

# Homework 3

2025-10-04

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I am first adding a model with per-capita variables to consider before starting homework 3. Homework 2's models are also included below.

Continuous target variable: Population, low access to store (% change), 2015-19 [PCH\_LACCESS\_POP\_15\_19] [ACCESS]

Continuous predictor variables: nine variables with per capita alternatives

1. Grocery stores (% change), 2016-20 [PCH\_GROC\_16\_20] [STORES] Grocery stores/1,000 pop (% change), 2016-20 [PCH\_GROCPTH\_16\_20]
2. Supercenters & club stores (% change), 2016-20 [PCH\_SUPERC\_16\_20] Supercenters & club stores/1,000 pop (% change), 2016-20 [PCH\_SUPERCPTH\_16\_20]
3. Convenience stores (% change), 2016-20 [PCH\_CONVS\_16\_20] Convenience stores/1,000 pop (% change), 2016-20 [PCH\_CONVSPTH\_16\_20]
4. Specialized food stores (% change), 2016-20 [PCH\_SPECS\_16\_20] Specialized food stores/1,000 pop (% change), 2016-20 [PCH\_SPECSPTH\_16\_20]
5. SNAP-authorized stores (% change), 2017-23 [PCH\_SNAPS\_17\_23] SNAP-authorized stores/1,000 pop (% change), 2017-23 [PCH\_SNAPSPTH\_17\_23]
6. WIC-authorized stores (% change), 2016-22 [PCH\_WICS\_16\_22] WIC-authorized stores/1,000 pop (% change), 2016-22 [PCH\_WICSPTH\_16\_22]
7. Fast-food restaurants (% change), 2016-20 [PCH\_FFR\_16\_20] Fast-food restaurants/1,000 pop (% change), 2016-20 [PCH\_FFRPTH\_16\_20]
8. Full-service restaurants (% change), 2016-20 [PCH\_FSR\_16\_20] Full-service restaurants/1,000 pop (% change), 2016-20 [PCH\_FSRPTH\_16\_20]
9. Direct farm sales (% change), 2012 - 17 [PCH\_DIRSALES\_12\_17] [LOCAL] Direct farm sales per capita (% change), 2012 - 17 [PCH\_PC\_DIRSALES\_12\_17]

Binary variable to add later on: Persistent-poverty counties, 2017-21 [PERPOV17\_21] [SOCIOECONOMIC]

```
install.packages("ggfortify", repos="http://cran.us.r-project.org")
```

```
## Installing package into 'C:/Users/harip/AppData/Local/R/win-library/4.5'  
## (as 'lib' is unspecified)
```

```
## package 'ggfortify' successfully unpacked and MD5 sums checked  
##
```

```
## The downloaded binary packages are in  
##   C:\Users\harip\AppData\Local\Temp\RtmpS6DxXm\downloaded_packages
```

```
install.packages("mvnormtest", repos="http://cran.us.r-project.org")
```

```
## Installing package into 'C:/Users/harip/AppData/Local/R/win-library/4.5'  
## (as 'lib' is unspecified)
```

```
## package 'mvnormtest' successfully unpacked and MD5 sums checked  
##
```

```
## The downloaded binary packages are in  
##   C:\Users\harip\AppData\Local\Temp\RtmpS6DxXm\downloaded_packages
```

```
install.packages("dataarium", repos="http://cran.us.r-project.org")
```

```
## Installing package into 'C:/Users/harip/AppData/Local/R/win-library/4.5'  
## (as 'lib' is unspecified)
```

```

## package 'datarium' successfully unpacked and MD5 sums checked
##
## The downloaded binary packages are in
##   C:\Users\harip\AppData\Local\Temp\RtmpS6DxXm\downloaded_packages
install.packages("ggplot2", repos="http://cran.us.r-project.org")

## Installing package into 'C:/Users/harip/AppData/Local/R/win-library/4.5'
## (as 'lib' is unspecified)

## package 'ggplot2' successfully unpacked and MD5 sums checked
##
## The downloaded binary packages are in
##   C:\Users\harip\AppData\Local\Temp\RtmpS6DxXm\downloaded_packages
install.packages("car", repos="http://cran.us.r-project.org")

## Installing package into 'C:/Users/harip/AppData/Local/R/win-library/4.5'
## (as 'lib' is unspecified)

## package 'car' successfully unpacked and MD5 sums checked
##
## The downloaded binary packages are in
##   C:\Users\harip\AppData\Local\Temp\RtmpS6DxXm\downloaded_packages
library(MASS)
library(car)

## Loading required package: carData
library(datarium)
library(ggplot2)
library(broom)
library(ggfortify)
library(tidyverse)

## -- Attaching core tidyverse packages ----- tidyverse 2.0.0 --
## v dplyr     1.1.4    v readr     2.1.5
## vforcats   1.0.0    v stringr   1.5.1
## v lubridate 1.9.4    v tibble    3.3.0
## v purrr     1.1.0    v tidyrr    1.3.1

## -- Conflicts ----- tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()   masks stats::lag()
## x dplyr::recode() masks car::recode()
## x dplyr::select() masks MASS::select()
## x purrr::some()  masks car::some()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors

library(mvnormtest)

library(readxl)
X2025_food_environment_atlas_data <- read_excel("2025-food-environment-atlas-data.xlsx",
  sheet = "ACCESS", skip = 1)
access <- read_excel("2025-food-environment-atlas-data.xlsx",
  sheet = "ACCESS", skip = 1)
access

```

```

## # A tibble: 3,144 x 68
##   FIPS State County  LACCESS_POP15 LACCESS_POP19 PCH_LACCESS_POP_15_19
##   <chr> <chr> <chr>      <dbl>      <dbl>          <dbl>
## 1 01001 AL Autauga     18093.    18503.         2.27
## 2 01003 AL Baldwin     46400.    45789.        -1.32
## 3 01005 AL Barbour     6684.     5634.        -15.7
## 4 01007 AL Bibb        296.      365.         23.5
## 5 01009 AL Blount     5856.     3902.        -33.4
## 6 01011 AL Bullock    6100.     7480.         22.6
## 7 01013 AL Butler     2478.     2508.         1.23
## 8 01015 AL Calhoun    34221.    42575.        24.4
## 9 01017 AL Chambers    6794.     6745.        -0.720
## 10 01019 AL Cherokee   3519.     3506.        -0.358
## # i 3,134 more rows
## # i 62 more variables: PCT_LACCESS_POP15 <dbl>, PCT_LACCESS_POP19 <dbl>,
## #   LACCESS_LOWI15 <dbl>, LACCESS_LOWI19 <dbl>, PCH_LACCESS_LOWI_15_19 <dbl>,
## #   PCT_LACCESS_LOWI15 <dbl>, PCT_LACCESS_LOWI19 <dbl>, LACCESS_HHNV15 <dbl>,
## #   LACCESS_HHNV19 <dbl>, PCH_LACCESS_HHNV_15_19 <dbl>,
## #   PCT_LACCESS_HHNV15 <dbl>, PCT_LACCESS_HHNV19 <dbl>, LACCESS_SNAP15 <dbl>,
## #   LACCESS_SNAP19 <dbl>, PCH_LACCESS_SNAP_15_19 <dbl>, ...
library(readxl)
X2025_food_environment_atlas_data <- read_excel("2025-food-environment-atlas-data.xlsx",
                                               sheet = "STORES", skip = 1)
stores <- read_excel("2025-food-environment-atlas-data.xlsx",
                     sheet = "STORES", skip = 1)
stores

## # A tibble: 3,144 x 41
##   FIPS State County  GROC16 GROC20 PCH_GROC_16_20 GROCPTH16 GROCPTH20
##   <chr> <chr> <chr>   <dbl> <dbl>       <dbl>      <dbl>          <dbl>
## 1 01001 AL Autauga     3      4        33.3    0.0542         0.0712
## 2 01003 AL Baldwin     29     29        0       0.140         0.126
## 3 01005 AL Barbour     4      5        25       0.155         0.203
## 4 01007 AL Bibb        5      4       -20       0.221         0.181
## 5 01009 AL Blount     5      4       -20       0.0870        0.0691
## 6 01011 AL Bullock    3    -9999      -9999     0.289        -9999
## 7 01013 AL Butler     3      3        0       0.150         0.154
## 8 01015 AL Calhoun    27     21       -22.2     0.235         0.185
## 9 01017 AL Chambers    7      5       -28.6     0.207         0.152
## 10 01019 AL Cherokee   5    -9999      -9999     0.194        -9999
## # i 3,134 more rows
## # i 33 more variables: PCH_GROCPTH_16_20 <dbl>, SUPERC16 <dbl>, SUPERC20 <dbl>,
## #   PCH_SUPERC_16_20 <dbl>, SUPERCPTH16 <dbl>, SUPERCPTH20 <dbl>,
## #   PCH_SUPERCPTH_16_20 <dbl>, CONVS16 <dbl>, CONVS20 <dbl>,
## #   PCH_CONVS_16_20 <dbl>, CONVSPTH16 <dbl>, CONVSPTH20 <dbl>,
## #   PCH_CONVSPTH_16_20 <dbl>, SPECS16 <dbl>, SPECS20 <dbl>,
## #   PCH_SPECS_16_20 <dbl>, SPECSPTH16 <dbl>, SPECSPTH20 <dbl>,...
library(readxl)
X2025_food_environment_atlas_data <- read_excel("2025-food-environment-atlas-data.xlsx",
                                               sheet = "RESTAURANTS", skip = 1)
restaurants <- read_excel("2025-food-environment-atlas-data.xlsx",
                           sheet = "RESTAURANTS", skip = 1)
restaurants

```

```

## # A tibble: 3,144 x 15
##   FIPS State County   FFR16 FFR20 PCH_FFR_16_20 FFRPTH16 FFRPTH20
##   <chr> <chr> <chr>   <dbl> <dbl>      <dbl>    <dbl>    <dbl>
## 1 01001 AL Autauga     44     45      2.27    0.796    0.801
## 2 01003 AL Baldwin    156    172     10.3    0.751    0.750
## 3 01005 AL Barbour    23     24      4.35    0.891    0.976
## 4 01007 AL Bibb        7      7       0       0.310    0.316
## 5 01009 AL Blount     23     24      4.35    0.400    0.415
## 6 01011 AL Bullock    3      3       0       0.289    0.301
## 7 01013 AL Butler     18     21     16.7    0.898    1.08
## 8 01015 AL Calhoun    95    104     9.47    0.826    0.917
## 9 01017 AL Chambers   29     32     10.3    0.859    0.974
## 10 01019 AL Cherokee   15     18     20      0.582    0.685
## # i 3,134 more rows
## # i 7 more variables: PCH_FFRPTH_16_20 <dbl>, FSR16 <dbl>, FSR20 <dbl>,
## #   PCH_FSR_16_20 <dbl>, FSRPTH16 <dbl>, FSRPTH20 <dbl>, PCH_FSRPTH_16_20 <dbl>

library(readxl)
X2025_food_environment_atlas_data <- read_excel("2025-food-environment-atlas-data.xlsx",
sheet = "LOCAL", skip = 1)
local <- read_excel("2025-food-environment-atlas-data.xlsx",
sheet = "LOCAL", skip = 1)
local

## # A tibble: 3,161 x 98
##   FIPS State County   DIRSALES_FARMS12 DIRSALES_FARMS17 PCH_DIRSALES_FARMS_1~1
##   <chr> <chr> <chr>      <dbl>          <dbl>          <dbl>
## 1 01001 AL Autauga      51            16           -68.6
## 2 01003 AL Baldwin     103            78           -24.3
## 3 01005 AL Barbour     13             9           -30.8
## 4 01007 AL Bibb         13            11           -15.4
## 5 01009 AL Blount      88            40           -54.5
## 6 01011 AL Bullock     12             2           -83.3
## 7 01013 AL Butler      31            20           -35.5
## 8 01015 AL Calhoun     50            52              4
## 9 01017 AL Chambers    22            13           -40.9
## 10 01019 AL Cherokee    14            14              0
## # i 3,151 more rows
## # i abbreviated name: 1: PCH_DIRSALES_FARMS_12_17
## # i 92 more variables: PCT_LOCLFARM12 <dbl>, PCT_LOCLFARM17 <dbl>,
## #   PCT_LOCLSALE12 <dbl>, PCT_LOCLSALE17 <dbl>, DIRSALES12 <dbl>,
## #   DIRSALES17 <dbl>, PCH_DIRSALES_12_17 <dbl>, PC_DIRSALES12 <dbl>,
## #   PC_DIRSALES17 <dbl>, PCH_PC_DIRSALES_12_17 <dbl>, FMRKT13 <dbl>,
## #   FMRKT18 <dbl>, PCH_FMRKT_13_18 <dbl>, FMRKTPTH13 <dbl>, ...
atlasog = merge(access, stores, by.x = "FIPS", by.y = "FIPS")
atlasog = merge(atlasog, restaurants, by.x = "FIPS", by.y = "FIPS")
atlasog = merge(atlasog, local, by.x = "FIPS", by.y = "FIPS")

## Warning in merge.data.frame(atlasog, local, by.x = "FIPS", by.y = "FIPS"):
## column names 'State.x', 'County.x', 'State.y', 'County.y' are duplicated in the
## result
```

Scatter plots and regression:

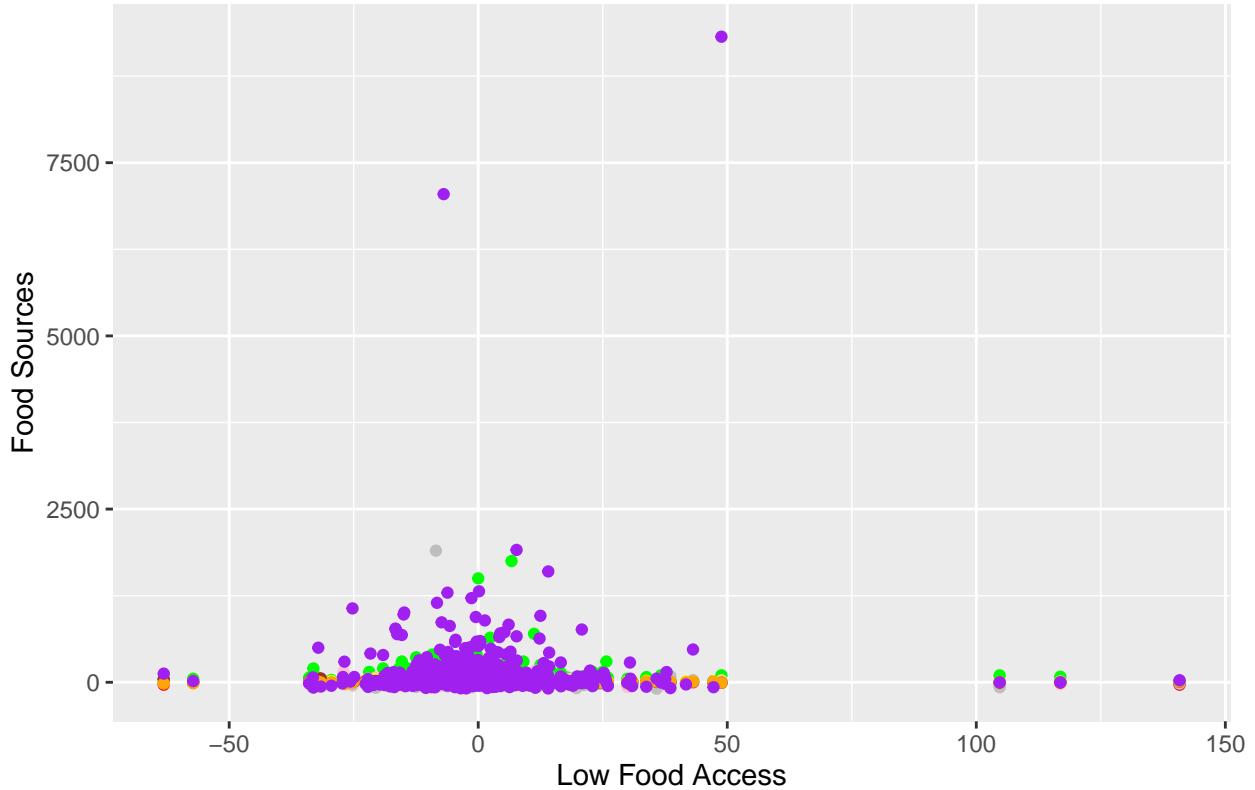
```

atlas = select(atlasog, PCH_LACCESS_POP_15_19, PCH_GROC_16_20, PCH_SUPERC_16_20, PCH_CONVS_16_20, PCH_S
atlas = filter(atlas, PCH_LACCESS_POP_15_19 != -9999, PCH_GROC_16_20 != -9999, PCH_SUPERC_16_20 != -9999
atlas = filter(atlas, PCH_LACCESS_POP_15_19 != -8888, PCH_GROC_16_20 != -8888, PCH_SUPERC_16_20 != -8888

# adjust Jupyter plot size
options(repr.plot.width=4, repr.plot.height=4)
ggplot(atlas) +
  geom_point(aes(y = PCH_GROC_16_20, x = PCH_LACCESS_POP_15_19), color="red")+
  geom_point(aes(y = PCH_SUPERC_16_20, x = PCH_LACCESS_POP_15_19), color="green")+
  geom_point(aes(y = PCH_CONVS_16_20, x = PCH_LACCESS_POP_15_19), color="blue")+
  geom_point(aes(y = PCH_SPECS_16_20, x = PCH_LACCESS_POP_15_19), color="pink")+
  geom_point(aes(y = PCH_SNAPS_17_23, x = PCH_LACCESS_POP_15_19), color="yellow")+
  geom_point(aes(y = PCH_WICS_16_22, x = PCH_LACCESS_POP_15_19), color="gray")+
  geom_point(aes(y = PCH_FFR_16_20, x = PCH_LACCESS_POP_15_19), color="brown")+
  geom_point(aes(y = PCH_FSR_16_20, x = PCH_LACCESS_POP_15_19), color="orange")+
  geom_point(aes(y = PCH_DIRSALES_12_17, x = PCH_LACCESS_POP_15_19), color="purple")+
  labs(title = "Low Food Access vs. Food Sources",
       x = "Low Food Access",
       y = "Food Sources")

```

## Low Food Access vs. Food Sources



```

#There are two points that are clearly outliers at thousands of percents higher than the others, so I a
atlas2 = filter(atlas, PCH_LACCESS_POP_15_19 < 5000, PCH_GROC_16_20 < 5000, PCH_SUPERC_16_20 < 5000, PCH_C
#normalize predictors
colMeans(atlas2)

```

```

## PCH_LACCESS_POP_15_19      PCH_GROC_16_20      PCH_SUPERC_16_20
##          0.2320956        -0.7079341       68.9385445
## PCH_CONVS_16_20            PCH_SPECS_16_20     PCH_SNAPS_17_23
##          2.6007777        -0.6579917       11.6952787
## PCH_WICS_16_22             PCH_FFR_16_20      PCH_FSR_16_20
##          -5.6402305        6.6306411       1.8834212
## PCH_DIRSALES_12_17
##          106.6679969

mutate(atlas2, PCH_GROC_16_20 = PCH_GROC_16_20 + 0.7079341) |>
select(PCH_GROC_16_20)

##      PCH_GROC_16_20
## 1    0.70793410
## 2    0.70793410
## 3    6.31541074
## 4    0.70793410
## 5   -1.46597894
## 6    5.25338865
## 7    7.85079124
## 8   -8.11559531
## 9   -27.06984368
## 10   31.47716487
## 11   20.70793410
## 12  -18.04206590
## 13  -9.29206590
## 14   0.49380134
## 15  12.47263998
## 16  -6.43492304
## 17   3.16695049
## 18  -21.87271106
## 19  -6.18861762
## 20  -8.96948525
## 21  33.14036653
## 22  -14.67668128
## 23  -18.04206590
## 24   9.47986392
## 25  17.37460077
## 26   8.40024179
## 27  -1.17378633
## 28  -10.40317701
## 29   12.70793410
## 30  -0.84848613
## 31  -15.95873257
## 32  -27.86349447
## 33   2.84697153
## 34  39.99364839
## 35  -2.92842954
## 36   7.85079124
## 37  -18.40971296
## 38   8.74364839
## 39   3.32890184
## 40   2.27043410
## 41   1.85406591
## 42   7.61702501

