title page

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INTRODUCTION: STUDY AREA DESCRIPTION

Our team has an interest in exploring the relationship between density and travel behavior. With a total population of c people, we selected the Denver-Lakewood-Aurora MSA both out of interest in exploring a western urban area but also because the MSA has a relatively low density: about 347 people per square mile (for context, the Boston-Cambridge-Newton MSA has a density of about 1,386 people per square mile). Unless otherwise noted, all data presented here has been pulled from Social Explorer, which uses the 2019 ACS 5-year Survey.

The principal cities of our MSA have higher densities, however. Denver has a density of 4,603 people per square mile, Lakewood has a density of 3,604 people per square mile, and Aurora has a density of 2,392. The low density of the MSA is likely due to the fact that much of its 8,345 square-mile area consists of rural land. Four of the ten counties in the MSA (Clear Creek, Gilpin, Park, and Elbert) are rural, located in the Rocky Mountains or on the southeastern edge of the MSA reaching into the plains. Combined, these four counties have an area of 4,590 square miles, more than half of the MSA. If we exclude these four counties, the new total population would be 2,832,969 and the new density would be about 754 people per square mile, more than double the original density. We will consider the entire MSA moving forward, but may nuance our proposal by focusing on the more urban counties of the MSA. The map below, from ESRI Business Analyst, shows the density distribution of the MSA by census tracts. The tracts near the center of Denver and Aurora are more dense than the tracts on the peripheries.

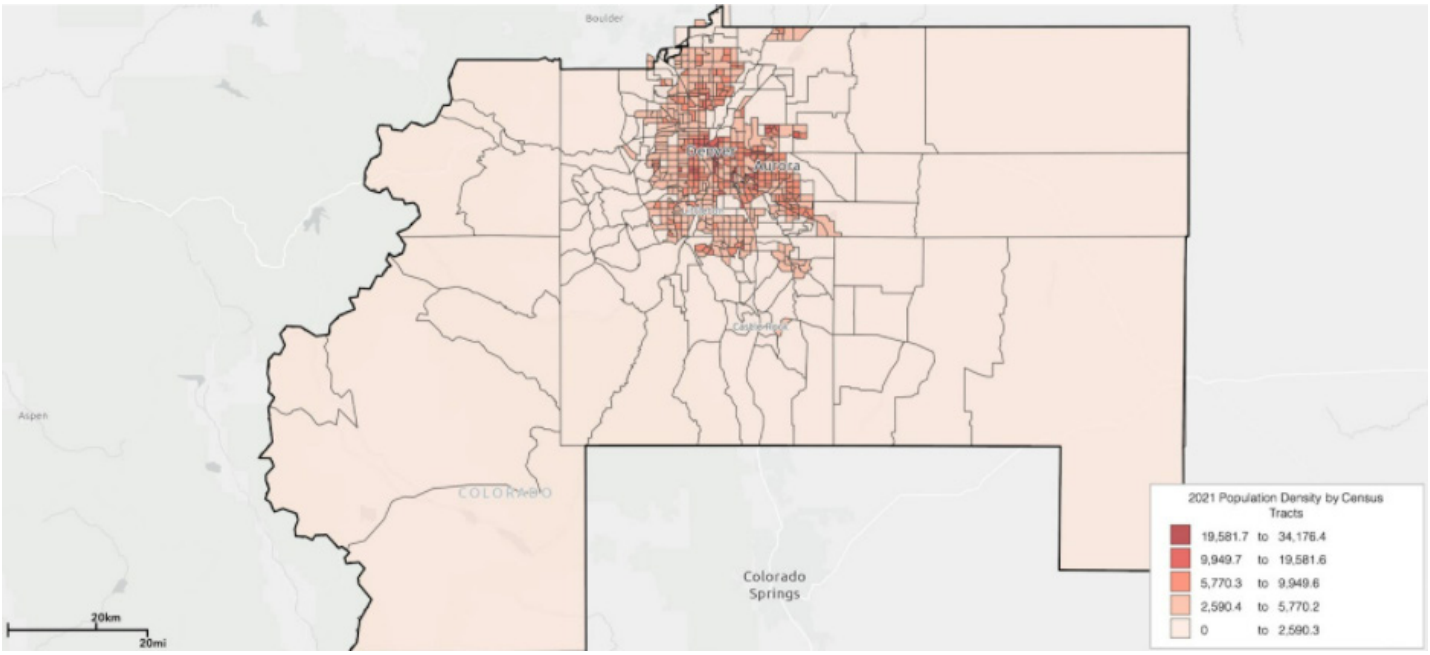

Figure 1: Population Density by Census Tract

The map below is zoomed in on the three principal cities and the density distribution by census tracts both in the cities and their surroundings.

