

EV charger

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GIS social characteristics of Tacoma

It is known that EV owners are more educated with higher income. Ye (2017) confirms, "Among the 15,408 survey respondents who specified their income, 77% had an annual household income of over \$100,000. Among the 18,848 respondents who specified their education level, 34% of them obtained a Bachelor's degree and 49% of them obtained a Graduate degree. Similarly, 81% of the respondents live in a single-family house; 75% of them are male, and 64% of them are white. According to this survey, EV owners are more likely to be male with relatively high income, possess a higher level of education attainment, and live in single family homes."

It is necessary in this regard to figure out the social characteristics of Tacoma for EV charger consideration. Here are several maps showing them.

Blocks with multi-family housings crossing the main area

A few blocks were chosen based on multi-family housings occupying the main area of the blocks. These blocks will be investigated against the rest of blocks to see any differences in terms of social characteristics.

14 variables (portion)

- Population density
- Male
- Age 35 to 64
- Non family household
- Education (Over bachelor)
- Rent household
- Median income
- Household income over \$100,000
- Housing built before 2000
- Commuter more than 45 min to work
- Rent households with no vehicle
- Rent % income

```
## corrpplot 0.84 loaded
```

It is estimated that more population density, more portion of rent housing with higher portion of no vehicle households, and less portion of non family households or more portion of family households are more likely correlated with blocks with more multi-family households.

Other regression model was built excluding the 3 erratic block groups as below.

Population density and portion of rent households are the main factor for MUD characteristics in Tacoma.

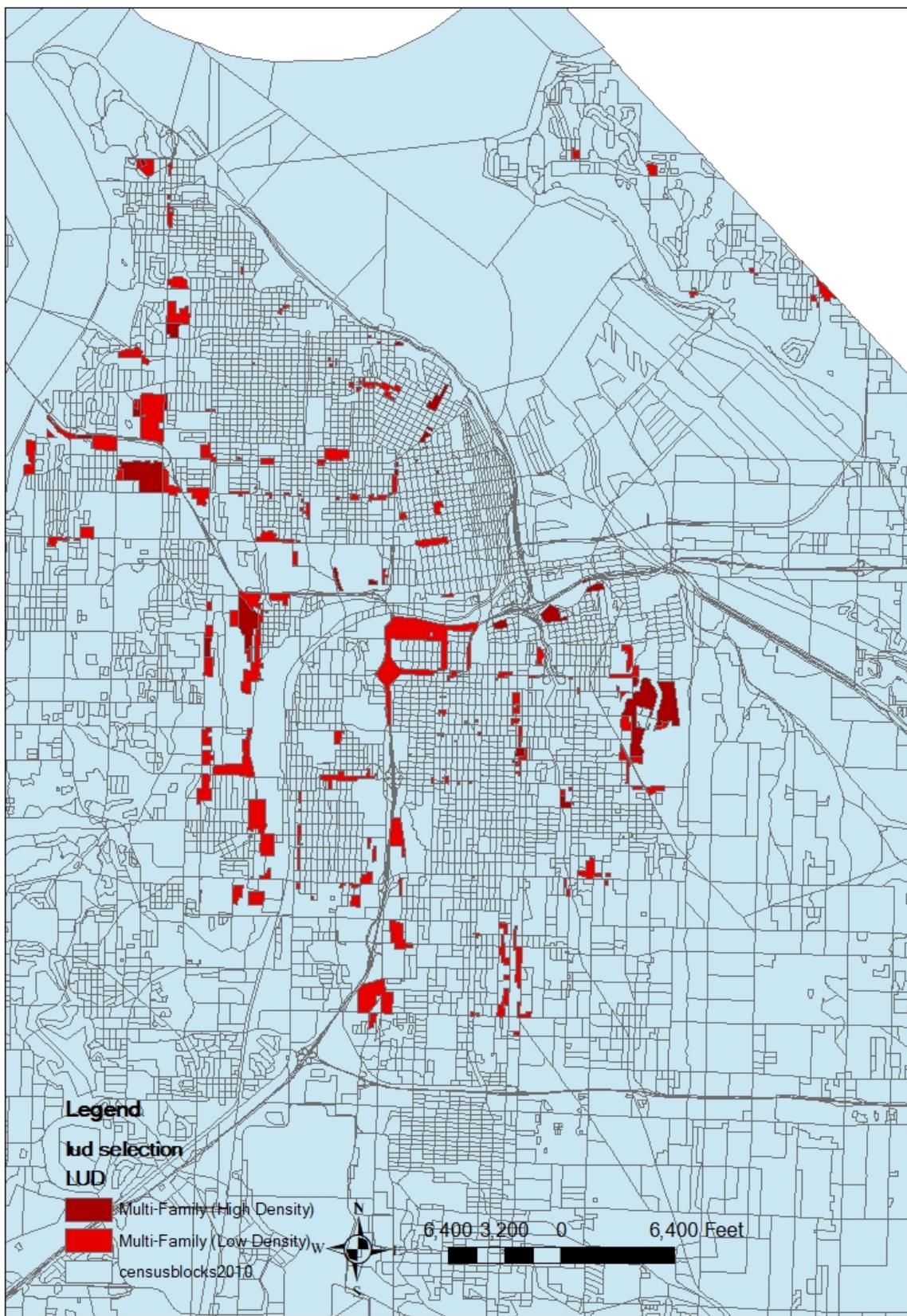


Figure 1: City of Tacoma with MUD
2

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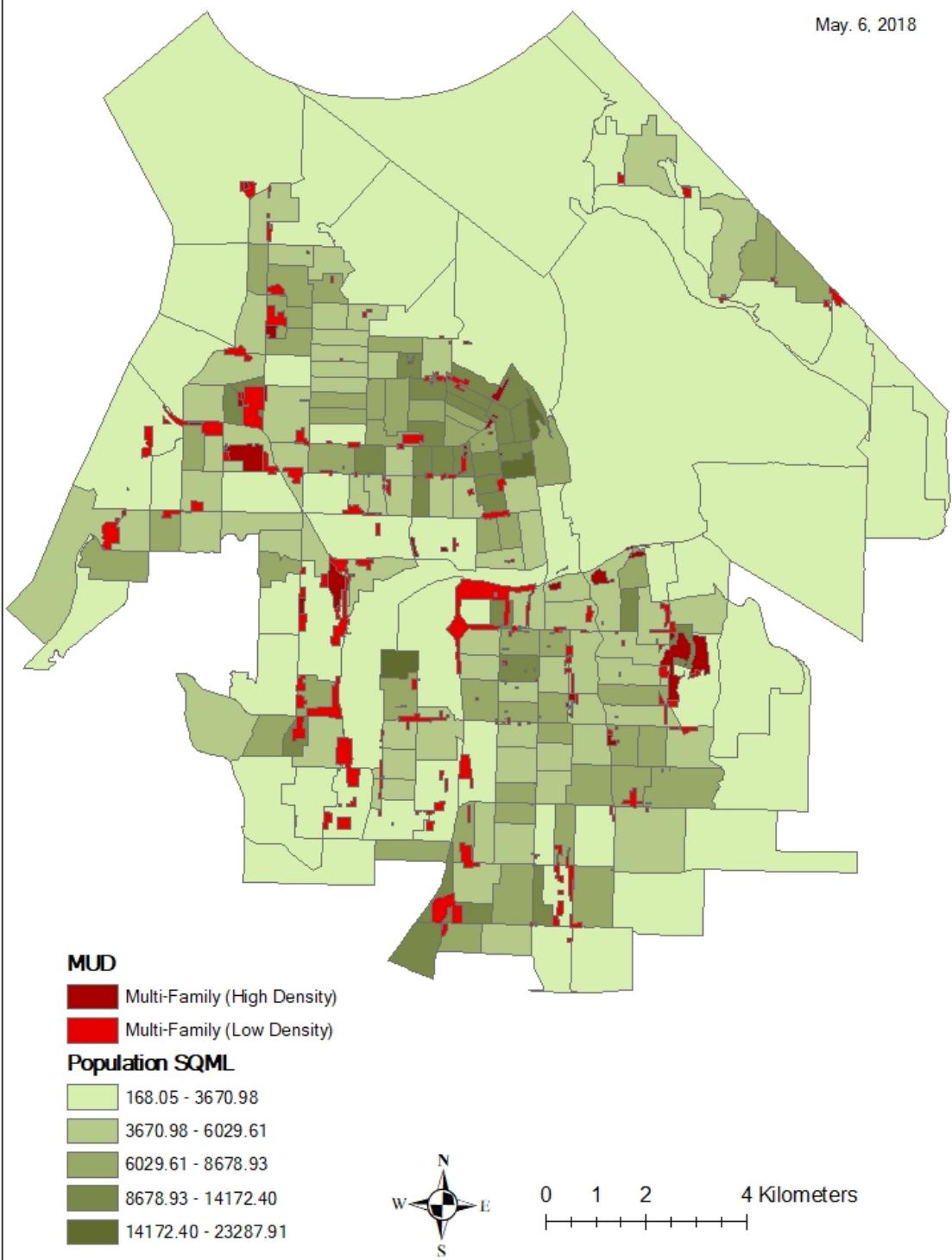


Figure 2: Population
3

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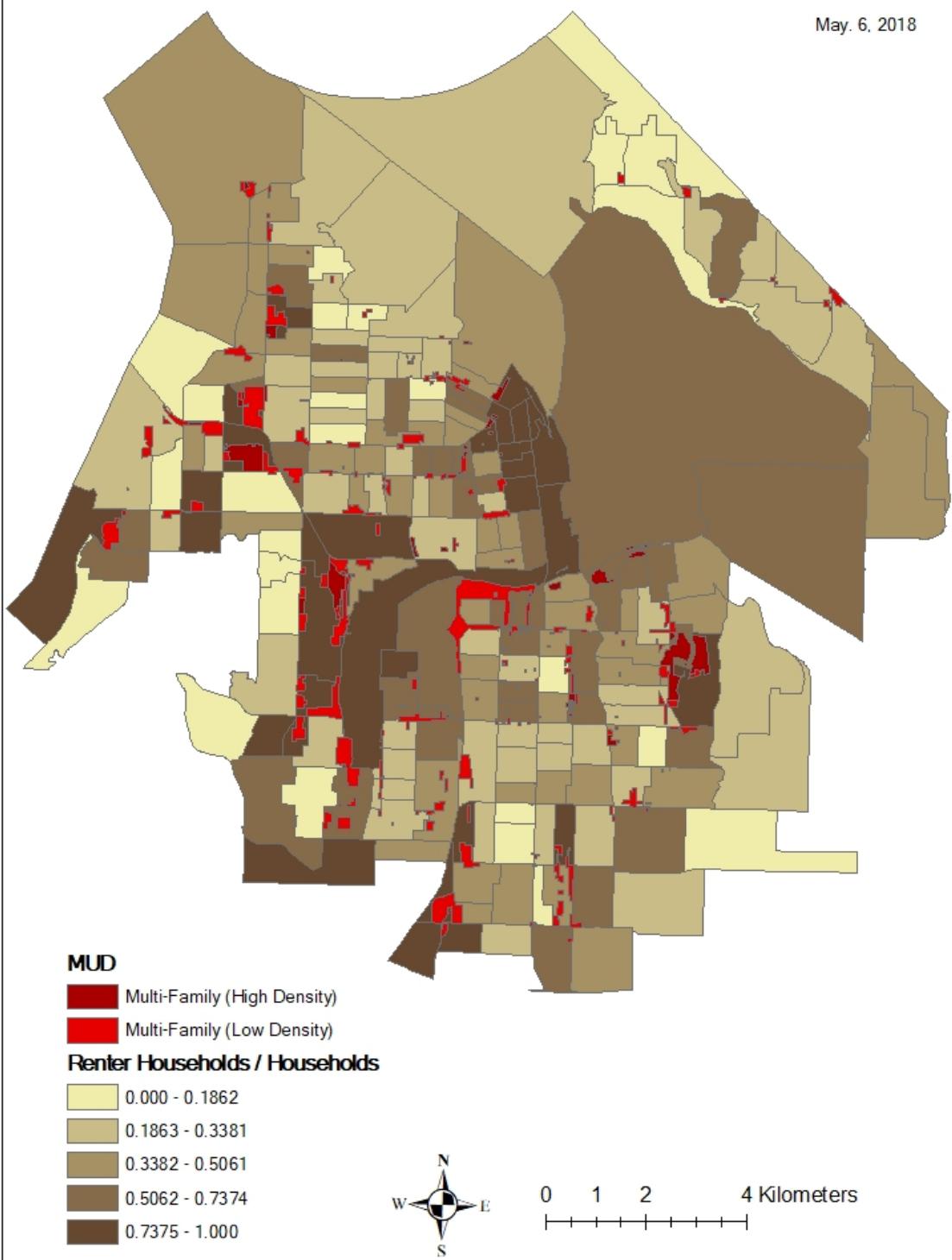