```

```

## 43      0.38430950
## 44      0.36251096
## 45      15.70793410
## 46     -12.33554416
## 47      0.15848355
## 48      4.04126743
## 49     -3.31505441
## 50     -7.74277013
## 51      17.85079124
## 52      2.09682299
## 53      1.42221981
## 54     -4.63557735
## 55      5.46983886
## 56     -5.17441884
## 57      5.49835326
## 58     -6.11024772
## 59      0.70793410
## 60     -0.34469748
## 61     -0.93141016
## 62      16.70793410
## 63      2.34727836
## 64     -19.29206590
## 65     -2.57075442
## 66      6.26348966
## 67     -18.33968495
## 68     -28.70383061
## 69     -8.66706590
## 70      2.15024179
## 71     -8.59439148
## 72     -10.65570226
## 73     -6.05535092
## 74      5.83613923
## 75     -32.62539923
## 76     -6.43492304
## 77      6.89350111
## 78     -12.05802335
## 79     -5.20604439
## 80     -1.61764730
## 81      4.15620996
## 82      5.70793410
## 83     -0.37023302
## 84      5.46983886
## 85      6.26348966
## 86      10.23174362
## 87      7.26531115
## 88      3.58149732
## 89      2.88184714
## 90      23.43520683
## 91      3.20793410
## 92      11.81904521
## 93      9.04126743
## 94      19.22645262
## 95     -8.22063733
## 96      3.64911057

```

```

## 97      -0.22374292
## 98       0.70793410
## 99      13.20793410
## 100      7.52611592
## 101      6.16247955
## 102      6.38975228
## 103     10.23174362
## 104      2.21547179
## 105      8.75391111
## 106      7.52611592
## 107     14.99364839
## 108    -11.65161646
## 109      16.33293410
## 110      13.94322822
## 111    -22.36898898
## 112      14.16947256
## 113      6.59028704
## 114      5.05576019
## 115      4.62950273
## 116      5.33756373
## 117     10.23174362
## 118     -0.60785537
## 119      0.70793410
## 120    -28.70383061
## 121     -2.06984368
## 122     -9.49614753
## 123     11.23424989
## 124     10.36310651
## 125      6.42221981
## 126     -6.69947331
## 127     14.99364839
## 128    -16.36523663
## 129      0.70793410
## 130    -21.51428812
## 131      0.70793410
## 132     -1.61764730
## 133     -9.56233617
## 134      2.83559367
## 135      9.21857240
## 136     -8.38297499
## 137     20.70793410
## 138     -7.29206590
## 139     -4.29206590
## 140      0.70793410
## 141     -1.92364485
## 142    -12.05657102
## 143     -4.81353829
## 144     -1.99476860
## 145     -4.29206590
## 146     22.93015632
## 147      8.40024179
## 148    -12.92842954
## 149     -1.46597894
## 150      4.27936267

```

```
## 151 -27.86349447
## 152 -9.70873257
## 153 -27.59395269
## 154 4.55408795
## 155 -8.18095479
## 156 13.61115991
## 157 0.70793410
## 158 -0.39096700
## 159 -4.46447969
## 160 -13.57778019
## 161 -7.62539923
## 162 -42.14920876
## 163 -6.98437359
## 164 8.81604221
## 165 -29.29206590
## 166 -12.80557941
## 167 -7.62539923
## 168 0.70793410
## 169 -26.56479317
## 170 -3.13821975
## 171 -29.29206590
## 172 0.70793410
## 173 0.70793410
## 174 0.70793410
## 175 15.34208044
## 176 -7.29206590
## 177 -14.29206590
## 178 13.20793410
## 179 0.70793410
## 180 40.70793410
## 181 -9.63689349
## 182 20.96109866
## 183 -8.38297499
## 184 -7.29206590
## 185 17.37460077
## 186 -10.40317701
## 187 5.97109199
## 188 0.70793410
## 189 5.52721121
## 190 -15.95873257
## 191 6.11333951
## 192 -13.57778019
## 193 8.40024179
## 194 20.70793410
## 195 -22.82147766
## 196 -0.83052744
## 197 7.85079124
## 198 -3.16303364
## 199 -8.38297499
## 200 -9.81838169
## 201 14.34429774
## 202 -16.93912472
## 203 0.70793410
## 204 7.15954700
```

```
## 205 -0.13240203
## 206 2.59472655
## 207 -7.62539923
## 208 -11.79206590
## 209 -2.94170094
## 210 10.23174362
## 211 7.85079124
## 212 -4.55522379
## 213 -4.29206590
## 214 0.70793410
## 215 2.04126743
## 216 -6.69947331
## 217 7.37460077
## 218 -6.26881009
## 219 9.21857240
## 220 8.87119941
## 221 13.20793410
## 222 -11.79206590
## 223 43.56507696
## 224 9.27936267
## 225 30.70793410
## 226 8.02500727
## 227 1.70295898
## 228 6.95793410
## 229 -11.05677178
## 230 -14.67668128
## 231 19.93870333
## 232 10.70793410
## 233 -17.65272164
## 234 -12.44996064
## 235 -25.00635161
## 236 5.05576019
## 237 -5.77855239
## 238 -6.02283513
## 239 6.59028704
## 240 2.18941558
## 241 -5.12539923
## 242 -6.26881009
## 243 -2.99576960
## 244 -6.16229491
## 245 36.00205175
## 246 -17.47388408
## 247 0.70793410
## 248 -39.29206590
## 249 0.70793410
## 250 -14.10688071
## 251 5.46983886
## 252 0.70793410
## 253 -9.29206590
## 254 0.70793410
## 255 0.70793410
## 256 27.98066137
## 257 1.77176389
## 258 -4.84762146
```

```
## 259 -13.69206590
## 260 -20.72063733
## 261 -22.01933863
## 262 0.27503367
## 263 13.61115991
## 264 -17.24078385
## 265 -11.79206590
## 266 9.79884319
## 267 -34.29206590
## 268 -2.46666907
## 269 -10.15626343
## 270 11.81904521
## 271 -13.57778019
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## 273 0.70793410
## 274 14.70793410
## 275 1.57000307
## 276 -17.47388408
## 277 -6.98437359
## 278 20.31577724
## 279 6.95793410
## 280 69.93870333
## 281 16.83696636
## 282 19.93870333
## 283 9.04126743
## 284 -9.29206590
## 285 3.83293410
## 286 70.70793410
## 287 10.70793410
## 288 0.70793410
## 289 -8.96948525
## 290 -4.29206590
## 291 8.02500727
## 292 -1.16122478
## 293 18.88975228
## 294 -7.98771807
## 295 -3.83752045
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## 298 28.48571188
## 299 17.37460077
## 300 23.78485718
## 301 -9.29206590
## 302 -4.84762146
## 303 0.70793410
## 304 14.04126743
## 305 0.70793410
## 306 -15.95873257
## 307 11.42221981
## 308 20.70793410
## 309 -6.98437359
## 310 7.60448582
## 311 -0.76265414
## 312 14.99364839
```

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## 314 17.37460077
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## 318 -2.69342644
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## 322 -1.83443878
## 323 2.59472655
## 324 -10.00635161
## 325 -0.31247406
## 326 -2.01933863
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## 333 34.04126743
## 334 -20.72063733
## 335 -14.14355105
## 336 -15.10996713
## 337 -6.43492304
## 338 7.37460077
## 339 -34.29206590
## 340 -18.48398509
## 341 -10.54608519
## 342 -17.47388408
## 343 -16.93912472
## 344 -18.37022221
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## 346 -21.80912428
## 347 6.59028704
## 348 -26.05262928
## 349 -12.51520640
## 350 -20.34469748
## 351 -6.69947331
## 352 -4.05397066
## 353 -7.18680274
## 354 -18.71355350
## 355 -9.20197581
## 356 -39.29206590
## 357 -2.86349447
## 358 2.88184714
## 359 -10.29002924
## 360 -4.05397066
## 361 -3.54738505
## 362 -21.51428812
## 363 -12.28175662
## 364 -9.63689349
## 365 14.99364839
## 366 20.06277281
```

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## 367 -16.43492304
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## 369 -1.21514282
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## 374 0.70793410
## 375 0.70793410
## 376 15.70793410
## 377 -6.69947331
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## 379 13.59453204
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## 381 0.70793410
## 382 6.95793410
## 383 0.70793410
## 384 -11.79206590
## 385 36.42221981
## 386 -21.51428812
## 387 13.75141236
## 388 0.70793410
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## 396 -6.89440508
## 397 -8.38297499
## 398 10.46403166
## 399 -12.92842954
## 400 6.16247955
## 401 -1.95873257
## 402 0.70793410
## 403 0.70793410
## 404 -8.38297499
## 405 -2.82147766
## 406 -6.43492304
## 407 -4.29206590
## 408 -12.92842954
## 409 5.62596689
## 410 10.23174362
## 411 -10.40317701
## 412 4.15620996
## 413 6.95793410
## 414 -35.83052744
## 415 17.37460077
## 416 -43.24810986
## 417 -2.48355526
## 418 8.40024179
## 419 -9.63689349
## 420 -11.79206590

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```
## 421 -24.29206590
## 422 13.20793410
## 423 -15.08153958
## 424 4.41163780
## 425 12.13650553
## 426 6.95793410
## 427 6.95793410
## 428 7.26531115
## 429 12.47263998
## 430 -4.55522379
## 431 -6.11024772
## 432 -3.23943432
## 433 7.85079124
## 434 -8.93062012
## 435 14.99364839
## 436 -12.99069604
## 437 -15.29206590
## 438 4.76198815
## 439 11.23424989
## 440 -4.78657139
## 441 -12.19529171
## 442 6.59028704
## 443 8.40024179
## 444 -11.05677178
## 445 -4.55522379
## 446 9.63650553
## 447 0.70793410
## 448 14.59682299
## 449 -17.14920876
## 450 -8.96948525
## 451 22.93015632
## 452 -10.91997288
## 453 16.44867484
## 454 3.73823713
## 455 -20.34469748
## 456 22.37460077
## 457 0.70793410
## 458 -6.43492304
## 459 18.35499292
## 460 3.44766013
## 461 0.70793410
## 462 3.65344220
## 463 0.70793410
## 464 -5.17441884
## 465 -8.66706590
## 466 -10.40317701
## 467 -14.44358105
## 468 4.15620996
## 469 13.20793410
## 470 9.69669814
## 471 -18.64690461
## 472 14.34429774
## 473 10.70793410
## 474 21.63816666
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## 475      0.70793410
## 476     -14.29206590
## 477     -1.51428812
## 478     -15.08153958
## 479      16.49740778
## 480      3.93374055
## 481     -36.79206590
## 482     -12.62539923
## 483      0.70793410
## 484     -6.55013042
## 485      9.32862376
## 486     -9.15122083
## 487     -25.95873257
## 488     -25.95873257
## 489      0.70793410
## 490     -16.93912472
## 491     -5.35267196
## 492     -7.88102296
## 493     -15.08153958
## 494     -14.29206590
## 495     -13.57778019
## 496     -15.95873257
## 497     18.88975228
## 498     -2.51787235
## 499     -2.78043799
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## 502      0.70793410
## 503      8.70793410
## 504     13.20793410
## 505      1.93342430
## 506     10.85286164
## 507      0.70793410
## 508     36.42221981
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## 510     26.74960077
## 511     -10.83052744
## 512     25.70793410
## 513      2.14396543
## 514     50.70793410
## 515     15.63330723
## 516     -11.19682780
## 517      0.70793410
## 518     18.88975228
## 519     32.52611592
## 520      0.70793410
## 521     17.37460077
## 522      0.70793410
## 523     -8.38297499
## 524      0.70793410
## 525     -10.40317701
## 526      0.70793410
## 527      0.70793410
## 528    100.70793410

```

```
## 529 -21.51428812
## 530 39.83836888
## 531 3.62460077
## 532 9.04126743
## 533 -15.95873257
## 534 4.68144403
## 535 0.70793410
## 536 -20.72063733
## 537 -13.57778019
## 538 8.02500727
## 539 0.70793410
## 540 -19.29206590
## 541 5.22406313
## 542 -1.41972547
## 543 -4.55522379
## 544 -2.74034176
## 545 16.98700387
## 546 13.20793410
## 547 0.70793410
## 548 -9.15122083
## 549 5.88034789
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## 552 27.98066137
## 553 14.99364839
## 554 6.95793410
## 555 39.59682299
## 556 0.70793410
## 557 -32.62539923
## 558 7.15954700
## 559 5.70793410
## 560 -6.43492304
## 561 13.69494709
## 562 -19.98172107
## 563 -4.05397066
## 564 16.09254948
## 565 5.70793410
## 566 0.70793410
## 567 -17.47388408
## 568 -3.53917015
## 569 -5.81380503
## 570 -4.05397066
## 571 -21.16706590
## 572 0.05433933
## 573 -0.52663380
## 574 -4.95244326
## 575 25.70793410
## 576 -6.60913907
## 577 3.56507696
## 578 -8.96948525
## 579 -24.29206590
## 580 8.40024179
## 581 -8.38297499
## 582 -5.17441884
```

```

## 583      1.95793410
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## 585     -25.60785537
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## 587      0.70793410
## 588     -3.22219690
## 589      4.87460077
## 590     17.37460077
## 591     -7.18680274
## 592      5.05576019
## 593     -9.29206590
## 594    -10.40317701
## 595    -20.34469748
## 596      0.70793410
## 597     -8.06399572
## 598      31.95793410
## 599     -32.62539923
## 600      0.70793410

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select(PCH_SUPERC_16_20)

##      PCH_SUPERC_16_20
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## 2     -35.6052112
## 3     -74.2017024
## 4     -35.6052112
## 5     -68.9385445
## 6     -68.9385445
## 7     -68.9385445
## 8     -52.2718778
## 9     -18.9385445
## 10    -28.9385445
## 11    -68.9385445
## 12    -35.6052112
## 13    -2.2718778
## 14    -35.9488538
## 15    31.0614555
## 16    -68.9385445
## 17    -27.7620739
## 18    -68.9385445
## 19    -68.9385445
## 20    -52.2718778
## 21    573.9185984
## 22    31.0614555
## 23    -68.9385445
## 24    -38.9385445
## 25    -48.9385445
## 26    -52.2718778
## 27    281.0614555
## 28    231.0614555
## 29    151.0614555
## 30    31.0614555
## 31    31.0614555
## 32    -43.9385445

```

```

## 33      31.0614555
## 34     -18.9385445
## 35      116.7757412
## 36      231.0614555
## 37       64.3947888
## 38      -8.9385445
## 39      108.8392333
## 40      81.0614555
## 41       1.4318259
## 42     -14.3930900
## 43      53.2836777
## 44      71.8021962
## 45      -18.9385445
## 46      331.0614555
## 47     1681.0614555
## 48     181.0614555
## 49     149.2432737
## 50     231.0614555
## 51     -35.6052112
## 52     -31.4385445
## 53     231.0614555
## 54     131.0614555
## 55     -18.9385445
## 56     81.0614555
## 57      97.7281222
## 58     131.0614555
## 59     -59.8476354
## 60     -48.9385445
## 61     -28.9385445
## 62     -35.6052112
## 63     -55.6052112
## 64     131.0614555
## 65     -33.2242588
## 66     -46.7163223
## 67     -35.6052112
## 68     -43.9385445
## 69     -68.9385445
## 70     111.0614555
## 71     145.3471698
## 72     231.0614555
## 73      41.0614555
## 74      97.7281222
## 75     -2.2718778
## 76     -35.6052112
## 77      71.0614555
## 78     -18.9385445
## 79      11.0614555
## 80     131.0614555
## 81     -35.6052112
## 82     -27.2718778
## 83     -22.0635445
## 84     -68.9385445
## 85     -68.9385445
## 86     -43.9385445

```

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## 87      -26.0814016
## 88      -40.3671159
## 89      -2.2718778
## 90      -48.9385445
## 91      -45.8616214
## 92      -35.6052112
## 93      -57.8274334
## 94      -31.4385445
## 95      -54.6528302
## 96      -18.9385445
## 97      -7.4000830
## 98      131.0614555
## 99      -28.9385445
## 100     -25.4602836
## 101     -57.8274334
## 102     -37.1203627
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## 104     7.9845324
## 105     -23.4839990
## 106     -52.2718778
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## 108     -26.0814016
## 109     -18.9385445
## 110     -48.9385445
## 111     -68.9385445
## 112     -40.3671159
## 113     -68.9385445
## 114     -18.9385445
## 115     -68.9385445
## 116     -10.6052112
## 117     -2.2718778
## 118     -61.7956874
## 119     31.0614555
## 120     -68.9385445
## 121     -54.6528302
## 122     -8.9385445
## 123     -18.9385445
## 124     -43.9385445
## 125     -68.9385445
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## 128     -18.9385445
## 129     -68.9385445
## 130     -18.9385445
## 131     -18.9385445
## 132     331.0614555
## 133     3.7887282
## 134     131.0614555
## 135     -45.8616214
## 136     -68.9385445
## 137     -43.9385445
## 138     -28.9385445
## 139     -28.9385445
## 140     -35.6052112

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## 141      -40.3671159
## 142       29.1006712
## 143      -11.7956874
## 144      -28.9385445
## 145      -35.6052112
## 146      -28.9385445
## 147      -15.0923907
## 148      -35.6052112
## 149      -50.7567263
## 150      -43.9385445
## 151      -35.6052112
## 152      -18.9385445
## 153       31.0614555
## 154      -68.9385445
## 155       64.3947888
## 156      -48.9385445
## 157      -48.9385445
## 158      -37.6885445
## 159      -26.0814016
## 160      -50.7567263
## 161      -35.6052112
## 162      -2.2718778
## 163      -35.6052112
## 164      -48.9385445
## 165      -18.9385445
## 166      -54.6528302
## 167      -46.7163223
## 168      -35.6052112
## 169      -52.2718778
## 170       47.7281222
## 171      -68.9385445
## 172      -73.2863706
## 173      -18.9385445
## 174      -2.2718778
## 175      -57.8274334
## 176      -54.6528302
## 177       6.0614555
## 178      -43.9385445
## 179      -18.9385445
## 180      -2.2718778
## 181      -68.9385445
## 182      -28.9385445
## 183      -35.6052112
## 184      -68.9385445
## 185       31.0614555
## 186      -35.6052112
## 187      -68.9385445
## 188      -18.9385445
## 189      -28.9385445
## 190      -18.9385445
## 191      -54.6528302
## 192      -68.9385445
## 193      -35.6052112
## 194      -18.9385445

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## 195      -18.9385445
## 196      -11.7956874
## 197      -35.6052112
## 198      -33.6444269
## 199      -35.6052112
## 200      -43.9385445
## 201      -93.9385445
## 202      -68.9385445
## 203      -54.6528302
## 204      -68.9385445
## 205      -76.6308522
## 206      -54.6528302
## 207      -68.9385445
## 208      -88.9385445
## 209      -18.9385445
## 210      -111.7956874
## 211      -85.6052112
## 212      -83.2242588
## 213      -2.2718778
## 214      -35.6052112
## 215      -28.9385445
## 216      -35.6052112
## 217      -18.9385445
## 218      -18.9385445
## 219      1.0614555
## 220      31.0614555
## 221      131.0614555
## 222      -18.9385445
## 223      131.0614555
## 224      -43.9385445
## 225      64.3947888
## 226      64.3947888
## 227      197.7281222
## 228      191.0614555
## 229      -18.9385445
## 230      131.0614555
## 231      31.0614555
## 232      -35.6052112
## 233      31.0614555
## 234      231.0614555
## 235      231.0614555
## 236      68.5614555
## 237      91.0614555
## 238      -18.9385445
## 239      231.0614555
## 240      119.9503444
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## 242      197.7281222
## 243      631.0614555
## 244      81.0614555
## 245      -68.9385445
## 246      -68.9385445
## 247      -18.9385445
## 248      -68.9385445