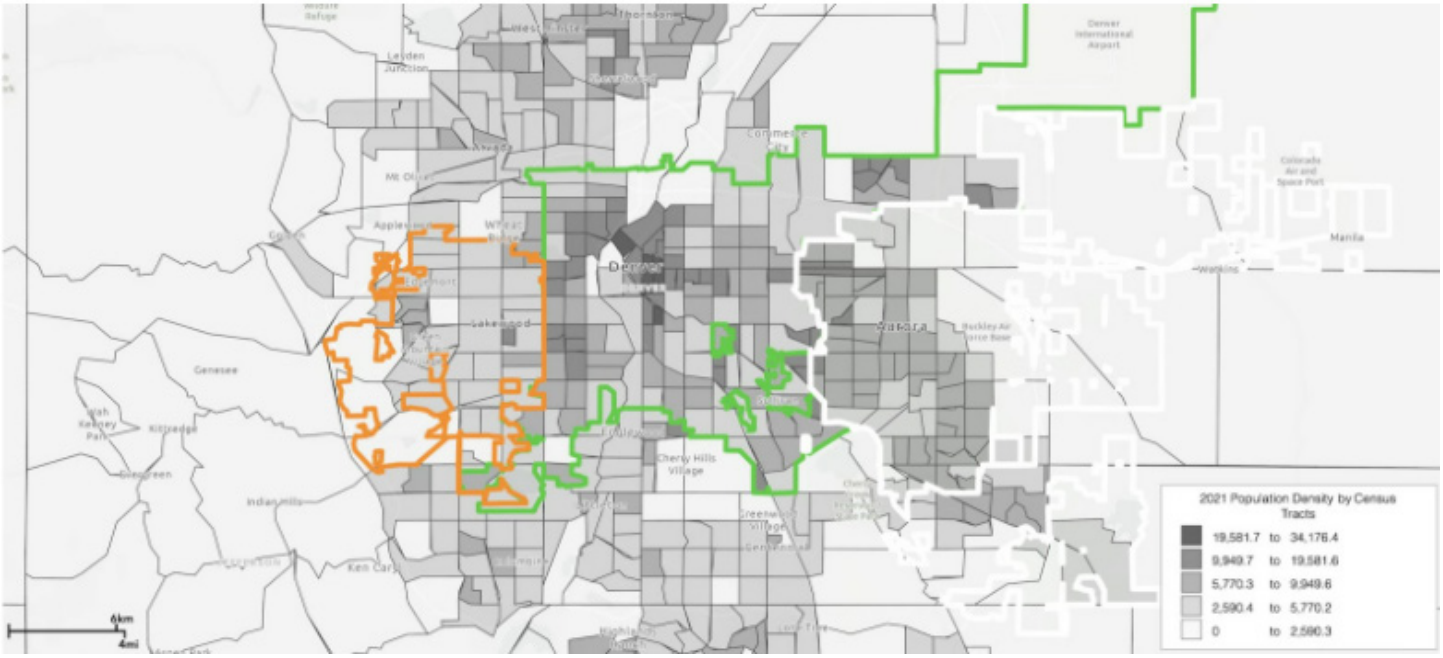

Figure 2: Population Density by Census Tract with Principal Cities Outlines

The MSA population has a median age of 36.5 years, with about 23% of the population under 18 years old and 13% above the age of 65. About 64% of the MSA identifies as white, 23% identify as Hispanic (including one or more or races), 5.5% identify as non-Hispanic Black, and 4.2% identify as non-Hispanic Asian.

With regards to employment and income, only 3.72% of the population is unemployed. The per capita income is $41,988 and the median household income is $79,664. About 30% of the population has a household income less than $50,000.