Figure 3: Rent household
4

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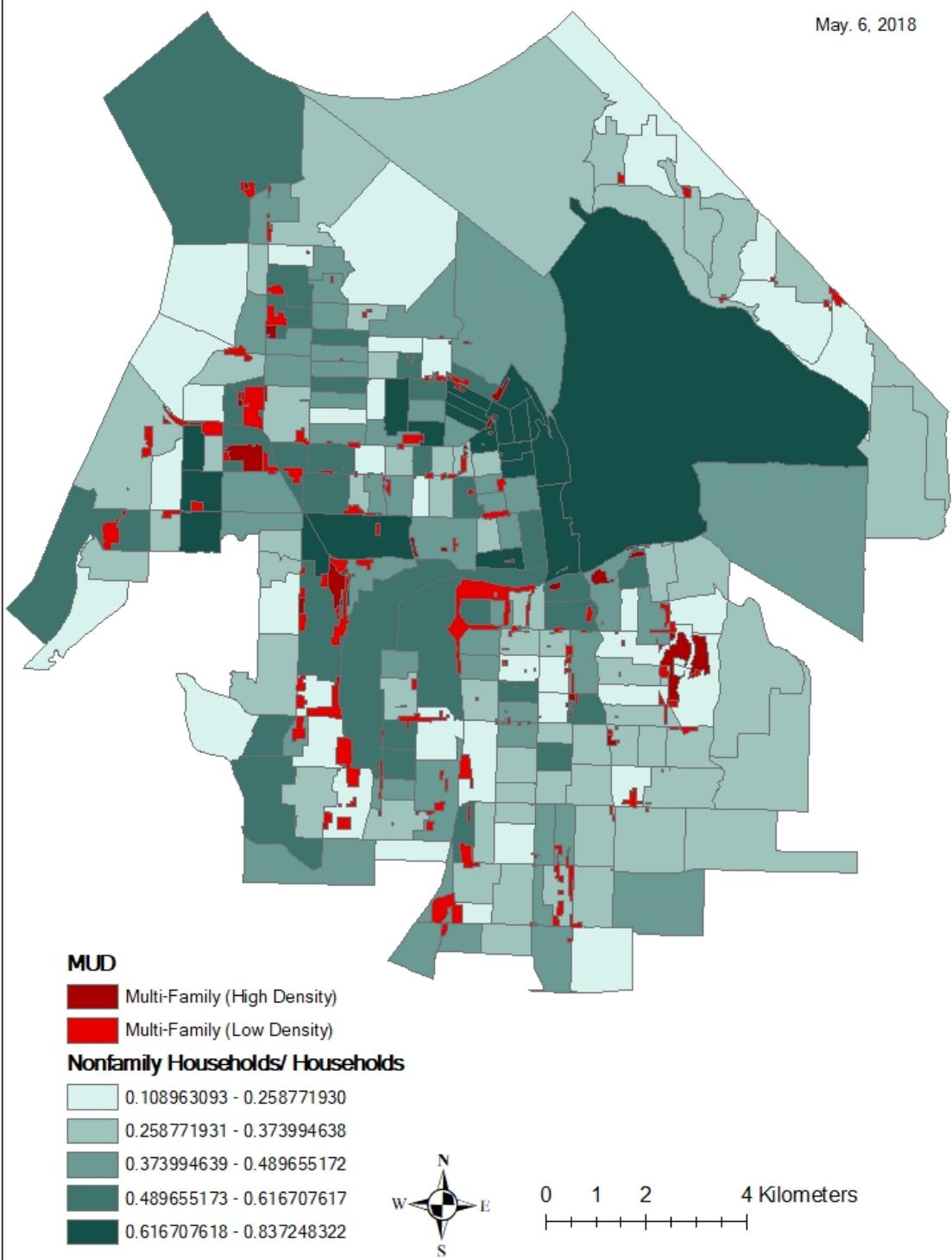


Figure 4: Nonfamily household
5

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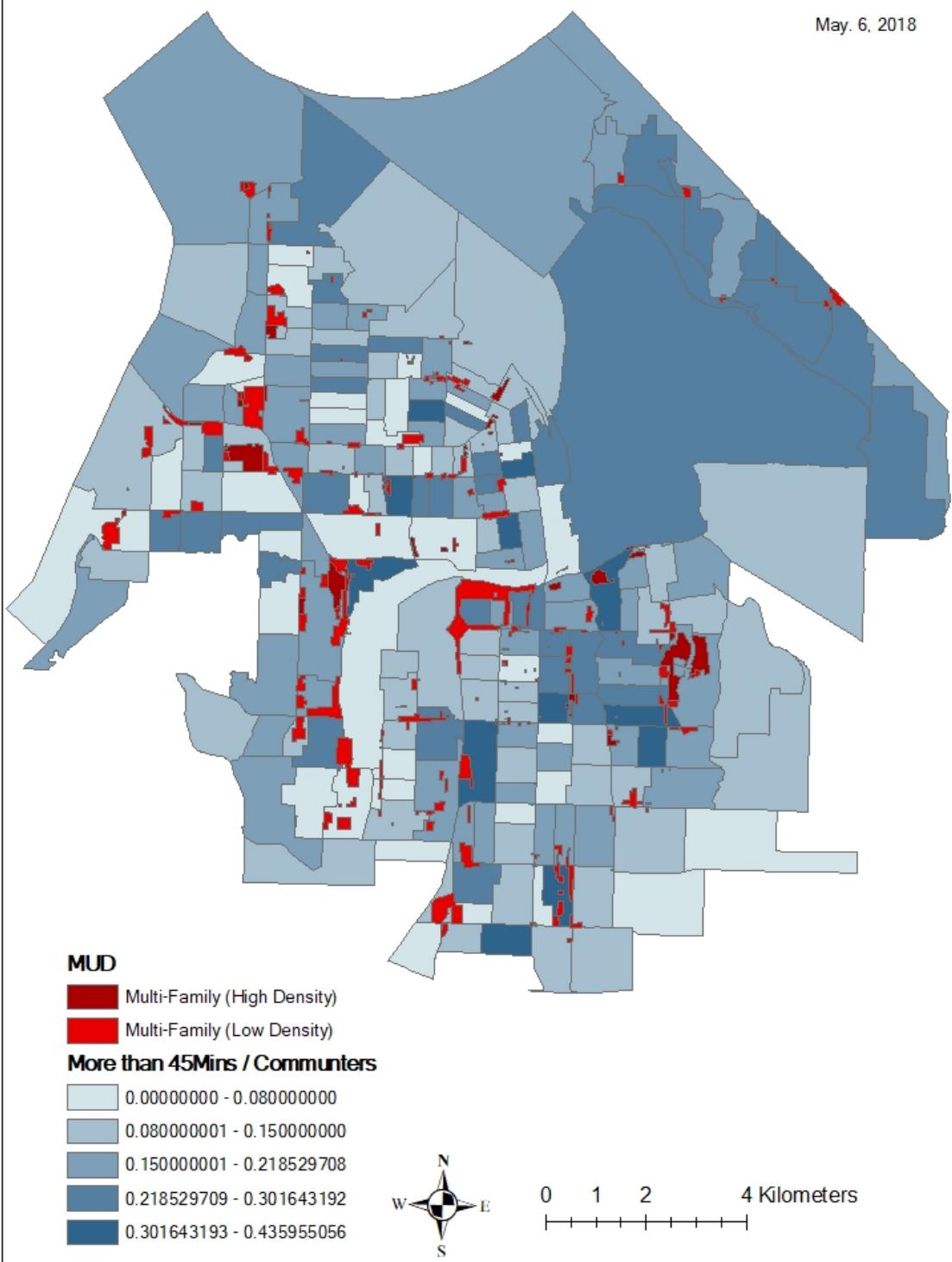


