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412

Appendix 1 for Assignment 6 – Geo Spatial Data Modeling

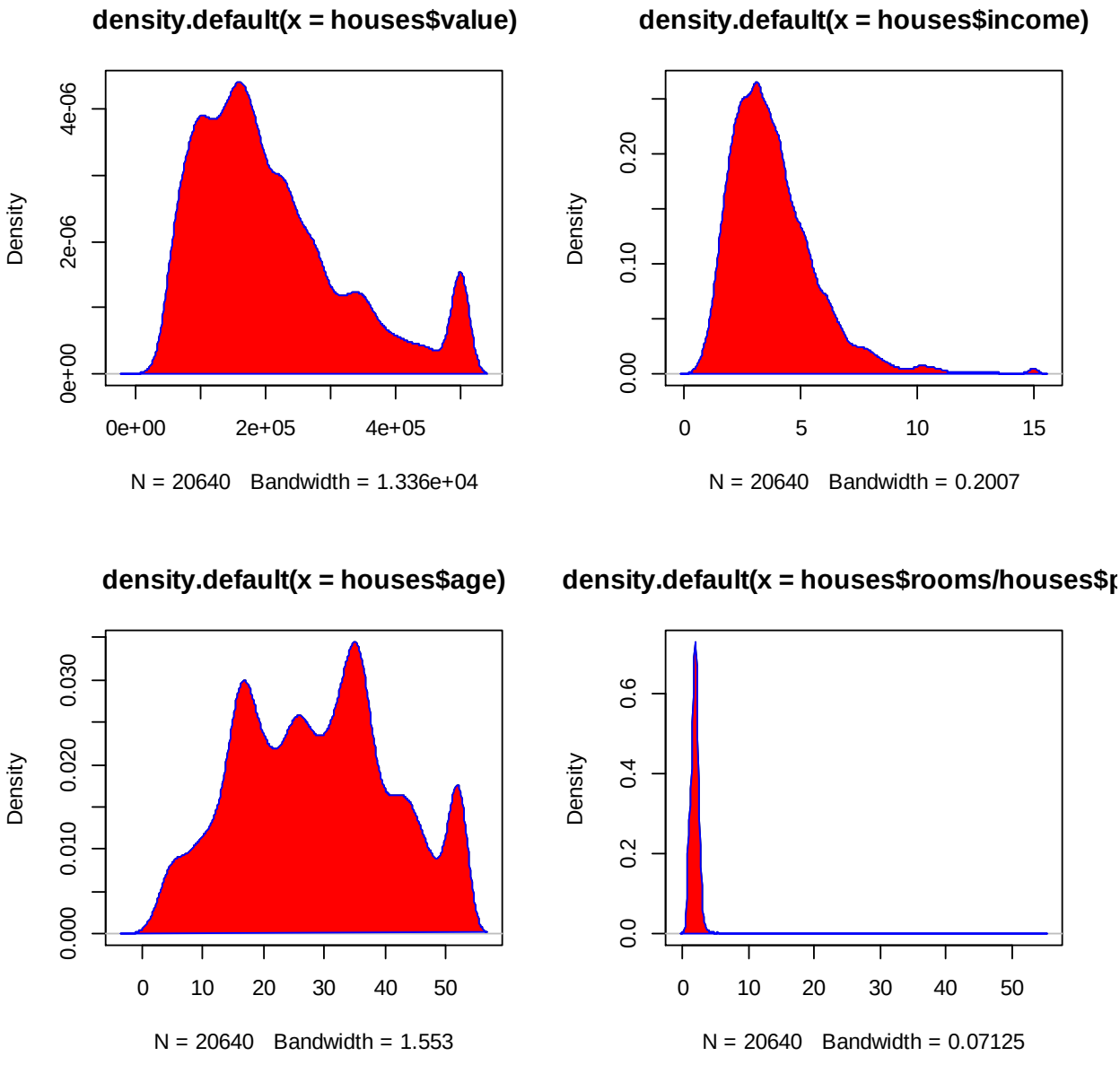
Output 1: Metadata

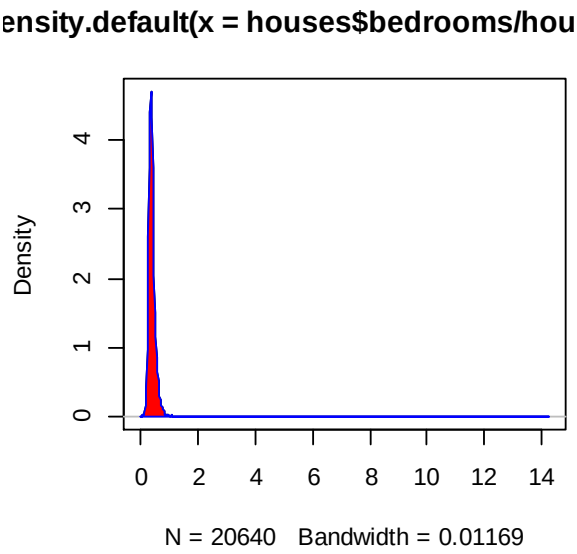
```
print(str(houses))
'data.frame':   20640 obs. of  9 variables:
 $ value    : num  452600 358500 352100 341300 342200 ...
 $ income   : num  8.33 8.3 7.26 5.64 3.85 ...
 $ age      : num  41 21 52 52 52 52 52 52 42 52 ...
 $ rooms    : num  880 7099 1467 1274 1627 ...
 $ bedrooms : num  129 1106 190 235 280 ...
 $ pop      : num  322 2401 496 558 565 ...
 $ hh       : num  126 1138 177 219 259 ...
 $ latitude : num  37.9 37.9 37.9 37.9 37.9 ...
 $ longitude: num  -122 -122 -122 -122 -122 ...
NULL
```

