CALIBRATION/VALIDATION REPORT - VERSION 9.0.0

WFRC / MAG

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1Wasatch Front Travel Demand Model Documentation

The Wasatch Front Travel Demand Model (WF TDM) is a macro transportation model. It forecasts daily travel patterns based on household characteristics and where people live in relation to the location of their daily activites and transportation opportunities. Travel decisions are based on a series of models that are calibrated to travel behavior of Wasatch Front residents measured from household travel diary surveys. Trips are assigned to a set of highway or transit-system routes by time of day based on where and by what mode people are likely to travel and the best route available to them.

The travel demand models are able to evaluate transportation and traffic impacts resulting from:

- transportation improvements
- provision of new modes of travel and/or enhancement of existing alternative modes
- changes in land use activity
- changes in travel behavior or policies/economic circumstances affecting behavior

As such, travel demand output is used to forecast where future travel demand is likely to exceed capacity and to assess the merits of future transportation investments. Travel demand output is also used to analyze air quality and other ancillary impacts of the transportation system.

The current WF TDM covers Weber, Davis, Salt Lake, and Utah Counties and a portion of Box Eder County. The WF TDM is jointly owned by the Wasatch Front Regional Council (WFRC) and the Mountainland Association of Governments (MAG). To request a copy of the WF TDM, please contact the following persons:

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- Matt DeLora (MAG): mdelora@magutah.org

2Life Cycle

The Life Cycle model determines the how much of the TAZ population and households from the processed socioeconomic input file will be in one of three life cycle categories:

- Life Cycle 1 – households with no children and no seniors
- Life Cycle 2 – households with children and no seniors
- Life Cycle 3 – households with seniors (may have children)

The Life Cycle model does its calculations in three phases:

- Determine the TAZ population that is in three age groups
- Determine each age group population that is in the three life cycle categories
- Determine the number of households in each life cycle category

2.1 Population by Age Group

The Life Cycle model first estimates how much of the TAZ population falls into one of three Age Group categories:

- Age Group 1 – 0 to 17 years old
- Age Group 2 – 18 to 64 years old
- Age Group 3 – 65+ years old

The initial share of the TAZ population in each Age Group is determined by multiplying the TAZ household population by the TAZ-level Age Group percentages in the `Lookup - BYTAZAgePct - AllCo.csv` file located in the `1_Inputs\\0_GlobalData\\1_HHDisag_AutoOwn` directory. These initial TAZ-level Age Group percentages were calculated from 2020 Census block and 2020 ACS block group data summarized at the TAZ level.

The Census data was also summarized at the medium district level. If the Census TAZ data had fewer than 50 people, the percentages from medium districts were used. The medium district distribution of 2020 Census Age Group percentages for the Wasatch Front can be seen in Figure 2.1. The share of population in each of the Age Groups varies significantly by geography. Urban areas tend to have the highest share of population 18-64 years old and the fewest children and seniors. Suburban and rural areas tend to have the highest share of children.

The initial TAZ-based population by Age Group is then factored to reflect the year being modeled. This is done using the county population by Age Group forecasts found in `ControlTotal_Age.csv` located in `1_Inputs\\2_SEData\\_ControlTotals` directory. The Age Group county-level percentages are calculated from county-level population projections from the Kem C. Gardner Policy Institute (GPI), 2020-2060 State and County Total Population by Sex and Single-Year of Age. The GPI projections show a trend in all counties in the Wasatch Front model space toward a more senior population and fewer children. Adult population in the age range of 18-64 also saw a slight increase in population share.

Figure 2.1: 2020 Census % Population by Age Group by Medium District.