Figure 5: Commuters
6

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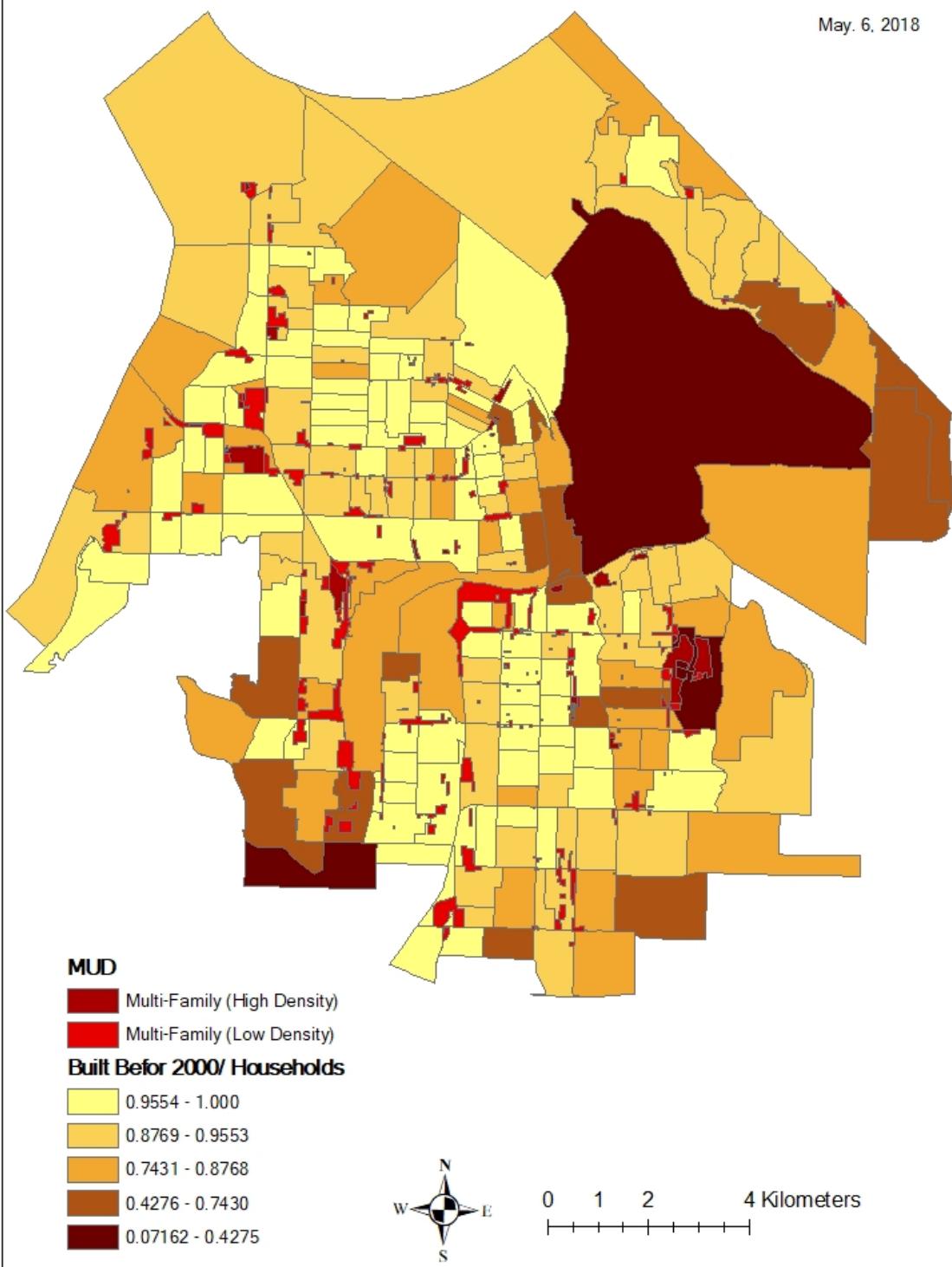


Figure 6: Housing built before 2000
7

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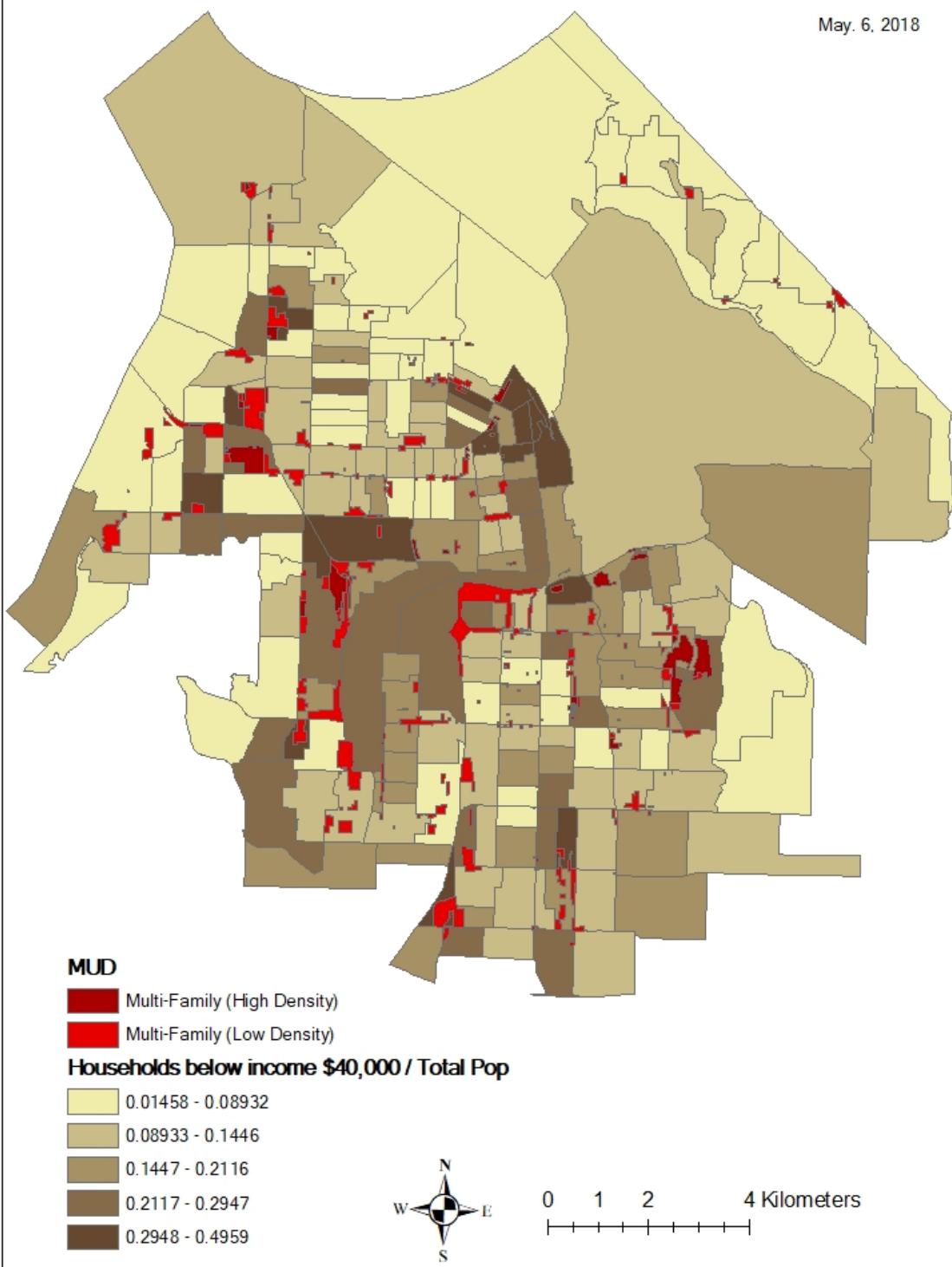


Figure 7: Median household incomes
8

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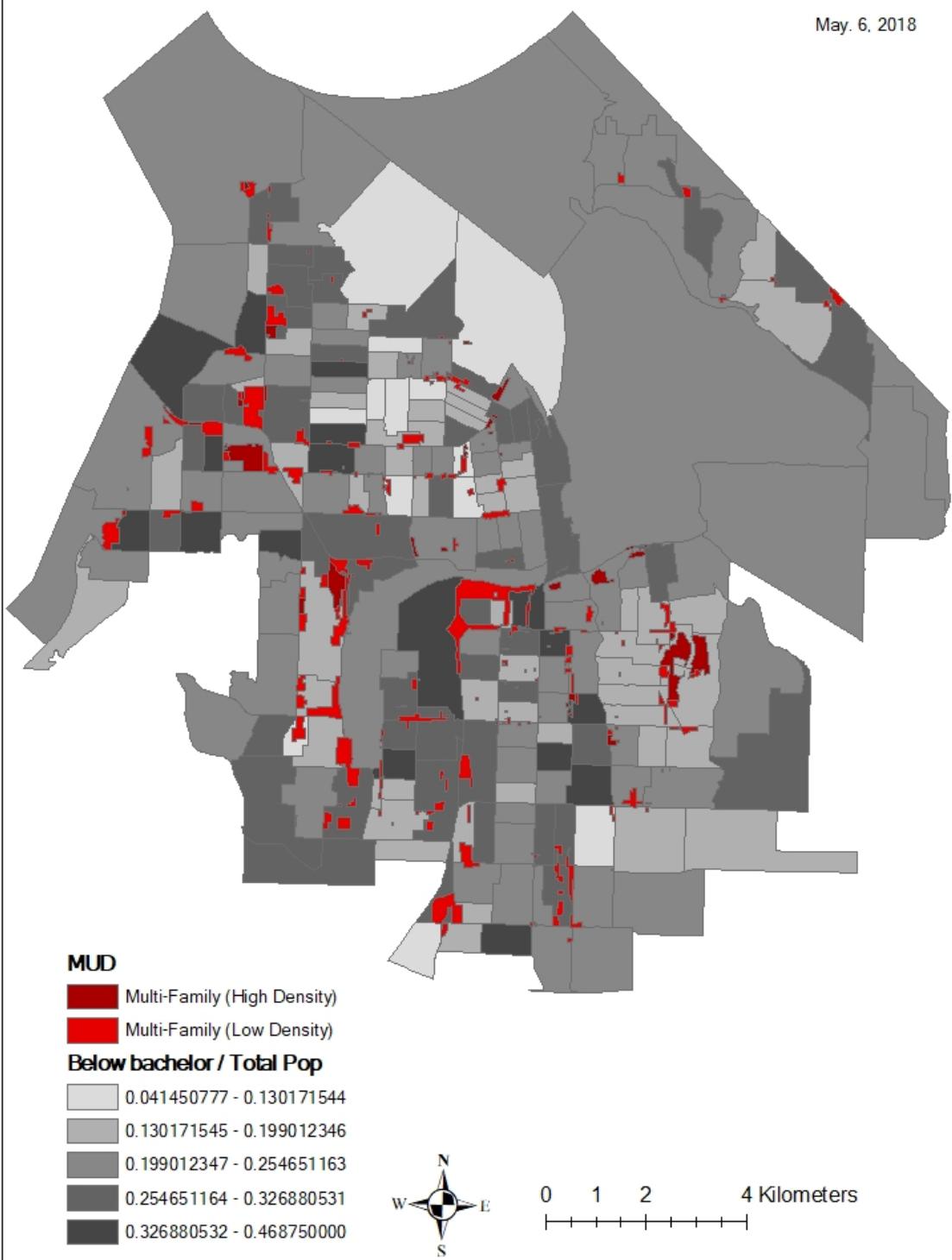