Among the working population that is 16 years old or older, the average commute to work lasts 28 minutes and driving remains the most common form of transportation to work with 75.26% of the population reporting driving alone to work. Another 8.42% work from home, 8.12% carpool, and only 4.27% use public transit. Only 2.19% of the population walks to work and less than 1% reported biking to work.

Since we will be looking at increasing density, it's important to note that the average household size is 2.57 people. It may be assumed that adding housing units to a tract will increase the population by that many residents per household. The MSA has 1,112,126 households and about 61% of those are married couples. Of the 1,173,990 housing units in the MSA, about 95% of them are occupied, and 64% of those are owner occupied. The median house value is at $380,900 and the median gross rent is $1,380. According to the Zillow Home Value Index, the typical home value in Denver as of December 2021 was $593,289 (an increase of nearly 19% over the last year), while in Aurora and Lakewood the typical home was valued at $479,349 and $590,585 respectively.

The majority of residential land in each principal city is zoned for single family or single unit development. Each city has a spectrum of residential development ranging from single-family to multi-family, with specific allowed development of two- or three-family units or ADUs in some instances.

Three major interstate highways cut through the MSA: I-25 runs north-south through the center of the MSA, I-70 runs east-west, and I-76 comes from the northeast towards the center of the MSA merging into I-70. Two toll roads, C-470 and E-470, form a ring road around the peripheries of Denver, Lakewood, and Aurora, allowing drivers to circumvent the city center. E-470 connects drivers directly to Denver International Airport (DIA). The Regional Transportation District (RTD) is the public transit agency that provides light rail and bus service to the region. Investment in redeveloping the Union Station area of downtown Denver over the last several years has improved access to the light rail in that area, although many areas are still not served by light rail. Additionally, a new line providing direct service to DIA has met ridership demand for direct transit to the airport from downtown.

PROPOSED CONDITIONS DESCRIPTION

We are interested in adding housing density to tracts across the MSA. We will add this density by increasing maximum Floor-to-Area-Ratios in multi-family residential zoned districts. Given the variety of population and unit density across the area, we are proposing a scaled increase in FARs.

This scaled approach is outlined as such:

- FAR < 3 = 50% increase
- FAR 3-5 = 25% increase
- FAR 5-8 = 15% increase
- FAR 8-10 = 10% increase
- FAR > 10 = 5% increase

Our proposal will assume that new FARs will be maximally used, adding 2.57 persons to the tract per additional unit. We will assume new units will average 1,000 SF. We will assume each story is 10' unless otherwise noted by a city's code.

Arvada:
Arvada has 10 residential zone district types, our proposal will focus on three multifamily residential districts (R6, R13, and R24). These districts are named based on how many units are allowed per acre (6, 13, or 24) and all have a maximum height restriction of 35 feet (3 stories). Based on the housing type (townhome vs. multiplex) the maximum building coverage percentage ranges from 55%-100%. Based on these restrictions, these zones can have a FAR ranging from 1.65 to 3. A 50% increase would result in a new FAR range of 2.475 to 4.5.

Aurora:
Aurora has 6 residential zone district types, our proposal will focus on two multifamily residential districts (R-3 and R-4). R-3 has a maximum height restriction of 45 feet (4 stories), R-4 is 65 feet (6 stories). There are no coverage or open space requirements in Aurora. R-3 has a current FAR of 4 and R-4 has a current FAR of 6. R-3 will increase by 25% to 5 and R-4 will increase by 15% to 6.9.

Centennial:
Centennial has 3 residential zone district types, our proposal will focus on the Urban Residential District (RU). RU has a maximum height restriction of 30 feet (3 stories). Centennial requires a minimum of 15% open space. RU has a current FAR of 2.55. RU will increase by 50% to 3.825.

Denver:
Denver has a fairly complex zoning code. There are three zone districts that include multi-family zoning: Suburban Neighborhood Context, Urban Edge Neighborhood Context, and General Urban Neighborhood Context. Within the Suburban Neighborhood Context, there are 5 multi-unit zones (S-MU-3, S-MU-5, S-MU-8, S-MU-12, S-MU-20). Within the Urban Edge Neighborhood Context, there is 1 multi-unit zone (E-MU-2.5) Within the General Urban Neighborhood Context, there are 5 multi-unit zones (G-MU-3, G-MU-5, G-MU-8, G-MU-12, G-MU-20). The number at the end of each zone indicates the number of permitted stories.