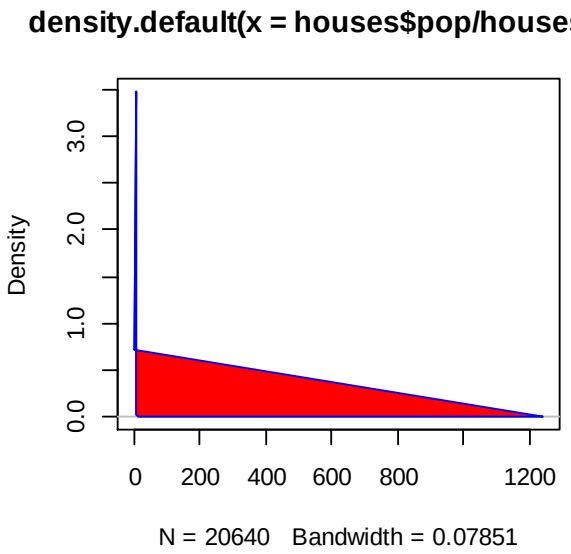
Output 2: Distribution of Data

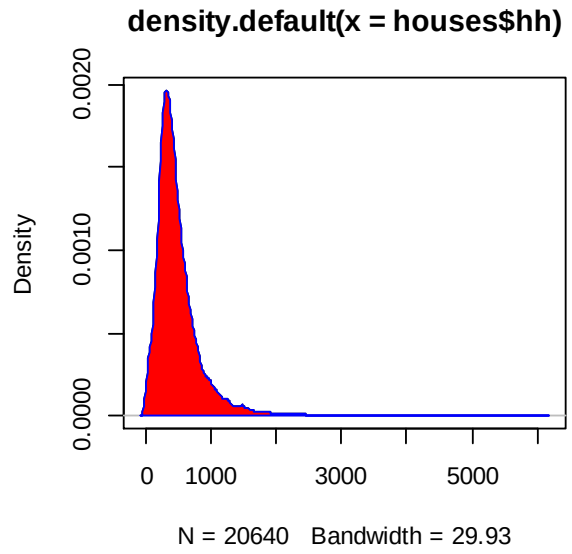
```
     value            income           age             rooms
 Min.   : 14999   Min.   : 0.4999   Min.   : 1.00   Min.   :    2
 1st Qu.:119600   1st Qu.: 2.5634   1st Qu.:18.00   1st Qu.: 1448
 Median :179700   Median : 3.5348   Median :29.00   Median : 2127
 Mean   :206856   Mean   : 3.8707   Mean   :28.64   Mean   : 2636
 3rd Qu.:264725   3rd Qu.: 4.7432   3rd Qu.:37.00   3rd Qu.: 3148
 Max.   :500001   Max.   :15.0001   Max.   :52.00   Max.   :39320
    bedrooms          pop             hh           latitude
 Min.   :   1.0   Min.   :    3   Min.   :   1.0   Min.   :32.54
 1st Qu.: 295.0   1st Qu.:  787   1st Qu.: 280.0   1st Qu.:33.93
 Median : 435.0   Median : 1166   Median : 409.0   Median :34.26
 Mean   : 537.9   Mean   : 1425   Mean   : 499.5   Mean   :35.63
 3rd Qu.: 647.0   3rd Qu.: 1725   3rd Qu.: 605.0   3rd Qu.:37.71
 Max.   :6445.0   Max.   :35682   Max.   :6082.0   Max.   :41.95
   longitude
 Min.   :-124.3
 1st Qu.:-121.8
 Median :-118.5
 Mean   :-119.6
 3rd Qu.:-118.0
 Max.   :-114.3
```

```
  vru_time        q_start           q_exit            q_time
Min.   :-192.00   Length:33344      Length:33344      Min.   :  0.00
1st Qu.:   6.00   Class :character   Class :character   1st Qu.:  0.00
Median :   9.00   Mode  :character   Mode  :character   Median :  9.00
Mean   :  10.46                                       Mean   : 41.79
3rd Qu.:  11.00                                       3rd Qu.: 57.00
Max.   :1860.00                                       Max.   :908.00
  outcome       ser_start         ser_exit          ser_time
AGENT  :27162   Length:33344      Length:33344      Min.   :   0.0
HANG   : 5904   Class :character   Class :character   1st Qu.:  15.0
PHANTOM:  278   Mode  :character   Mode  :character   Median :  80.0
                                                      Mean   : 144.3
                                                      3rd Qu.: 180.0
                                                      Max.   :4264.0
  server
Length:33344
Class :character
Mode  :character
```


density.default(x = houses$value)
Density
0e+00
2e-06
4e-06
0e+00
2e+05
4e+05
N = 20640 Bandwidth = 1.336e+04
density.default(x = houses$income)
Density
0.00
0.10
0.20
0
5
10
15
N = 20640 Bandwidth = 0.2007
density.default(x = houses$age)
Density
0.000
0.010
0.020
0.030
0
10
20
30
40
50
N = 20640 Bandwidth = 1.553
density.default(x = houses$rooms/houses$p
Density
0.0
0.2
0.4
0.6
0
10
20
30
40
50
N = 20640 Bandwidth = 0.07125