Figure 8: Education
9

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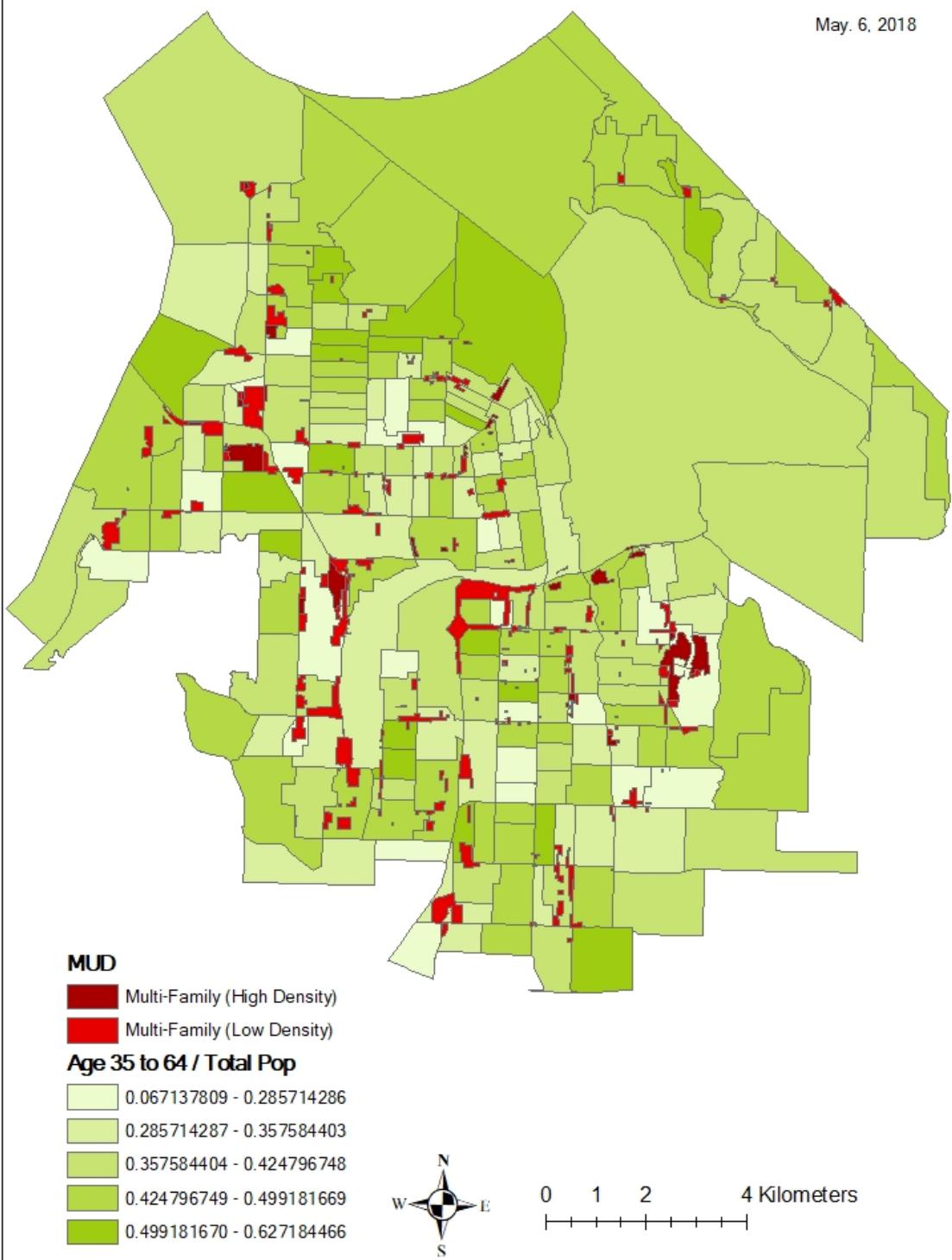


Figure 9: Population age
10

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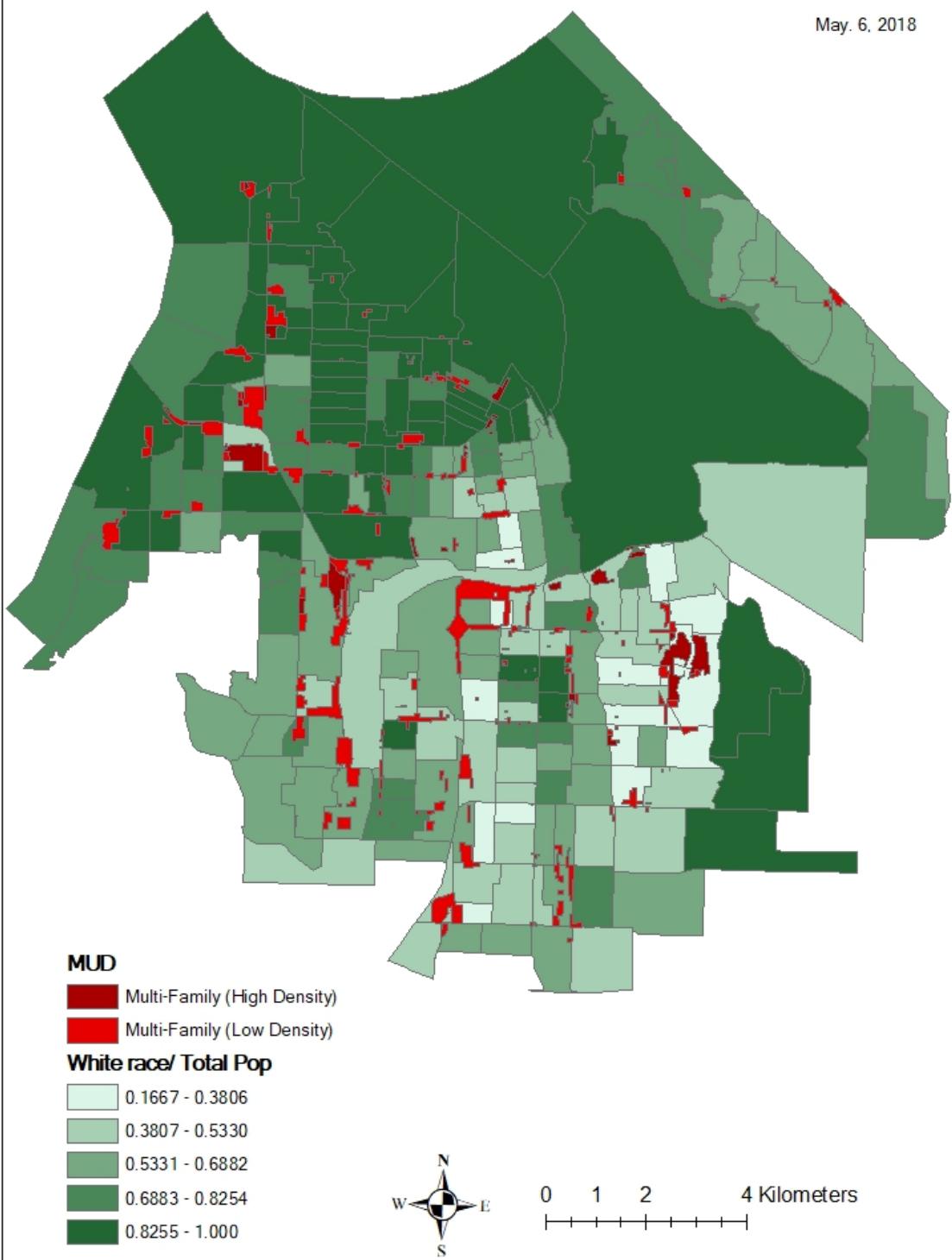


Figure 10: White race
11

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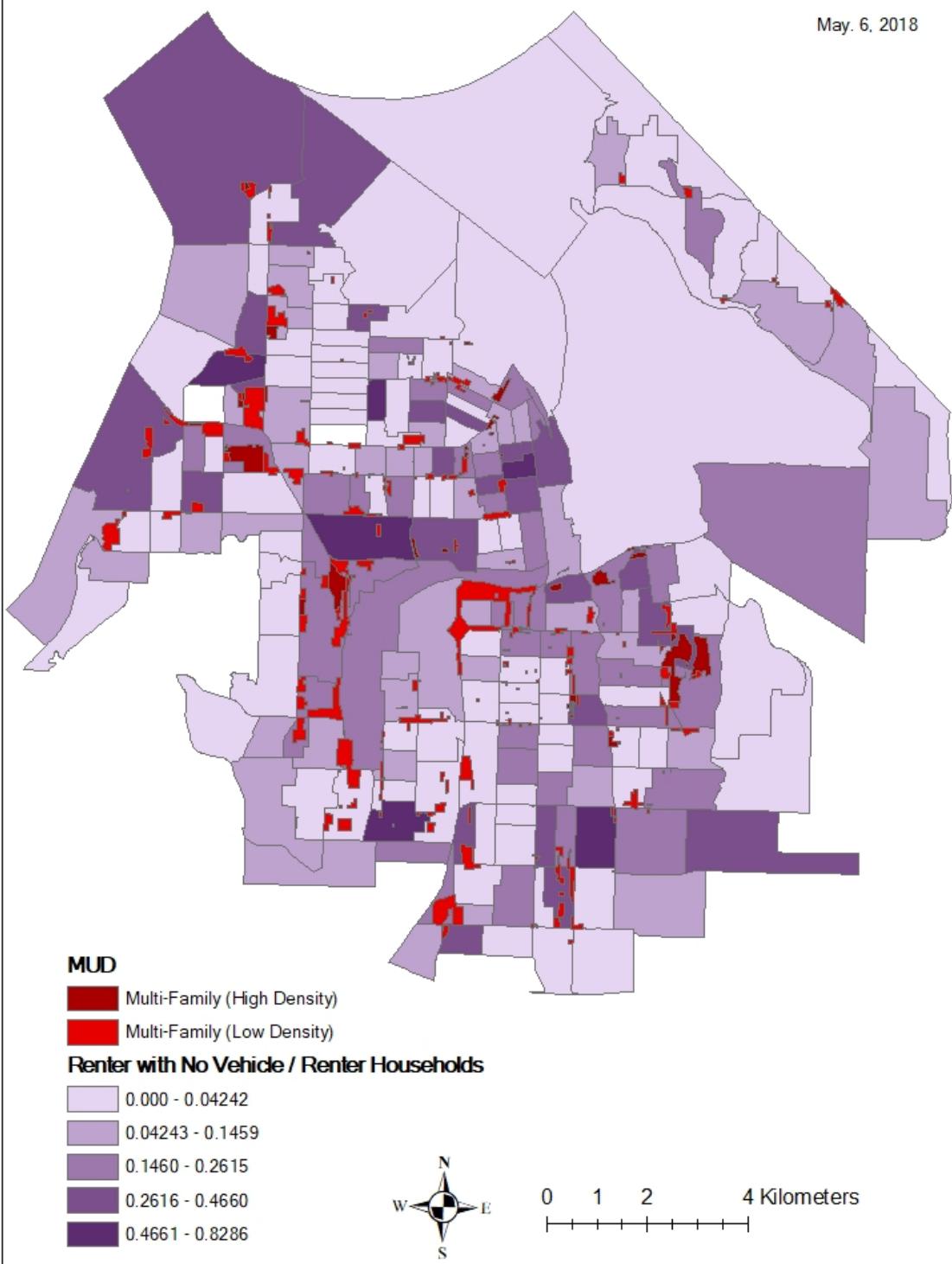


