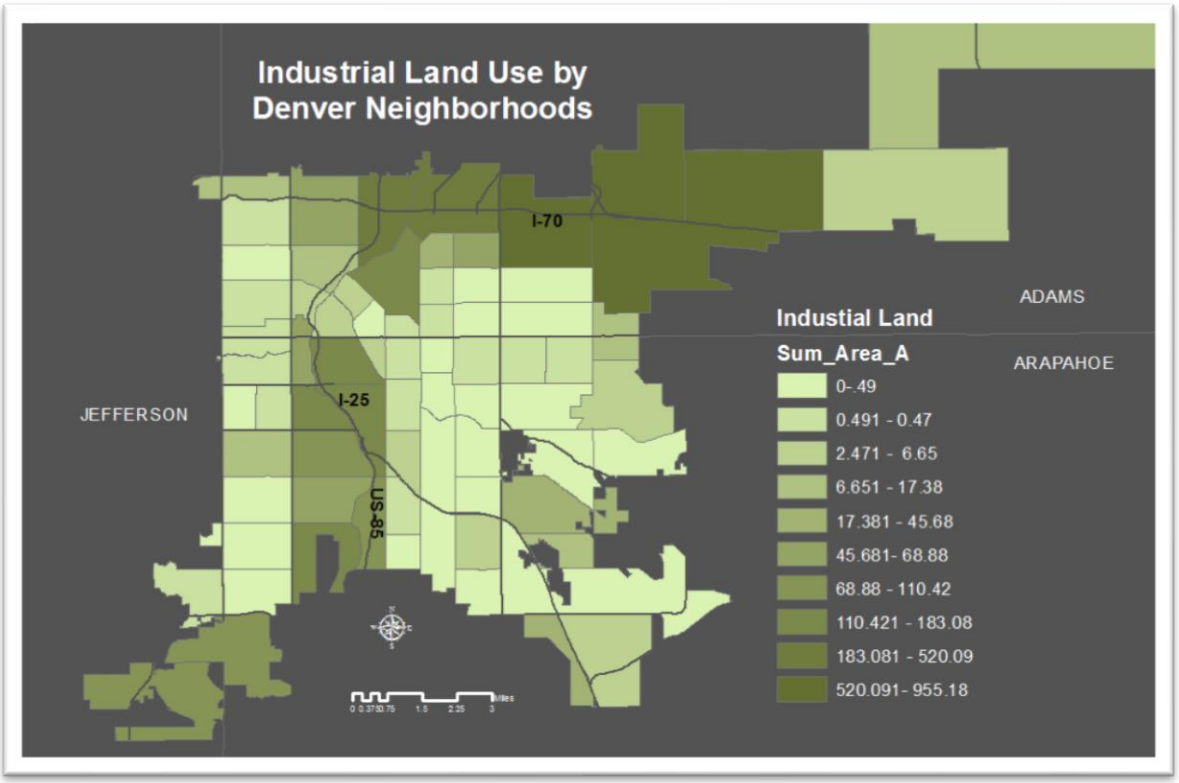
Table 1: Bus Stops

Southmoor Park
Stapleton
Sun Valley
West Colfax
DIA
Elyria Swansea
Union Station
University Hills
Overland
Lincoln Park
University
Platt Park

Table 2: Light Rail

5.3 Industrial Land Use

With Denver housing expanding, we must also consider what type of zoning is nearby. Looking at land use by parcel, I combined land use falling under manufacturing, indusial parks or factories into one common bin of "industrial lands". We see a very strong relationship with neighborhoods containing a high area of industrial lands (sum of all acres) to the vicinity of major highways, such are I-25, I-70 and US-85. These neighborhoods may be deemed as undesirable to some. Neighborhoods with the least amount of industry fall in central Denver. This trend is not surprising as this part of Denver has been zoned for housing for a long period. Historically, industrial parks tend to follow major rivers. We can see this trend even today as we see a darker green for neighborhoods following US-85 which runs adjacent to the Platte River. Table 3 shows which neighborhoods to avoid if you want to be far from industrial parks.