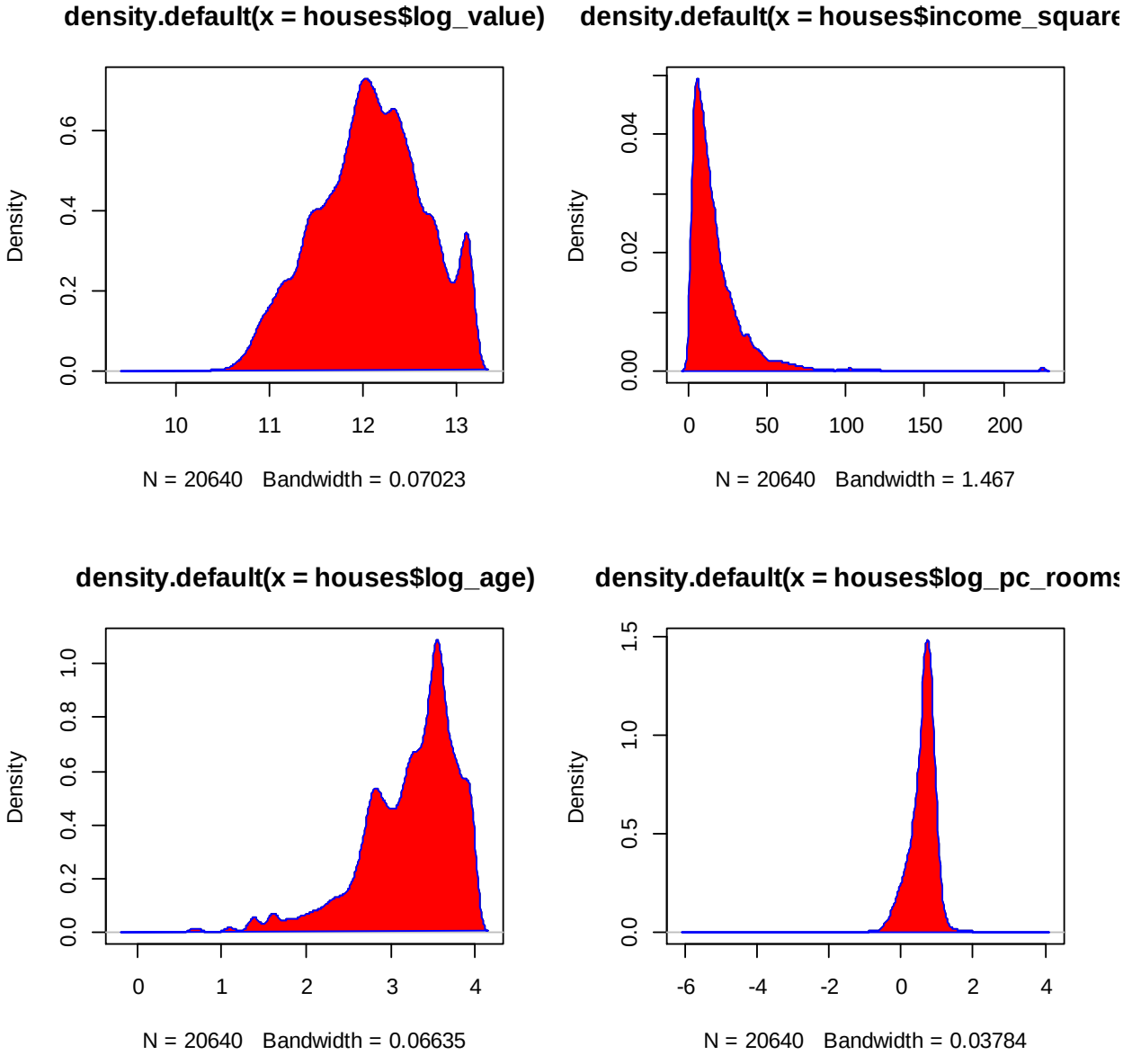


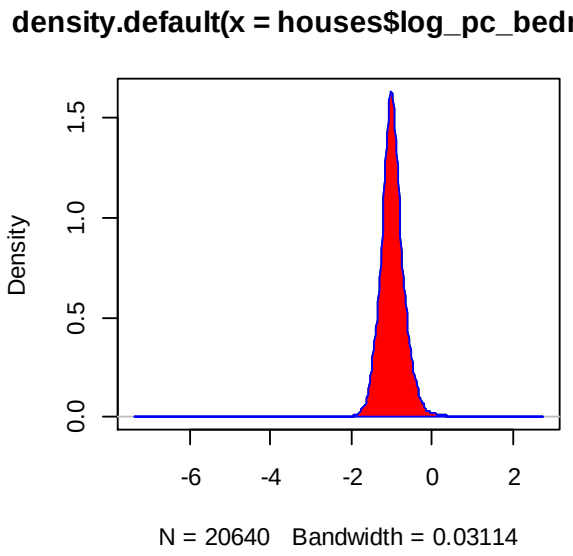


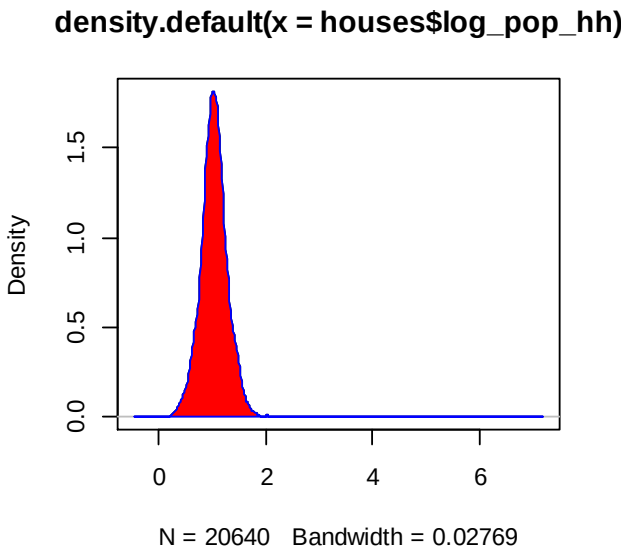
Output 3: Variables after Log Transformations

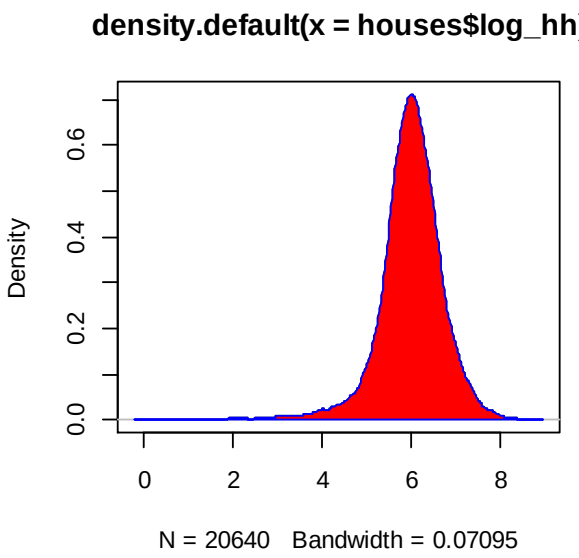
```
print(str(houses))
'data.frame':   20640 obs. of  17 variables:
 $ value         : num  452600 358500 352100 341300 342200 ...
 $ income        : num  8.33 8.3 7.26 5.64 3.85 ...
 $ age           : num  41 21 52 52 52 52 52 52 42 52 ...
 $ rooms         : num  880 7099 1467 1274 1627 ...
 $ bedrooms      : num  129 1106 190 235 280 ...
 $ pop           : num  322 2401 496 558 565 ...
 $ hh            : num  126 1138 177 219 259 ...
 $ latitude      : num  37.9 37.9 37.9 37.9 37.9 ...
 $ longitude     : num  -122 -122 -122 -122 -122 ...
```

```
 $ log_value      : num  13 12.8 12.8 12.7 12.7 ...
 $ income_squared : num  69.3 68.9 52.7 31.8 14.8 ...
 $ income_cubed   : num  577 572.1 382.2 179.7 56.9 ...
 $ log_age        : num  3.71 3.04 3.95 3.95 3.95 ...
 $ log_pc_rooms   : num  1.005 1.084 1.084 0.826 1.058 ...
 $ log_pc_bedrooms: num  -0.915 -0.775 -0.96 -0.865 -0.702 ...
 $ log_pop_hh     : num  0.938 0.747 1.03 0.935 0.78 ...
 $ log_hh         : num  4.84 7.04 5.18 5.39 5.56 ...
NULL
>
> # check data frame object and variable values
> print(summary(houses))
    value          income           age           rooms
 Min.   : 14999   Min.   : 0.4999   Min.   : 1.00   Min.   :    2
 1st Qu.:119600   1st Qu.: 2.5634   1st Qu.:18.00   1st Qu.: 1448
 Median :179700   Median : 3.5348   Median :29.00   Median : 2127
 Mean   :206856   Mean   : 3.8707   Mean   :28.64   Mean   : 2636
 3rd Qu.:264725   3rd Qu.: 4.7432   3rd Qu.:37.00   3rd Qu.: 3148
 Max.   :500001   Max.   :15.0001   Max.   :52.00   Max.   :39320
   bedrooms          pop             hh          latitude
 Min.   :   1.0   Min.   :    3   Min.   :   1.0   Min.   :32.54
 1st Qu.: 295.0   1st Qu.:  787   1st Qu.: 280.0   1st Qu.:33.93
 Median : 435.0   Median : 1166   Median : 409.0   Median :34.26
 Mean   : 537.9   Mean   : 1425   Mean   : 499.5   Mean   :35.63
 3rd Qu.: 647.0   3rd Qu.: 1725   3rd Qu.: 605.0   3rd Qu.:37.71
 Max.   :6445.0   Max.   :35682   Max.   :6082.0   Max.   :41.95
  longitude       log_value      income_squared      income_cubed
 Min.   :-124.3   Min.   : 9.616   Min.   :  0.2499   Min.   :   0.125
 1st Qu.:-121.8   1st Qu.:11.692   1st Qu.:  6.5710   1st Qu.:  16.844
 Median :-118.5   Median :12.099   Median : 12.4948   Median :  44.167
 Mean   :-119.6   Mean   :12.085   Mean   : 18.5912   Mean   : 111.190
 3rd Qu.:-118.0   3rd Qu.:12.486   3rd Qu.: 22.4984   3rd Qu.: 106.716
 Max.   :-114.3   Max.   :13.122   Max.   :225.0030   Max.   :3375.068
   log_age       log_pc_rooms      log_pc_bedrooms      log_pop_hh
 Min.   :0.000   Min.   :-5.9729   Min.   :-7.3079   Min.   :-0.3677
 1st Qu.:2.890   1st Qu.: 0.4203   1st Qu.:-1.1531   1st Qu.: 0.8878
 Median :3.367   Median : 0.6616   Median :-0.9888   Median : 1.0361
 Mean   :3.225   Mean   : 0.6045   Mean   :-0.9731   Mean   : 1.0433
 3rd Qu.:3.611   3rd Qu.: 0.8312   3rd Qu.:-0.8150   3rd Qu.: 1.1885
 Max.   :3.951   Max.   : 4.0114   Max.   : 2.6529   Max.   : 7.1256
    log_hh
 Min.   :0.000
 1st Qu.:5.635
 Median :6.014
 Mean   :5.981
 3rd Qu.:6.405
 Max.   :8.713
```