Figure 11: Rent households with No vehicle
12

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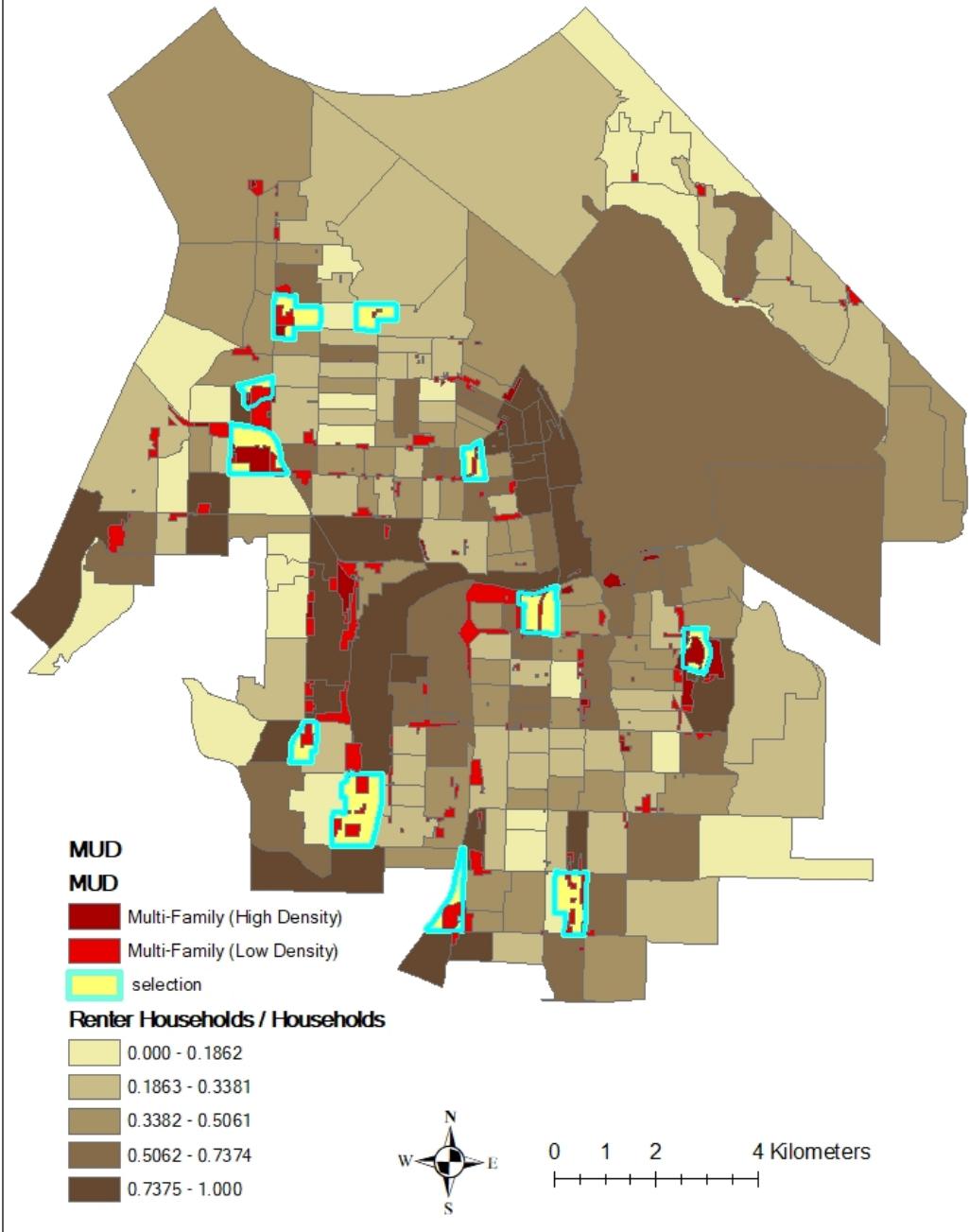


Figure 12: Selection of blocks

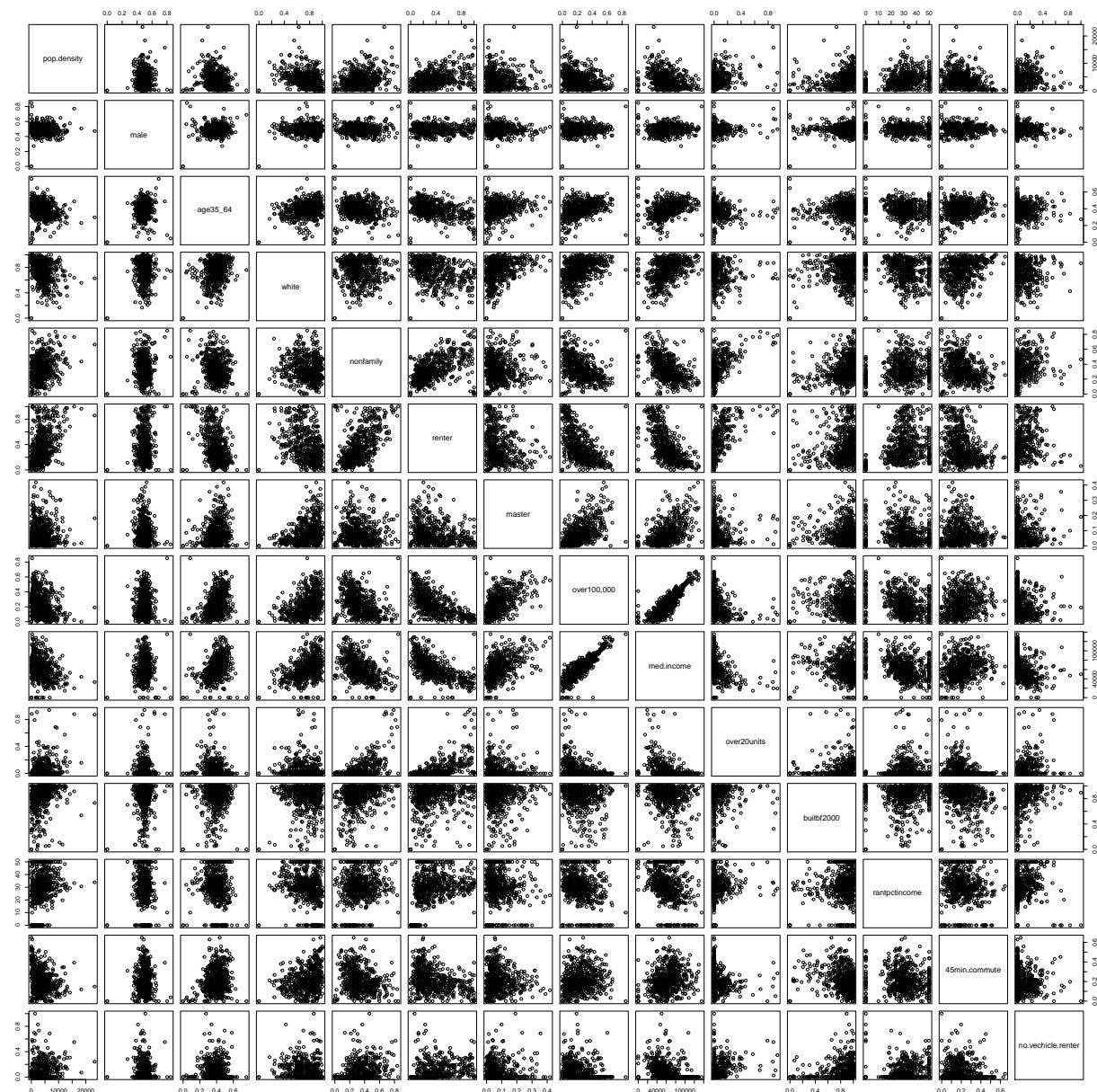


Figure 13: Independant variable plots

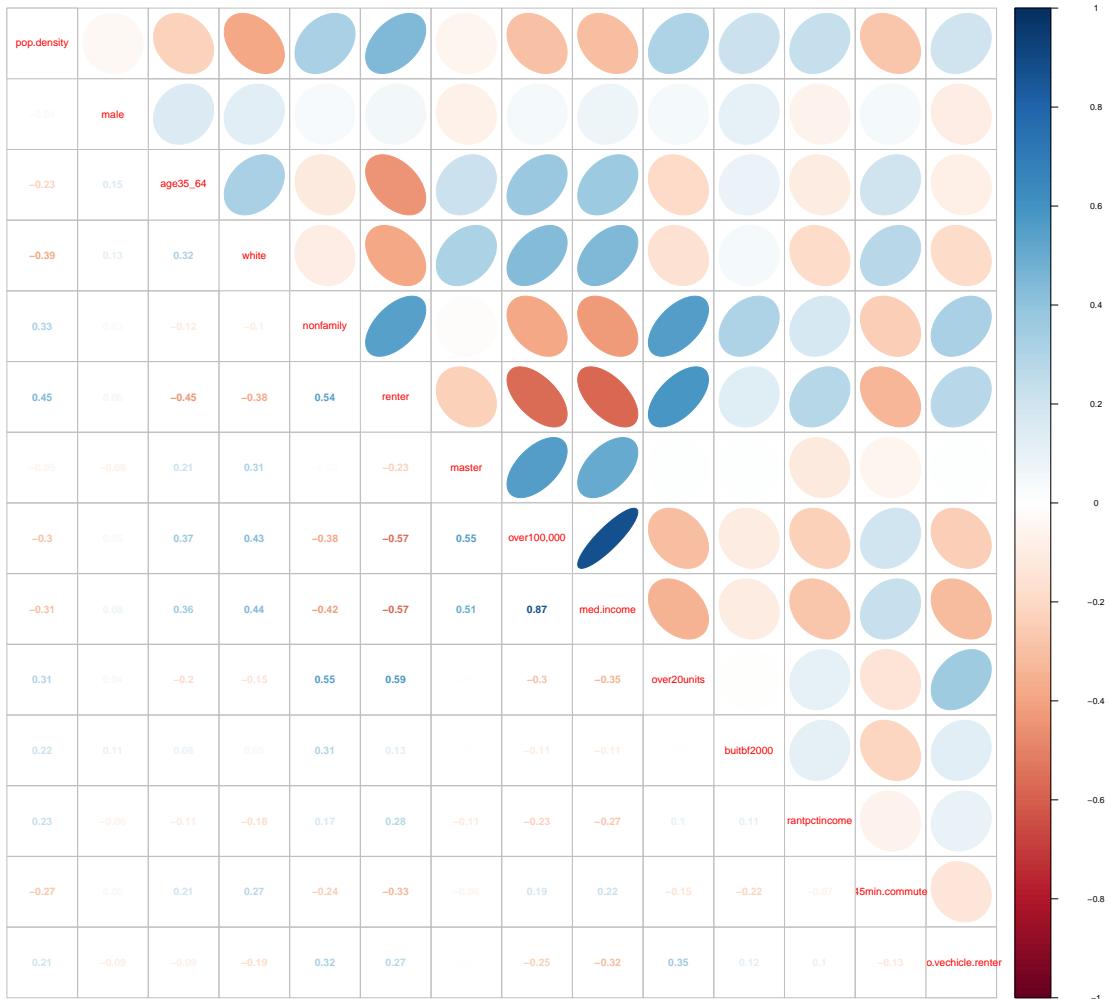


Figure 14: Correlations of indipendeant variables

Table 1: Binomial logistic model *

| | Estimate | Std. Error | z value | Pr(> z) |
|--------------------|------------|------------|-----------|-----------|
| (Intercept) | -5.8072650 | 0.9263109 | -6.269240 | 0.0000000 |
| pop.density | 0.0001583 | 0.0000768 | 2.061436 | 0.0392615 |
| nonfamily | -3.6263804 | 2.0501884 | -1.768803 | 0.0769267 |
| renter | 3.3332370 | 1.2661521 | 2.632572 | 0.0084741 |
| no.vechicle.renter | 4.3534712 | 1.8372864 | 2.369512 | 0.0178116 |