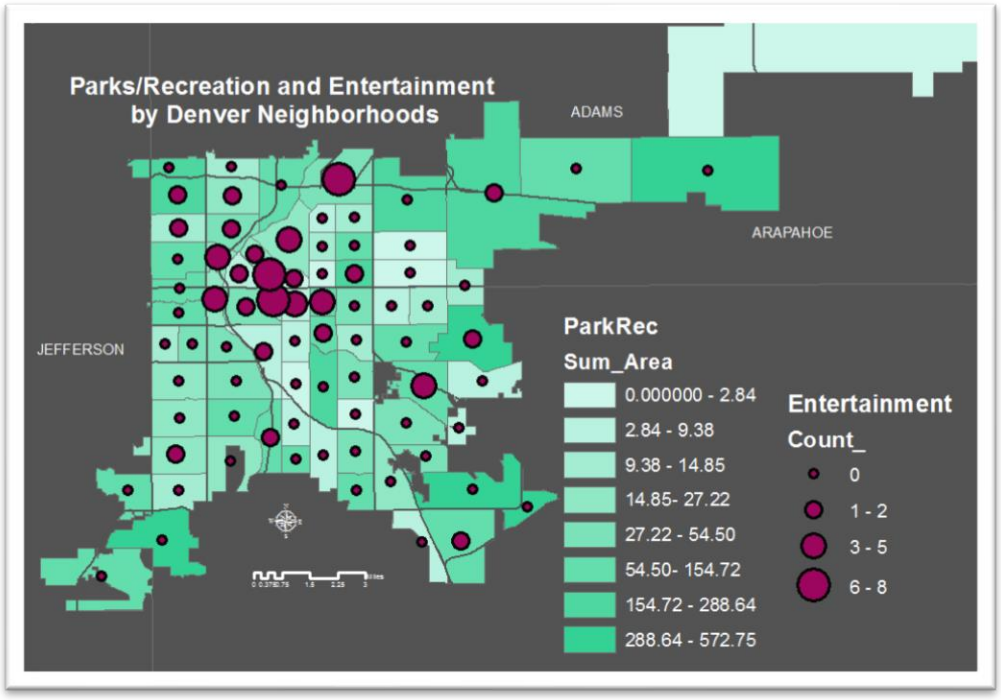
Map C

Stapleton	955.18284
Montbello	809.375737
Northeast Park Hill	674.385019
Elyria Swansea	520.097635
Globeville	366.960443
Valverde	183.087466
Baker	176.132442
College View - South Platte	171.052999
Lincoln Park	157.902179
Five Points	143.440736
Fort Logan	110.421997
Marston	110.421997
Overland	103.151931

Table 3: Industrial Lands (Acres)

5.4 Parks, Recreation and Entertainment

Denver has one of the highest public parks per capita in the nation. Where are these parks located? Map D shows the number of parks (in acres) and other recreation activities by neighborhood. We can also see indoor entertainment (bowling lanes, theaters, etc.) by the size of the symbol. In general, inner-city neighborhoods offer more indoor entertainment. Overall, most neighborhoods have public parks, maybe except for DIA, for example. See Table 4 and 5 for the top contenders for outdoor and indoor entertainment.



Map D

Gateway - Green Valley Ranch
Lowry Field
Hampden
Kennedy
Fort Logan
City Park
Washington Park
Regis
Stapleton
Berkeley

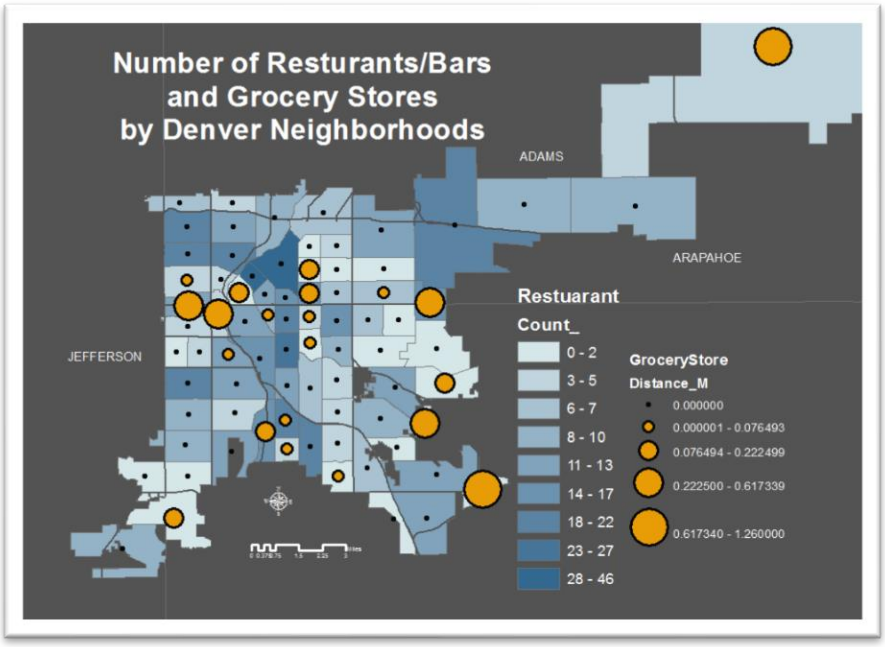
Table 4: Parks

Elyria Swansea
Civic Center
CBD
Cheesman Park
Sun Valley
Five Points
Jefferson Park
Washington Virginia Vale
Capitol Hill
Baker