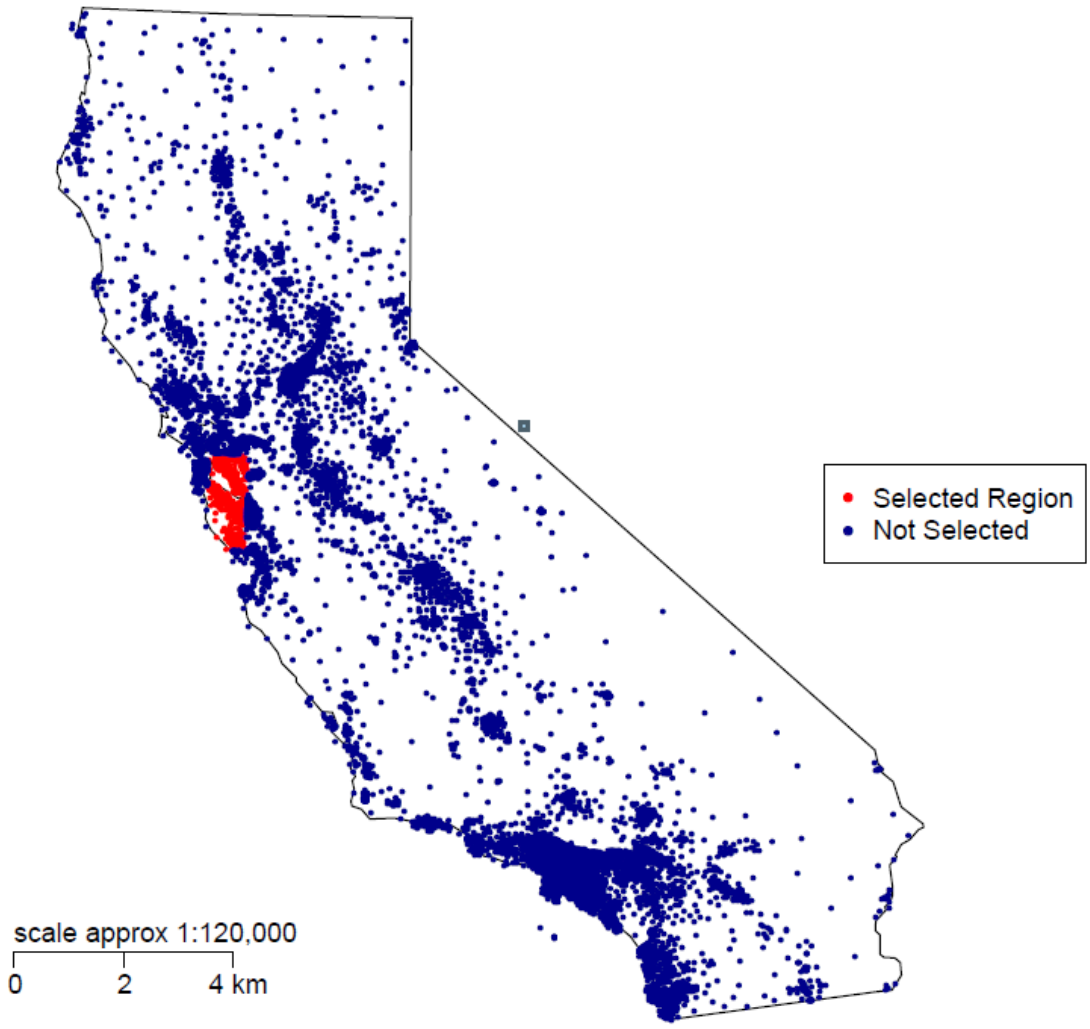

density.default(x = houses$log_value)
Density
0.0
0.2
0.4
0.6
10
11
12
13
N = 20640 Bandwidth = 0.07023
density.default(x = houses$income_square
Density
0.00
0.02
0.04
0
50
100
150
200
N = 20640 Bandwidth = 1.467
density.default(x = houses$log_age)
Density
0.0
0.2
0.4
0.6
0.8
1.0
0
1
2
3
4
N = 20640 Bandwidth = 0.06635
density.default(x = houses$log_pc_rooms
Density
0.0
0.5
1.0
1.5
-6
-4
-2
0
2
4
N = 20640 Bandwidth = 0.03784