* AIC is 95.92

Table 2: Binomial logistic model *

| | Estimate | Std. Error | z value | Pr(> z) |
|-------------|------------|------------|-----------|-----------|
| (Intercept) | -7.0291502 | 1.0766785 | -6.528551 | 0.0000000 |
| pop.density | 0.0001444 | 0.0000783 | 1.844661 | 0.0650868 |
| renter | 3.7222820 | 1.5444505 | 2.410101 | 0.0159481 |

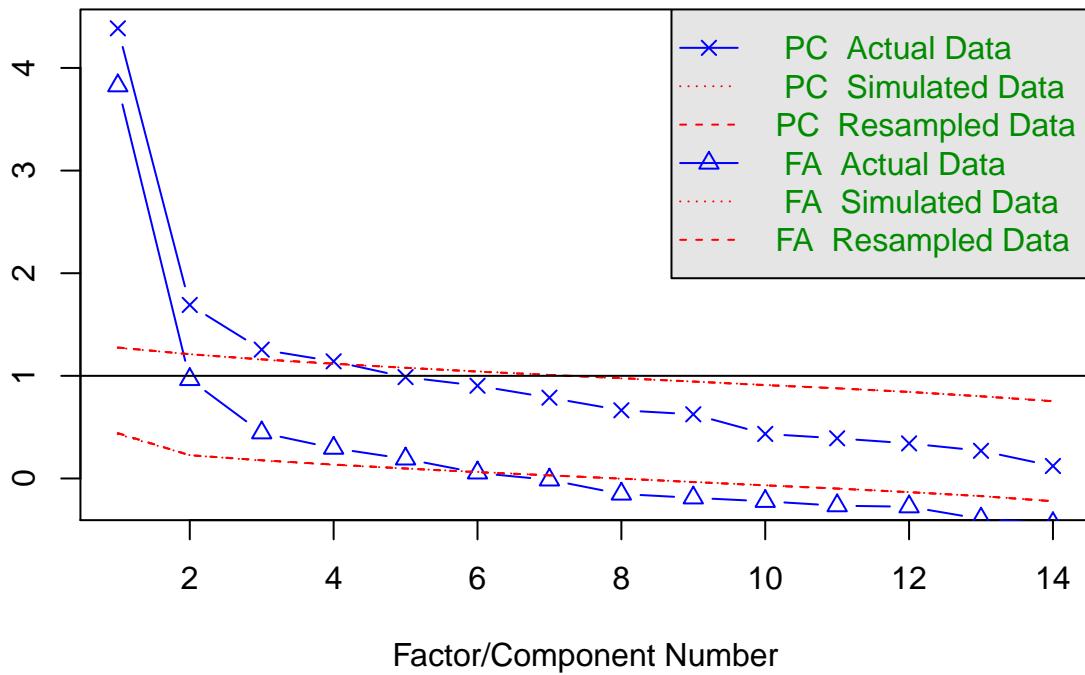
* AIC is 72.75

Factor and cluster analysis

To verify the characteristics of those blocks chosen above, factor and cluster analysis was performed. Two factors were chosen and the first factor (PA1) is related to the variables: “non-family households”, “buiding units over 20”, “rent households”,“population density”,“rent households with no vehicle”,“housings built before 2000 year” and the rest of variables are in the 2nd factor (PA2).

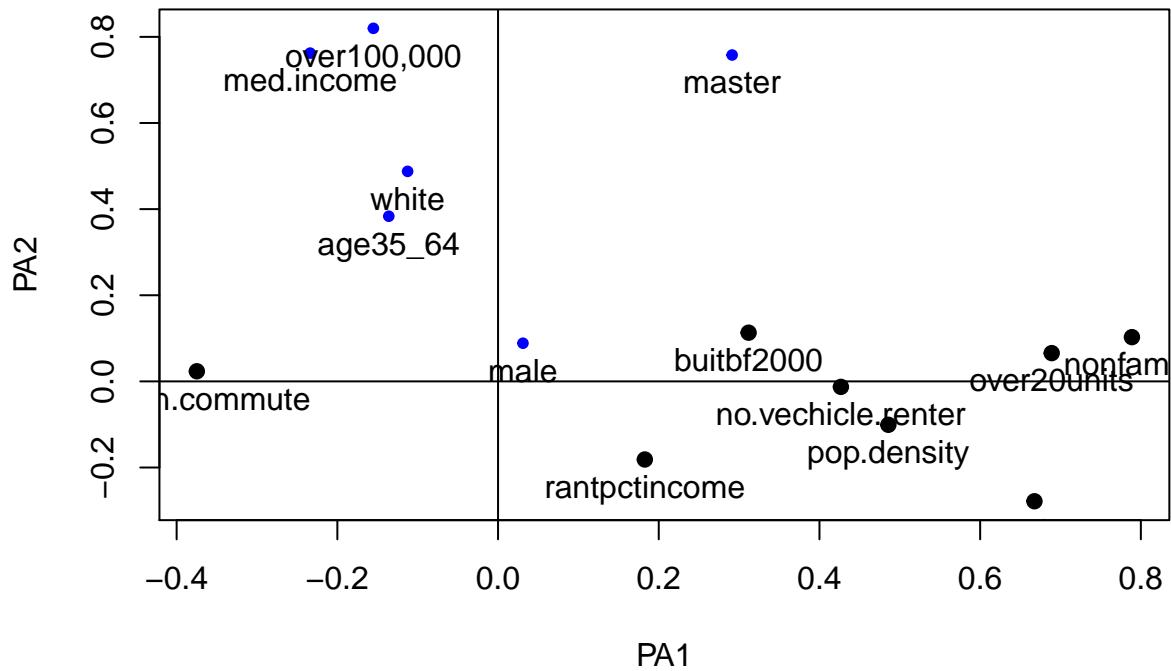
eigenvalues of principal components and factor analysis

Parallel Analysis Scree Plots

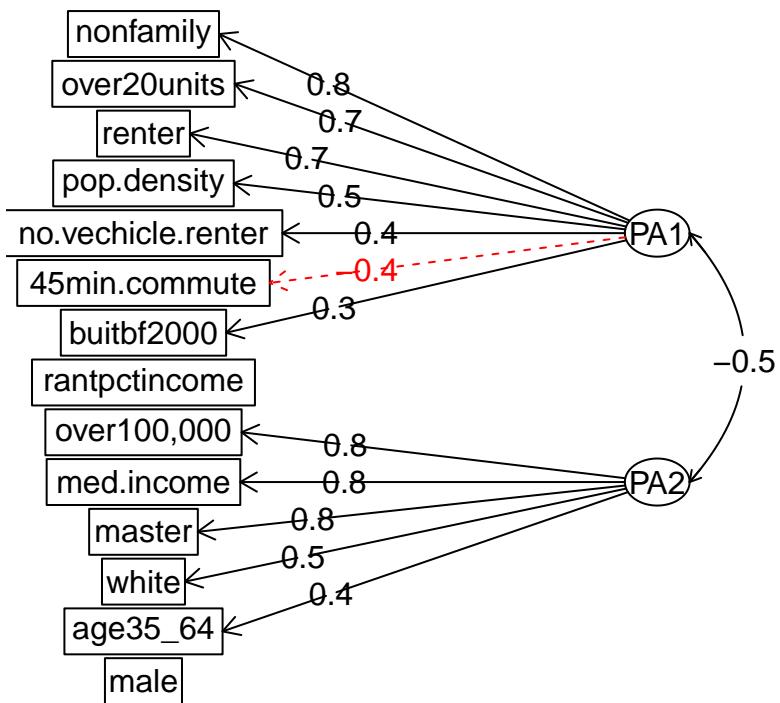


```
## Parallel analysis suggests that the number of factors = 5 and the number of components = 3
```