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## 249      -28.9385445
## 250      -41.6658172
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## 255      -43.9385445
## 256      -31.4385445
## 257      -28.9385445
## 258      -35.6052112
## 259      -11.0438077
## 260      131.0614555
## 261      -35.6052112
## 262      -28.1978038
## 263      -40.3671159
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## 265      -48.9385445
## 266      -68.9385445
## 267      -68.9385445
## 268      -18.9385445
## 269      -47.7264233
## 270      31.0614555
## 271      -18.9385445
## 272      131.0614555
## 273      -18.9385445
## 274      0.2922247
## 275      25.7982976
## 276      131.0614555
## 277      -68.9385445
## 278      31.0614555
## 279      6.0614555
## 280      -35.6052112
## 281      -18.9385445
## 282      14.3947888
## 283      -18.9385445
## 284      -48.9385445
## 285      -43.9385445
## 286      -35.6052112
## 287      -68.9385445
## 288      31.0614555
## 289      -18.9385445
## 290      -35.6052112
## 291      -68.9385445
## 292      -45.8616214
## 293      -48.9385445
## 294      -43.9385445
## 295      16.7757412
## 296      131.0614555
## 297      31.0614555
## 298      -18.9385445
## 299      -18.9385445
## 300      -18.9385445
## 301      -35.6052112
## 302      -28.9385445

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## 303      -68.9385445
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## 305      -35.6052112
## 306      -18.9385445
## 307      -35.6052112
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## 309      231.0614555
## 310      31.0614555
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## 312      -18.9385445
## 313      2.4900269
## 314      -18.9385445
## 315      31.0614555
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## 321      -35.6052112
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## 329      -42.2718778
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## 331      -43.9385445
## 332      -18.9385445
## 333      -2.2718778
## 334      -2.2718778
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## 339      -18.9385445
## 340      -35.6052112
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## 351      11.0614555
## 352      -68.9385445
## 353      231.0614555
## 354      231.0614555
## 355      81.0614555
## 356      -35.6052112

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## 357      -2.2718778
## 358      81.0614555
## 359      97.7281222
## 360      -18.9385445
## 361      -35.6052112
## 362      -18.9385445
## 363      31.0614555
## 364      -43.9385445
## 365      -28.9385445
## 366      -52.2718778
## 367      -35.6052112
## 368      -68.9385445
## 369      -68.9385445
## 370      -57.8274334
## 371      -68.9385445
## 372      -6.4385445
## 373      -48.9385445
## 374      -0.1885445
## 375      -28.9385445
## 376      -18.9385445
## 377      -43.9385445
## 378      -35.6052112
## 379      -8.0689793
## 380      -43.9385445
## 381      -2.2718778
## 382      -18.9385445
## 383      -43.9385445
## 384      131.0614555
## 385      -68.9385445
## 386      -18.9385445
## 387      -40.3671159
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## 390      -18.9385445
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## 394      -2.2718778
## 395      -8.9385445
## 396      -18.9385445
## 397      -68.9385445
## 398      31.0614555
## 399      -18.9385445
## 400      16.7757412
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## 402      -2.2718778
## 403      31.0614555
## 404      -68.9385445
## 405      -43.9385445
## 406      -68.9385445
## 407      6.0614555
## 408      -43.9385445
## 409      14.3947888
## 410      59.6328841

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```

## 411      -68.9385445
## 412      -18.9385445
## 413      -48.9385445
## 414      -54.6528302
## 415      -68.9385445
## 416      -47.8859129
## 417      -43.9385445
## 418      -68.9385445
## 419      -53.5539291
## 420      -18.9385445
## 421      -18.9385445
## 422      -43.9385445
## 423      -43.9385445
## 424      -68.9385445
## 425      -57.8274334
## 426      -68.9385445
## 427      -68.9385445
## 428      -46.7163223
## 429      -68.9385445
## 430      -54.6528302
## 431      -32.5749081
## 432      -45.1290207
## 433      -68.9385445
## 434      -38.9385445
## 435      -35.6052112
## 436      122.7281222
## 437      -35.6052112
## 438      16.7757412
## 439      -2.2718778
## 440      1.0614555
## 441      -18.9385445
## 442      -2.2718778
## 443      156.0614555
## 444      -18.9385445
## 445      -2.2718778
## 446      31.0614555
## 447      231.0614555
## 448      -18.9385445
## 449      -93.9385445
## 450      -2.2718778
## 451      -18.9385445
## 452      -2.2718778
## 453      181.0614555
## 454      -18.9385445
## 455      31.0614555
## 456      31.0614555
## 457      231.0614555
## 458      31.0614555
## 459      -35.6052112
## 460      31.0614555
## 461      181.0614555
## 462      291.0614555
## 463      81.0614555
## 464      16.7757412

```

```

## 465      -18.9385445
## 466      -48.9385445
## 467      -43.9385445
## 468      31.0614555
## 469      -68.9385445
## 470      -31.4385445
## 471      -68.9385445
## 472      -50.7567263
## 473      -24.4941001
## 474      -11.7956874
## 475      -88.9385445
## 476      -40.3671159
## 477      -52.2718778
## 478      131.0614555
## 479      -54.6528302
## 480      -28.9385445
## 481      -2.2718778
## 482      -18.9385445
## 483      -18.9385445
## 484      -32.5749081
## 485      -43.9385445
## 486      -41.6658172
## 487      -35.6052112
## 488      -68.9385445
## 489      -43.9385445
## 490      -68.9385445
## 491      -40.3671159
## 492      -40.3671159
## 493      -35.6052112
## 494      31.0614555
## 495      -18.9385445
## 496      -18.9385445
## 497      -18.9385445
## 498      -43.9385445
## 499      -57.3106375
## 500      -58.9385445
## 501      -18.9385445
## 502      -58.9385445
## 503      -46.7163223
## 504      -18.9385445
## 505      -46.2112718
## 506      -63.6753866
## 507      -35.6052112
## 508      -18.9385445
## 509      -50.1885445
## 510      -53.5539291
## 511      -54.6528302
## 512      -68.9385445
## 513      -43.9385445
## 514      6.0614555
## 515      -45.4091327
## 516      -18.9385445
## 517      -18.9385445
## 518      -68.9385445

```

```

## 519      -40.3671159
## 520      -18.9385445
## 521      -18.9385445
## 522      -35.6052112
## 523       3.7887282
## 524     131.0614555
## 525      -18.9385445
## 526      -43.9385445
## 527      -93.9385445
## 528      -68.9385445
## 529      -18.9385445
## 530      -28.9385445
## 531      -49.7896083
## 532      -35.6052112
## 533      -43.9385445
## 534      -12.6885445
## 535      -35.6052112
## 536       6.0614555
## 537      -43.9385445
## 538      -52.2718778
## 539      -68.9385445
## 540      -68.9385445
## 541      -48.2488893
## 542      -40.3671159
## 543      -18.9385445
## 544      -68.9385445
## 545     131.0614555
## 546      -35.6052112
## 547      -35.6052112
## 548       6.0614555
## 549      -2.2718778
## 550      -41.6658172
## 551      -68.9385445
## 552      -2.2718778
## 553      -26.0814016
## 554      -18.9385445
## 555      -18.9385445
## 556      -18.9385445
## 557      -35.6052112
## 558      -43.9385445
## 559      -68.9385445
## 560      -68.9385445
## 561      -31.4385445
## 562      -28.9385445
## 563      -18.9385445
## 564      -68.9385445
## 565      -37.6885445
## 566      -43.9385445
## 567      -93.9385445
## 568      -43.2242588
## 569      -8.9385445
## 570      -38.9385445
## 571      -35.6052112
## 572      -35.6052112

```

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## 573      -23.4839990
## 574      -40.3671159
## 575      -68.9385445
## 576      -2.2718778
## 577      -56.4385445
## 578      6.0614555
## 579      -35.6052112
## 580      -68.9385445
## 581      -68.9385445
## 582      -8.9385445
## 583      71.0614555
## 584      -68.9385445
## 585      -18.9385445
## 586      -35.6052112
## 587      -35.6052112
## 588      -26.0814016
## 589      31.0614555
## 590      -35.6052112
## 591      -18.9385445
## 592      -2.2718778
## 593      131.0614555
## 594      -2.2718778
## 595      -35.6052112
## 596      -35.6052112
## 597      11.0614555
## 598      -18.9385445
## 599      -35.6052112
## 600      -35.6052112

mutate(atlas2, PCH_CONVS_16_20 = PCH_CONVS_16_20 - 2.6007777) |>
select(PCH_CONVS_16_20)

```

```

##      PCH_CONVS_16_20
## 1      -2.600777700
## 2       0.216123708
## 3     -1.511453081
## 4      15.766569239
## 5     -10.434879082
## 6     -12.060237159
## 7     -6.200777700
## 8     -1.258495821
## 9     -7.863935595
## 10    12.493561923
## 11   -12.757027700
## 12    0.789052808
## 13   -8.850777700
## 14   -2.806963267
## 15    3.992628893
## 16   -9.618321560
## 17   -8.607844838
## 18   -6.215235531
## 19   -1.366209799
## 20   -7.146232245
## 21  -16.181024614
## 22  -10.293085392

```

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## 23      -0.517444367
## 24      -2.600777700
## 25      -2.600777700
## 26      -27.952890376
## 27      -3.206838306
## 28      -8.006183105
## 29      0.986666246
## 30      -4.567990815
## 31      47.399222300
## 32      14.859539760
## 33      -5.417679108
## 34      18.329454858
## 35      6.869690732
## 36      14.065888967
## 37      -3.899478999
## 38      1.464262950
## 39      4.705158373
## 40      -8.661383761
## 41      16.039573177
## 42      -3.642444367
## 43      12.160137061
## 44      -4.315817278
## 45      28.118176548
## 46      -12.383386396
## 47      -2.600777700
## 48      2.449727351
## 49      -2.326052425
## 50      -11.831546931
## 51      -16.731212483
## 52      14.213381592
## 53      -2.600777700
## 54      10.362185263
## 55      9.899222300
## 56      8.864190453
## 57      -7.676919832
## 58      -9.743634843
## 59      16.599222300
## 60      3.095424832
## 61      -10.600777700
## 62      -5.934111033
## 63      8.448946057
## 64      -6.172206271
## 65      -0.036675136
## 66      4.375966486
## 67      -8.850777700
## 68      -8.661383761
## 69      7.788832690
## 70      -1.810263866
## 71      -1.330936430
## 72      -2.600777700
## 73      4.631926703
## 74      -0.846391735
## 75      4.542079443
## 76      4.671949573

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## 77      -3.756847064
## 78      -3.750202987
## 79       4.861908867
## 80       0.677910825
## 81       0.732555633
## 82      -0.594088737
## 83      -2.343377443
## 84      14.348374842
## 85      -9.953718876
## 86     -17.074461911
## 87       6.310113389
## 88      -0.003375103
## 89      -8.347904137
## 90       5.595943611
## 91      -0.441309261
## 92     -12.600777700
## 93       3.447609397
## 94     10.165179747
## 95      4.295774024
## 96      7.121444522
## 97      1.649781584
## 98     -19.673948432
## 99      -6.446931546
## 100     -2.791253890
## 101     3.486178822
## 102     -0.422559878
## 103     7.761916601
## 104     -8.231408331
## 105     -2.916235113
## 106     15.660091865
## 107     8.308313209
## 108     -1.130189465
## 109     -2.015982378
## 110     -3.302532086
## 111     3.247175516
## 112     1.723546624
## 113     8.666827934
## 114     7.846983494
## 115     5.627070401
## 116     5.873798571
## 117     2.571636093
## 118     2.277271080
## 119     16.446841348
## 120     10.979469214
## 121     11.891975923
## 122     6.314884951
## 123     -1.062316162
## 124     9.335561823
## 125     -1.666198261
## 126     -6.838065836
## 127     3.715011774
## 128     22.002396903
## 129     13.085496810
## 130     5.669898992

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```

## 131      -4.295692954
## 132     -14.721989821
## 133     -16.510552136
## 134     -24.634676005
## 135      -7.957920557
## 136      9.163928182
## 137      3.920961430
## 138      -7.957920557
## 139      12.783837685
## 140      20.732555633
## 141     -9.545222144
## 142     -4.328801742
## 143     -7.668345268
## 144     -2.600777700
## 145     -17.184111033
## 146     -22.600777700
## 147     -3.600777700
## 148     -2.600777700
## 149      0.732555633
## 150     -5.775380875
## 151      6.833184564
## 152      4.478868318
## 153      11.891975923
## 154     -16.685284742
## 155     -8.245938990
## 156     -2.600777700
## 157     -14.881479454
## 158      4.140795334
## 159      1.497582956
## 160      8.251935478
## 161      3.281575241
## 162      0.177000078
## 163     -13.711888811
## 164     13.341251286
## 165     -18.600777700
## 166      5.595943611
## 167     -0.328050427
## 168     -0.815063414
## 169      4.375966486
## 170     -7.362682462
## 171      4.671949573
## 172      10.827793729
## 173      1.654541449
## 174      4.065888967
## 175     13.560838462
## 176     14.065888967
## 177     12.264087165
## 178     12.153320661
## 179      8.037520172
## 180     -6.856096849
## 181      6.701547881
## 182      1.794826696
## 183    -18.927308312
## 184     -0.402975502

```

```

## 185 -2.600777700
## 186 -12.600777700
## 187 -5.934111033
## 188 -10.293085392
## 189 -3.501678601
## 190 -24.822999922
## 191 -10.809732924
## 192 -16.663277700
## 193 14.706914608
## 194 -7.146232245
## 195 21.641646542
## 196 -9.022796049
## 197 -4.641594027
## 198 2.268136158
## 199 -33.156333256
## 200 -8.723226680
## 201 -2.600777700
## 202 -8.600777700
## 203 -7.747836524
## 204 5.452913575
## 205 -0.219825319
## 206 7.555472300
## 207 -10.443914955
## 208 -3.882828982
## 209 2.662380195
## 210 -3.590876710
## 211 3.224465018
## 212 5.581040482
## 213 -2.600777700
## 214 6.629991531
## 215 -4.655572221
## 216 -0.003375103
## 217 -11.450335222
## 218 -20.618795718
## 219 -14.600777700
## 220 -5.155522226
## 221 -4.452629552
## 222 -16.554266072
## 223 -5.457920557
## 224 -1.085626185
## 225 -1.424307112
## 226 -5.069913502
## 227 -11.159336259
## 228 0.543876388
## 229 -2.600777700
## 230 -13.127093489
## 231 -16.062316162
## 232 7.014606915
## 233 -12.288277700
## 234 3.325148226
## 235 -17.306660053
## 236 -3.574803674
## 237 8.065888967
## 238 -3.417104231

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```

## 239      4.946392111
## 240      0.369519330
## 241     -2.600777700
## 242     -2.202371325
## 243     -1.312117906
## 244      4.826278003
## 245    -22.600777700
## 246     -4.071365935
## 247     -8.483130641
## 248      1.399222300
## 249    -14.228684677
## 250    -14.881479454
## 251      0.256365157
## 252    -41.062316162
## 253    -19.694794794
## 254     -5.303480403
## 255    -11.051481925
## 256    -10.495514542
## 257     -6.533361970
## 258    -19.267444367
## 259     -1.607400217
## 260      7.076641655
## 261      0.101925003
## 262     -7.269082368
## 263    -11.424307112
## 264     -1.302076401
## 265      1.102926004
## 266     -9.497329424
## 267    -13.315063414
## 268    -12.216162315
## 269     -5.394724149
## 270     -8.795467965
## 271     -2.600777700
## 272    -2.600777700
## 273      3.113508014
## 274    -2.600777700
## 275     -5.658881676
## 276    -13.127093489
## 277      7.655632556
## 278    -10.725777700
## 279     -9.267444367
## 280    -2.600777700
## 281      42.399222300
## 282     -0.713985247
## 283     -0.219825319
## 284      7.925538089
## 285     -4.163277700
## 286      5.091529992
## 287    -21.205428863
## 288      8.210033111
## 289     -11.556001581
## 290    -10.600777700
## 291    -12.249900507
## 292     -9.418959518

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```

## 293 -16.886491986
## 294 -8.414731188
## 295 -2.600777700
## 296 -24.222399322
## 297 -2.600777700
## 298 -13.127093489
## 299 -16.114291214
## 300 -6.948603787
## 301 -11.424307112
## 302 4.946392111
## 303 -2.600777700
## 304 2.553861475
## 305 -2.600777700
## 306 -2.600777700
## 307 6.549549097
## 308 -5.378555478
## 309 15.177000078
## 310 -4.188079287
## 311 4.628137963
## 312 -9.179725068
## 313 -3.907967242
## 314 15.256365157
## 315 -3.899478999
## 316 -9.428086937
## 317 -2.600777700
## 318 2.065888967
## 319 -13.470342917
## 320 2.775566386
## 321 4.806629707
## 322 4.065888967
## 323 -3.352657399
## 324 1.632026533
## 325 7.048345107
## 326 -6.718424759
## 327 22.772356628
## 328 -2.600777700
## 329 -15.934111033
## 330 -5.934111033
## 331 -15.934111033
## 332 -18.816993916
## 333 -15.836071818
## 334 -5.631080730
## 335 5.840780742
## 336 117.278740372
## 337 -3.571651486
## 338 7.655632556
## 339 -12.034739964
## 340 12.846376772
## 341 10.219735121
## 342 -19.267444367
## 343 0.677910825
## 344 89.640601610
## 345 -2.943243453
## 346 66.068750197

```

```

## 347 -8.624874086
## 348 14.570939472
## 349 10.796351487
## 350 17.853767755
## 351 1.149222300
## 352 -11.860036959
## 353 18.827793729
## 354 27.487717875
## 355 10.586035487
## 356 0.970650871
## 357 7.708500651
## 358 1.346590721
## 359 9.770356321
## 360 6.490131391
## 361 -5.430966379
## 362 -9.122516830
## 363 18.248643149
## 364 -11.242753009
## 365 -1.715821948
## 366 17.947167505
## 367 3.146348737
## 368 -1.437987002
## 369 -5.934111033
## 370 -7.926221487
## 371 2.116203432
## 372 -0.670275769
## 373 -2.600777700
## 374 6.621124317
## 375 -0.328050427
## 376 7.121444522
## 377 -6.172206271
## 378 12.467715451
## 379 -2.032595882
## 380 1.624574413
## 381 -11.691686791
## 382 -6.109549630
## 383 -12.278197055
## 384 -16.393881148
## 385 -4.684111033
## 386 -2.600777700
## 387 3.874042444
## 388 6.019911955
## 389 -5.069913502
## 390 -0.473118126
## 391 -9.557299439
## 392 17.399222300
## 393 -19.673948432
## 394 5.891791302
## 395 12.493561923
## 396 -5.395808756
## 397 15.917740819
## 398 -11.775089627
## 399 -4.188079287
## 400 -8.964414064

```

```

## 401    19.884429401
## 402     7.399222300
## 403     4.671949573
## 404     2.399222300
## 405     7.399222300
## 406     2.050385091
## 407    -8.055323155
## 408     1.172807206
## 409   -13.549682809
## 410    -2.095727195
## 411     7.076641655
## 412    -9.545222144
## 413    -5.164880264
## 414    22.700427119
## 415    -2.600777700
## 416    22.303436859
## 417    -6.392246894
## 418    -2.600777700
## 419    10.362185263
## 420     1.944676845
## 421     2.161127062
## 422   -13.315063414
## 423    13.308313209
## 424     5.211722300
## 425     9.087533988
## 426    13.615438516
## 427    21.537153334
## 428    -6.948603787
## 429     8.510333411
## 430     7.925538089
## 431     2.471686068
## 432    -0.028430433
## 433     3.281575241
## 434    -0.457920557
## 435    13.528254558
## 436    -1.904722016
## 437     9.899222300
## 438    -0.181422861
## 439    14.420498896
## 440    -5.010416254
## 441    -4.050053062
## 442   -17.494394721
## 443    -2.600777700
## 444    -8.850777700
## 445     9.899222300
## 446     5.810437253
## 447    10.947609397
## 448     1.522933640
## 449    -5.879466225
## 450   -14.365483582
## 451    -8.315063414
## 452     2.301183084
## 453     0.732555633
## 454     1.565888967