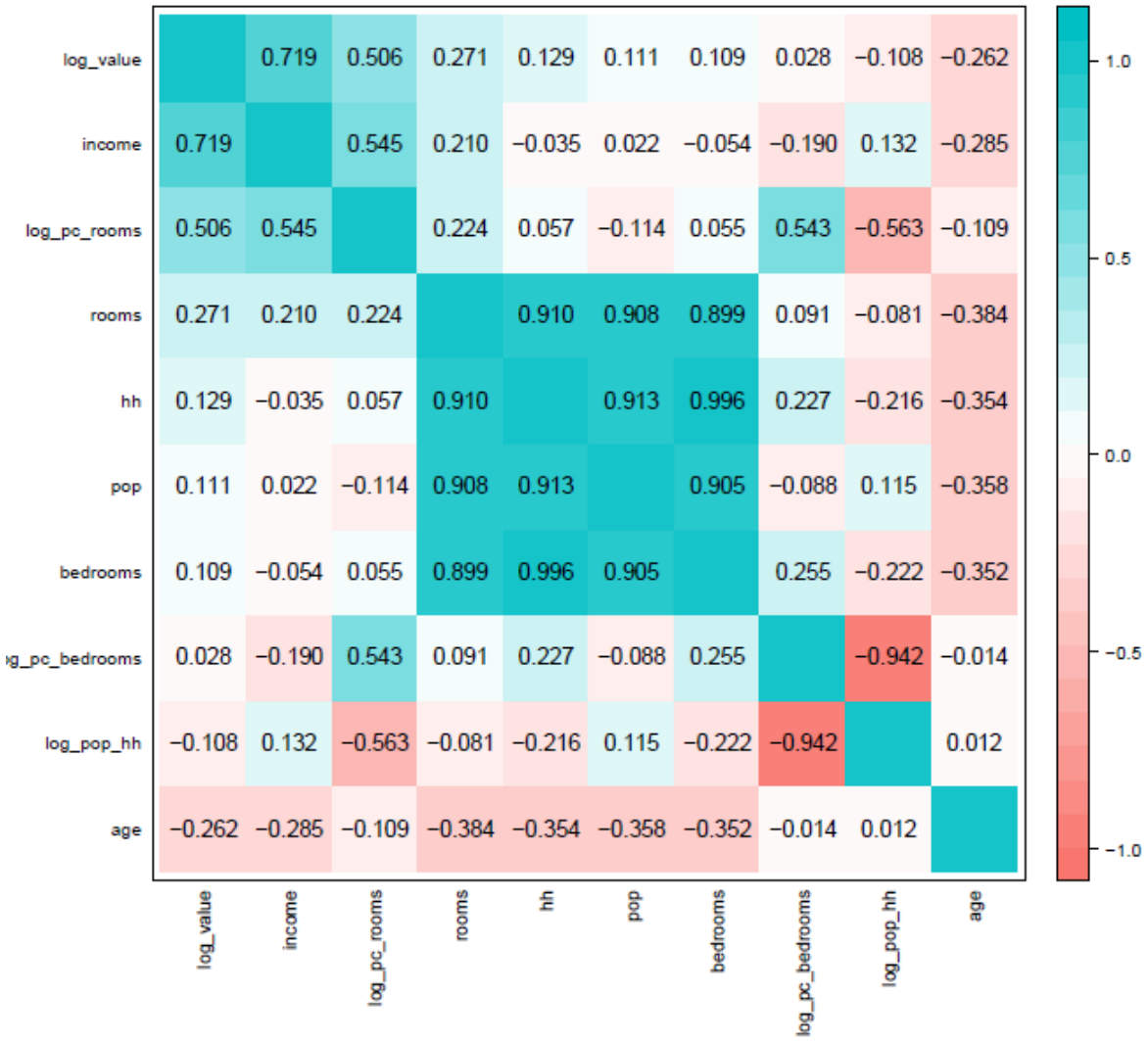

density.default(x = houses$log_pc_bedroo
Density
0.0
0.5
1.0
1.5
-6
-4
-2
0
2
N = 20640 Bandwidth = 0.03114


density.default(x = houses$log_pop_hh)
Density
0.0
0.5
1.0
1.5
0
2
4
6
N = 20640 Bandwidth = 0.02769


density.default(x = houses$log_hh)
Density
0.0
0.2
0.4
0.6
0
2
4
6
8
N = 20640 Bandwidth = 0.07095

Output 4: Spatial Map Selected Region





Output 6: Correlation Map

Output 7: Linear Regression without Spatial Points

Call:
lm(formula = pace.barry.model, data = houses.train)

Coefficients:

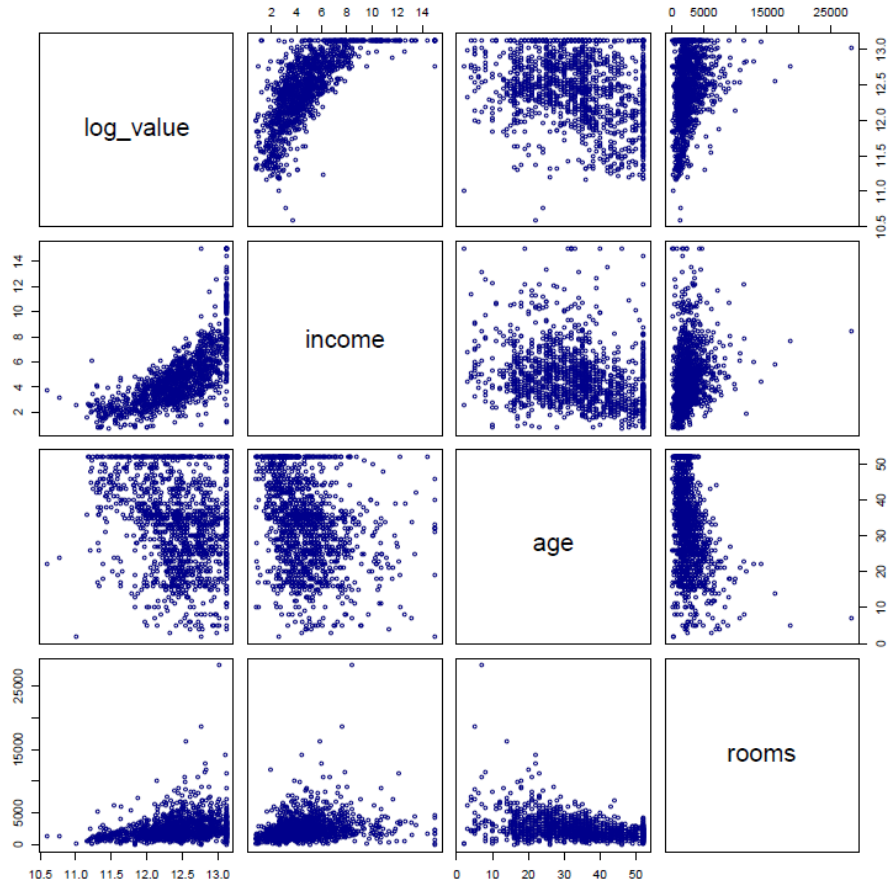
(Intercept)	income	income_squared	income_cubed
11.4237051	0.3051386	-0.0063915	-0.0003248

log_age	log_pc_rooms	log_pc_bedrooms	log_pop_hh
0.0573435	-0.3002109	0.0402894	-0.5801412