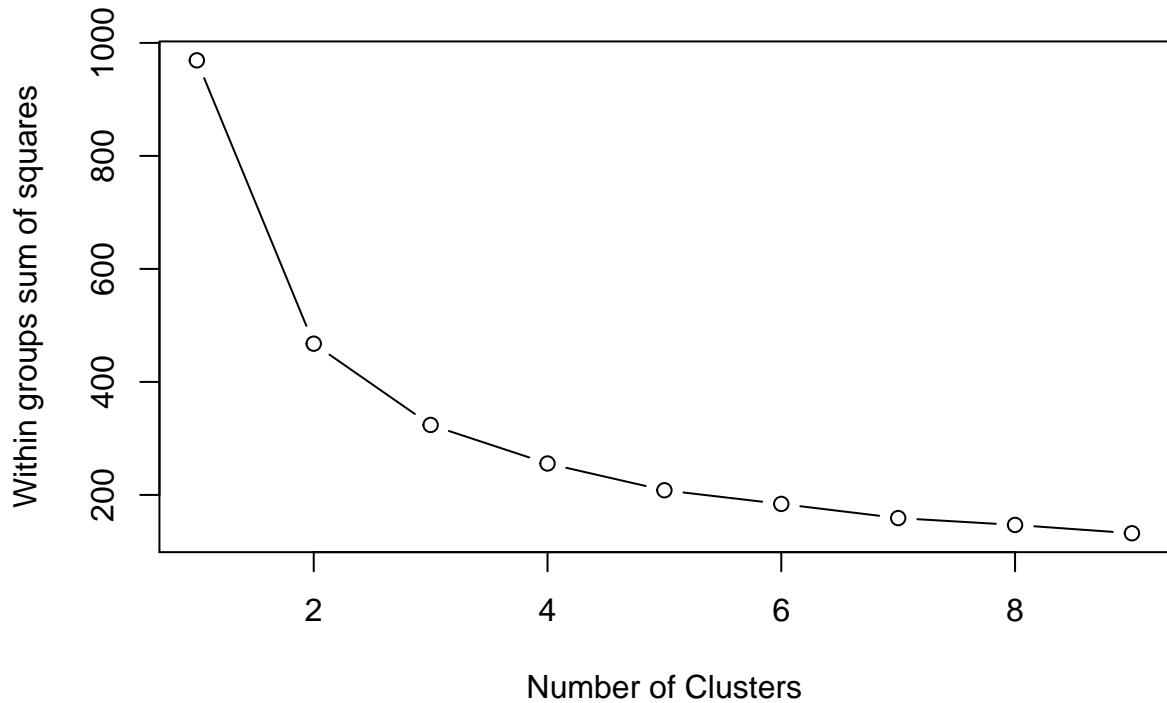
Factor Analysis



Factor Analysis



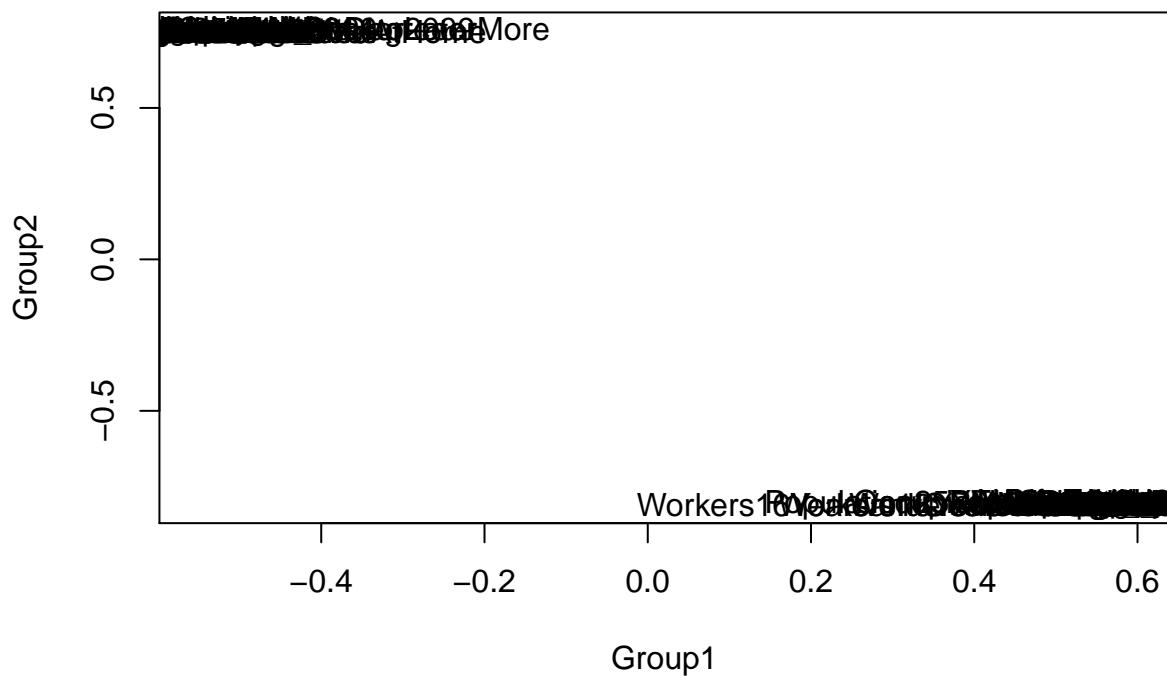
```
## [1] 969.1251
```

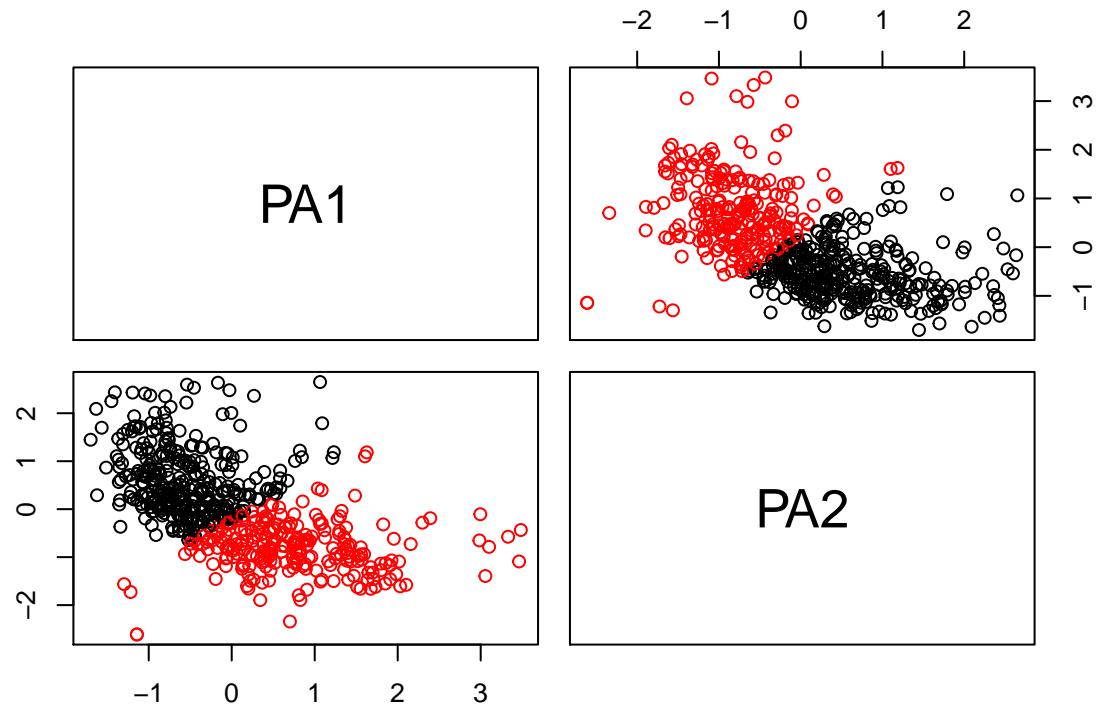


```
##          PA1          PA2
## 1 -0.5523910  0.5931719
## 2  0.7528367 -0.8084157
```

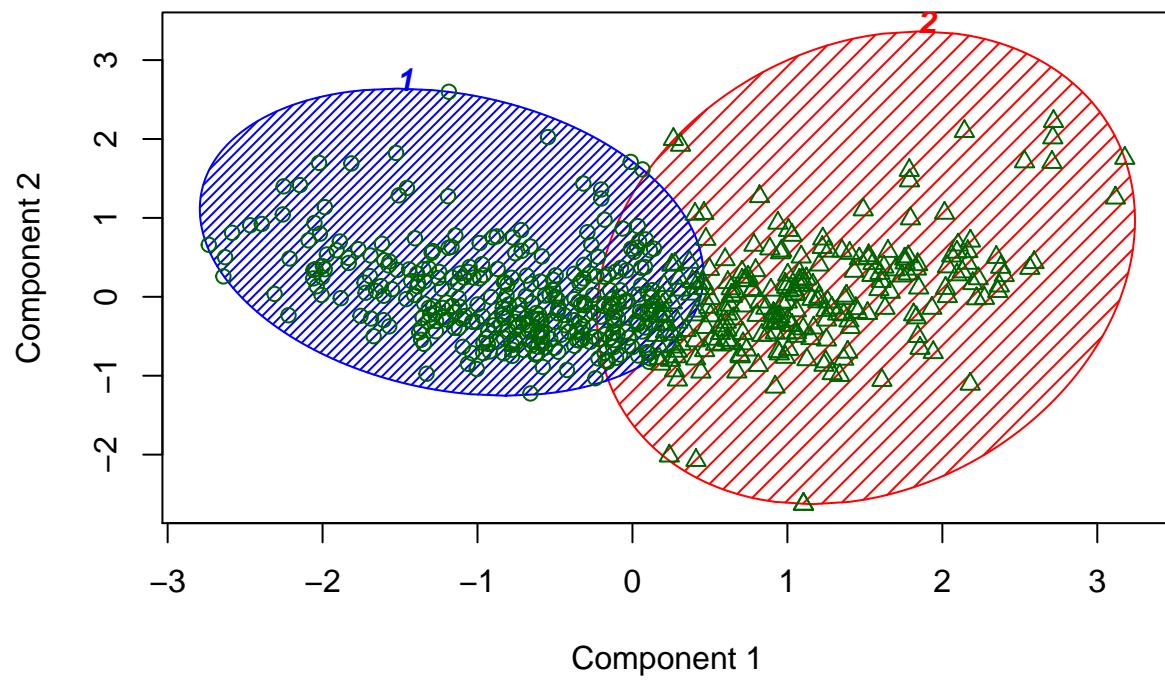
```
##
##    1   2
## 323 237
```

```
##          PA1          PA2
## 1 -0.5523910  0.5931719
## 2  0.7528367 -0.8084157
```

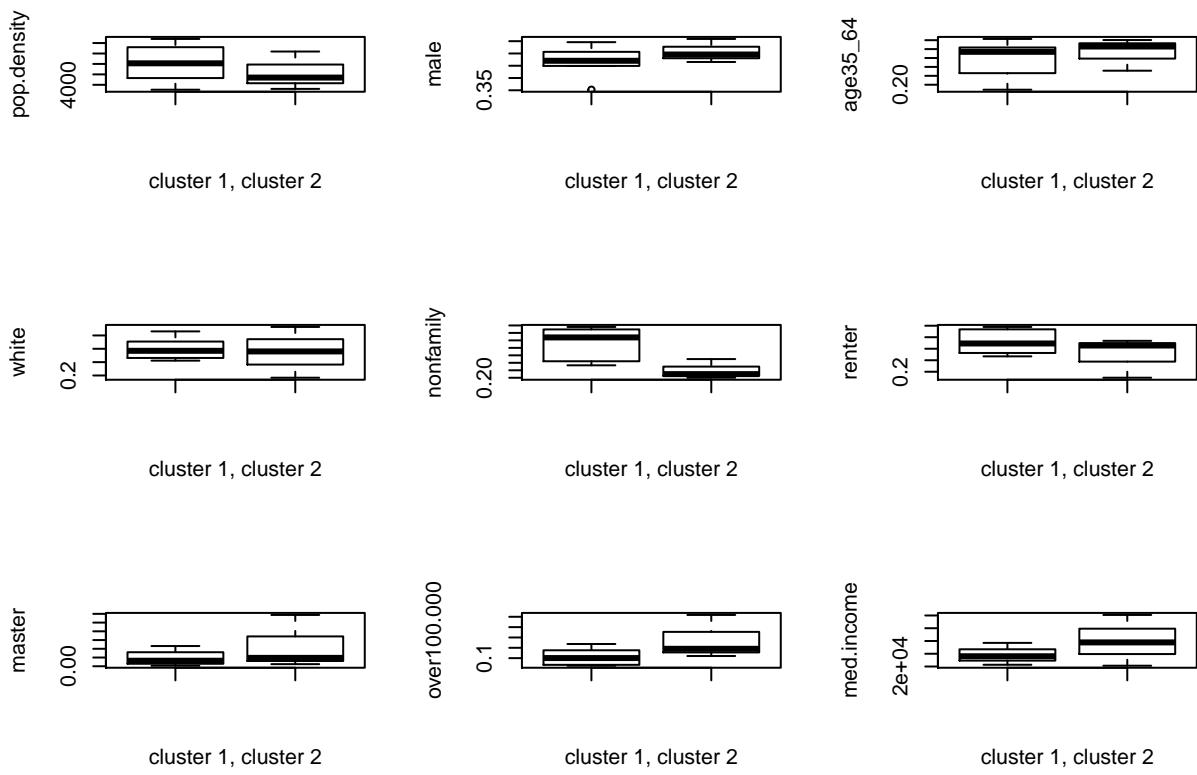




CLUSPLOT(dat1)