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```

## 455      7.799222300
## 456     -4.408006616
## 457     -0.559961373
## 458     -4.774690743
## 459      1.035585936
## 460      1.965432346
## 461     13.240806458
## 462     15.120741287
## 463     -2.600777700
## 464     -8.949984049
## 465     -1.843201942
## 466     -2.600777700
## 467     -3.325415381
## 468    -15.934111033
## 469     10.075278638
## 470     -0.390832949
## 471     14.380354375
## 472     -4.487570153
## 473      6.539007246
## 474      6.843666744
## 475      7.744049886
## 476     10.664528422
## 477     -0.328050427
## 478     -2.600777700
## 479     -2.600777700
## 480      2.161127062
## 481     -4.295692954
## 482    -15.276834038
## 483     -6.350777700
## 484      6.939858342
## 485     -3.585999375
## 486   -16.822999922
## 487      4.861908867
## 488     -0.748925848
## 489     13.113508014
## 490    -14.365483582
## 491     29.174923235
## 492     17.440544614
## 493     -3.916567174
## 494     28.827793729
## 495      5.595943611
## 496      5.873798571
## 497   -28.407229313
## 498     -2.600777700
## 499     -0.899207019
## 500      7.603303933
## 501     -2.600777700
## 502     -5.321866135
## 503     10.660871046
## 504     -4.684111033
## 505      3.699852363
## 506     11.092168358
## 507     -0.782595882
## 508    25.247323566

```

```

## 509 -4.260528737
## 510 30.732555633
## 511 6.542079443
## 512 2.483968063
## 513 8.904451950
## 514 -1.108240387
## 515 1.089259200
## 516 0.625028752
## 517 -3.866600485
## 518 -4.452629552
## 519 -5.792267062
## 520 5.926354083
## 521 14.065888967
## 522 -2.600777700
## 523 20.148037466
## 524 -6.109549630
## 525 30.732555633
## 526 -4.240121962
## 527 -9.122516830
## 528 10.732555633
## 529 12.399222300
## 530 -13.000777700
## 531 8.570006403
## 532 -7.664068839
## 533 -5.990608208
## 534 2.522561958
## 535 -19.549930242
## 536 -12.012542406
## 537 -4.324915631
## 538 22.954777856
## 539 -6.172206271
## 540 -1.130189465
## 541 -2.600777700
## 542 -7.025556461
## 543 7.399222300
## 544 -4.873504973
## 545 -1.525508883
## 546 -20.378555478
## 547 -4.487570153
## 548 -10.934111033
## 549 14.966789868
## 550 3.136927218
## 551 18.827793729
## 552 -9.743634843
## 553 3.113508014
## 554 4.716295471
## 555 -16.554266072
## 556 13.528254558
## 557 16.003873463
## 558 6.973690385
## 559 -5.826584152
## 560 2.756365157
## 561 -0.725777700
## 562 -1.085626185

```

```

## 563    11.684936586
## 564    -6.304481404
## 565    -8.983756423
## 566    -11.075353971
## 567    164.065888967
## 568    -7.901131057
## 569    -3.952129051
## 570    -0.426864657
## 571    -8.483130641
## 572    -10.895708576
## 573    1.372732234
## 574    11.288111189
## 575    -14.365483582
## 576    -7.502738484
## 577    6.094874474
## 578    -7.306660053
## 579    11.684936586
## 580    1.747048387
## 581    1.944676845
## 582    0.887594393
## 583    -7.926221487
## 584    -0.517444367
## 585    -16.446931546
## 586    -5.232356647
## 587    4.946392111
## 588    3.053984205
## 589    -17.415592515
## 590    4.806629707
## 591    -5.010416254
## 592    3.748428649
## 593    -5.039802090
## 594    -4.728437274
## 595    5.091529992
## 596    -9.873504973
## 597    1.600902972
## 598    -16.886491986
## 599    -12.278197055
## 600    -15.504003506

mutate(atlas2, PCH_SPECS_16_20 = PCH_SPECS_16_20 + 0.6579917) |>
select(PCH_SPECS_16_20)

##      PCH_SPECS_16_20
## 1    8.0653991
## 2   -32.6753416
## 3   -16.8420083
## 4   -24.3420083
## 5   -8.0376605
## 6   -24.3420083
## 7   -15.3420083
## 8   -22.4189314
## 9    25.6579917
## 10  -10.4531194
## 11  125.6579917
## 12  -32.6753416

```

```

## 13      25.6579917
## 14      0.6579917
## 15      0.6579917
## 16      33.9913250
## 17      -13.8347619
## 18      0.6579917
## 19      39.1195302
## 20      0.6579917
## 21      -21.5642305
## 22      25.6579917
## 23      14.9437060
## 24      -34.6361259
## 25      -10.4531194
## 26      -7.0343160
## 27      -9.8683241
## 28      46.8118379
## 29      -15.1314820
## 30      -15.7803645
## 31      8.3502994
## 32      -13.6277226
## 33      13.1579917
## 34      40.6579917
## 35      -0.3585267
## 36      7.3246584
## 37      17.3246584
## 38      -1.6147356
## 39      9.0300847
## 40      -8.4329174
## 41      8.1579917
## 42      6.6103727
## 43      5.9211496
## 44      -7.2715237
## 45      -10.8804698
## 46      3.5151346
## 47      2.5447842
## 48      6.0633971
## 49      -12.2207962
## 50      -29.3420083
## 51      -30.1112391
## 52      -8.7170083
## 53      -5.1391097
## 54      -12.6753416
## 55      -49.3420083
## 56      3.5991682
## 57      2.2973360
## 58      -27.1197861
## 59      -3.1881621
## 60      -16.0086750
## 61      -7.3420083
## 62      5.6579917
## 63      -3.9931711
## 64      -49.3420083
## 65      -25.8125965
## 66      12.0865631

```

```

## 67      -27.1197861
## 68      -27.9134369
## 69      -24.3420083
## 70      -12.1079657
## 71      -9.7897695
## 72      -14.7266237
## 73      -26.7613631
## 74      0.6579917
## 75      -49.3420083
## 76      -13.6277226
## 77      -6.6590815
## 78      4.1062676
## 79      -26.7613631
## 80      -7.6753416
## 81      -4.8975639
## 82      -22.1991512
## 83      -6.5788504
## 84      -10.4531194
## 85      0.6579917
## 86      -19.3420083
## 87      22.8802139
## 88      -8.9164764
## 89      -28.5086750
## 90      33.9913250
## 91      -8.1139381
## 92      -7.0343160
## 93      -10.0562940
## 94      -3.8874628
## 95      -16.0086750
## 96      40.6579917
## 97      -9.4166352
## 98      20.6579917
## 99      8.9913250
## 100     -16.8858679
## 101     -6.4848654
## 102     -8.1257921
## 103     -2.7902842
## 104     4.9590670
## 105     -7.0343160
## 106     -13.6277226
## 107     50.6579917
## 108     3.0970161
## 109     -33.9573929
## 110     14.4510951
## 111     -43.7864527
## 112     15.8095069
## 113     -13.6277226
## 114     33.9913250
## 115     0.6579917
## 116     -12.2452341
## 117     20.6579917
## 118     -15.7056447
## 119     -19.3420083
## 120     50.6579917

```

```

## 121      -21.5642305
## 122       0.6579917
## 123      13.1579917
## 124     -1.2650852
## 125     -17.5238265
## 126      20.6579917
## 127     -14.7266237
## 128     -56.4848654
## 129      50.6579917
## 130     -26.0086750
## 131      33.9913250
## 132     -9.3420083
## 133     -4.6517428
## 134     -7.6753416
## 135      14.9437060
## 136      20.6579917
## 137     -13.6277226
## 138      0.6579917
## 139      72.0865631
## 140      60.6579917
## 141     -13.6277226
## 142     -6.1978003
## 143     -17.1991512
## 144     -7.0343160
## 145     -19.3420083
## 146      0.6579917
## 147      2.8319047
## 148     -16.0086750
## 149      5.9211496
## 150     -16.0086750
## 151      0.6579917
## 152      18.3050505
## 153      22.8802139
## 154     -11.8420083
## 155      6.5403446
## 156      23.7349148
## 157      17.3246584
## 158      26.5839176
## 159      0.6579917
## 160      0.6579917
## 161     -49.3420083
## 162      40.6579917
## 163     -32.6753416
## 164     -19.3420083
## 165      0.6579917
## 166      25.6579917
## 167     125.6579917
## 168     -32.6753416
## 169      17.3246584
## 170      14.4510951
## 171      14.9437060
## 172     -20.4958545
## 173      0.6579917
## 174      17.3246584

```

```

## 175      -16.0086750
## 176      -9.3420083
## 177      -32.6753416
## 178      -35.7056447
## 179      -13.6277226
## 180      -36.8420083
## 181      -10.4531194
## 182      -6.7494157
## 183      33.9913250
## 184      -10.4531194
## 185      50.6579917
## 186      -36.8420083
## 187      -36.8420083
## 188      -19.3420083
## 189      18.8398099
## 190      25.6579917
## 191      7.1096046
## 192      -5.5920083
## 193      -10.4531194
## 194      17.3246584
## 195      25.6579917
## 196      0.6579917
## 197      -49.3420083
## 198      0.6579917
## 199      0.6579917
## 200      20.6579917
## 201      0.6579917
## 202      17.3246584
## 203      75.6579917
## 204      33.9913250
## 205      -34.1246170
## 206      38.1579917
## 207      0.6579917
## 208      -27.9134369
## 209      -39.3420083
## 210      -36.8420083
## 211      17.3246584
## 212      45.1024361
## 213      -17.5238265
## 214      -8.4329174
## 215      -3.9931711
## 216      67.3246584
## 217      33.9913250
## 218      7.1096046
## 219      -7.4501164
## 220      -16.5295083
## 221      -21.5642305
## 222      33.9913250
## 223      0.6579917
## 224      0.6579917
## 225      -24.3420083
## 226      -4.6051662
## 227      3.7829917
## 228      -5.2243612

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```

## 229      17.3246584
## 230     -17.5238265
## 231      -7.6753416
## 232      25.6579917
## 233     -13.3770960
## 234     -20.9106358
## 235      10.6579917
## 236     -8.8658178
## 237      3.5991682
## 238      0.6579917
## 239     -7.6753416
## 240     -12.3854866
## 241     -9.8683241
## 242     -3.1881621
## 243      1.9079917
## 244      7.4761735
## 245     -13.6277226
## 246      10.6579917
## 247     -49.3420083
## 248      0.6579917
## 249     -26.6147356
## 250      0.6579917
## 251     -41.4472715
## 252      40.6579917
## 253      50.6579917
## 254      0.6579917
## 255     -26.6147356
## 256     -16.7333126
## 257      4.7120458
## 258     -24.3420083
## 259     -0.4172771
## 260      33.9913250
## 261     -4.6051662
## 262     -17.8035468
## 263     -11.3420083
## 264     -20.1753416
## 265      0.6579917
## 266     -49.3420083
## 267      20.6579917
## 268      3.8837982
## 269      2.2123958
## 270     -36.1841136
## 271      0.6579917
## 272     -19.3420083
## 273      80.6579917
## 274     -4.8975639
## 275     -5.9457819
## 276     -24.3420083
## 277     -42.1991512
## 278     -17.9466595
## 279     -15.1314820
## 280     -49.3420083
## 281      0.6579917
## 282     -22.0692810

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```

## 283      -18.3896273
## 284      -29.3420083
## 285       0.6579917
## 286       0.6579917
## 287      -39.3420083
## 288      -32.6753416
## 289      -49.3420083
## 290      -19.3420083
## 291      -34.6361259
## 292      -11.5371303
## 293      -19.3420083
## 294      -32.6753416
## 295       -8.4329174
## 296      -32.6753416
## 297       0.6579917
## 298      -11.8420083
## 299      33.9913250
## 300      25.6579917
## 301      -20.7705797
## 302       0.6579917
## 303      -32.6753416
## 304      -4.3420083
## 305      -26.6147356
## 306      -24.3420083
## 307      -10.4531194
## 308      -39.3420083
## 309     150.6579917
## 310       0.6579917
## 311      -11.3420083
## 312      -27.9134369
## 313      -11.1067142
## 314      13.1579917
## 315       0.6579917
## 316      4.2724495
## 317      2.7856513
## 318      4.8246584
## 319      -34.6361259
## 320      -25.0562940
## 321     39.1195302
## 322     16.0426071
## 323      -8.8156925
## 324     11.5013652
## 325      -16.3231404
## 326      -13.4596554
## 327      2.9835731
## 328      -32.6753416
## 329      6.7804407
## 330     20.6579917
## 331     57.8008488
## 332      -16.0086750
## 333      -54.8975639
## 334     18.3050505
## 335      4.1062676
## 336      -2.8975639

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```

## 337      11.7691028
## 338     -10.4531194
## 339      0.6579917
## 340     -20.7705797
## 341     -0.4914336
## 342      50.6579917
## 343      0.6579917
## 344     -7.6622595
## 345     -32.6753416
## 346     -15.1314820
## 347     -11.1067142
## 348     -12.6753416
## 349     -15.4710406
## 350     -9.3420083
## 351     -13.6277226
## 352     -16.0086750
## 353      0.6579917
## 354     -13.6277226
## 355     -9.7586750
## 356      33.9913250
## 357     -40.2510992
## 358      0.6579917
## 359     -3.1076987
## 360     -49.3420083
## 361     -8.8658178
## 362     -32.6753416
## 363     -6.7744407
## 364     -11.8420083
## 365     -22.4189314
## 366     -30.5920083
## 367     -32.6753416
## 368      33.9913250
## 369      6.2135473
## 370      0.6579917
## 371     -24.3420083
## 372     -36.8420083
## 373     -32.6753416
## 374     -17.5238265
## 375      4.5041455
## 376     -26.6147356
## 377      0.6579917
## 378     -16.0086750
## 379      14.4510951
## 380     -27.9134369
## 381      60.6579917
## 382      22.8802139
## 383     -13.6277226
## 384      0.6579917
## 385      0.6579917
## 386     100.6579917
## 387      5.4198965
## 388     -36.8420083
## 389      0.6579917
## 390     17.3246584

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```

## 391      -6.2985300
## 392       8.3502994
## 393      67.3246584
## 394      0.6579917
## 395     167.3246584
## 396     -11.8420083
## 397     -19.3420083
## 398      -6.4848654
## 399      50.6579917
## 400     -19.3420083
## 401     -16.0086750
## 402      16.0426071
## 403      60.6579917
## 404     67.3246584
## 405      3.8837982
## 406      0.6579917
## 407      0.6579917
## 408      0.6579917
## 409     -8.0376605
## 410      4.2294203
## 411     -61.8420083
## 412     27.9307190
## 413     40.6579917
## 414      0.6579917
## 415     -43.7864527
## 416     -14.2356253
## 417      3.7829917
## 418     67.3246584
## 419     33.9913250
## 420     -26.6147356
## 421     33.9913250
## 422      0.6579917
## 423     -3.8874628
## 424     -42.1991512
## 425     -24.3420083
## 426     -19.3420083
## 427      0.6579917
## 428     -14.9670083
## 429      50.6579917
## 430     17.3246584
## 431     -30.7705797
## 432     -10.8003416
## 433      50.6579917
## 434      7.8008488
## 435      0.6579917
## 436     -12.0002361
## 437     40.6579917
## 438     -9.7586750
## 439     13.1579917
## 440     -18.0086750
## 441      0.6579917
## 442     -32.6753416
## 443     -12.8555218
## 444     40.6579917

```

```

## 445      31.9079917
## 446     -30.9209557
## 447     -15.0562940
## 448      50.6579917
## 449      13.1579917
## 450     -21.5642305
## 451      0.6579917
## 452      15.6579917
## 453      11.7691028
## 454     -16.0086750
## 455     -26.3690353
## 456     -16.0086750
## 457     -9.3420083
## 458      0.6579917
## 459     -16.0086750
## 460      4.2724495
## 461     -13.6277226
## 462     -4.2870632
## 463      10.6579917
## 464     -7.6753416
## 465     -9.6868359
## 466      0.6579917
## 467     -16.0086750
## 468     -20.7705797
## 469      33.9913250
## 470     -1.3420083
## 471     -6.0086750
## 472     -11.3420083
## 473      24.4675155
## 474      0.6579917
## 475      50.6579917
## 476      0.6579917
## 477      10.6579917
## 478     -13.6277226
## 479     -27.9134369
## 480     -27.9134369
## 481      11.7691028
## 482     -39.3420083
## 483      0.6579917
## 484     -13.2954967
## 485     -4.6051662
## 486      0.6579917
## 487      0.6579917
## 488      25.6579917
## 489     -27.9134369
## 490     -39.3420083
## 491      33.9913250
## 492     -14.4363479
## 493     -16.0086750
## 494      75.6579917
## 495      19.4079917
## 496     -49.3420083
## 497      50.6579917
## 498      0.6579917

```

```

## 499      -19.0950947
## 500      25.6579917
## 501     -11.8420083
## 502      24.1874035
## 503      19.7056107
## 504     -59.3420083
## 505     -11.2231964
## 506     -17.1991512
## 507     -19.3420083
## 508      300.6579917
## 509     -5.5920083
## 510      5.2034462
## 511      7.3246584
## 512     -24.3420083
## 513     -5.2943893
## 514      50.6579917
## 515      15.7523313
## 516     -20.3946399
## 517      0.6579917
## 518      33.9913250
## 519     -37.8035468
## 520     -16.0086750
## 521      0.6579917
## 522      133.9913250
## 523     -3.3420083
## 524      0.6579917
## 525     -24.3420083
## 526     -32.6753416
## 527      67.3246584
## 528     -16.0086750
## 529      33.9913250
## 530     -37.8035468
## 531     -3.9397094
## 532      40.6579917
## 533     -24.3420083
## 534     -27.9134369
## 535      25.6579917
## 536     -32.6753416
## 537      13.1579917
## 538      20.6579917
## 539      20.6579917
## 540      16.4474654
## 541      12.1334015
## 542      42.5934756
## 543      42.3246584
## 544     -14.7266237
## 545     -16.9890671
## 546      0.6579917
## 547      60.6579917
## 548      4.6579917
## 549      25.6579917
## 550      5.6579917
## 551     -19.3420083
## 552      50.6579917

```

```

## 553      13.1579917
## 554      150.6579917
## 555      0.6579917
## 556     -16.0086750
## 557     -49.3420083
## 558     -35.7056447
## 559      0.6579917
## 560      0.6579917
## 561     -15.4710406
## 562     -20.7705797
## 563      73.3852644
## 564      0.6579917
## 565     -5.2243612
## 566      0.6579917
## 567     -39.3420083
## 568      1.6889195
## 569      5.4198965
## 570     -1.0369236
## 571      0.6579917
## 572     -4.6991512
## 573     -7.9134369
## 574     -9.6868359
## 575     -13.6277226
## 576     -13.6277226
## 577      5.9211496
## 578     -19.3420083
## 579      33.9913250
## 580      50.6579917
## 581      33.9913250
## 582     -32.6753416
## 583     -7.6753416
## 584     167.3246584
## 585     -66.0086750
## 586     -44.7965538
## 587     -7.0343160
## 588     -14.5962456
## 589      6.9079917
## 590     -14.7266237
## 591      0.6579917
## 592     18.8398099
## 593     -16.0086750
## 594      0.6579917
## 595      0.6579917
## 596     22.8802139
## 597     -13.6277226
## 598     -36.1841136
## 599     -24.3420083
## 600      75.6579917

mutate(atlas2, PCH_SNAPS_17_23 = PCH_SNAPS_17_23 - 11.6952787) |>
select(PCH_SNAPS_17_23)

```