Suburban Neighborhood Context has a maximum of 50% building coverage. This makes current maximum FARs for each zone and updates per our proposal as follows:
S-MU-3: current FAR 1.5 -> increase of 50% to 2.25
S-MU-5: current FAR 2.5 -> increase of 50% to 3.75
S-MU-8: current FAR 4 -> increase of 25% to 5
S-MU-12: current FAR 6 -> increase of 15% to 6.9
S-MU-20: current FAR 10 -> increase of 5% to 10.5

Urban Edge Neighborhood Context has a maximum of 37.5% building coverage. This makes current maximum FAR for the zone and update per our proposal as follows:
E-MU-2.5: current FAR 0.94 -> increase of 50% to 1.41

General Urban Neighborhood Context has a maximum of 50% building coverage. This makes current maximum FARs for each zone and updates per our proposal as follows:
G-MU-3: current FAR 1.5 -> increase of 50% to 2.25
G-MU-5: current FAR 2.5 -> increase of 50% to 3.75
G-MU-8: current FAR 4 -> increase of 25% to 5
G-MU-12: current FAR 6 -> increase of 15% to 6.9
G-MU-20: current FAR 10 -> increase of 5% to 10.5

Thornton:
Thornton has 5 residential zone district types, our proposal will focus on the Multifamily District (MF). MF has a maximum height restriction of 60 feet (6 stories). Thornton has a maximum site coverage of 60%. MF has a current FAR of 3.6. MF will increase by 25% to 4.5.

Westminster:
Westminster has 7 residential zone district types, our proposal will focus on two multifamily districts (R3 and R4). Both R3 and R4 have a maximum height restriction of 35 feet (3 stories) and a maximum site coverage of 30%. R3 and R4 have current FARs of 0.9. Both will increase by 50% to 1.4.

EXISTING + PROPOSED ZONE CONDITIONS

The Denver-Lakewood-Aurora MSA is home to 2,892,066 residents. Our analysis reveals that the majority of this population surrounds the Downtown Denver Area, as highlighted by the small size of census tracts (which are usually home to 1,000-8,000 residents). The increased square footage of census tracts outside the central area indicates the lessened population density outside the central downtown.

Figure 3: Existing Population per Tract

Our proposal adds households and therefore population to multi-family zones across several jurisdictions. As seen below, this proposal affects some municipalities and tracts within them more than others. Rather than the existing peak population near 12,500, some of these proposed tracts have close to 40,000 residents.

Figure 4: Proposed Population per Tract

The MSA has just over 1,000,000 households. The existing distribution of households aligns with population, where there are high numbers of households in the small tracts near downtown and then a maintenance or decrease of household number for much larger tracts. Here we do see a bigger differentiation between western and eastern suburbs, where western tracts seem to have more households, even if there populations were fairly similar to their eastern counterparts.

Figure 5: Existing Households per Tract

Our proposal adds a significant number of households, evident through the jump in the legend. Tracts were household dense around 7,000 units in the existing conditions, while now some see upwards of 15,000 units. Similar to the proposed population, these increases are especially apparent in a few tracts.