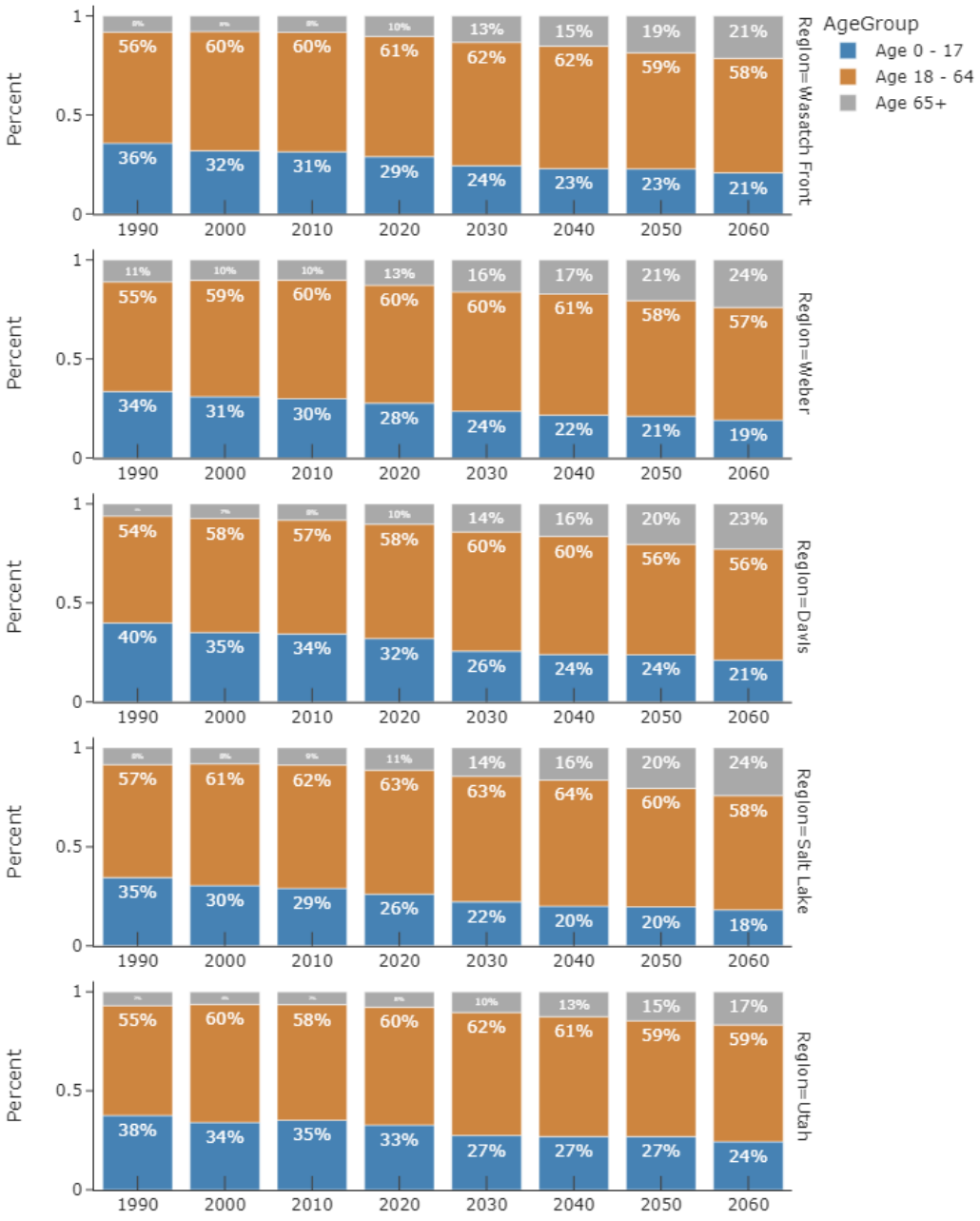

Figure 2.2: GPI County Population Projections by Age Group for Wasatch Front Counties.

???UPDATE TO USE 2023-06-09 version instead of 2023-04-28???

The 2020 model base year population by county and Age Group was compared to the 2020 GPI county-level population by Age Group, shown in Figure 2.3. The model's estimate of the population in each Age Group mirrors the GPI county-level projections.

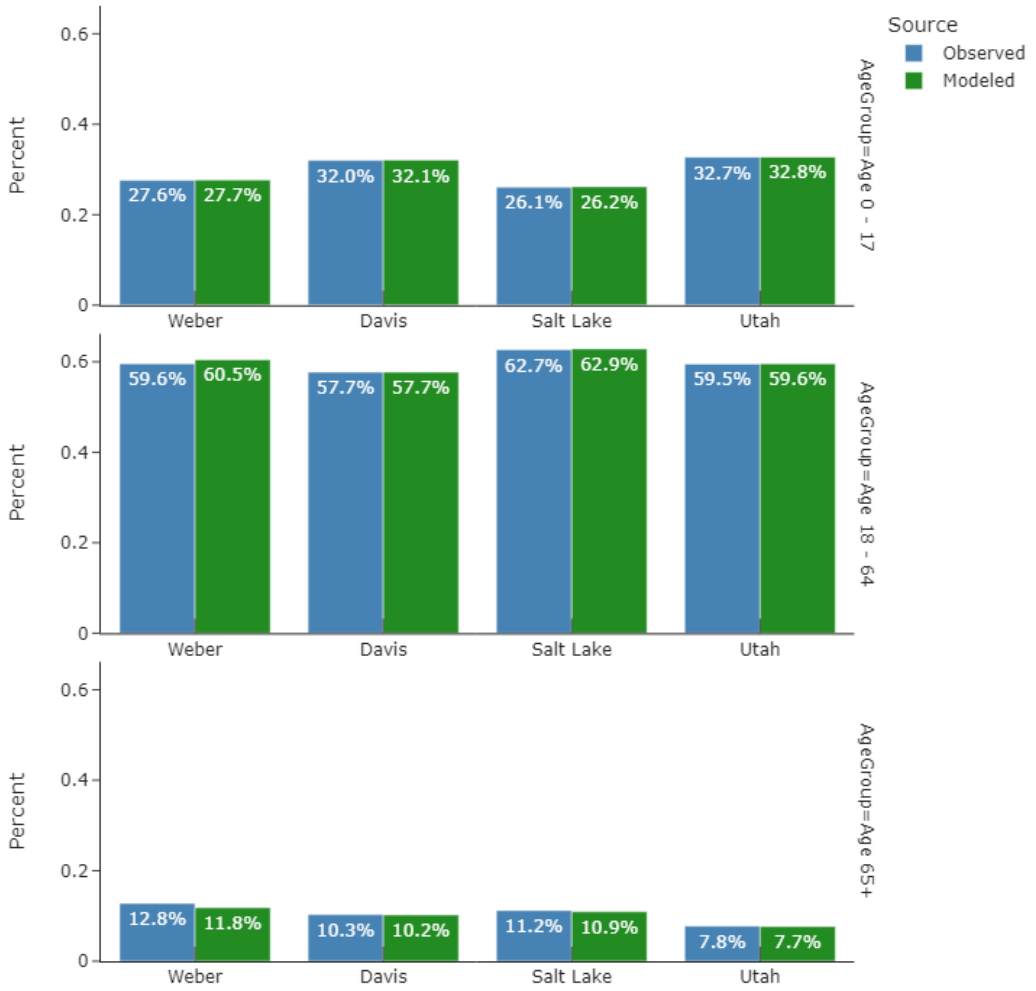

Figure 2.3: 2020 Model vs. 2020 GPI – % Population by Age Group and County.

2.2 Population by Life Cycle

The Life Cycle model uses parameters estimated from the 2012 Household Survey to convert population in Age Groups to population in a Life Cycle category. Unique parameters were estimated for each county and are found in Table 2.1.