```

##      PCH_SNAPS_17_23
## 1      1.811100428
## 2     -12.183083590

```

```

## 3      -16.685766276
## 4      -13.933416660
## 5       1.160959665
## 6       3.536508982
## 7      -14.018458899
## 8      -2.136168059
## 9     -15.085109289
## 10      8.545201723
## 11     -6.389156397
## 12     -3.673888739
## 13     -2.116048391
## 14     -9.499862488
## 15     -1.579192694
## 16     -7.766707237
## 17     -8.975411232
## 18     -5.042155321
## 19     -4.967798765
## 20    -12.372479613
## 21      5.537730638
## 22     -5.572829779
## 23      2.770130579
## 24     -3.318315085
## 25     -0.521303709
## 26    -10.453042682
## 27     -3.728572424
## 28     -5.718472059
## 29     12.090890352
## 30     -7.670510824
## 31      1.923398439
## 32      1.398246233
## 33     -0.991552885
## 34     -6.368947085
## 35     -8.698850449
## 36     -2.102032240
## 37      1.553360407
## 38     -4.050396021
## 39     -1.390072401
## 40     -6.707155283
## 41      3.015605394
## 42      3.685243074
## 43     -0.639971312
## 44     -2.826404150
## 45      3.868923609
## 46     10.563857500
## 47      5.771132891
## 48      0.030307238
## 49     -2.858688887
## 50    -10.151904519
## 51     -1.946534689
## 52      5.388507311
## 53      0.256143038
## 54     -4.054082449
## 55     -6.289873179
## 56    -10.779561992

```

```

## 57      -2.079893644
## 58      -2.850207861
## 59      10.129977648
## 60      12.629044954
## 61      2.083712046
## 62      20.517608110
## 63      12.122147982
## 64      18.034451906
## 65      1.447578852
## 66      38.185389940
## 67      8.693070833
## 68      -14.397981461
## 69      22.111541216
## 70      -3.728572424
## 71      0.878011171
## 72      -1.565408285
## 73      1.722857897
## 74      -4.355829294
## 75      -6.176101740
## 76      11.879851763
## 77      3.526621286
## 78      -11.867692496
## 79      -0.741054114
## 80      -10.164255317
## 81      -11.449578460
## 82      -8.948221977
## 83      -9.686005171
## 84      -4.809051092
## 85      -19.208231981
## 86      -8.510565336
## 87      -4.267600592
## 88      -10.524057325
## 89      -6.449649866
## 90      5.968142931
## 91      -7.360183294
## 92      -18.223468836
## 93      -1.397406157
## 94      -13.366861756
## 95      -6.289873179
## 96      -6.416468199
## 97      -15.390096243
## 98      -0.104981955
## 99      -8.946864422
## 100     -6.046534594
## 101     -1.985852774
## 102     -9.180729445
## 103     2.975380365
## 104     -13.000761684
## 105     0.999735300
## 106     0.216548387
## 107     1.361101572
## 108     -5.753687437
## 109     -7.037907179
## 110     -9.259018000

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```

## 111 -13.487952169
## 112 3.078117792
## 113 -1.985852774
## 114 -9.985241469
## 115 -1.610698279
## 116 -0.163857039
## 117 -3.455903586
## 118 -6.589806135
## 119 -3.160246428
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## 121 15.784966890
## 122 -9.334511812
## 123 3.781866495
## 124 3.487628404
## 125 -13.759609039
## 126 4.621360247
## 127 -0.379489477
## 128 -13.948311623
## 129 0.544906084
## 130 2.014398996
## 131 9.369023744
## 132 -8.873318728
## 133 -14.054191883
## 134 -0.535541113
## 135 1.782982294
## 136 7.952815477
## 137 7.159137194
## 138 2.153229181
## 139 6.389827196
## 140 -13.419416602
## 141 -3.404246863
## 142 -6.253987368
## 143 8.468049471
## 144 1.690548365
## 145 2.916965906
## 146 35.113231127
## 147 9.971793596
## 148 15.277835314
## 149 13.270238344
## 150 -0.784924086
## 151 0.237493936
## 152 -5.758501585
## 153 -0.205448683
## 154 10.996015016
## 155 -5.512898501
## 156 -5.678086813
## 157 -6.126271303
## 158 8.568715517
## 159 0.024760668
## 160 4.893287126
## 161 14.347886507
## 162 -0.311741408
## 163 6.685834352
## 164 -1.052136953

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## 165 -11.062367316
## 166 3.148471300
## 167 3.870231096
## 168 -8.598375614
## 169 -5.611628588
## 170 7.689061586
## 171 2.697245066
## 172 5.653605883
## 173 -0.067371901
## 174 -1.182680662
## 175 -0.872044142
## 176 5.401496355
## 177 9.157802050
## 178 1.152403299
## 179 0.400529329
## 180 25.013583605
## 181 2.441935007
## 182 2.932381098
## 183 -1.067878302
## 184 4.129637186
## 185 -7.969496306
## 186 5.203330461
## 187 0.926080171
## 188 39.272464220
## 189 -5.507653769
## 190 -8.838135775
## 191 8.466664736
## 192 0.499843065
## 193 -11.502600472
## 194 -6.906546171
## 195 -16.120057638
## 196 2.612295572
## 197 10.359101717
## 198 -6.222920473
## 199 -5.028612192
## 200 9.264720384
## 201 1.532234613
## 202 3.994702761
## 203 -11.195854958
## 204 -7.679374273
## 205 -13.945084866
## 206 2.657113497
## 207 -28.838135298
## 208 9.535975878
## 209 -24.666425284
## 210 4.851483766
## 211 -22.464509543
## 212 -6.963996943
## 213 -1.905068930
## 214 -12.706951793
## 215 -1.680551108
## 216 -24.905081328
## 217 -13.363580998
## 218 -7.011437948

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## 219      7.394481127
## 220     -4.244976099
## 221      0.645146791
## 222      0.033862535
## 223      1.201127474
## 224      4.406415407
## 225     -3.474420126
## 226      3.219975893
## 227     -1.108835753
## 228     11.074803774
## 229      7.154561464
## 230     29.288329546
## 231      8.897801821
## 232      5.325997774
## 233    -25.736211355
## 234      0.475013201
## 235     -1.325576361
## 236     -2.754709776
## 237     -0.176953848
## 238     -0.458709295
## 239     -0.566114958
## 240      1.254507486
## 241      2.675091211
## 242     -4.915617521
## 243     -5.946948107
## 244      0.065065805
## 245     -8.961465653
## 246      1.125234072
## 247    -1.186070021
## 248     18.739503328
## 249      0.992034380
## 250     -6.320204790
## 251     -1.836123999
## 252     -6.389156397
## 253     -1.916099127
## 254      4.246750299
## 255      2.733830873
## 256      2.866974298
## 257      7.814197008
## 258     13.304721300
## 259    -10.432734187
## 260      2.487844889
## 261     -9.322739657
## 262    -12.859911140
## 263      1.909737055
## 264      3.783613626
## 265     -5.603634413
## 266     -1.771614607
## 267     -8.805105265
## 268     -5.070181425
## 269    -12.804702933
## 270     13.279443209
## 271      6.853108827
## 272     14.479216997

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```

## 273 -2.242542799
## 274 -4.370683249
## 275 -5.318917807
## 276 15.436503832
## 277 0.105963175
## 278 2.283792917
## 279 -5.621525820
## 280 6.161864702
## 281 10.285607759
## 282 -4.089193876
## 283 3.558958475
## 284 -10.705179687
## 285 4.998401110
## 286 16.979419176
## 287 -0.789548453
## 288 -1.417165335
## 289 2.297019426
## 290 0.454253618
## 291 2.201397364
## 292 0.020618860
## 293 1.154685442
## 294 -6.175381239
## 295 -9.342337425
## 296 5.279511873
## 297 -7.901651915
## 298 -12.923779901
## 299 14.733293001
## 300 -16.791939314
## 301 -0.857840117
## 302 -7.688737448
## 303 32.625434343
## 304 5.200704042
## 305 24.216323320
## 306 -13.449664648
## 307 -5.140657004
## 308 -13.547130521
## 309 0.574659769
## 310 -12.530933316
## 311 -2.039475973
## 312 -2.864729460
## 313 -3.024758871
## 314 -3.043366964
## 315 -2.268576201
## 316 -1.408364828
## 317 -7.295675810
## 318 -4.896761950
## 319 -11.469545062
## 320 -2.243483122
## 321 22.498271410
## 322 -10.654966648
## 323 -4.556635435
## 324 -5.374035414
## 325 1.378228609
## 326 -10.147291120

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```

## 327    10.238849108
## 328     1.108611528
## 329    -1.650493200
## 330    -5.471212443
## 331    -6.891785200
## 332     0.709784929
## 333    44.826461260
## 334   19.159739916
## 335   -0.777662809
## 336   -1.532677229
## 337   -3.242041166
## 338   -0.698361929
## 339   -14.868442829
## 340   -13.138782914
## 341     3.035688822
## 342   18.795127336
## 343   -7.969496306
## 344   -6.062564905
## 345   -2.705645140
## 346  -10.670268472
## 347     0.693224375
## 348     0.751073305
## 349   -0.827058371
## 350   -9.626313265
## 351     3.025885050
## 352   -2.802356299
## 353   -3.587170179
## 354   -9.638078507
## 355   -6.600831087
## 356   -0.994171675
## 357   -0.005528029
## 358   -4.892557676
## 359   -2.374818380
## 360   17.109069292
## 361   -9.627942618
## 362  -10.878475900
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## 365   -11.614698525
## 366  -15.113139685
## 367  -19.726485785
## 368   -5.066707190
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## 371  -13.793180760
## 372   -2.138774450
## 373  -10.658060845
## 374  -12.901215609
## 375   -7.849124964
## 376  -11.381010945
## 377   -3.646989401
## 378   -9.491586025
## 379  -9.198563870
## 380  -9.695278700

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## 381      9.075599138
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## 383      1.789835398
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## 386     -5.471212443
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## 388      0.304721300
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## 390     11.189851229
## 391     -7.024638231
## 392     24.153777544
## 393     14.325725023
## 394     -2.690705832
## 395      8.304721300
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## 399     -2.999626692
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## 401     -3.469809111
## 402     10.183688585
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## 413     -4.950410898
## 414     -4.105145987
## 415     -3.540772017
## 416     -7.593159254
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## 419     -7.799174841
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## 423     -0.494634207
## 424      6.614579622
## 425      3.137257044
## 426      3.373214189
## 427     18.671212618
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## 430     -9.148031290
## 431     -0.143672522
## 432     -8.884249743
## 433     14.386304323
## 434     -6.960538443

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```

## 435 -3.381739195
## 436 1.395002787
## 437 -1.304809149
## 438 -3.623646315
## 439 -10.298630651
## 440 10.863643114
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## 445 4.369201128
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## 452 8.757125322
## 453 0.431349222
## 454 6.630301897
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## 482 -8.282309349
## 483 -13.419416602
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## 485 -7.335417326
## 486 -6.897578295
## 487 -10.847167667
## 488 -18.062991675

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```

## 489      13.690415804
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## 491      2.590435449
## 492     -4.440358217
## 493     -5.749332960
## 494     -4.856568869
## 495     -6.695278700
## 496      7.510018770
## 497     12.595719759
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## 502     -4.123477038
## 503     11.299153749
## 504     -0.676567610
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## 507     26.661918108
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## 512     14.689086382
## 513     17.130536501
## 514     23.546222154
## 515      4.336785738
## 516     18.911002581
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## 518     14.142558519
## 519     23.051707689
## 520      3.629396860
## 521      0.645146791
## 522     67.542010729
## 523     19.273843233
## 524      4.395539705
## 525     40.269786302
## 526    -10.480703767
## 527     32.422366564
## 528     18.900203173
## 529     11.338429872
## 530      8.573478166
## 531      7.698865358
## 532     10.654485170
## 533     13.304721300
## 534     -4.145823534
## 535      5.768569414
## 536      4.575288240
## 537      0.899818842
## 538     25.115451280
## 539     -4.302282389
## 540      4.549132769
## 541     -0.520145949
## 542      8.139050905

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```

## 543 11.050347750
## 544 1.226069872
## 545 -9.626313265
## 546 -1.086582716
## 547 -6.280116137
## 548 -6.164533194
## 549 24.978980486
## 550 1.120685999
## 551 -0.175433691
## 552 11.231549684
## 553 -5.164666231
## 554 -27.522616919
## 555 -3.180427130
## 556 -0.755371626
## 557 -17.025769289
## 558 -0.695278700
## 559 -13.508859451
## 560 -5.433419283
## 561 -8.502871569
## 562 11.562241976
## 563 5.848580782
## 564 -9.277071055
## 565 -3.040152128
## 566 1.512268488
## 567 -9.163633164
## 568 -5.846428927
## 569 -6.536795195
## 570 -2.068159636
## 571 -10.102655109
## 572 -0.163437422
## 573 -0.111354406
## 574 -4.923158224
## 575 -0.067371901
## 576 -3.985267218
## 577 1.818234865
## 578 -8.724981602
## 579 0.761864130
## 580 -14.068160113
## 581 -2.604369696
## 582 6.317143862
## 583 11.018962328
## 584 4.019007151
## 585 3.617221300
## 586 -13.610987480
## 587 4.564198915
## 588 -1.887130316
## 589 -4.349824007
## 590 31.894465868
## 591 -14.455114182
## 592 10.959184114
## 593 18.739503328
## 594 -0.277461584
## 595 20.820060198
## 596 28.169585649

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```

## 597      4.542437975
## 598      1.831692163
## 599     -3.347749289
## 600     -1.401160772
mutate(atlas2, PCH_WICS_16_22 = PCH_WICS_16_22 + 5.6402305) |>
select(PCH_WICS_16_22)

##      PCH_WICS_16_22
## 1     -1.25632122
## 2      1.09477595
## 3     -0.68888342
## 4     -27.69310283
## 5      7.91295777
## 6     -0.60976950
## 7     -1.63249677
## 8     13.64023050
## 9    -12.00682832
## 10   -21.28284642
## 11   10.18568505
## 12   -12.00682832
## 13    8.58140697
## 14   -14.97201440
## 15    9.34393420
## 16   -6.85976950
## 17   -1.13943052
## 18   -11.85976950
## 19   -14.35976950
## 20   -6.35976950
## 21    2.51523050
## 22   -2.05207719
## 23   -2.05207719
## 24   -6.55489145
## 25    36.89023050
## 26   -5.07405521
## 27    0.81264429
## 28   -3.05542167
## 29    8.76523050
## 30   -15.65606580
## 31   18.68370876
## 32   -19.35976950
## 33   -10.50560283
## 34   19.27659414
## 35   -19.17366528
## 36    11.89023050
## 37   -13.00383730
## 38   -18.24036651
## 39   -12.10170498
## 40    10.29139329
## 41    3.21108070
## 42   -0.64907768
## 43   -5.08938323
## 44   -13.18928604
## 45   -10.40915222
## 46   -21.38679653

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## 47      -11.75107385
## 48      -0.60976950
## 49       4.93600515
## 50     -13.59053873
## 51      10.64023050
## 52      -0.74274822
## 53       9.27659414
## 54     -13.92498689
## 55     -22.93119807
## 56      -5.85402237
## 57     -10.35976950
## 58       9.34393420
## 59      -4.61617976
## 60      34.21165907
## 61      5.64023050
## 62      17.40493638
## 63      5.64023050
## 64      5.64023050
## 65     -11.43294023
## 66      -2.69310283
## 67      -8.64548379
## 68     -23.77153421
## 69      12.30689717
## 70      -9.15266891
## 71     -13.08123069
## 72      46.54932141
## 73     -14.90031004
## 74       7.96581190
## 75      5.64023050
## 76     -22.13754728
## 77     -16.80874909
## 78      23.82204868
## 79      20.34611285
## 80       9.21165907
## 81     -16.23476950
## 82       1.93652680
## 83       2.39698726
## 84     -15.41240108
## 85      12.30689717
## 86       0.64023050
## 87      11.89023050
## 88       0.64023050
## 89       8.41800828
## 90      5.64023050
## 91       0.84570995
## 92      12.30689717
## 93       7.04868120
## 94      5.64023050
## 95     -2.25450634
## 96      0.64023050
## 97       7.65635953
## 98      16.75134161
## 99       9.80689717
## 100     11.42535447

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## 101      2.86245272
## 102      6.33953120
## 103     -0.02014686
## 104     -3.36877851
## 105     19.43333395
## 106      9.64023050
## 107     29.16964226
## 108     23.03153485
## 109      9.80689717
## 110     14.26092016
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## 112     -7.40324776
## 113    -11.02643617
## 114     -0.24212244
## 115    -17.88918126
## 116     -3.15097829
## 117      5.64023050
## 118    -23.39202756
## 119      5.64023050
## 120    -25.60976950
## 121    -22.48476950
## 122     20.27437684
## 123     -6.85976950
## 124     -1.35976950
## 125    -16.23476950
## 126     9.21165907
## 127      5.64023050
## 128     -3.45067859
## 129    -14.35976950
## 130     -5.47088061
## 131     -3.45067859
## 132     -1.25632122
## 133      4.27036749
## 134      1.47356383
## 135     11.04563591
## 136    -19.35976950
## 137     -5.47088061
## 138     -6.85976950
## 139     -4.88608529
## 140      5.64023050
## 141    11.70083656
## 142     -2.96543399
## 143      1.53064146
## 144     33.27180945
## 145    -10.14924318
## 146    -19.35976950
## 147     12.78308764
## 148     -3.88357902
## 149     23.14023050
## 150     -1.76717691
## 151      1.93652680
## 152     -6.85976950
## 153     -5.47088061
## 154     -9.98476950

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```

## 155 -23.30713792
## 156 -8.90522405
## 157 -2.35976950
## 158 -1.02643617
## 159 -4.65388715
## 160 2.19195464
## 161 -37.21691236
## 162 -5.47088061
## 163 -27.69310283
## 164 5.64023050
## 165 -6.85976950
## 166 -27.69310283
## 167 -21.02643617
## 168 -8.64548379
## 169 27.86245272
## 170 23.64023050
## 171 -4.35976950
## 172 -17.61558345
## 173 -16.58199172
## 174 12.78308764
## 175 -3.45067859
## 176 -11.02643617
## 177 -25.39425226
## 178 5.64023050
## 179 -10.14924318
## 180 0.64023050
## 181 -7.51766424
## 182 5.64023050
## 183 -15.41240108
## 184 -5.07405521
## 185 -9.74438488
## 186 -4.35976950
## 187 5.64023050
## 188 5.64023050
## 189 10.90338839
## 190 5.64023050
## 191 -3.05542167
## 192 -5.47088061
## 193 -10.14924318
## 194 -15.78834093
## 195 -17.43669258
## 196 -15.04942467
## 197 -1.50262664
## 198 -14.73013987
## 199 -30.07405521
## 200 13.33253819
## 201 28.71715358
## 202 14.73113959
## 203 -1.50262664
## 204 19.27659414
## 205 -32.69310283
## 206 5.64023050
## 207 -17.43669258
## 208 -39.81431495