Table 5: Entertainment

5.5 Other Conveniences; Restaurants, Bars and Grocery Stores

Map E shows other neighborhood components like restaurants, bars and grocery stores. The darker the color the more restaurants/bars a neighborhood has. Also, the symbol shows the distance in miles to the nearest grocery store. If the neighborhood contains a store within its boundaries, then the distance is zero and a small dot will appear. Most neighborhoods had a least one grocery store within it. See Table 6 for neighborhoods where the nearest store was more than a quarter mile away. Table 7 shows the neighborhoods ranking the highest for number of restaurants/bars.



Map E

Stapleton	0.385085
Villa Park	0.451971
Jefferson Park	0.542784
Washington Virginia Vale	0.617339
Gateway - Green Valley Ranch	0.924071
Hampden	1.26

Table 6: Grocery Stores

Five Points	46
Union Station	41
Speer	27
Capitol Hill	22
Highland	21
Berkeley	21
Platt Park	20
Stapleton	20
Westwood	19
West Highland	19

Table 7: Restaurants and Bars

5.6 Choice of Neighborhood?

Our analysis considers many different variables. It is hard to determine the best neighborhood when all the parameters are involved. If we were only concerned with price, crime, decent public transportation, vicinity of grocery stores and avoiding neighborhoods with a significant number of industrial parks, then neighborhoods in the southeast region would be good selections. These areas include Bear Valley, Fort Logan, Mar Lee and Overland. If entertainment, restaurants/bars and public transportation were the only factors at hand, then inner-city neighborhoods like Five Points, Civic Center and Capitol Hill would be the best options. Personally, an area such as Windsor speaks to me as it ranks low on the list for rent price, crime and industrial parcels.

6. Improvements

If I were to make improvements on a few aspects, I would firstly reconsider the crime layer, as data presented was in raw numeric form, with no sense of reference. More importantly, the layer considered crimes like "public disturbance" or "embezzlement"; although I did remove traffic incidences from the data. These types of crime wouldn't affect someone living in the neighborhood. However, forcible theft and violent crimes would.

Also, the rent prices by neighborhood did not consider the size of house/unit in which you were renting. The price of a studio vs the price of an entire house is obviously very different. This fact alone skews my results a bit. If we were further able to break down rentals by type, this project would have been much stronger applicable to reality.