Figure 6: Proposed Households per Tract

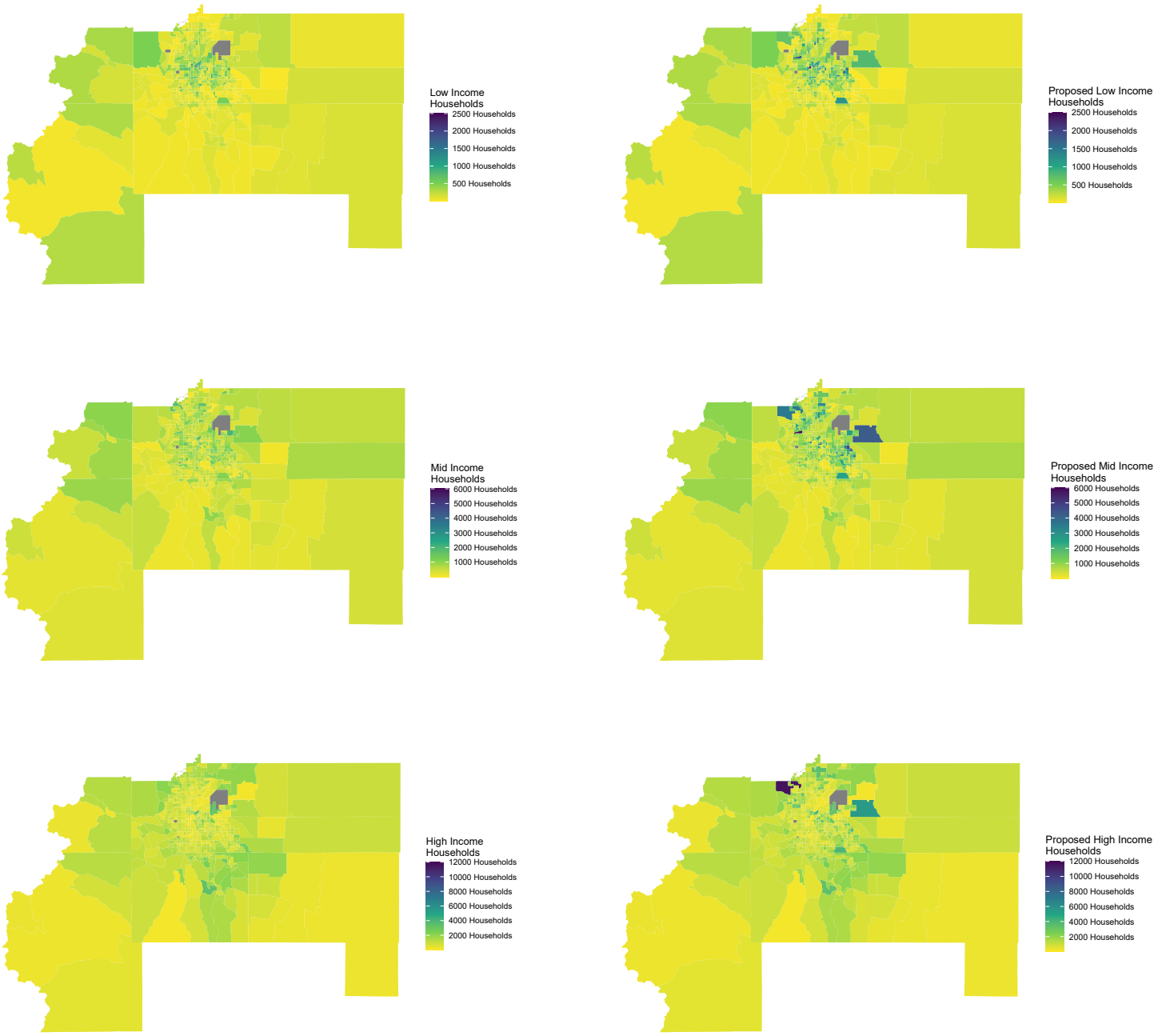

Figure 7: Existing (left) versus Proposed (right) Low, Mid, and High Income Households

The six maps above show low, mid, and high income households across the MSA tracts in existing conditions, the left column, and after our proposal, on the right. The ratios of low to mid to high income households stay the same per our assumptions, so the change in maps reveals the tracts which overlay multi-family zoning, and therefore received household increases.

Unsurprisingly, the majority of households that do not have a vehicle available are near downtown, where street networks are more walkable or bikable, or where there are transportation options available. Even so, zero car households are fairly rare, even in tracts with close to 1000 car-free households, they only make up about 10%.