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## 210 41.35451621
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## 214 -17.43669258
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## 216 16.16654629
## 217 53.64023050
## 218 -1.50262664
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## 222 5.64023050
## 223 -24.79455211
## 224 -16.94041466
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## 272    13.33253819
## 273    13.97356383
## 274    -0.70897585
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## 295     5.64023050
## 296    18.14023050
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## 298     5.64023050
## 299    42.00386686
## 300    15.64023050
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## 303   -19.35976950
## 304    10.76843563
## 305    17.40493638
## 306   -12.54158768
## 307    15.01523050
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## 310   -26.61783402
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## 349 2.78308764
## 350 -11.02643617
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## 353 5.64023050
## 354 -19.64712582
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## 360 14.73113959
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## 365 3.36750323
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## 368 -7.47452360
## 369 -22.93119807
## 370 -11.20187476
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## 374    -13.05135829
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## 376      9.48638435
## 377   -13.27868842
## 378     -5.47088061
## 379      2.32531337
## 380     -5.89823104
## 381     -2.69310283
## 382     -0.24212244
## 383      5.64023050
## 384   -17.88918126
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## 386   -12.54158768
## 387      5.64023050
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## 417     41.03846059
## 418      5.64023050
## 419   -12.87828802
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## 421     -8.64548379
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## 423     -5.07405521
## 424   -10.14924318
```

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## 430     -6.85976950
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## 432     11.38735694
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## 434   -20.11734526
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## 444    -2.05207719
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## 447   -34.10335924
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## 449   -12.00682832
## 450   -25.60976950
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## 453   -18.97515412
## 454     1.09477595
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## 467     -6.85976950
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## 469   -27.69310283
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## 472    -7.26299531
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## 476    -7.12572695
## 477   -13.10976950
## 478    13.33253819
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## 487     -2.69310283
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## 490     14.73113959
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## 506    -16.09889993
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## 514      5.64023050
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## 522      5.64023050
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## 527    -74.35976950
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## 531     14.42401428
## 532     -7.69310283

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## 562 0.37707261
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## 567 -22.93119807
## 568 -11.20759559
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## 578 9.21165907
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## 581 45.64023050
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## 584 -27.69310283
## 585 -17.27643617
## 586 -6.12447538

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## 587 -24.79455211
## 588 -34.79039151
## 589 5.64023050
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## 591 -28.23073724
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## 593 16.75134161
## 594 -6.85976950
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## 598 -2.69310283
## 599 -5.47088061
## 600 -8.64548379

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select(PCH_FFR_16_20)

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## 3    -10.43882164
## 4     1.82006313
## 5     2.37836791
## 6    10.86935890
## 7    10.03602557
## 8     8.04825798
## 9    -2.18619666
## 10    3.24590211
## 11   -1.95227853
## 12    3.71418649
## 13   -2.72439110
## 14    4.13858967
## 15    0.74640808
## 16   11.11129438
## 17    1.32731686
## 18    5.49057102
## 19   -5.91121664
## 20    4.93960683
## 21   16.68224234
## 22    7.65507319
## 23   -4.24968872
## 24   -2.52105206
## 25   -3.71801974
## 26   -1.39808296
## 27   -0.28880042
## 28   -7.26355249
## 29    4.92428044
## 30    8.82677215
## 31  -20.03270296
## 32    0.16547540
## 33    1.99290782
## 34    9.09969598
## 35   -0.87071854
## 36   -1.33963581

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```

## 37 -3.13413760
## 38 2.08148011
## 39 -5.07692209
## 40 -0.64261715
## 41 5.82880082
## 42 5.36935890
## 43 4.31300241
## 44 -2.68327268
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## 46 4.90782044
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## 48 2.96238216
## 49 -8.05551157
## 50 0.79793033
## 51 -1.71260831
## 52 -4.90650317
## 53 1.96042419
## 54 -0.34648809
## 55 1.84393517
## 56 2.46026799
## 57 -4.10698179
## 58 -3.99906215
## 59 -2.46397443
## 60 -7.22352648
## 61 -0.79122504
## 62 -3.87834752
## 63 6.01044242
## 64 -6.63064110
## 65 -8.69960662
## 66 -1.09558575
## 67 10.95177648
## 68 -8.51743355
## 69 6.49435890
## 70 -4.97318254
## 71 6.07838900
## 72 6.96159191
## 73 -6.77878925
## 74 -5.64054209
## 75 1.18185890
## 76 17.28240238
## 77 10.15768007
## 78 7.56688976
## 79 -12.33189538
## 80 3.01402895
## 81 -4.65695689
## 82 -6.09730777
## 83 -2.50389092
## 84 -5.33193980
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## 86 11.79041153
## 87 10.55685890
## 88 1.05181729
## 89 7.19914613
## 90 14.29959146

```

```

## 91      1.66375142
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## 96     -0.08858503
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## 112     -7.90048237
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## 115     3.67863725
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## 158     -4.03583072
## 159     -3.34425612
## 160      7.76935890
## 161    -12.26444392
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## 168      1.36935890
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## 171     -8.01952999
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## 173     -3.82690278
## 174      3.01848171
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## 196     -7.61748321
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```

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```
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## 283 -0.91635539
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```

```
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select(PCH_FSR_16_20)

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## 15      5.259435943
## 16      2.116578800
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## 531  3.739068760
## 532  0.389306073
## 533 -7.501398728
## 534  4.436660349
## 535 -0.188505946
## 536 -5.308078734
## 537 -15.744807339
## 538  18.116578800
## 539 -6.645325962
## 540 -1.883421200
## 541  2.969519976
## 542 -0.883421200
## 543 -6.691113508
## 544 -9.854435693
## 545 -1.883421200
## 546  7.005467689
## 547  1.820282504
## 548 -5.416990105
## 549  4.783245467
## 550  1.591482275
## 551 -11.093947516
## 552 -9.236362376
## 553  0.748157747
## 554 -5.965053853
## 555  2.610960822
## 556  1.688007371
## 557 -0.617598415
## 558 -7.216754533
## 559 -1.883421200
## 560 -1.883421200
## 561 -1.692945010
## 562  7.965063648
## 563  3.116578800
## 564 -14.674118874
## 565  14.116578800
## 566 -0.412832965

```

```

## 567 13.116578800
## 568 0.846815149
## 569 1.781500266
## 570 3.445175603
## 571 1.477923338
## 572 8.079678431
## 573 4.568191703
## 574 -1.883421200
## 575 9.480215164
## 576 1.564854662
## 577 0.406655136
## 578 -8.650338493
## 579 -7.824015259
## 580 -8.860165386
## 581 1.506409308
## 582 -3.368569715
## 583 -0.817323119
## 584 0.616578800
## 585 -7.815624590
## 586 -14.504780423
## 587 -0.014262321
## 588 0.199912133
## 589 -9.621516438
## 590 0.748157747
## 591 -0.308618050
## 592 -1.883421200
## 593 2.226167841
## 594 -1.883421200
## 595 5.456028341
## 596 6.653164166
## 597 0.070976194
## 598 -1.883421200
## 599 -0.031569348
## 600 -6.108773313

mutate(atlas2, PCH_DIRSALES_12_17 = PCH_DIRSALES_12_17 - 106.6679969) |>
select(PCH_DIRSALES_12_17)

##      PCH_DIRSALES_12_17
## 1      -27.655651
## 2      -17.697409
## 3      -70.602423
## 4     -114.452428
## 5     -122.301420
## 6      51.551181
## 7     -93.928032
## 8     -147.631852
## 9     -145.393487
## 10    -31.969202
## 11    -139.360305
## 12     17.112491
## 13    -176.677640
## 14     616.898882
## 15    -151.416855
## 16    -140.630261

```

```

## 17      -157.503863
## 18      -106.460097
## 19       243.783616
## 20       335.251195
## 21      -96.358719
## 22      -55.780423
## 23      -1.667997
## 24     -129.426618
## 25      366.502735
## 26      -52.103682
## 27      725.114949
## 28      211.537692
## 29      -78.608295
## 30      -59.575908
## 31      -50.727121
## 32      377.765965
## 33      93.129983
## 34     1803.824508
## 35     -148.246722
## 36     -108.739971
## 37     -116.544112
## 38     1107.909382
## 39     -131.528332
## 40      23.919526
## 41      395.552616
## 42      13.020062
## 43      -82.466523
## 44      -65.530814
## 45      -80.207631
## 46      479.888767
## 47      227.940382
## 48      853.236538
## 49      67.456517
## 50     -100.207684
## 51     -127.903518
## 52      147.460104
## 53      576.013225
## 54      286.983836
## 55      959.747504
## 56     -53.489893
## 57      758.758884
## 58     -22.878479
## 59     -15.432937
## 60     -86.132283
## 61     -139.525955
## 62     -135.239425
## 63     -66.504062
## 64     142.220892
## 65     146.273180
## 66     -124.471657
## 67      25.636646
## 68     -124.473380
## 69     -59.823199
## 70     -162.255844

```

```

## 71      -43.383938
## 72      -15.850119
## 73      -39.438359
## 74       68.521258
## 75      -97.430883
## 76      421.532374
## 77      321.787288
## 78      -38.304760
## 79     -106.667997
## 80      -79.923811
## 81      171.109781
## 82      -64.706144
## 83      -98.667997
## 84      -33.940724
## 85      182.107513
## 86     -163.334664
## 87       11.959454
## 88      21.238980
## 89     -88.211621
## 90      -97.306295
## 91      -85.216209
## 92      295.529805
## 93     -114.408583
## 94      -16.350802
## 95     -72.022328
## 96     -93.402691
## 97     -61.820179
## 98     -124.667997
## 99      -29.203208
## 100     79.152899
## 101     900.474860
## 102    -113.616965
## 103    -136.793896
## 104    -74.525140
## 105     18.162703
## 106     199.046289
## 107    -63.451916
## 108    1040.501814
## 109    -159.004445
## 110     668.441173
## 111    -126.667997
## 112    -155.820539
## 113     -38.063346
## 114      10.979062
## 115    -106.667997
## 116    -165.491526
## 117    -131.438639
## 118     -3.542997
## 119    -193.830159
## 120    -139.167997
## 121     -5.288687
## 122    -110.221296
## 123    -166.667997
## 124     11.513821

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```

## 125      -107.467997
## 126      -149.320327
## 127       307.915336
## 128      -106.667997
## 129       488.570098
## 130      1493.332003
## 131      -162.223552
## 132        75.285893
## 133        3.504629
## 134      -108.807637
## 135      -100.651737
## 136       -90.970322
## 137      -137.082743
## 138      -30.607148
## 139      -112.700479
## 140      -112.713337
## 141      -34.016640
## 142      162.507630
## 143        -6.031054
## 144        -3.568486
## 145        40.892979
## 146      -126.060182
## 147      -120.678004
## 148      -185.974217
## 149      -73.976704
## 150      -54.174559
## 151      -146.029699
## 152      -99.325002
## 153      -110.029341
## 154      -160.667997
## 155       178.858319
## 156      -156.165484
## 157        27.406077
## 158      -157.901181
## 159      -100.074590
## 160      -111.889516
## 161        30.421205
## 162      -176.796477
## 163        19.400379
## 164      -115.777901
## 165      -85.334664
## 166      -138.526404
## 167        -77.362441
## 168       178.156906
## 169      -122.100096
## 170      -40.448158
## 171      -84.554975
## 172      -37.976408
## 173      -117.554073
## 174        -75.527646
## 175      -118.999230
## 176      -177.828607
## 177      -171.121662
## 178      -59.445775

```

```

## 179      -66.450606
## 180      392.259617
## 181     -100.707732
## 182      -66.641750
## 183      -68.986837
## 184     -159.022046
## 185      42.394503
## 186     -156.841007
## 187     -83.327957
## 188     -188.486179
## 189     -140.868740
## 190     -154.494084
## 191     -160.514151
## 192     -137.917997
## 193     -98.593463
## 194     -33.241423
## 195      66.114878
## 196     -86.242465
## 197      6.189146
## 198     -123.762014
## 199     -22.008906
## 200      115.736375
## 201     -149.525140
## 202      29.382160
## 203     -117.487669
## 204     -137.280242
## 205     -191.213451
## 206     -73.940724
## 207     -34.590075
## 208     -43.334664
## 209      293.332003
## 210      92.647072
## 211     -119.814549
## 212     -132.249392
## 213      123.766786
## 214     -71.885388
## 215     -20.477049
## 216     -49.701705
## 217     -122.161643
## 218     -3.199789
## 219     -101.667997
## 220      62.390827
## 221     -113.800061
## 222      147.389974
## 223     -132.940909
## 224      205.747272
## 225     -7.356465
## 226      30.028009
## 227     -7.384390
## 228     -90.442370
## 229     -53.696229
## 230      73.977164
## 231      26.536407
## 232     -137.615365

```

## 233	-106.667997
## 234	-84.792997
## 235	-37.787130
## 236	-147.726269
## 237	-41.408494
## 238	-114.922714
## 239	-97.769120
## 240	115.190642
## 241	-65.848325
## 242	50.162910
## 243	-98.047307
## 244	86.038663
## 245	-123.155933
## 246	-32.510120
## 247	-59.263153
## 248	-90.953711
## 249	-106.024220
## 250	-71.093529
## 251	124.271813
## 252	-21.511747
## 253	-120.455082
## 254	-59.065865
## 255	-85.806097
## 256	-70.379908
## 257	-86.435824
## 258	-96.788965
## 259	-27.996572
## 260	-27.866154
## 261	545.896106
## 262	90.992822
## 263	-60.405434
## 264	-122.797029
## 265	-128.415209
## 266	-54.730012
## 267	-77.265012
## 268	-2.132723
## 269	-33.131961
## 270	-107.141183
## 271	-155.540177
## 272	-121.353312
## 273	-121.603062
## 274	43.071586
## 275	-151.515970
## 276	-171.875874
## 277	-119.518079
## 278	-36.362320
## 279	-114.451415
## 280	14.288723
## 281	-117.518798
## 282	-101.925851
## 283	-46.092917
## 284	-149.276693
## 285	53.700667
## 286	-61.213451

```

## 287      -149.945308
## 288      -89.640970
## 289      -70.260230
## 290      -32.891089
## 291      -58.591074
## 292      73.678824
## 293      109.836857
## 294      63.676831
## 295      30.639695
## 296      269.522479
## 297      -179.923811
## 298      27.519195
## 299      -78.814116
## 300      -50.535921
## 301      -110.124787
## 302      -33.007283
## 303      190.629300
## 304      -125.119022
## 305      -72.484323
## 306      -15.363649
## 307      -20.001330
## 308      -18.216114
## 309      -97.441567
## 310      -68.169973
## 311      -13.089653
## 312      -63.214554
## 313      -43.959727
## 314      22.587777
## 315      450.996237
## 316      -52.927839
## 317      130.064397
## 318      176.350871
## 319      -39.615974
## 320      -6.874876
## 321      32.452253
## 322      331.445211
## 323      -37.078181
## 324      173.318105
## 325      167.145872
## 326      320.889984
## 327      557.207601
## 328      -1.877299
## 329      -177.442645
## 330      1206.489898
## 331      -100.651284
## 332      654.652758
## 333      -110.841620
## 334      -101.057436
## 335      96.375871
## 336      -106.667997
## 337      -54.901212
## 338      -74.747093
## 339      18.052361
## 340      -68.173829

```

```

## 341      -111.829473
## 342      -9.811415
## 343      -141.195684
## 344      -17.296016
## 345      -66.025019
## 346      -106.667997
## 347      -85.677898
## 348      -38.582142
## 349      -75.233398
## 350      154.990034
## 351      -110.012788
## 352      -28.827088
## 353      -36.257462
## 354      -106.667997
## 355      -40.684390
## 356      -56.776144
## 357      108.800040
## 358      -123.705034
## 359      102.681142
## 360      -129.828431
## 361      100.780633
## 362      -106.229400
## 363      98.253263
## 364      -58.457074
## 365      -67.404193
## 366      189.277949
## 367      -53.655949
## 368      -12.808348
## 369      208.114612
## 370      -129.242624
## 371      -119.882283
## 372      363.005708
## 373      33.434831
## 374      60.700424
## 375      -130.197409
## 376      -141.313666
## 377      -143.432703
## 378      -38.824860
## 379      475.900810
## 380      -174.925258
## 381      149.332003
## 382      -113.119610
## 383      121.903432
## 384      -183.435674
## 385      -84.341794
## 386      -60.488595
## 387      -70.736438
## 388      39.511405
## 389      -65.636056
## 390      -46.725085
## 391      3.766786
## 392      -75.721705
## 393      -49.427792
## 394      -86.126596

```

```
## 395      -88.970402
## 396      -15.415512
## 397      -122.566614
## 398      -97.779108
## 399      -124.504254
## 400      -104.683870
## 401      -23.142651
## 402      -21.387927
## 403      -122.683323
## 404      -106.551311
## 405      146.540559
## 406      -71.467997
## 407      -106.594522
## 408      -46.864075
## 409      -135.971746
## 410      -57.412678
## 411      -55.362313
## 412      11.513821
## 413      -124.103894
## 414      33.058030
## 415      210.255080
## 416      385.764436
## 417      -117.278076
## 418      -101.890669
## 419      -19.380123
## 420      -147.577088
## 421      -137.800072
## 422      -112.608591
## 423      -19.112931
## 424      59.657954
## 425      195.368797
## 426      -67.317472
## 427      -100.530813
## 428      -30.139013
## 429      -173.891647
## 430      -108.902379
## 431      -117.696713
## 432      -146.436844
## 433      835.285388
## 434      -71.332416
## 435      705.930995
## 436      50.854939
## 437      -37.667268
## 438      38.540182
## 439      -123.819451
## 440      53.410230
## 441      -97.611552
## 442      85.833976
## 443      129.111820
## 444      -145.129535
## 445      188.273864
## 446      1186.907422
## 447      -177.256232
## 448      -29.728939
```

```

## 449      -50.227319
## 450      18.211308
## 451     -89.401810
## 452      328.707820
## 453     -40.798578
## 454     -35.422168
## 455      55.559757
## 456     -120.335115
## 457     -106.750984
## 458      -3.164209
## 459     -79.138585
## 460      125.704509
## 461     -84.940024
## 462     -12.223552
## 463     -162.420685
## 464     -88.038002
## 465     -24.344436
## 466     -53.159225
## 467     -130.494084
## 468      -54.716045
## 469     -165.794981
## 470     -108.919182
## 471     -130.775140
## 472     -137.239196
## 473      -27.399704
## 474     -194.909008
## 475      50.212737
## 476     -114.480497
## 477     -89.460790
## 478      173.766786
## 479     -69.189736
## 480     -150.953711
## 481     -160.211304
## 482      63.099445
## 483     -84.727069
## 484      524.828066
## 485     -144.133562
## 486     -63.101820
## 487      785.784833
## 488      -5.001330
## 489     -73.101563
## 490     -132.634848
## 491     -60.326533
## 492      22.257623
## 493      3.858319
## 494     -4.681242
## 495     -95.934815
## 496     -135.071753
## 497     -154.667997
## 498     -122.754953
## 499     -160.077088
## 500     -195.788367
## 501     -138.136528
## 502     -144.167997

```

```

## 503      -39.707644
## 504      153.072263
## 505      -169.539284
## 506      -77.096012
## 507      -102.501330
## 508      -123.994730
## 509      -147.727600
## 510      -30.448485
## 511      24.727352
## 512      -130.001330
## 513      -138.514151
## 514      871.572744
## 515      93.990475
## 516      -111.575972
## 517      -80.505206
## 518      -168.572759
## 519      -26.495583
## 520      587.852551
## 521      -161.530840
## 522      254.870465
## 523      -152.892253
## 524      -68.370125
## 525      22.832003
## 526      -190.758906
## 527      -95.304361
## 528      -152.122542
## 529      -137.917997
## 530      -151.235216
## 531      507.381590
## 532      -142.223552
## 533      -96.141681
## 534      650.825861
## 535      -154.919745
## 536      -99.525140
## 537      -128.334664
## 538      -48.930892
## 539      267.877458
## 540      -141.461594
## 541      19.612627
## 542      -152.504020
## 543      -139.239425
## 544      -69.233902
## 545      -42.736551
## 546      -54.127581
## 547      599.266069
## 548      -50.971794
## 549      288.697082
## 550      -88.951461
## 551      -107.540090
## 552      214.165336
## 553      -73.843569
## 554      -106.667997
## 555      -106.667997
## 556      -106.667997

```

```

## 557      -106.667997
## 558      -106.667997
## 559      -106.667997
## 560      -106.667997
## 561      188.570098
## 562      28.830843
## 563      -108.322843
## 564      92.846566
## 565      -77.714342
## 566      -140.041783
## 567      -147.165509
## 568      -31.791337
## 569      -93.587428
## 570      -12.537907
## 571      67.824983
## 572      40.801639
## 573      -138.329576
## 574      -99.234013
## 575      417.209072
## 576      -17.537562
## 577      -100.288103
## 578      -157.334664
## 579      -92.526583
## 580      -130.521208
## 581      -39.646720
## 582      -78.426239
## 583      -69.512502
## 584      -75.008608
## 585      -115.085847
## 586      -92.194313
## 587      -3.037634
## 588      -29.309506
## 589      -164.617477
## 590      -118.466836
## 591      -36.217246
## 592      -75.759964
## 593      -97.425573
## 594      -21.909054
## 595      -121.161993
## 596      -62.605700
## 597      -76.213451
## 598      -47.952401
## 599      29.010395
## 600      3.476931

cor(atlas2)