It is found the clusters are decided by the first factor (PA1). The first clustered group is more related to the higher value of PA1. Among the 11 chosen block groups with MUD, 3 block groups are clustered into the cluster 2nd group. We tried to go further analysis the difference between the 1st and the 2nd clustered group of the block groups chosen.



```

##   pop.density      male      age35_64      white
## Min.    : 3062  Min.    :0.3523  Min.    :0.1720  Min.    :0.4223
## 1st Qu.: 5392  1st Qu.:0.4493  1st Qu.:0.2778  1st Qu.:0.4732
## Median  : 8119  Median  :0.4702  Median  :0.3848  Median  :0.5698
## Mean    : 8136  Mean    :0.4688  Mean    :0.3434  Mean    :0.5955
## 3rd Qu.:10599  3rd Qu.:0.4974  3rd Qu.:0.4027  3rd Qu.:0.6908
## Max.   :12787  Max.   :0.5460  Max.   :0.4571  Max.   :0.8604
##   nonfamily      renter      master      over100.000
## Min.    :0.2833  Min.    :0.4674  Min.    :0.003106  Min.    :0.02683
## 1st Qu.:0.3104  1st Qu.:0.5332  1st Qu.:0.018097  1st Qu.:0.03581
## Median :0.4699  Median :0.6913  Median :0.031601  Median :0.10082
## Mean   :0.4288  Mean   :0.7194  Mean   :0.046371  Mean   :0.11098
## 3rd Qu.:0.5166  3rd Qu.:0.9231  3rd Qu.:0.067806  3rd Qu.:0.17282
## Max.   :0.5400  Max.   :0.9787  Max.   :0.115686  Max.   :0.23667
##   med.income      over20units      buitbf2000      rantpctincome
## Min.    :22727  Min.    :0.0000  Min.    :0.8405  Min.    :28.60
## 1st Qu.:29696  1st Qu.:0.1211  1st Qu.:0.8879  1st Qu.:29.70
## Median :36070  Median :0.1542  Median :0.9551  Median :33.35
## Mean   :38050  Mean   :0.1639  Mean   :0.9331  Mean   :35.02
## 3rd Qu.:45439  3rd Qu.:0.2114  3rd Qu.:0.9748  3rd Qu.:40.60
## Max.   :57031  Max.   :0.3256  Max.   :1.0000  Max.   :44.50
##   X45min.commute      no.vechicle.renter
## Min.    :0.06738  Min.    :0.05205
## 1st Qu.:0.09991  1st Qu.:0.16511
## Median :0.10368  Median :0.20556
## Mean   :0.14269  Mean   :0.21595

```

```

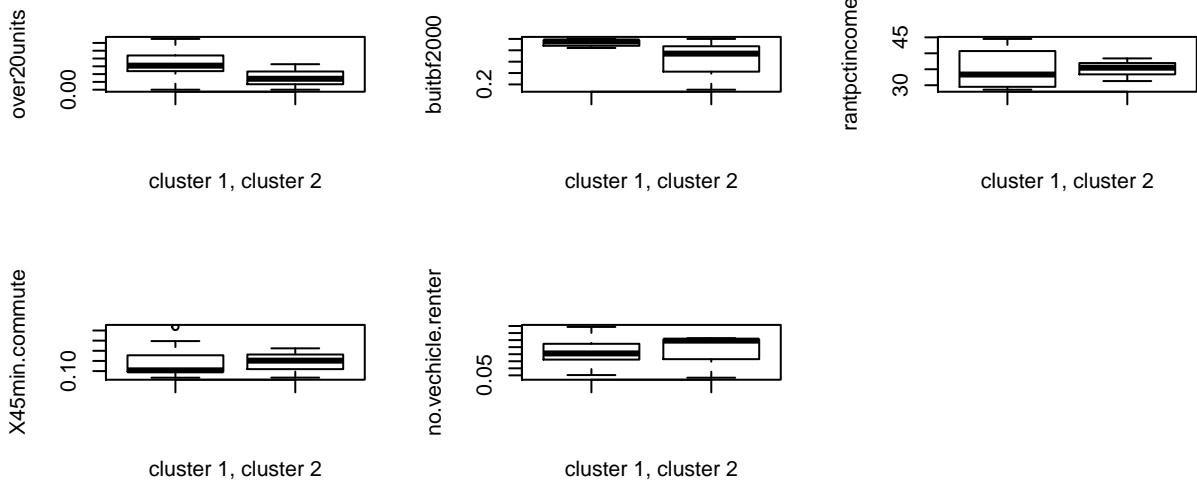
## 3rd Qu.:0.14302 3rd Qu.:0.25659
## Max. :0.31761 Max. :0.39344

##   pop.density      male      age35_64      white
## Min.    : 3221  Min.    :0.4653  Min.    :0.2788  Min.    :0.1667
## 1st Qu.: 4304  1st Qu.:0.4805  1st Qu.:0.3467  1st Qu.:0.3637
## Median  : 5387  Median  :0.4957  Median  :0.4145  Median  :0.5606
## Mean    : 6328  Mean    :0.5067  Mean    :0.3814  Mean    :0.5516
## 3rd Qu.: 7881  3rd Qu.:0.5275  3rd Qu.:0.4328  3rd Qu.:0.7440
## Max.    :10374  Max.    :0.5592  Max.    :0.4510  Max.    :0.9274
##   nonfamily      renter      master      over100.000
## Min.    :0.2004  Min.    :0.09643  Min.    :0.01205  Min.    :0.1206
## 1st Qu.:0.2124  1st Qu.:0.37626  1st Qu.:0.03004  1st Qu.:0.1554
## Median  :0.2244  Median  :0.65610  Median  :0.04803  Median  :0.1902
## Mean    :0.2499  Mean    :0.49663  Mean    :0.11796  Mean    :0.2762
## 3rd Qu.:0.2747  3rd Qu.:0.69673  3rd Qu.:0.17092  3rd Qu.:0.3541
## Max.    :0.3250  Max.    :0.73735  Max.    :0.29380  Max.    :0.5179
##   med.income      over20units      buitbf2000      rantpctincome
## Min.    : 21250  Min.    :0.00000  Min.    :0.1070  Min.    :31.30
## 1st Qu.: 39518  1st Qu.:0.03502  1st Qu.:0.4242  1st Qu.:33.40
## Median  : 57786  Median  :0.07004  Median  :0.7415  Median  :35.50
## Mean    : 59956  Mean    :0.07782  Mean    :0.6162  Mean    :35.07
## 3rd Qu.: 79310  3rd Qu.:0.11673  3rd Qu.:0.8707  3rd Qu.:36.95
## Max.    :100833  Max.    :0.16341  Max.    :1.0000  Max.    :38.40
##   X45min.commute      no.vechicle.renter
## Min.    :0.06771  Min.    :0.03346
## 1st Qu.:0.10956  1st Qu.:0.16488
## Median  :0.15142  Median  :0.29630
## Mean    :0.14371  Mean    :0.21458
## 3rd Qu.:0.18171  3rd Qu.:0.30514
## Max.    :0.21199  Max.    :0.31398

```

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | | | |
|-------|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|---|---|---|
| [1] | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| [54] | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | |
| [107] | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | |
| [160] | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | |
| [213] | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | |
| [266] | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | |
| [319] | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 1 | 2 | 1 | 2 | 1 | 2 | 1 | | | | | | | | |
| [372] | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | |
| [425] | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | |
| [478] | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | | | | | | | | |
| [531] | 1 | 2 | 2 | 1 | 1 | 2 | 2 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | | | | | | | |

Figure 15: Identifying Blocks



It is also found the 2nd clustered group which has the lower value of PA1 has the noticeable characteristics with lower population density, lower non-family households, higher median income, lower unit in a building, etc.

This analysis is essential to make a decision to have EV chargers considering these different social characteristics with MUD especially addressing equity.

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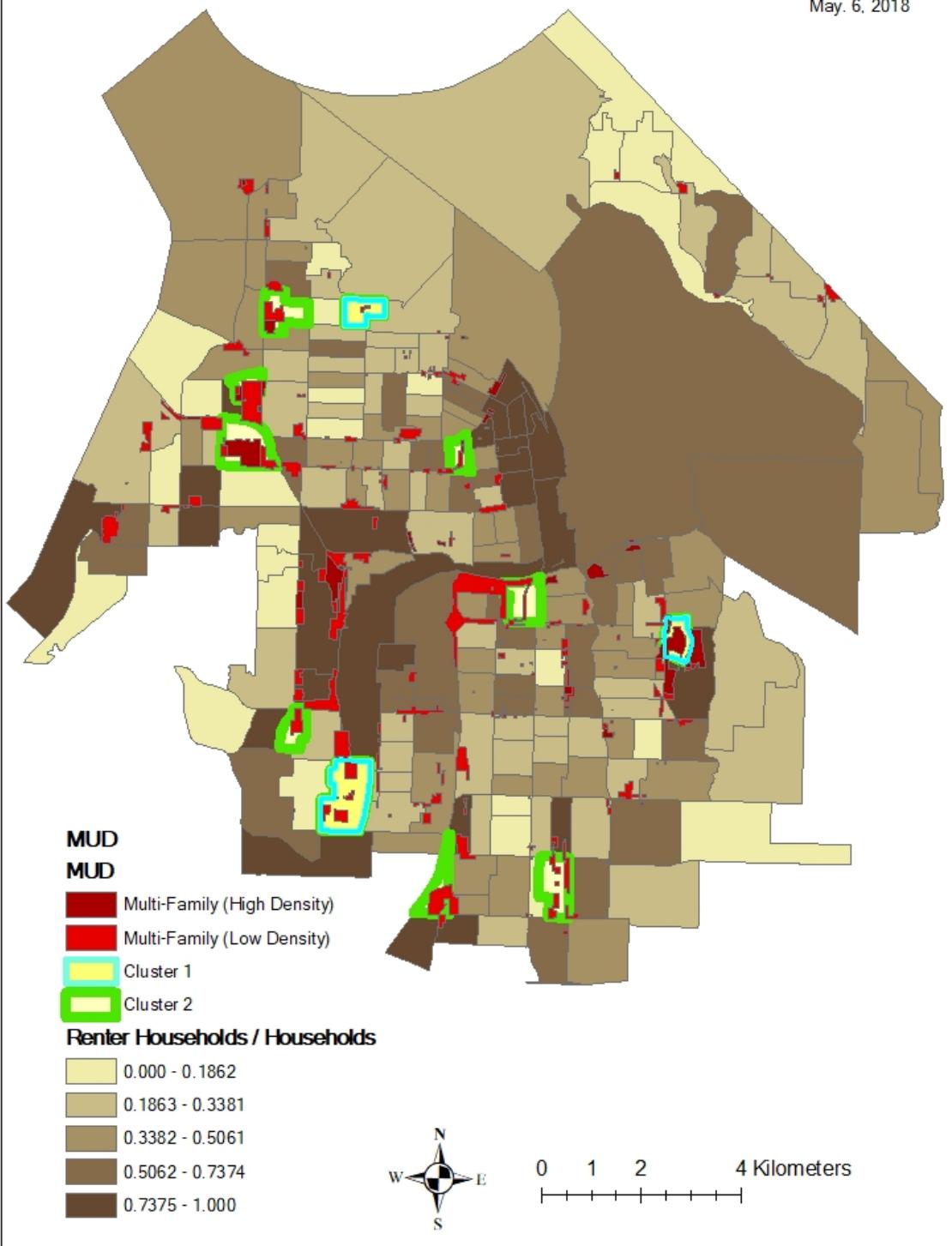


Figure 16: Clustered Blocks
27