Table 2.1: Percent of Age Group Population in Life Cycle 2 by County

County	0-17 Population Age Group (LC2 Fac 0-17)	18-64 Population Age Group (LC2 Fac 18-64)
Box Elder	0.993	0.664
Weber	0.982	0.606
Davis	0.974	0.711
Salt Lake	0.961	0.525
Utah	0.981	0.659

Only factors for Life Cycle 2 were estimated. Life Cycle 1 has no children leaving the 0-17 population to be divided between Life Cycles 2 and 3. Life Cycle 3 has no adults age 18-64 leaving the 18-64 population to be divided between Life Cycles 1 and 2. All of 65+ population lies completely within Life Cycle 3. Table 2.2 contains the equations used to calculate Life Cycle population.

Table 2.2: Equations to Calculate Age Group Population in Each Life Cycle Category

Age Group	Life Cycle 1	Life Cycle 2	Life Cycle 3
0-17	0	LC2 Fac 0-17	1 – (LC2 Fac 0-17)
18-64	1 – (LC2 Fac 18-64)	LC2 Fac 18-64	0
65+	0	0	1

Almost all of the child-aged population is contained within Life Cycle 2, ranging between 96.1% in Salt Lake County and 99.3% in Box Elder County. The remaining child population is in Life Cycle 3. The majority of the adult-not-a-senior population is contained in Life Cycle category 2, ranging between 52.5% in Salt Lake County and 71.1% in Davis County, with the remainder falling into Life Cycle 1.

The shares of the modeled 2019 base year population by Life Cycle were compared to the 2012 Household Survey at the county level. The model's estimate of population by Life Cycle category seemed reasonable at this level of geography with all modeled comparison points falling within 4% of the observed data.

2.3 Households by Life Cycle

The Life Cycle model calculates households by Life Cycle using the average household size for each Life Cycle category. Unique average household sizes were estimated for each county and Life Cycle from the 2012 Household Survey.

Table 2.3: Average Household Size by Life Cycle and County

County	Household Size for Life Cycle 1	Household Size for Life Cycle 2	Household Size for Life Cycle 3
Box Elder	1.86	4.21	2.41
Weber	1.88	4.53	1.81
Davis	2.14	4.68	2.33

County	Household Size for Life Cycle 1	Household Size for Life Cycle 2	Household Size for Life Cycle 3
Salt Lake	1.86	4.44	1.81
Utah	2.11	4.75	2.21

The TAZ-level population by Life Cycle category are divided by the average household size factors to generate an estimate of the share of TAZ-level households in each Life Cycle category. The share of households in each Life Cycle category is then multiplied by the total households in the TAZ to get the adjusted number of households per Life Cycle category.

A final check is made to avoid unrealistic household sizes for zones with smaller populations. The number of households for a given Life Cycle category are capped at the minimum and maximum household sizes found in Table 2.4.

Table 2.4: Allowed Minimum and Maximum Average Household Size by Life Cycle

Life Cycle Category	Minimum Household Size	Maximum Household Size
1	1	4
2	2	8
3	1	4

The shares of the modeled 2019 base year households by Life Cycle were compared to the 2012 Household Survey at the county level. The model's estimate of households by Life Cycle category seemed reasonable at this level of geography with all modeled comparison points falling within 1.5% of the observed data.

Figure 2.4: 2019 Model vs. 2012 Household Survey – % Population by Life Cycle and County.

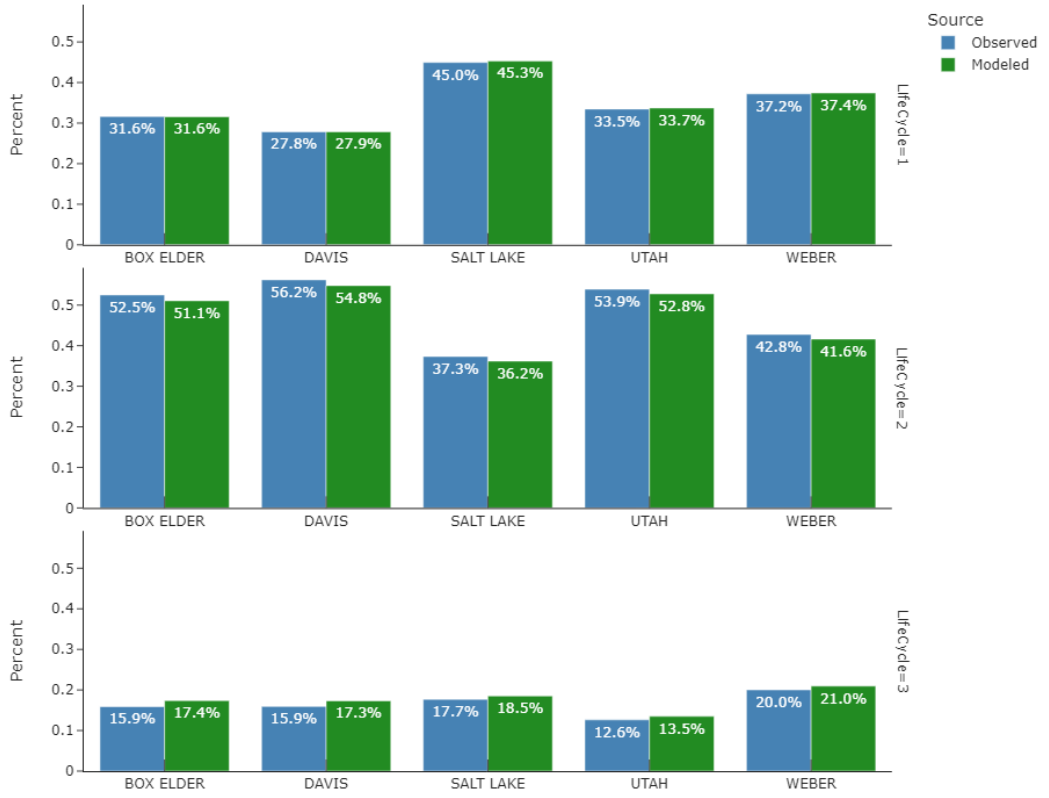

Figure 2.5: 2019 Model vs. 2012 Household Survey – % Households by Life Cycle and County.