log_hh
0.0687831

Call:

```
lm(formula = pace.barry.model, data = houses.train)

Residuals:
    Min      1Q  Median      3Q     Max
-1.83104 -0.15433 -0.01033  0.16552  1.61647

Coefficients:
                Estimate Std. Error t value Pr(>|t|)
(Intercept)     11.4237051  0.1401238  81.526  < 2e-16 ***
income           0.3051386  0.0306469   9.957  < 2e-16 ***
income_squared  -0.0063915  0.0046487  -1.375  0.16940
income_cubed    -0.0003248  0.0002113  -1.537  0.12449
log_age          0.0573435  0.0182177   3.148  0.00168 **
log_pc_rooms    -0.3002109  0.0572792  -5.241 1.86e-07 ***
log_pc_bedrooms  0.0402894  0.1096682   0.367  0.71340
log_pop_hh      -0.5801412  0.1067262  -5.436 6.51e-08 ***
log_hh           0.0687831  0.0122027   5.637 2.12e-08 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 0.2842 on 1298 degrees of freedom
Multiple R-squared:  0.6452,    Adjusted R-squared:  0.643
F-statistic:   295 on 8 and 1298 DF,  p-value: < 2.2e-16

>
> # direct calculation of root-mean-squared prediction error
 [1] 0.2832567
> # report R-squared on training data
> print(cor(houses.train$log_value,predict(pace.barry.train.fit))^2)
[1] 0.6451926


Training set proportion of variance accounted  for by linear regression =  0.645>
> # test model fit to training set on the test set
 [1] 0.2584695
 [1] 0.7015261
>


10-fold CV results:
      CV
0.1961384
```



Output 8: Full Tree Regression

	CP	nsplit	rel error	xerror	xstd
1	0.39438424	0	1.0000000	1.0021816	0.03788014
2	0.10644598	1	0.6056158	0.6312032	0.02541968
3	0.06723167	2	0.4991698	0.5225227	0.02540437
4	0.02706050	3	0.4319381	0.4539892	0.02397689
5	0.02457305	4	0.4048776	0.4449655	0.02520428
6	0.01701520	5	0.3803046	0.4112027	0.02496583
7	0.01634933	6	0.3632894	0.4047483	0.02489414
8	0.01434153	7	0.3469400	0.4016213	0.02495083
9	0.01000000	8	0.3325985	0.3964548	0.02431400

Variable importance

income	log_pc_rooms	log_pc_bedrooms	log_pop_hh	age
43	18	12	11	6
rooms	hh	bedrooms	pop	
6	1	1	1	

Node number 1: 1307 observations, complexity param=0.3943842
 mean=12.42984, MSE=0.2261351
 left son=2 (711 obs) right son=3 (596 obs)
 Primary splits:
   income   < 4.62305   to the left, improve=0.39438420, (0 missing)
   log_pc_rooms < 0.708089 to the left, improve=0.26342530, (0 missing)
   rooms   < 1941   to the left, improve=0.10513490, (0 missing)
   age   < 35.5   to the right, improve=0.09750198, (0 missing)
   log_pop_hh < 1.164632 to the right, improve=0.05747476, (0 missing)
 Surrogate splits:
   log_pc_rooms   < 0.8192164 to the left, agree=0.721, adj=0.388, (0 split)
   log_pc_bedrooms < -0.8752156 to the right, agree=0.651, adj=0.235, (0 split)
   age   < 35.5   to the right, agree=0.630, adj=0.190, (0 split)
   rooms   < 2705.5   to the left, agree=0.627, adj=0.181, (0 split)
   log_pop_hh   < 0.8740992 to the left, agree=0.617, adj=0.159, (0 split)

Node number 2: 711 observations, complexity param=0.106446
 mean=12.15641, MSE=0.1779834
 left son=4 (215 obs) right son=5 (496 obs)
 Primary splits:
   income   < 2.66755   to the left, improve=0.2486128, (0 missing)
   log_pop_hh < 0.9774789 to the right, improve=0.1569347, (0 missing)
   log_pc_rooms < 0.532225 to the left, improve=0.1198823, (0 missing)
   rooms   < 1806   to the left, improve=0.1180630, (0 missing)
   hh   < 420.5   to the left, improve=0.1147604, (0 missing)
 Surrogate splits:
   log_pc_rooms   < 0.03791093 to the left, agree=0.716, adj=0.060, (0 split)
   rooms   < 405   to the left, agree=0.710, adj=0.042, (0 split)
   hh   < 126.5   to the left, agree=0.710, adj=0.042, (0 split)
   pop   < 218.5   to the left, agree=0.709, adj=0.037, (0 split)
   log_pc_bedrooms < -1.666657 to the left, agree=0.707, adj=0.033, (0 split)

Node number 3: 596 observations, complexity param=0.06723167
 mean=12.75601, MSE=0.08800114
 left son=6 (343 obs) right son=7 (253 obs)
 Primary splits:
   income   < 6.33795   to the left, improve=0.37886360, (0 missing)
   log_pc_rooms   < 0.78489   to the left, improve=0.28082770, (0 missing)
   log_pop_hh   < 1.174025 to the right, improve=0.07793179, (0 missing)
   log_pc_bedrooms < -1.074462 to the left, improve=0.06883916, (0 missing)
   pop   < 1621.5   to the right, improve=0.02589955, (0 missing)

```
  Surrogate splits:
     log_pc_rooms    < 0.914585   to the left,  agree=0.772, adj=0.462, (0 split)
     hh              < 217        to the right, agree=0.601, adj=0.059, (0 split)
     bedrooms        < 223.5      to the right, agree=0.599, adj=0.055, (0 split)
     pop             < 582        to the right, agree=0.591, adj=0.036, (0 split)
     log_pc_bedrooms < -0.9242346 to the right, agree=0.591, adj=0.036, (0 split)

Node number 4: 215 observations,    complexity param=0.02457305
  mean=11.83691, MSE=0.165809
  left son=8 (144 obs) right son=9 (71 obs)
  Primary splits:
     log_pop_hh     < 0.8187751  to the right, improve=0.2037304, (0 missing)
     log_pc_bedrooms < -0.7643257 to the left,  improve=0.1634555, (0 missing)
     hh             < 408        to the left,  improve=0.1367841, (0 missing)
     bedrooms       < 433.5      to the left,  improve=0.1195585, (0 missing)
     pop            < 1190       to the left,  improve=0.1101065, (0 missing)
  Surrogate splits:
     log_pc_bedrooms < -0.7558615 to the left,  agree=0.921, adj=0.761, (0 split)
     log_pc_rooms    < 0.7259301  to the left,  agree=0.772, adj=0.310, (0 split)
     hh              < 520        to the left,  agree=0.735, adj=0.197, (0 split)
     rooms           < 2809       to the left,  agree=0.726, adj=0.169, (0 split)
     bedrooms        < 649.5      to the left,  agree=0.726, adj=0.169, (0 split)

Node number 5: 496 observations,    complexity param=0.0270605
  mean=12.29491, MSE=0.1198312
  left son=10 (274 obs) right son=11 (222 obs)
  Primary splits:
     log_pop_hh     < 0.8707028  to the right, improve=0.13456370, (0 missing)
     log_pc_bedrooms < -0.8947055 to the left,  improve=0.11769040, (0 missing)
     rooms          < 2019.5     to the left,  improve=0.08868108, (0 missing)
     hh             < 423.5      to the left,  improve=0.08866103, (0 missing)
     bedrooms       < 409.5      to the left,  improve=0.08822457, (0 missing)
  Surrogate splits:
     log_pc_bedrooms < -0.8381954 to the left,  agree=0.915, adj=0.811, (0 split)
     log_pc_rooms    < 0.6579236  to the left,  agree=0.726, adj=0.387, (0 split)
     hh              < 665        to the left,  agree=0.637, adj=0.189, (0 split)
     bedrooms        < 687.5      to the left,  agree=0.635, adj=0.185, (0 split)
     age             < 30.5       to the right, agree=0.631, adj=0.176, (0 split)

Node number 6: 343 observations,    complexity param=0.01434153
  mean=12.5992, MSE=0.07010273
  left son=12 (185 obs) right son=13 (158 obs)
```