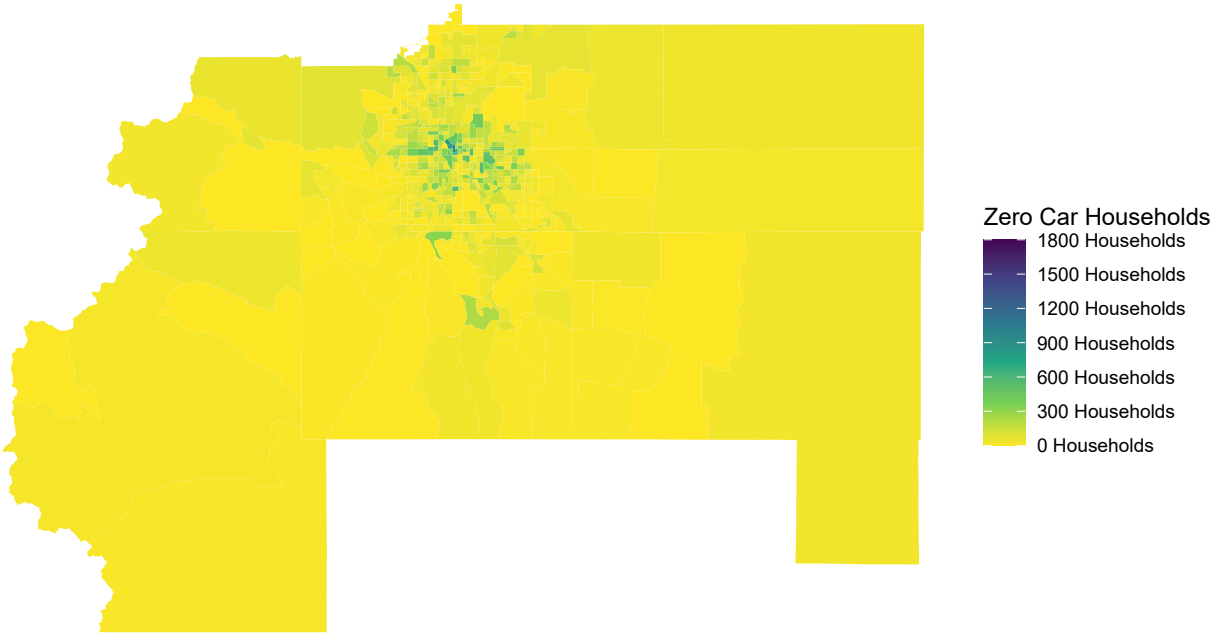

Figure 8: Existing Households with No Vehicles Available

Our proposal maintains the percentage of zero-car to car-available households. Because more central jurisdictions tend to have more multi-family zones, we see the increase in zero-car households in the core of the MSA.