3Household Disaggregation

The Household Disaggregation model classifies a TAZ's households by:

- Household Size
- Income
- Number of Workers

Household Disaggregation is done in three steps with each step adding another level of disaggregation: estimating the distribution of households by size group, further disaggregation by income group and income level, and further disaggregation by number of workers per household. This results in 96 groupings when using the four income groups or 48 groupings when using low/high income levels.

For disaggregation to household size groups, the following lookup files contain the distribution of households across the six household size groups according the average household size for the three life cycle categories: `Lookup - HH Size_LC1.csv`, `Lookup - HH Size_LC2.csv`, and `Lookup - HH Size_LC3.csv`. The distributions in these files are grouped by county. There is also a third lookup file that contains a regional distribution used for comparison purposes: `Lookup - HH Size.csv`. When computing income ratios, the regional median household income of $74,946 (2019 dollars) is used from the latest ACS.

Further disaggregation by income groups is done in multiple steps. First a target TAZ distribution by income is calculated using a county distribution found in `Lookup - Income.csv`. Then a Fratar/Furness balancing method is used to get the matrix distribution across income groups and household sizes. The matrix is initialized with the values found in Table 3.1, which is hard-coded into the `2_HHDisaggregation.s` script with the source being the 2012 Household Survey. The balancing method is run through until convergence is reached at (0.0001) or a max of 15 iterations.

Table 3.1: Initialization Seed Values for Household Size and income Group

Household Size	Income Group 1 Seed	Income Group 2 Seed	Income Group 3 Seed	Income Gruop 4 Seed
1	0.591	0.167	0.21	0.032
2	0.286	0.155	0.351	0.208
3	0.253	0.18	0.351	0.216
4	0.211	0.151	0.395	0.243
5	0.154	0.157	0.46	0.229
6	0.118	0.122	0.479	0.281

Final disaggregation by worker is a simple distribution which is found in the `Lookup - Worker.csv` file. This file contains a distribution across the worker groups by each of the 24 combinations of the six household size groups and the four income groups. Households are then aggregated back to the two income levels (low/high).

3.1 Household Size

The Household Disaggregation model estimates how many households are in six Household Size categories:

- 1 person households
- 2 person households
- 3 person households
- 4 person households
- 5 person households
- 6 or more person households

The model uses the TAZ's average household size to look up the share of households in each of the six Household Size categories. This is done independently for each of the three Life Cycle categories estimated in the previous model step.

???Is there newer data than the 2018 spreadsheet???

2010 Census Block Group data was used to determine the initial relationship between average household size and the number of households in each size category. To increase sample size, all Block Groups in Utah were included. Draft curves were estimated from the data's polynomial trendline as shown in Figure 3.1.

The results from the equations derived from the Census data were adjusted to remove negative values and to smooth and scale the resulting curves. The sum of the individual curves at any given average household size is 1. Figure 3.2 shows the smoothed curves for household size share by average household size.

The 2012 Household Survey was used to estimate the share of households in each Household Size category by Life Cycle. The entire statewide database was used and aggregated to medium districts in order to obtain sufficient number of survey records in a group yet preserve a sufficient number of observations to estimate lookup curves by Life Cycle. The estimated Life Cycle curves were then used to weight the Household Size lookup curves derived from the Census data (termed "All Data" in Figure 3.3) to obtain Household Size lookup curves by Life Cycle.

The Household Size lookup curves were then calibrated to county-level household size data from the 2010 Census as shown in Figure 3.4, Figure 3.5, and Figure 3.6. The county-level adjustments were done to tailor to the lookup curves to account for local variations.

The shares of the modeled 2015 base year households by Household Size category were validated to 2010 Census and 2016 ACS data at the county level. The model's estimate of households by each of the six Household Size category matches within about 2% of the observed data for all counties.

???Update to use 2019 Model???»