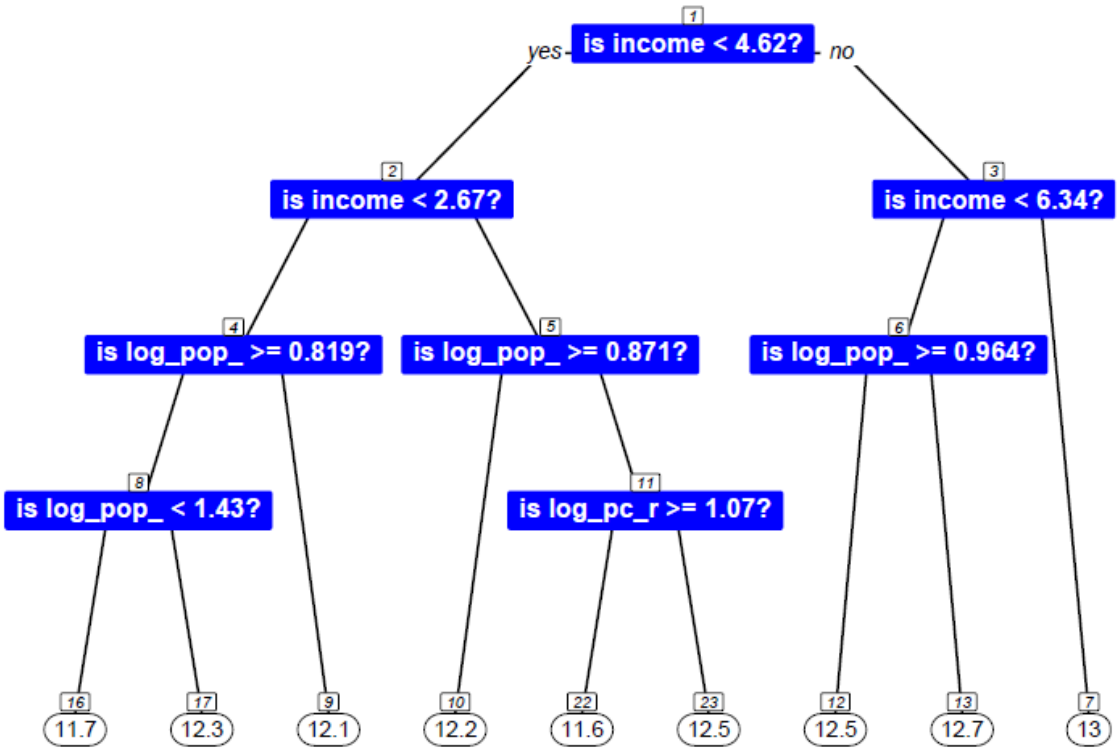
```
  Primary splits:
      log_pop_hh      < 0.9635097  to the right, improve=0.17628270, (0 missing)
      log_pc_rooms    < 0.7706807  to the left,  improve=0.16965260, (0 missing)
      log_pc_bedrooms < -1.084654  to the left,  improve=0.15027320, (0 missing)
      income          < 5.37135    to the left,  improve=0.05541173, (0 missing)
      age             < 49.5       to the left,  improve=0.03725613, (0 missing)
  Surrogate splits:
      log_pc_bedrooms < -0.9449526 to the left,  agree=0.895, adj=0.772, (0 split)
      log_pc_rooms    < 0.7620612  to the left,  agree=0.770, adj=0.500, (0 split)
      age             < 38.5       to the left,  agree=0.659, adj=0.259, (0 split)
      pop             < 1103       to the right, agree=0.586, adj=0.101, (0 split)
      bedrooms        < 1011.5     to the left,  agree=0.569, adj=0.063, (0 split)

Node number 7: 253 observations
  mean=12.96862, MSE=0.03372549

Node number 8: 144 observations,    complexity param=0.01634933
  mean=11.70786, MSE=0.1341078
  left son=16 (131 obs) right son=17 (13 obs)
  Primary splits:
      log_pop_hh      < 1.431683   to the left,  improve=0.25022280, (0 missing)
      log_pc_bedrooms < -1.397417  to the right, improve=0.24649740, (0 missing)
      log_pc_rooms    < -0.2011101 to the right, improve=0.24010050, (0 missing)
      pop             < 1190       to the left,  improve=0.13455880, (0 missing)
      hh              < 406.5      to the left,  improve=0.09877935, (0 missing)
  Surrogate splits:
      log_pc_bedrooms < -1.412594  to the right, agree=0.986, adj=0.846, (0 split)
      log_pc_rooms    < -0.350903  to the right, agree=0.958, adj=0.538, (0 split)
      rooms           < 100.5      to the right, agree=0.924, adj=0.154, (0 split)
      bedrooms        < 36.5       to the right, agree=0.917, adj=0.077, (0 split)
      hh              < 36.5       to the right, agree=0.917, adj=0.077, (0 split)

Node number 9: 71 observations
  mean=12.09866, MSE=0.1278119

Node number 10: 274 observations
  mean=12.18061, MSE=0.08968683

Node number 11: 222 observations,    complexity param=0.0170152
  mean=12.43598, MSE=0.1210095
  left son=22 (7 obs) right son=23 (215 obs)
  Primary splits:
```

```
    log_pc_rooms    < 1.068216   to the right, improve=0.18720100, (0 missing)
    income          < 3.31965    to the left,  improve=0.11992980, (0 missing)
    log_pc_bedrooms < -0.3974216 to the right, improve=0.07871486, (0 missing)
    log_pop_hh      < 0.4496501  to the left,  improve=0.07760785, (0 missing)
    pop             < 717.5      to the left,  improve=0.05319119, (0 missing)

Node number 12: 185 observations
  mean=12.49646, MSE=0.05628792

Node number 13: 158 observations
  mean=12.71949, MSE=0.0594507

Node number 16: 131 observations
  mean=11.65015, MSE=0.08620894

Node number 17: 13 observations
  mean=12.28936, MSE=0.2450745

Node number 22: 7 observations
  mean=11.60185, MSE=0.4893609

Node number 23: 215 observations
  mean=12.46314, MSE=0.08562601

n= 1307

node), split, n, deviance, yval
      * denotes terminal node

 1) root 1307 295.558500 12.42984
   2) income< 4.62305 711 126.546200 12.15641
     4) income< 2.66755 215  35.648940 11.83691
       8) log_pop_hh>=0.8187751 144  19.311520 11.70786
        16) log_pop_hh< 1.431683 131  11.293370 11.65015 *
        17) log_pop_hh>=1.431683 13   3.185969 12.28936 *
       9) log_pop_hh< 0.8187751 71   9.074646 12.09866 *
     5) income>=2.66755 496  59.436260 12.29491
      10) log_pop_hh>=0.8707028 274  24.574190 12.18061 *
      11) log_pop_hh< 0.8707028 222  26.864100 12.43598
        22) log_pc_rooms>=1.068216 7   3.425526 11.60185 *
        23) log_pc_rooms< 1.068216 215  18.409590 12.46314 *
   3) income>=4.62305 596  52.448680 12.75601
```

```
    6) income< 6.33795 343  24.045240 12.59920
     12) log_pop_hh>=0.9635097 185  10.413270 12.49646 *
     13) log_pop_hh< 0.9635097 158   9.393211 12.71949 *
    7) income>=6.33795 253   8.532549 12.96862 *
>
> # root-mean-squared for trees on training set
 [1] 0.2742484
> # report R-squared on training data
 [1] 0.6674015
```