Figure 9: Proposed Households with No Vehicles Available

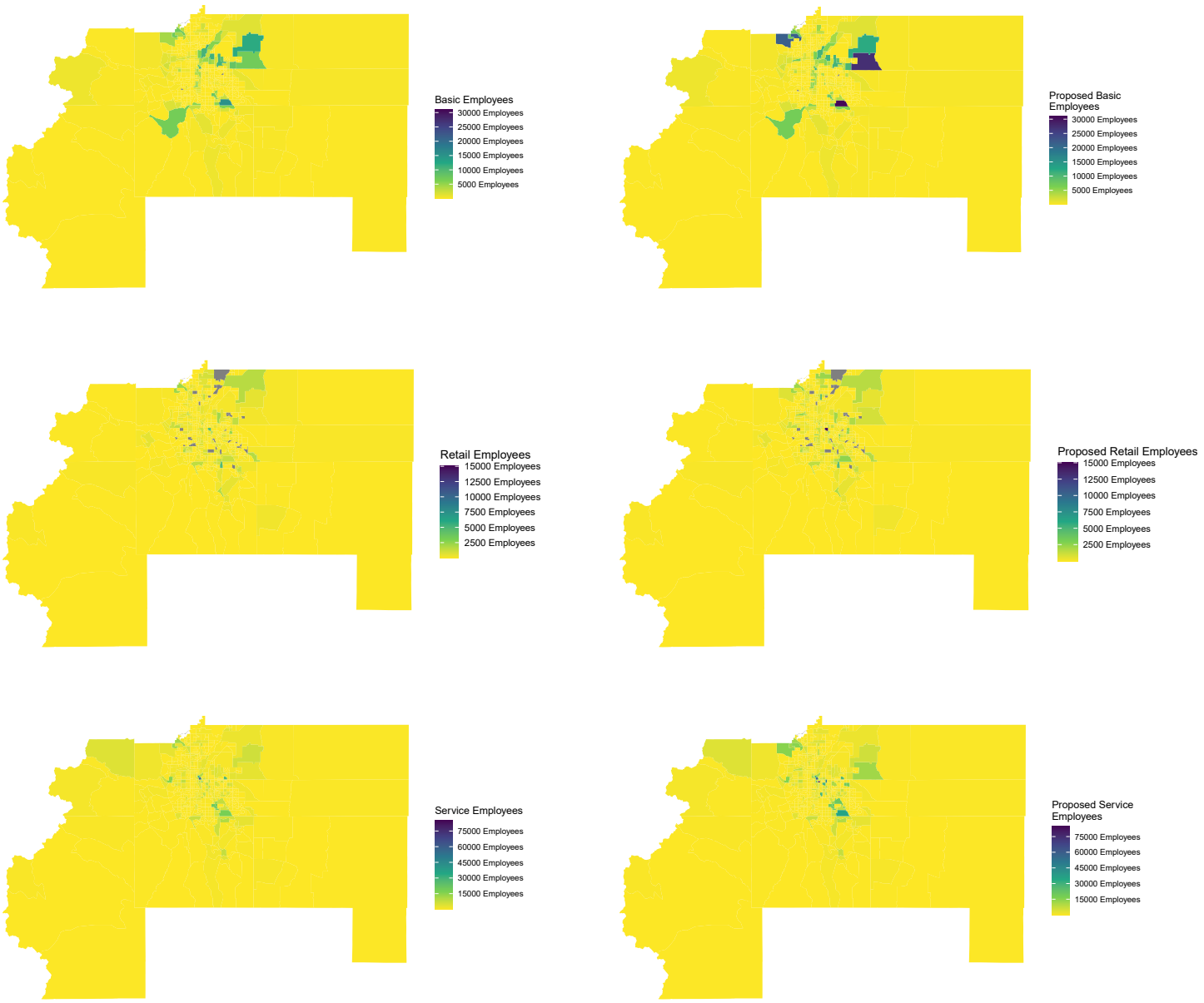

Figure 10:Existing (left) versus Proposed (right) Basic, Retail, and Service Employees.

The six maps above show basic, retail, and service employees across the MSA tracts in existing conditions, the left column, and after our proposal, on the right. The ratios of basic to retail to service employees stay the same per our assumptions, so the change in maps reveals the tracts which overlay multi-family zoning, and therefore received household increases.