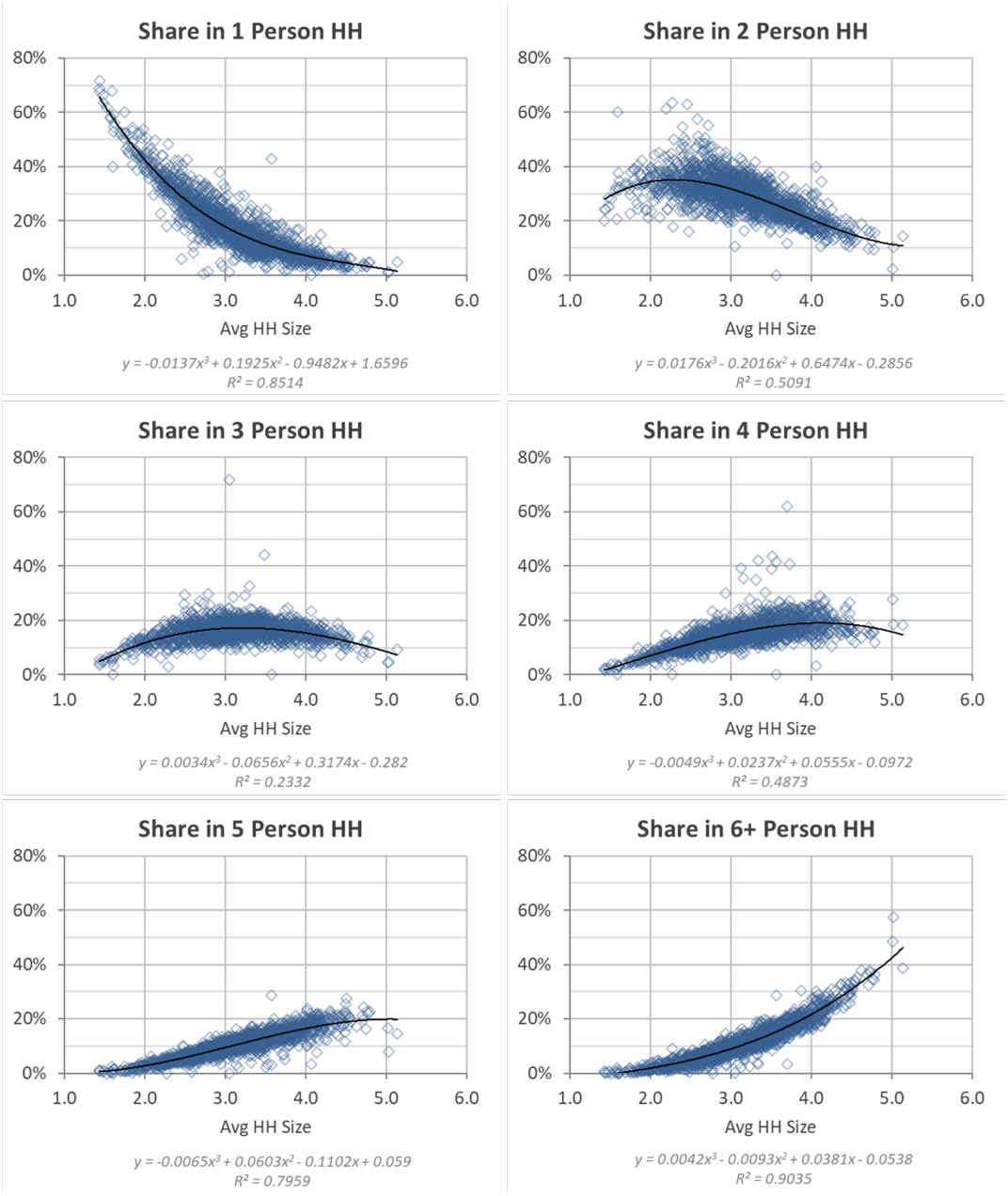

Figure 3.1: 2010 Census Block Group Data - Household Size Share by Average Household Size.

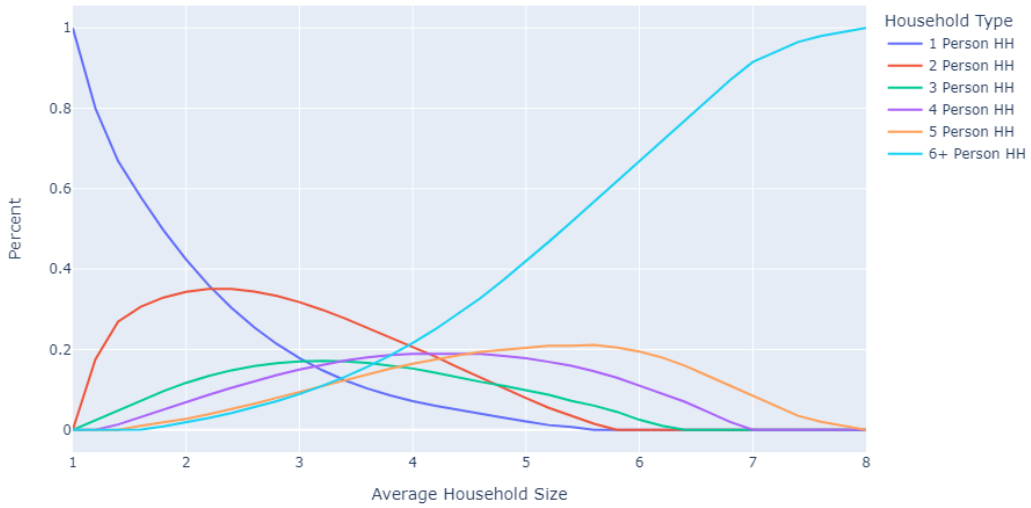

Figure 3.2: Household Size Share by Average Household Size – All Data.