Training set proportion of variance accounted for by tree-structured regression (full model) = 0.667>

```
> # root-mean-squared for trees on test set
 [1] 0.2936755
> # report R-squared on training data
> print(cor(houses.test$log_value,houses.test$rpart.train.fit.full.pred)^2)
[1] 0.6191817
```




```
>
```

Output 9: Random Forest

set.seed (9999)

Type of random forest: regression

Number of trees: 500

No. of variables tried at each split: 3

Mean of squared residuals: 0.06922999

% Var explained: 69.39

root-mean-squared for random forest on training set

[1] 0.1156064

R-squared on training data

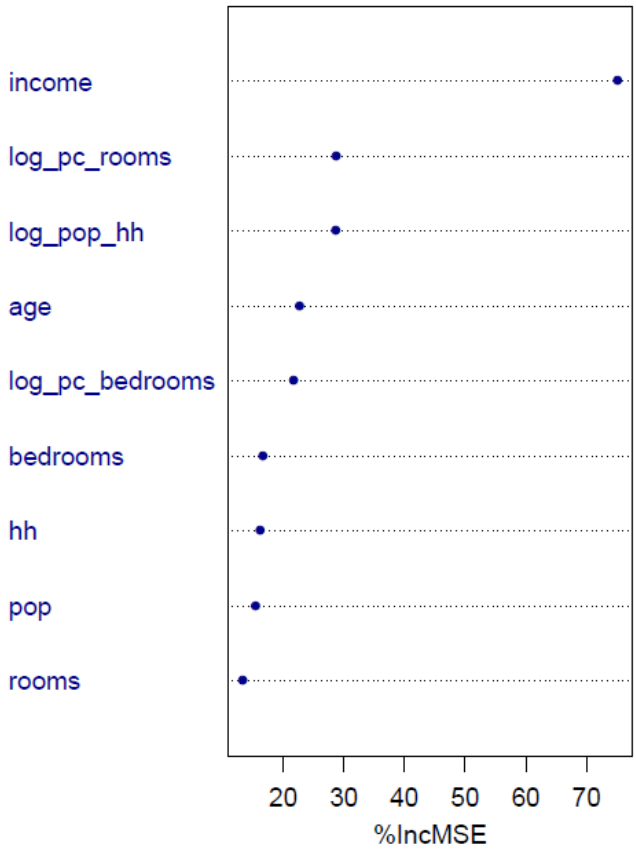
[1] 0.9500061

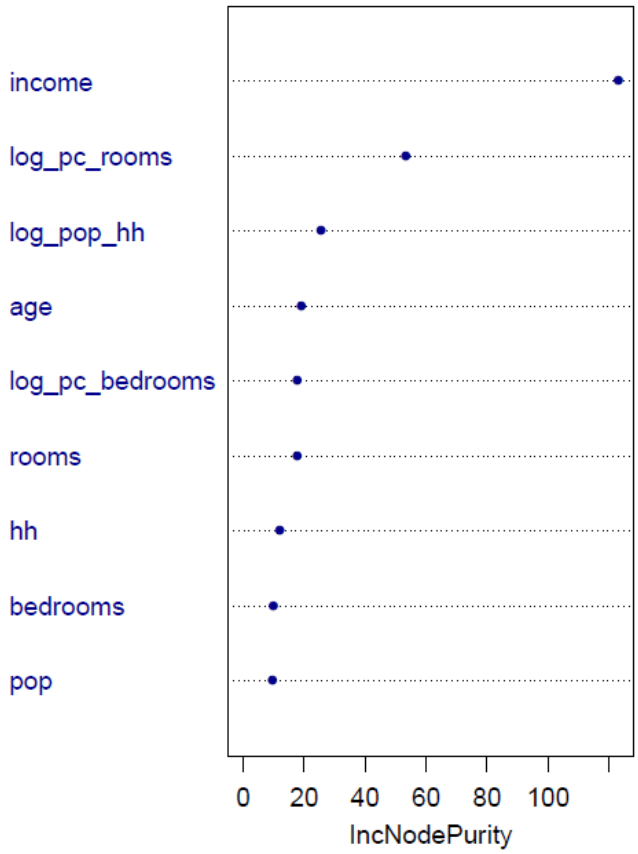
root-mean-squared for random forest on training set

[1] 0.2452678

report R-squared on training data

[1] 0.7304121





Output 10: Geographically weighted regression

```
root-mean-squared for grw on training set
 [1] 0.1625623
R-squared on training data
 [1] 0.8837034

root-mean-squared for grw on test set
 0.2329649
R-squared on training data
 [1] 0.7697659

Test set proportion of variance accounted  for by geographically-weighted regression =  0.770>
> # ------------------------------------
> # Construct a hybrid prediction
> # ------------------------------------
>
> houses.train$hybrid.pred <- (houses.train$rf.train.fit.full.pred +
+   houses.train$grw.train.fit.pred) / 2  # average of two best predictors
>
> houses.test$hybrid.pred <- (houses.test$rf.train.fit.full.pred +
+   houses.test$grw.train.fit.pred) / 2  # average of two best predictors
>
> cat("\n\nTraining set proportion of variance accounted",
+     " for by hybrid model = ",
+   sprintf("%1.3f",cor(houses.train$log_value,houses.train$hybrid.pred)^2),sep=" ")


Training set proportion of variance accounted  for by hybrid model =  0.935>
> cat("\n\nTest set proportion of variance accounted",
+   " for by hybrid model = ",
+   sprintf("%1.3f",cor(houses.test$log_value,
+   houses.test$hybrid.pred)^2),sep=" ")


Test set proportion of variance accounted  for by hybrid model =  0.813>
```