7. Future Works.

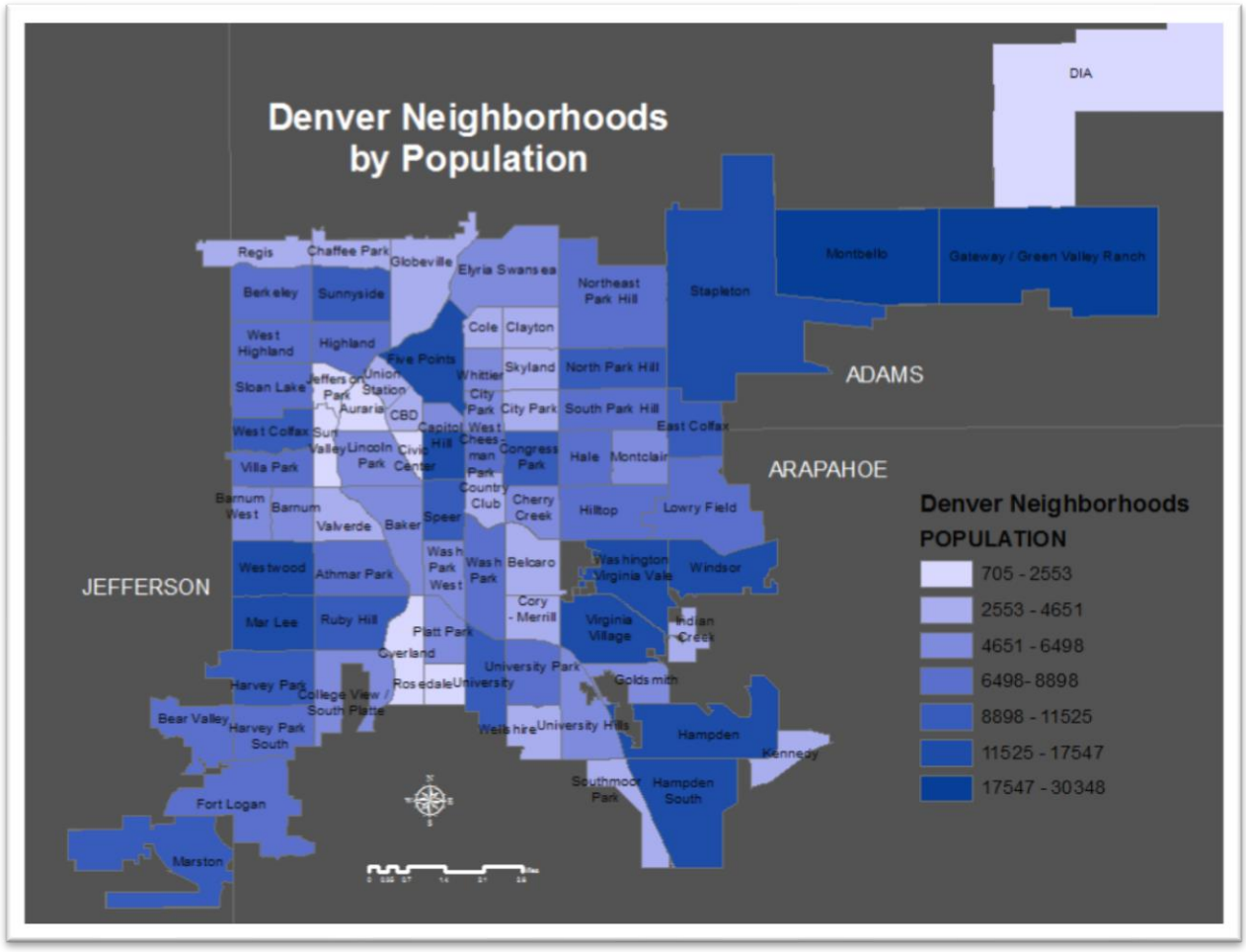
If I were to take this project one step further, I would first consider using a linear optimization and modeling software (such as GAMS or AMPL). The data would be extremely easy to implement as it would simply be a set of two-dimensional matrices, defining the x-y position of various conveniences and individual rental units (or say, the mid-points of neighborhoods). The minimizing function would be defined by the sum of Euclidian distances between an unit and the concerned community entity (restaurant, light rail station, etc.). We could also simultaneously minimize a second single-vector function of crime (raw numbers). Possible constraints to consider would be the upper bound on cost as well as the existence of "conveniences" (otherwise the program just wouldn't select anything, as 0 certainly a great solution when we are trying to minimize!) An exact mathematical solution would be a great addition to the visuals of ArcMap and its geospatial tools.

I would also like to run regression testing as it is likely that a parameter, like rent price, can be determined by a set of predictors (like crime, vicinity to public transportation, etc.). It would have been a great source to have implemented Zillow API into my project as I would have then been able to join information about individual housing units to an active address layer. This way, I could have considered true distance from a specific house rather than an entire neighborhood. Also, I would have liked to include counties outside of Denver.