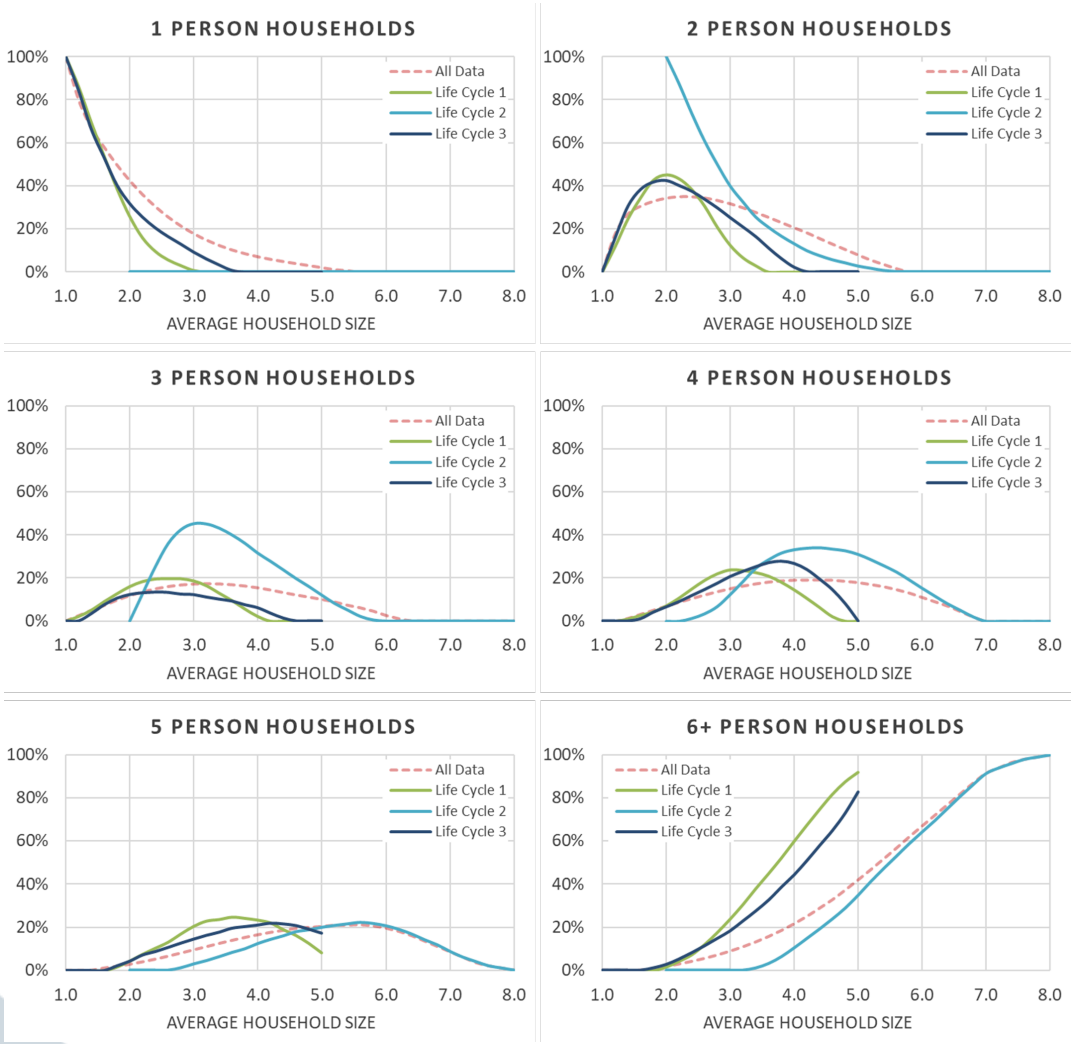

Figure 3.3: Comparison of Life Cycle and All Data Household Size Lookup Curves.

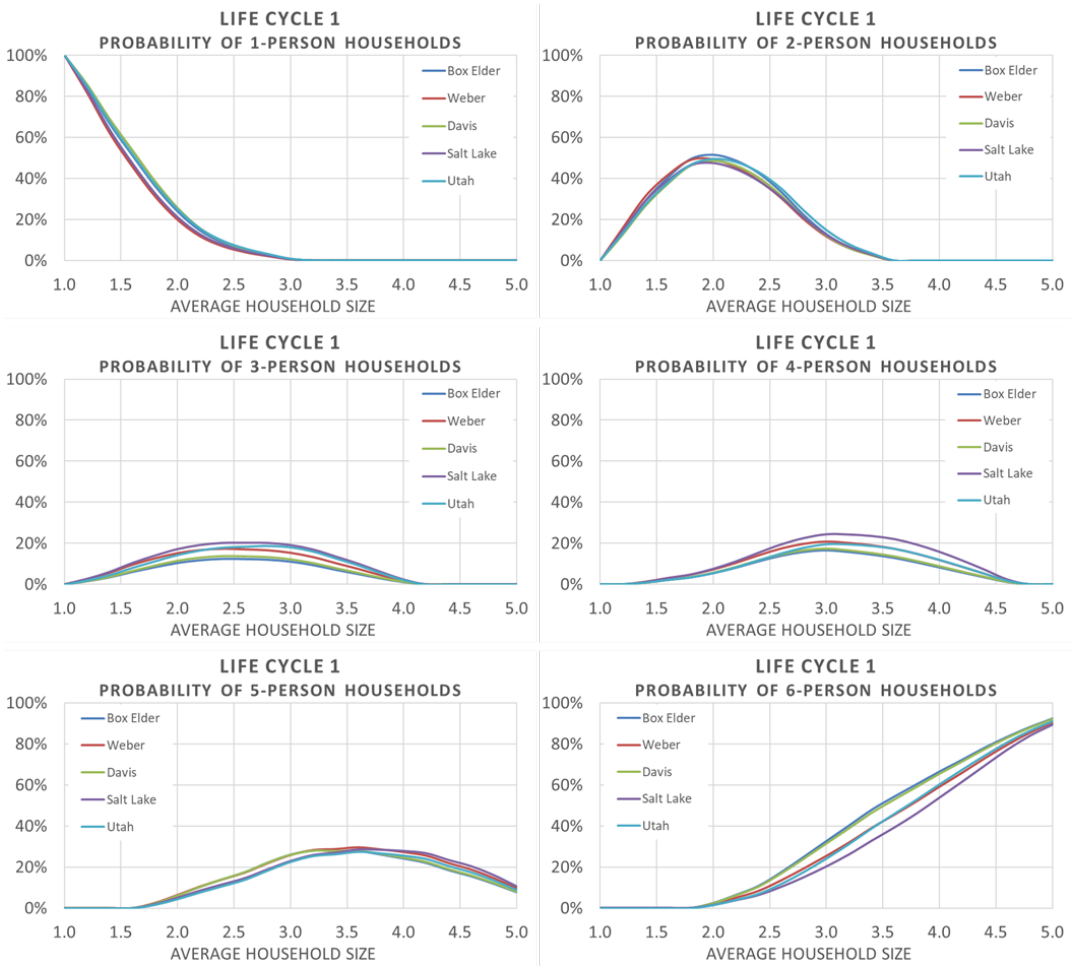

Figure 3.4: Comparison of Household Size Lookup Curves by County – Life Cycle 1.