##          PCH_LACCESS_POP_15_19 PCH_GROC_16_20 PCH_SUPER_C_16_20
## PCH_LACCESS_POP_15_19      1.00000000 -0.12825303   0.01054011
## PCH_GROC_16_20            -0.12825303   1.00000000 -0.03476868
## PCH_SUPER_C_16_20          0.01054011  -0.03476868   1.00000000
## PCH_CONVS_16_20           -0.04837386  -0.10194873   0.08313836
## PCH_SPECS_16_20           -0.01327074  -0.03113158  -0.03446943
## PCH_SNAPS_17_23           -0.07170763   0.14143289  -0.01624929
## PCH_WICS_16_22            -0.04365784  -0.00269269  -0.03008571

```

```

## PCH_FFR_16_20          -0.17928865    0.14941098    -0.09015193
## PCH_FSR_16_20          0.04399629    0.08591949    -0.11639025
## PCH_DIRSALES_12_17     -0.04141853    0.05904253    0.06667660
##                               PCH_CONVS_16_20 PCH_SPECS_16_20 PCH_SNAPS_17_23
## PCH_LACCESS_POP_15_19   -0.048373860   -0.01327074   -0.071707633
## PCH_GROC_16_20          -0.101948734   -0.03113158   0.141432885
## PCH_SUPERC_16_20         0.083138361   -0.03446943   -0.016249294
## PCH_CONVS_16_20          1.000000000   0.03017534   0.001181517
## PCH_SPECS_16_20          0.030175344   1.000000000  0.078258999
## PCH_SNAPS_17_23          0.001181517   0.07825900   1.000000000
## PCH_WICS_16_22           0.018046555   -0.03976880   -0.031334023
## PCH_FFR_16_20            -0.012903865   0.06940831   0.095304847
## PCH_FSR_16_20            0.095275731   0.06975211   0.090492833
## PCH_DIRSALES_12_17      0.026334746   -0.01929969   -0.036825560
##                               PCH_WICS_16_22 PCH_FFR_16_20 PCH_FSR_16_20
## PCH_LACCESS_POP_15_19   -0.043657843   -0.17928865   0.043996289
## PCH_GROC_16_20           -0.002692690   0.14941098   0.085919490
## PCH_SUPERC_16_20          0.030085712   -0.09015193   -0.116390245
## PCH_CONVS_16_20           0.018046555   -0.01290386   0.095275731
## PCH_SPECS_16_20           0.039768796   0.06940831   0.069752112
## PCH_SNAPS_17_23           0.031334023   0.09530485   0.090492833
## PCH_WICS_16_22            1.000000000   -0.01633849   0.005264114
## PCH_FFR_16_20             -0.016338491   1.000000000  0.063304297
## PCH_FSR_16_20              0.005264114   0.06330430   1.000000000
## PCH_DIRSALES_12_17       -0.029665757   0.06431184   -0.024182203
##                               PCH_DIRSALES_12_17
## PCH_LACCESS_POP_15_19     -0.04141853
## PCH_GROC_16_20            0.05904253
## PCH_SUPERC_16_20           0.06667660
## PCH_CONVS_16_20            0.02633475
## PCH_SPECS_16_20            -0.01929969
## PCH_SNAPS_17_23            -0.03682556
## PCH_WICS_16_22             -0.02966576
## PCH_FFR_16_20              0.06431184
## PCH_FSR_16_20              -0.02418220
## PCH_DIRSALES_12_17        1.000000000

mshapiro.test(t(atlas2[,1:9]))

```

```

##
##  Shapiro-Wilk normality test
##
## data:  Z
## W = 0.12859, p-value < 2.2e-16
atlas2_long <- atlas2 |>
  pivot_longer(cols = c("PCH_GROC_16_20", "PCH_SUPERC_16_20", "PCH_CONVS_16_20", "PCH_SPECS_16_20", "PCH_WICS_16_22"),
               names_to = "sources",
               values_to = "food")
atlas2_long

## # A tibble: 5,400 x 3
##       PCH_LACCESS_POP_15_19 sources      food
##   <dbl> <chr>          <dbl>
## 1      -1.32 PCH_GROC_16_20      0

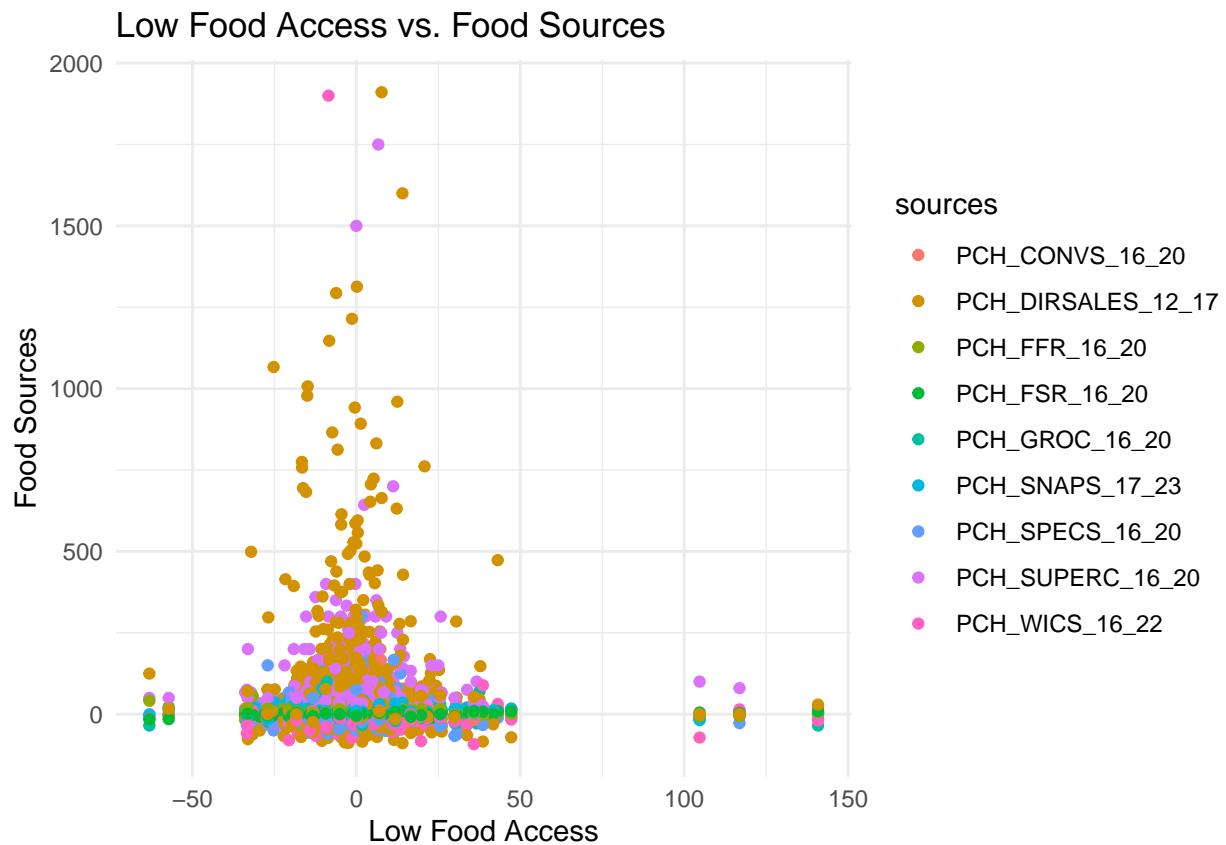
```

```

## 2          -1.32 PCH_SUPERC_16_20    28.6
## 3          -1.32 PCH_CONVS_16_20     0
## 4          -1.32 PCH_SPECS_16_20   7.41
## 5          -1.32 PCH_SNAPS_17_23  13.5
## 6          -1.32 PCH_WICS_16_22  -6.90
## 7          -1.32 PCH_FFR_16_20   10.3
## 8          -1.32 PCH_FSR_16_20   4.24
## 9          -1.32 PCH_DIRSALES_12_17 79.0
## 10         -8.19 PCH_GROC_16_20     0
## # i 5,390 more rows

options(repr.plot.width = NULL, repr.plot.height = NULL)
ggplot(atlas2_long, aes(x = PCH_LACCESS_POP_15_19, y = food, color = sources)) +
  geom_point() +
  labs(title = "Low Food Access vs. Food Sources",
       x = "Low Food Access",
       y = "Food Sources") +
  theme_minimal()

```



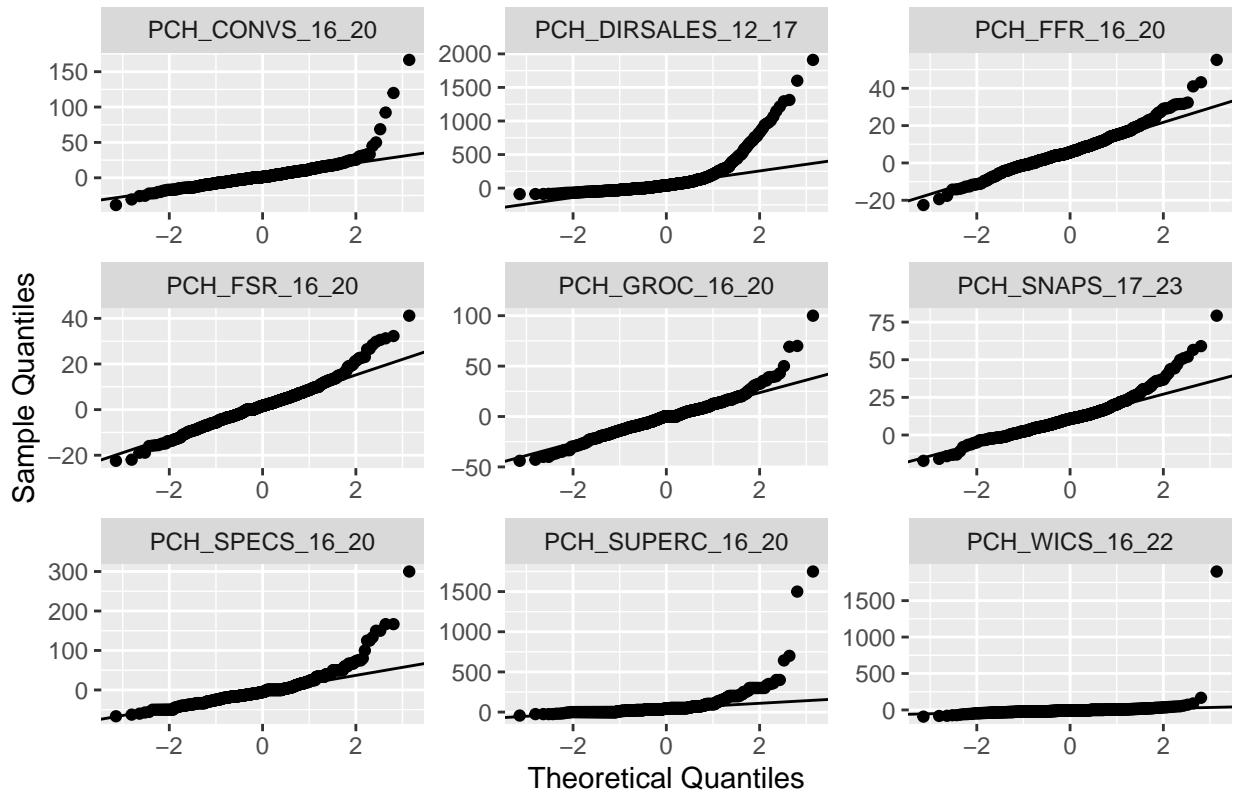
```

options(repr.plot.width = 8, repr.plot.height = 3)

ggplot(atlas2_long, aes(sample = food)) +
  stat_qq() +
  stat_qq_line() +
  facet_wrap(~sources, scales = "free") +
  labs(title = "Q-Q Plots for Food Sources",
       x = "Theoretical Quantiles", y = "Sample Quantiles")

```

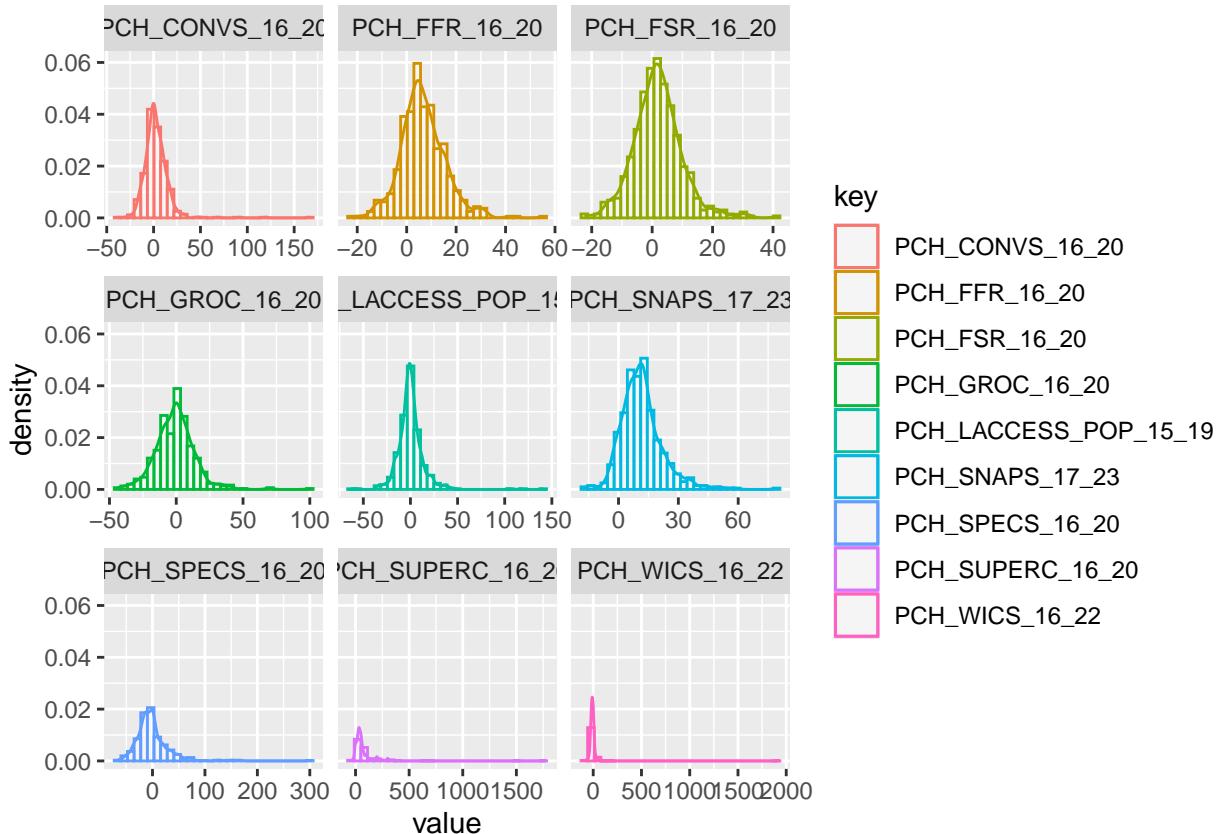
## Q-Q Plots for Food Sources



```
options(repr.plot.width = 8, repr.plot.height = 3)

d <- gather(atlas2[,c(1:9)])
ggplot(d,aes(x = value, color=key)) +
  facet_wrap(~key,scales = "free_x") +
  geom_histogram(aes(y=after_stat(density)), alpha=0.5,
                 position="identity",fill="white")+
  geom_density(alpha=.2)

## `stat_bin()` using `bins = 30`. Pick better value `binwidth`.
```



```

model <- lm(PCH_LACCESS_POP_15_19 ~ ., data = atlas2)
model

##
## Call:
## lm(formula = PCH_LACCESS_POP_15_19 ~ ., data = atlas2)
##
## Coefficients:
##             (Intercept)      PCH_GROC_16_20      PCH_SUPERC_16_20      PCH_CONVS_16_20
##             2.7315104        -0.1089864         0.0007048        -0.0718614
##     PCH_SPECS_16_20      PCH_SNAPS_17_23      PCH_WICS_16_22      PCH_FFR_16_20
##            -0.0032387        -0.0692429        -0.0089636        -0.2667556
##     PCH_FSR_16_20  PCH_DIRSALES_12_17
##            0.1400873        -0.0016520

predict(model, newdata=data.frame(PCH_GROC_16_20=1, PCH_SUPERC_16_20=1, PCH_CONVS_16_20=1, PCH_SPECS_16_20=1))

##
##           1
## 2.341602

summary(model)

##
## Call:
## lm(formula = PCH_LACCESS_POP_15_19 ~ ., data = atlas2)
##
## Residuals:
##    Min     1Q   Median     3Q    Max 
## -110    -50     10     50    110 

```

```

## -57.382 -6.965 -0.849 5.095 134.086
##
## Coefficients:
##                               Estimate Std. Error t value Pr(>|t|)
## (Intercept)           2.7315104  1.0976782  2.488  0.01311 *
## PCH_GROC_16_20      -0.1089864  0.0412257 -2.644  0.00842 **
## PCH_SUPERC_16_20     0.0007048  0.0050674  0.139  0.88944
## PCH_CONVS_16_20      -0.0718614  0.0433000 -1.660  0.09752 .
## PCH_SPECS_16_20      -0.0032387  0.0187694 -0.173  0.86306
## PCH_SNAPS_17_23      -0.0692429  0.0572575 -1.209  0.22702
## PCH_WICS_16_22      -0.0089636  0.0074607 -1.201  0.23006
## PCH_FFR_16_20       -0.2667556  0.0673227 -3.962 8.33e-05 ***
## PCH_FSR_16_20        0.1400873  0.0760650  1.842  0.06602 .
## PCH_DIRSALES_12_17  -0.0016520  0.0026964 -0.613  0.54033
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 14.65 on 590 degrees of freedom
## Multiple R-squared: 0.05645, Adjusted R-squared: 0.04206
## F-statistic: 3.922 on 9 and 590 DF, p-value: 7.339e-05
confint(model)

##          2.5 %    97.5 %
## (Intercept) 0.575678184 4.887342592
## PCH_GROC_16_20 -0.189953410 -0.028019341
## PCH_SUPERC_16_20 -0.009247625 0.010657134
## PCH_CONVS_16_20 -0.156902236 0.013179402
## PCH_SPECS_16_20 -0.040101685 0.033624247
## PCH_SNAPS_17_23 -0.181696180 0.043210305
## PCH_WICS_16_22 -0.023616370 0.005689086
## PCH_FFR_16_20 -0.398976856 -0.134534329
## PCH_FSR_16_20 -0.009303806 0.289478395
## PCH_DIRSALES_12_17 -0.006947646 0.003643666

anova(model)

## Analysis of Variance Table
##
## Response: PCH_LACCESS_POP_15_19
##             Df Sum Sq Mean Sq F value    Pr(>F)
## PCH_GROC_16_20   1  2207   2207.5 10.2855 0.001413 **
## PCH_SUPERC_16_20  1      5      5.0  0.0232 0.879120
## PCH_CONVS_16_20   1   524   523.5  2.4393 0.118862
## PCH_SPECS_16_20   1    31    31.0  0.1443 0.704169
## PCH_SNAPS_17_23   1   362   361.8  1.6859 0.194647
## PCH_WICS_16_22   1   269   268.8  1.2524 0.263550
## PCH_FFR_16_20    1  3358   3358.4 15.6481 8.557e-05 ***
## PCH_FSR_16_20    1   740    739.5  3.4457 0.063915 .
## PCH_DIRSALES_12_17  1    81     80.6  0.3754 0.540330
## Residuals      590 126628   214.6
## ---
## Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
# rerunning the regression after omitting insigificant variables

```

```

atlas3 = select(atlas2, PCH_LACCESS_POP_15_19, PCH_GROC_16_20, PCH_CONVS_16_20, PCH_FFR_16_20, PCH_FSR_16_20)