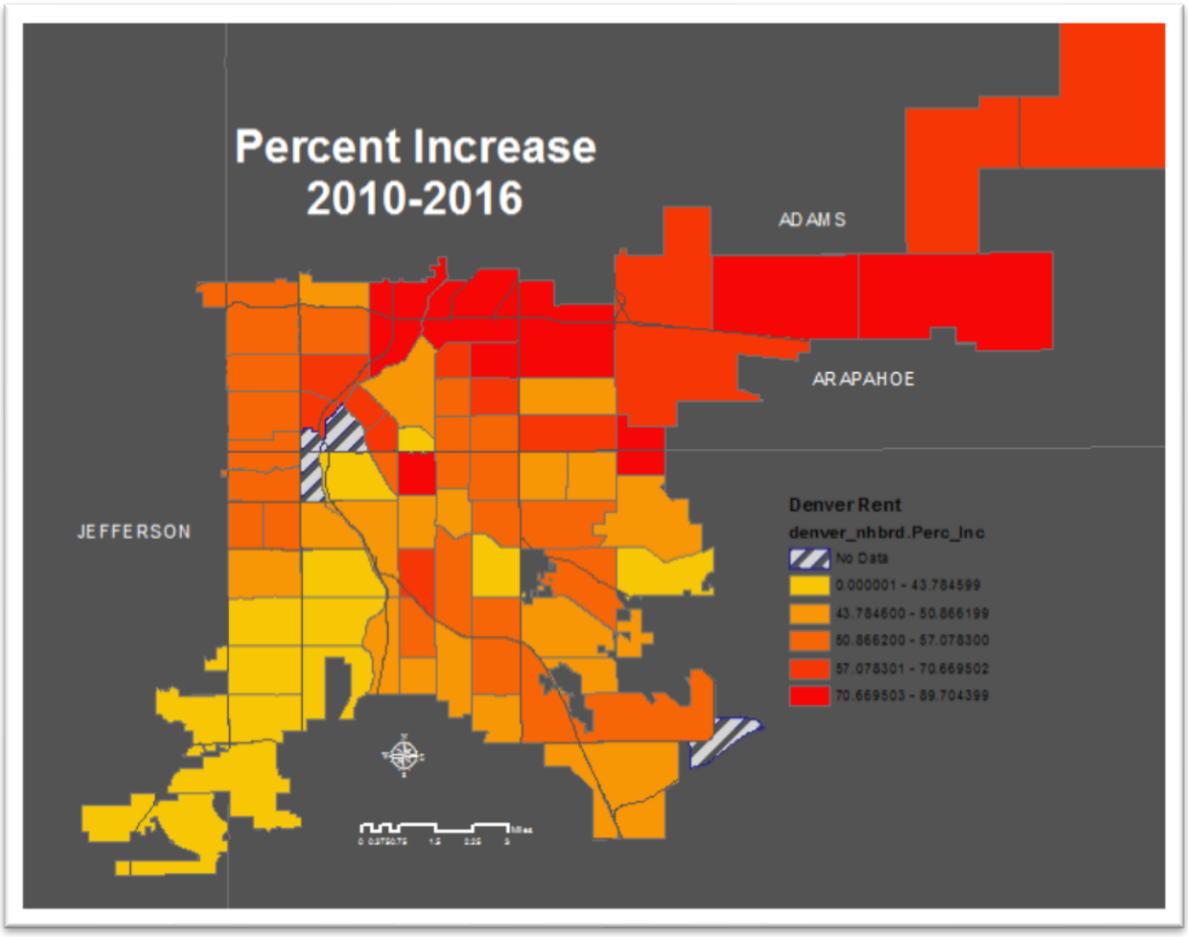
8. Conclusions

In sum, this GIS project has provided insight to Denver rents prices. Map A displayed a (although somewhat vague) general indirect relationship between crime and rent prices. A second map showed which neighborhoods have the best public transportation options. We also looked at which neighborhoods sit among industrial parks. Avoid major highways if you do not want to live close to these types of areas. As this project was geared towards a slightly younger market (early 20's to mid-30's) I also wanted to include public parks and entertainment. Map D displayed Denver's vast number of parks over all neighborhoods but showed only inner-city areas with indoor entertainment options. Lastly we looked at a spatial distribution of restaurants, bars and food stores. High density of the food service industry was present among inner-city areas yet grocery stores were not. Hopefully rental hunting will be a litle easier with some GIS knowledge about Denver County.

Appendix A


Denver Neighborhoods
by Population
DIA
Montbello
Gateway / Green Valley Ranch
Stapleton
Northeast Park Hill
Regis
Chaffee Park
Globeville
Elyria Swansea
Berkeley
Sunnyside
West Highland
Highland
Cole
Clayton
Five Points
Whittier
Skyland
North Park Hill
Sloan Lake
Jefferson Park
Union Station
City Park
City Park
South Park Hill
Aurarian
CBD
Capitol Hill
West Chees-man Park
East Colfax
West Colfax
Sun Valley
Lincoln Park
Civic Center
Congress Park
Hale
Montclair
ADAMS
Villa Park
Country Club
Cherry Creek
Barnum West
Barnum
Valverde
Baker
Speer
Hilltop
Lowry Field
ARAPAHOE
Denver Neighborhoods
POPULATION
705 - 2553
2553 - 4651
4651 - 6498
6498- 8898
8898 - 11525
11525 - 17547
17547 - 30348
Wash Park West
Wash Park
Belcaro
Washington Virginia Vale
Windsor
JEFFERSON
Westwood
Athmar Park
Cory - Merrill
Mar Lee
Ruby Hill
Virginia Village
Indian Creek
Platt Park
Overland
University Park
Harvey Park
College View / South Platte
Rosedale
University
Goldsmith
Bear Valley
Harvey Park South
Wellshire
University Hills
Hampden
Kennedy
Southmoor Park
Hampden South
Fort Logan
Marston

Appendix B:


Percent Increase
2010-2016
ADAMS
ARAPAHOE
JEFFERSON
Denver Rent
denver_nhbrd.Perc_Inc
No Data
0.000001 - 43.784599
43.784600 - 50.866199
50.866200 - 57.078300
57.078301 - 70.669502
70.669503 - 89.704399