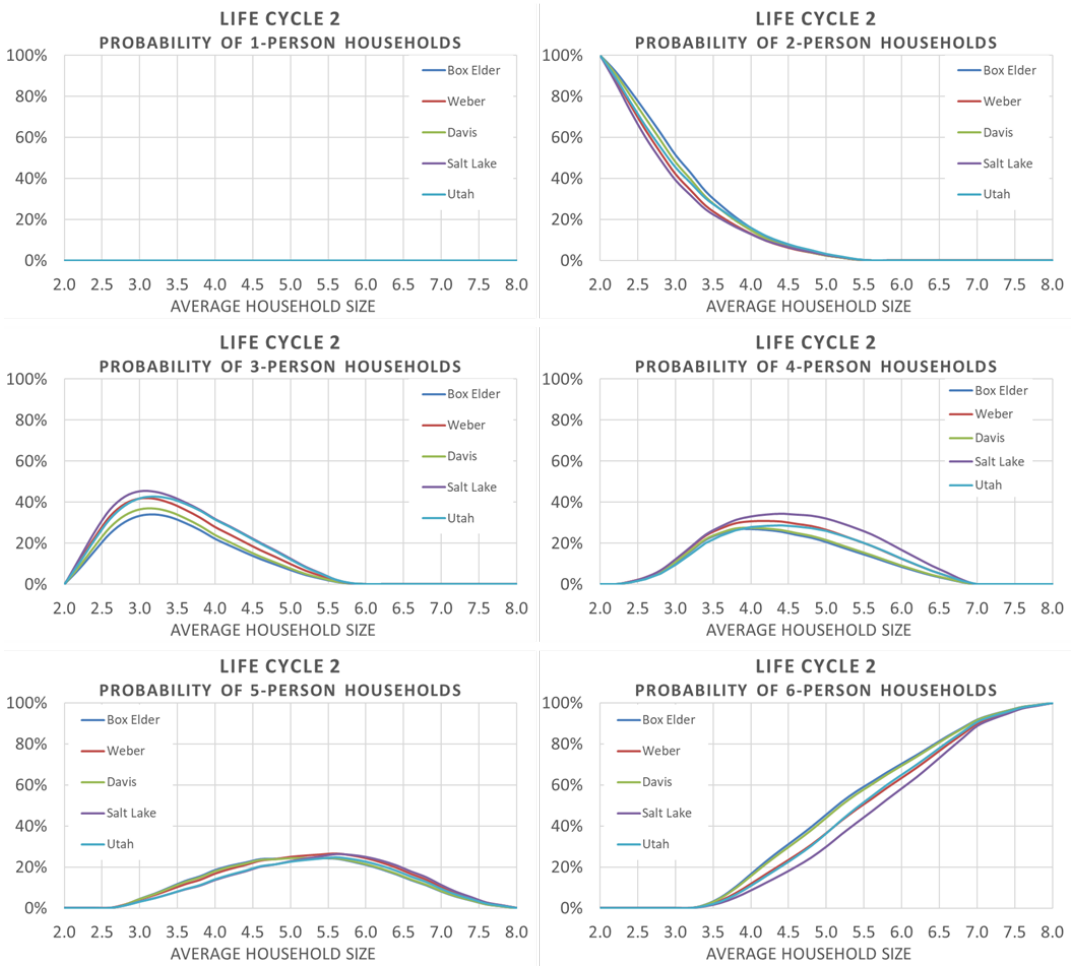

Figure 3.5: Comparison of Household Size Lookup Curves by County – Life Cycle 2.