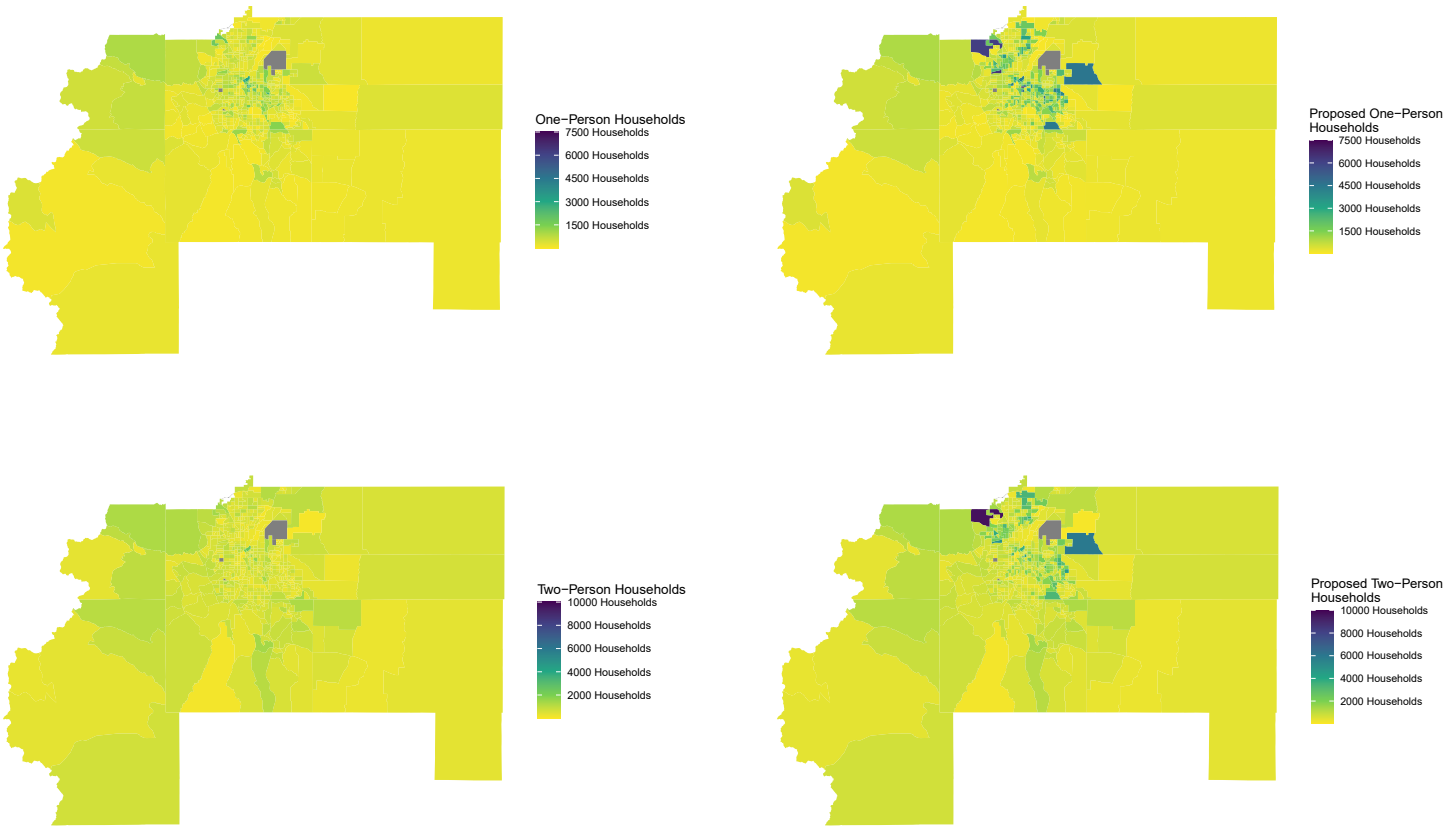

Figure 11: Existing (left) versus Proposed (right) One and Two Person Households

The four maps above show one and two person households across the MSA tracts in existing conditions, the left column, and after our proposal, on the right. The ratios of one and two person households compared to total households stay the same per our assumptions, so the change in maps reveals the tracts which overlay multi-family zoning, and therefore received household increases. Given our proposal is adding solely multi-family units, we chose to designate these households as one or two person only, no larger.

Existing Conditions Summary of Variables:

Variable <chr>	Average <dbl>	Standard deviation <dbl>	Median <dbl>
basic_emp	623.03871	1638.8601	108.0
hh_income_high	946.97267	524.0082	842.0
hh_income_low	224.30064	184.9907	166.0
hh_income_mid	620.93730	347.1401	574.0
housing_units	1891.84887	802.4370	1812.0
nocar	99.72669	134.5266	50.0
oneperson_hh	506.17846	402.5089	407.0
population	4660.38585	1946.3886	4448.5
retail_emp	244.48871	431.7376	90.5
service_emp	1609.03065	3735.2709	583.0
twoperson_hh	615.06431	272.7655	584.5

11 rows

Proposed Summary of Variables:

Variable <chr>	Average <dbl>	Standard deviation <dbl>	Median <dbl>
new_basic	798.4101	2424.0003	127.2663
new_hh_income_high	1149.3486	836.6467	971.3750
new_hh_income_low	287.2174	288.1387	192.4000
new_hh_income_mid	810.7390	705.2310	610.5000
new_nocar	125.0116	185.1424	57.5000
new_oneperson_hh	820.7401	921.2454	481.5000
new_retail	329.4870	771.9666	115.0492
new_service	2265.3940	5943.0249	654.5000
new_total_housing_units	2315.5785	1520.4037	1997.7050
new_total_tract_population	6112.9770	4447.0253	4978.5000
new_twoperson_hh	948.2001	820.1789	700.0000

11 rows

In addition to spatial comparison, we wanted to pull out some summary statistics for our existing versus proposed conditions. Aside from a useful tool to compare averages before and after, we find it interesting how large the standard deviations are and how different the medians are from the averages. These are likely influenced by the great variation in tract size and zoning type across the MSA.