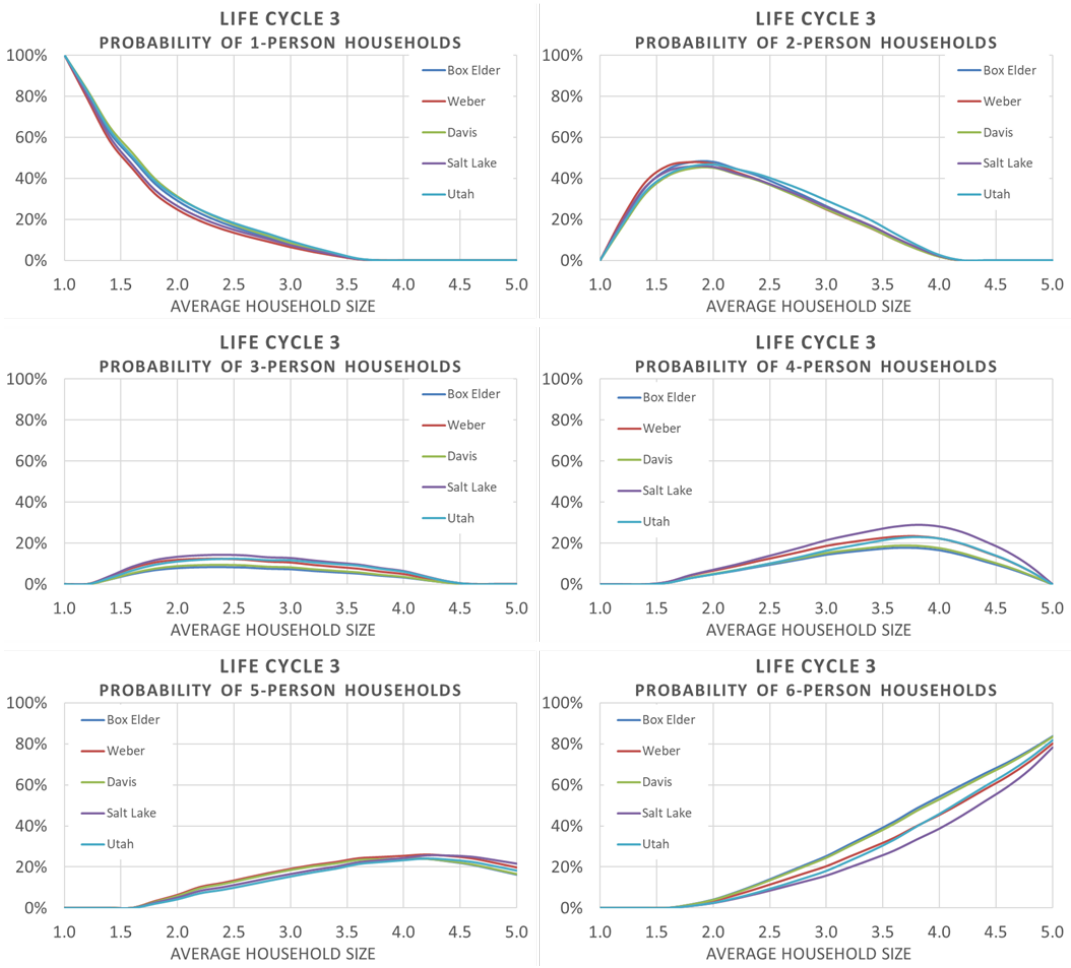

Figure 3.6: Comparison of Household Size Lookup Curves by County – Life Cycle 3.

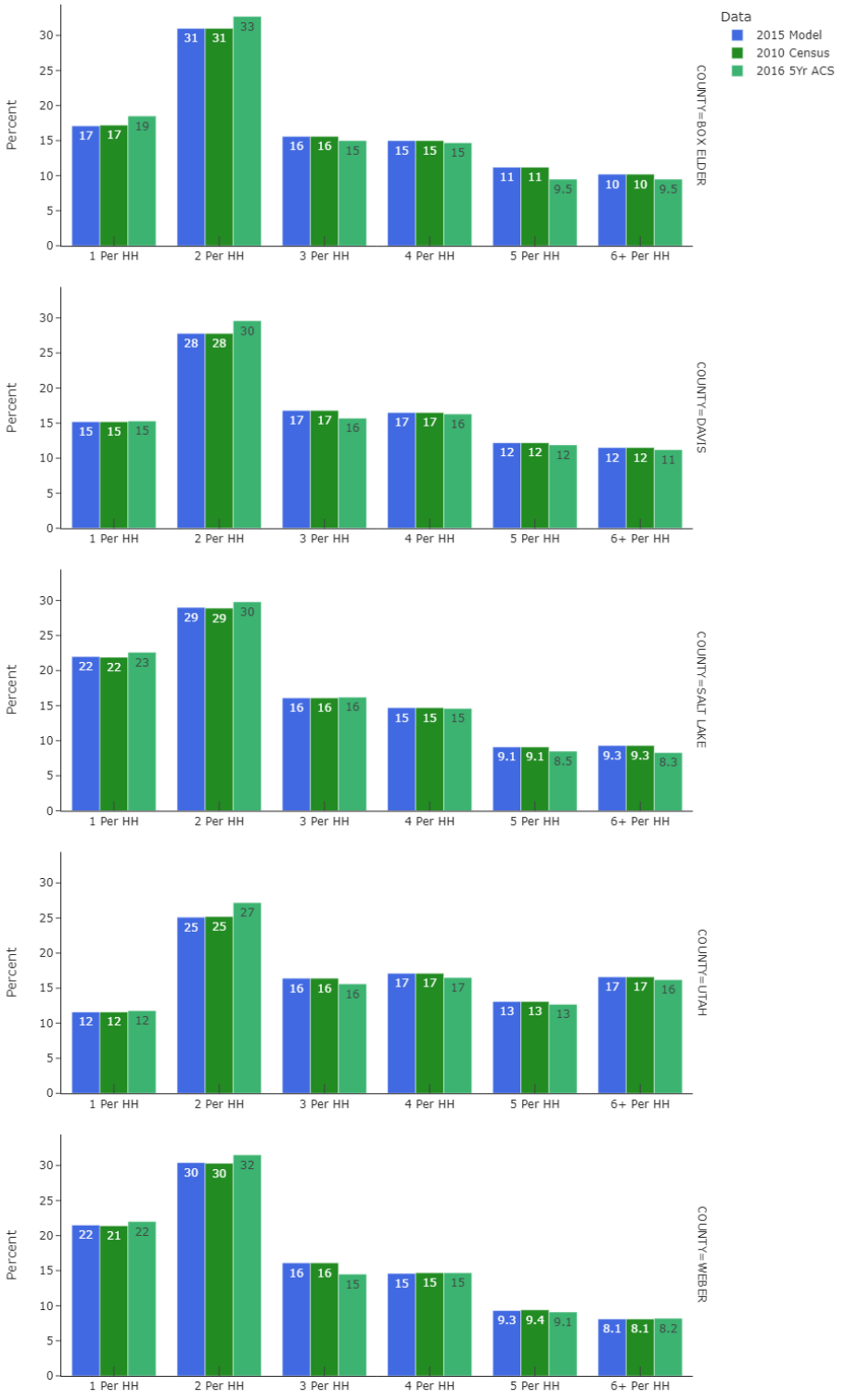

Figure 3.7: 2015 Model vs. 2010 Census & 2016 ACS – % Households by Household Size.

3.2 Income

???UPDATE???

- Income Gruops (Income Levels) in 2016 dollars:
  - 1: $0 to 35,000 (Low)
  - 2: $35,000 to 60,000 (High)
  - 3: $60,000 to 100,000 (High)
  - 4: $100,000 and above (High)

3.3 Worker

- Worker Groups: 0, 1, 2, 3+ workers per household

???Make more validation charts???