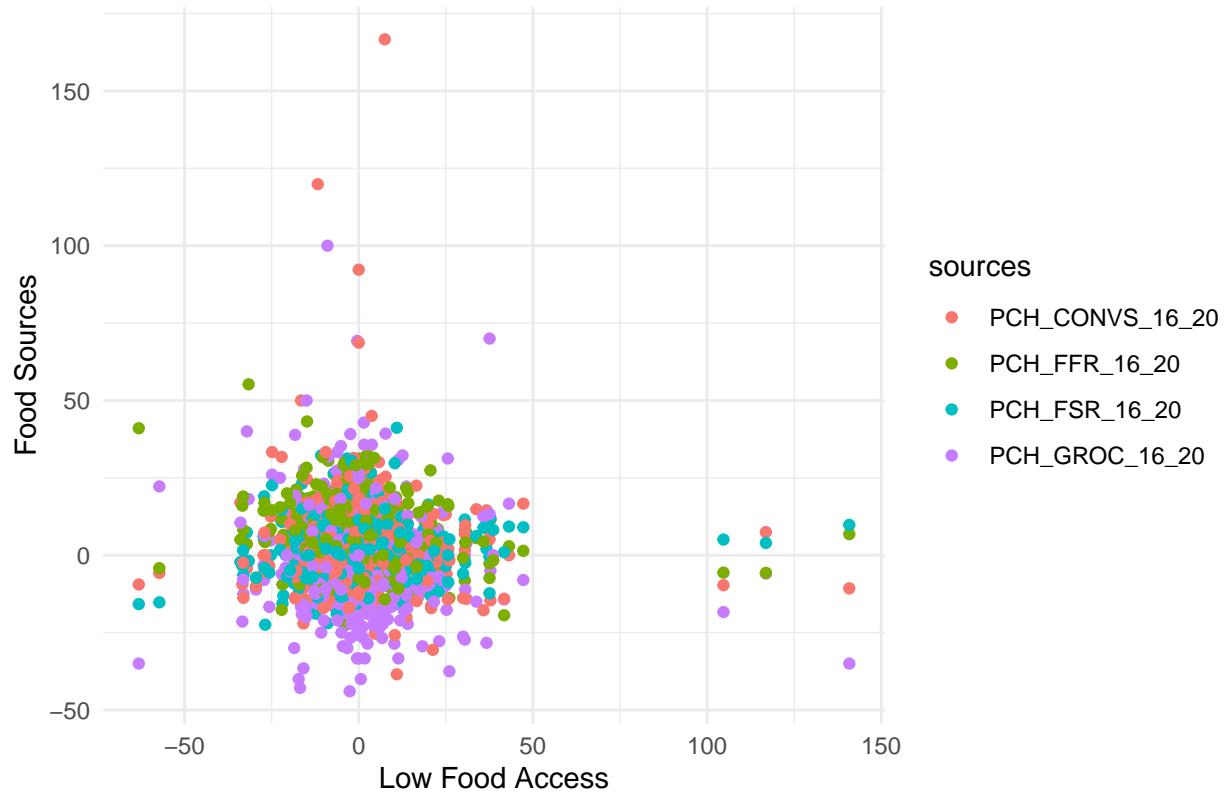
atlas3_long <- atlas3 |>
  pivot_longer(cols = c("PCH_GROC_16_20", "PCH_CONVS_16_20", "PCH_FFR_16_20", "PCH_FSR_16_20"),
               names_to = "sources",
               values_to = "food")
atlas3_long

## # A tibble: 2,400 x 3
##   PCH_LACCESS_POP_15_19 sources      food
##   <dbl> <chr>        <dbl>
## 1 -1.32  PCH_GROC_16_20    0
## 2 -1.32  PCH_CONVS_16_20   0
## 3 -1.32  PCH_FFR_16_20   10.3
## 4 -1.32  PCH_FSR_16_20   4.24
## 5 -8.19   PCH_GROC_16_20    0
## 6 -8.19   PCH_CONVS_16_20  2.82
## 7 -8.19   PCH_FFR_16_20   4.31
## 8 -8.19   PCH_FSR_16_20   2.74
## 9 -0.0797 PCH_GROC_16_20   5.61
## 10 -0.0797 PCH_CONVS_16_20  1.09
## # i 2,390 more rows

options(repr.plot.width = NULL, repr.plot.height = NULL)
ggplot(atlas3_long, aes(x = PCH_LACCESS_POP_15_19, y = food, color = sources)) +
  geom_point() +
  labs(title = "Low Food Access vs. Food Sources",
       x = "Low Food Access",
       y = "Food Sources") +
  theme_minimal()

```

## Low Food Access vs. Food Sources



```
colMeans(atlas3)
```

```
## PCH_LACCESS_POP_15_19          PCH_GROC_16_20          PCH_CONVS_16_20
##      0.2320956                 -0.7079341            2.6007777
## PCH_FFR_16_20                  PCH_FSR_16_20
##      6.6306411                 1.8834212
```

```
cor(atlas3)
```

```
##                                     PCH_LACCESS_POP_15_19 PCH_GROC_16_20 PCH_CONVS_16_20
## PCH_LACCESS_POP_15_19           1.00000000 -0.12825303 -0.04837386
## PCH_GROC_16_20                  -0.12825303  1.00000000 -0.10194873
## PCH_CONVS_16_20                 -0.04837386 -0.10194873  1.00000000
## PCH_FFR_16_20                  -0.17928865  0.14941098 -0.01290386
## PCH_FSR_16_20                  0.04399629  0.08591949  0.09527573
##                                     PCH_FFR_16_20 PCH_FSR_16_20
## PCH_LACCESS_POP_15_19   -0.17928865  0.04399629
## PCH_GROC_16_20              0.14941098  0.08591949
## PCH_CONVS_16_20             -0.01290386  0.09527573
## PCH_FFR_16_20                1.00000000  0.06330430
## PCH_FSR_16_20               0.06330430  1.00000000
```

```
mshapiro.test(t(atlas3[,1:3]))
```

```
##
##  Shapiro-Wilk normality test
##
## data: Z
```

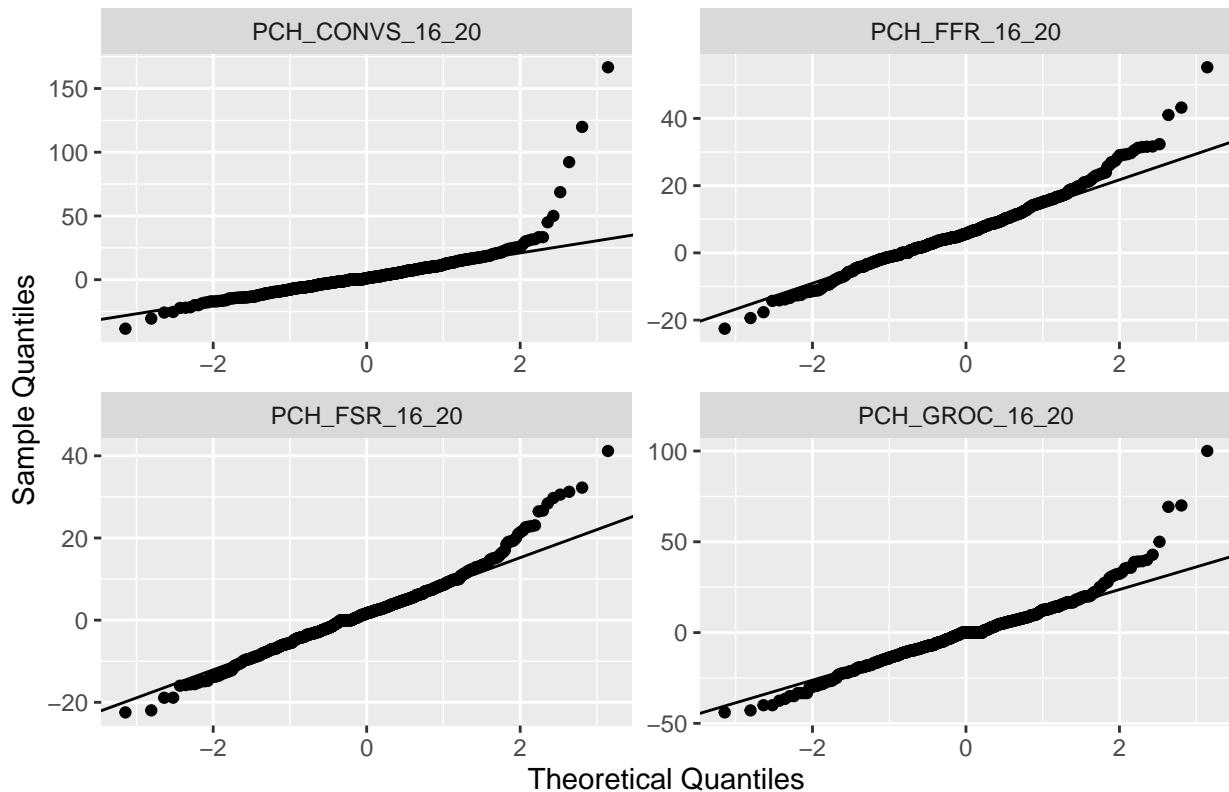
```

## W = 0.74753, p-value < 2.2e-16
options(repr.plot.width = 8, repr.plot.height = 3)

ggplot(atlas3_long, aes(sample = food)) +
  stat_qq() +
  stat_qq_line() +
  facet_wrap(~sources, scales = "free") +
  labs(title = "Q-Q Plots for Food Sources",
       x = "Theoretical Quantiles", y = "Sample Quantiles")

```

## Q-Q Plots for Food Sources



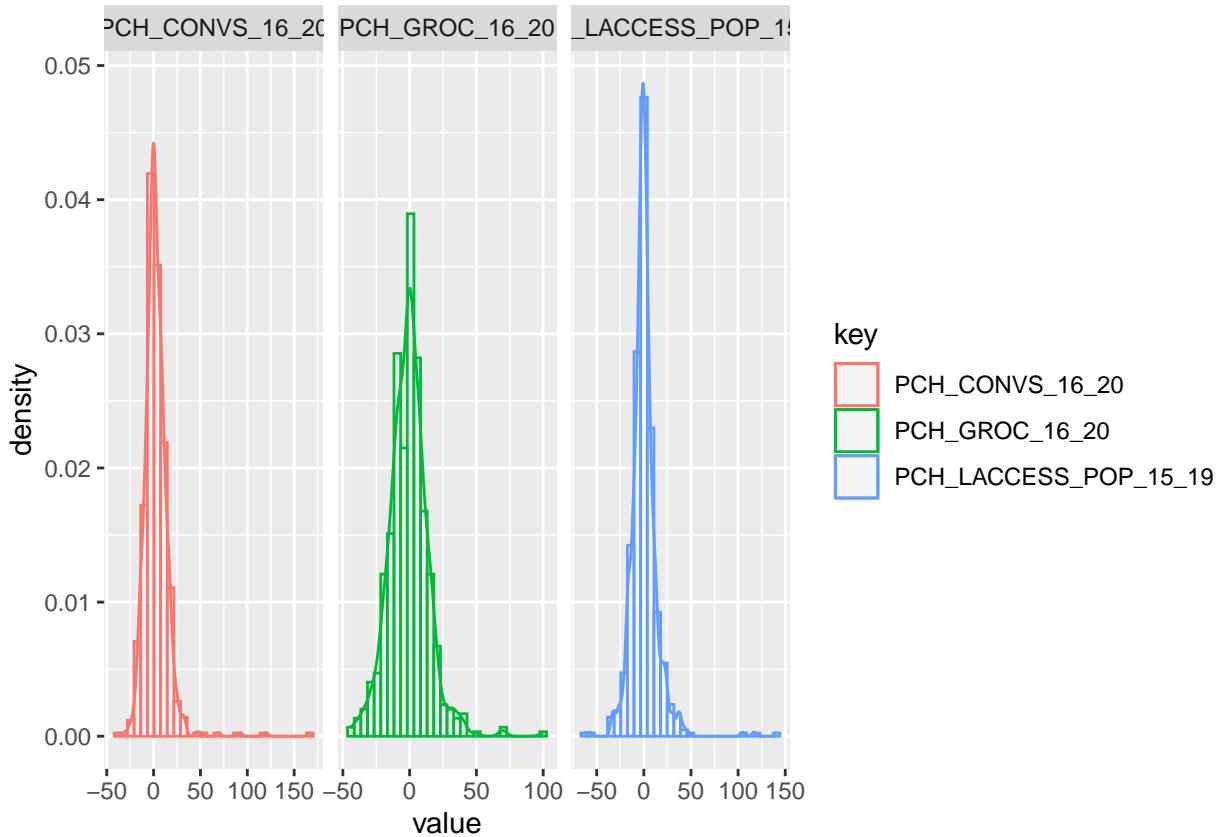
```

options(repr.plot.width = 8, repr.plot.height = 3)

d <- gather(atlas3[,c(1:3)])
ggplot(d,aes(x = value, color=key)) +
  facet_wrap(~key,scales = "free_x") +
  geom_histogram(aes(y=after_stat(density)), alpha=0.5,
                 position="identity",fill="white")+
  geom_density(alpha=.2)

## `stat_bin()` using `bins = 30`. Pick better value `binwidth`.

```



```

model2 <- lm(PCH_LACCESS_POP_15_19 ~ ., data = atlas3)
model2

##
## Call:
## lm(formula = PCH_LACCESS_POP_15_19 ~ ., data = atlas3)
##
## Coefficients:
## (Intercept)    PCH_GROC_16_20    PCH_CONVS_16_20    PCH_FFR_16_20
##           1.91722        -0.11632        -0.07371        -0.27525
##   PCH_FSR_16_20
##           0.13238
#predict(model2, newdata=data.frame(PCH_GROC_16_20=1,PCH_CONVS_16_20=1,PCH_FFR_16_20=1,PCH_FSR_16_20=1))

#summary(model2)
#confint(model2)
#anova(model2)

#per capita variables
atlaspc = select(atlasog, PCH_LACCESS_POP_15_19, PCH_GROCPHTH_16_20, PCH_SUPERCPHTH_16_20, PCH_CONVSPHTH_16_20)
atlaspc = filter(atlaspc, PCH_LACCESS_POP_15_19 != -9999, PCH_GROCPHTH_16_20 != -9999, PCH_SUPERCPHTH_16_20 != -9999)
atlaspc = filter(atlaspc, PCH_LACCESS_POP_15_19 != -8888, PCH_GROCPHTH_16_20 != -8888, PCH_SUPERCPHTH_16_20 != -8888)

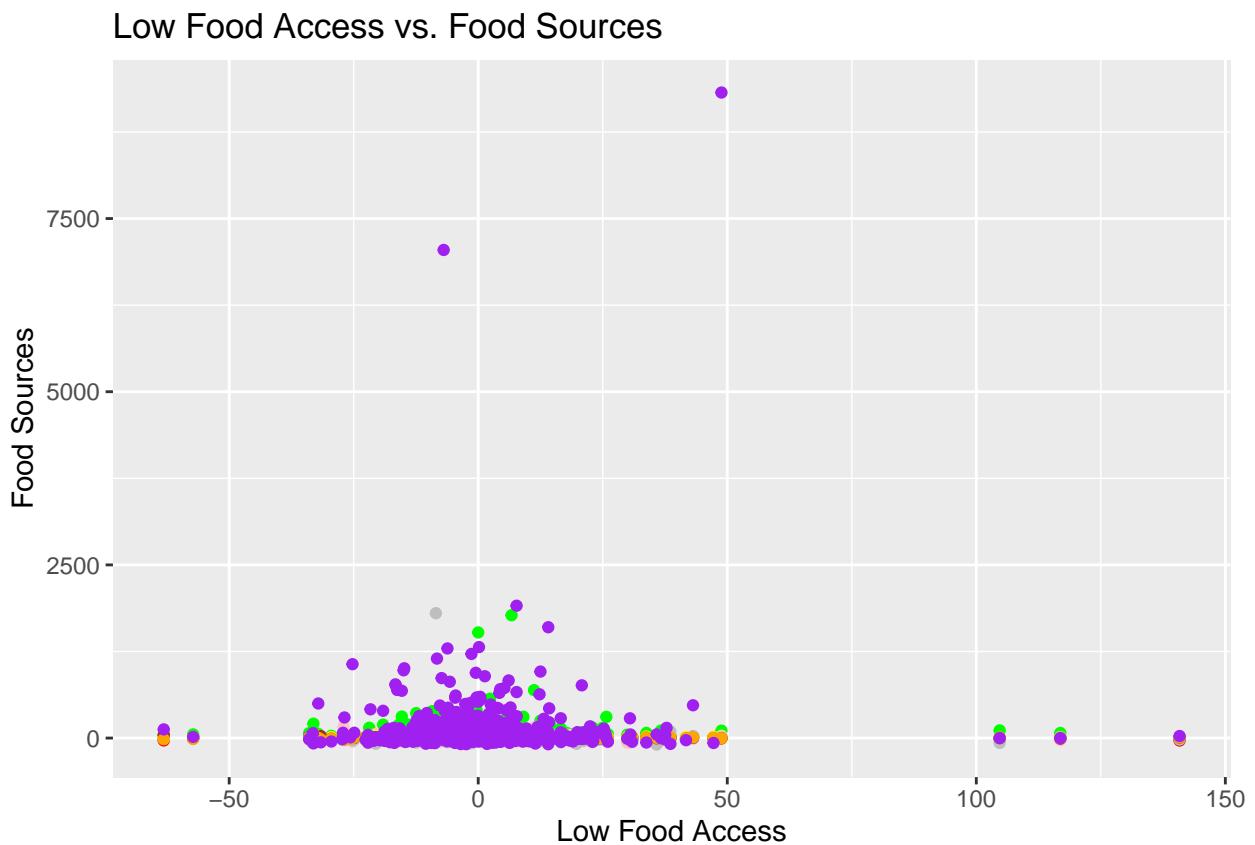
# adjust Jupyter plot size
options(repr.plot.width=4, repr.plot.height=4)
ggplot(atlaspc) +

```

```

geom_point(aes(y = PCH_GROCPTH_16_20, x = PCH_LACCESS_POP_15_19), color="red")+
geom_point(aes(y = PCH_SUPERCPTH_16_20, x = PCH_LACCESS_POP_15_19), color="green")+
geom_point(aes(y = PCH_CONVSPTH_16_20, x = PCH_LACCESS_POP_15_19), color="blue")+
geom_point(aes(y = PCH_SPECSPTH_16_20, x = PCH_LACCESS_POP_15_19), color="pink")+
geom_point(aes(y = PCH_SNAPSPTH_17_23, x = PCH_LACCESS_POP_15_19), color="yellow")+
geom_point(aes(y = PCH_WICSPTH_16_22, x = PCH_LACCESS_POP_15_19), color="gray")+
geom_point(aes(y = PCH_FFRPTH_16_20, x = PCH_LACCESS_POP_15_19), color="brown")+
geom_point(aes(y = PCH_FSRPTH_16_20, x = PCH_LACCESS_POP_15_19), color="orange")+
geom_point(aes(y = PCH_PC_DIRSALES_12_17, x = PCH_LACCESS_POP_15_19), color="purple")+
labs(title = "Low Food Access vs. Food Sources",
x = "Low Food Access",
y = "Food Sources")

```



#There are two points that are clearly outliers at thousands of percents higher than the others, so I am going to remove them.

```

atlaspc2 = filter(atlaspc, PCH_LACCESS_POP_15_19 < 5000, PCH_GROCPTH_16_20 < 5000, PCH_SUPERCPTH_16_20 < 5000)

#normalize predictors
colMeans(atlaspc2)

```

## PCH_LACCESS_POP_15_19	PCH_GROCPTH_16_20	PCH_SUPERCPTH_16_20
## 0.24494421	-3.19971535	64.48811454
## PCH_CONVSPTH_16_20	PCH_SPECSPTH_16_20	PCH_SNAPSPTH_17_23
## 0.01554808	-3.02762626	9.07525966
## PCH_WICSPTH_16_22	PCH_FFRPTH_16_20	PCH_FSRPTH_16_20
## -9.98176367	3.86165602	-0.73829191
## PCH_PC_DIRSALES_12_17		

```

##          107.15593946

mutate(atlaspc2, PCH_GROCPTH_16_20 = PCH_GROCPTH_16_20) |>
select(PCH_GROCPTH_16_20)

##      PCH_GROCPTH_16_20
## 1      -9.3768965
## 2      -2.0876384
## 3       6.4398125
## 4      -0.9071651
## 5      -7.9663482
## 6      2.5330160
## 7      7.7796674
## 8      -7.7037021
## 9     -28.2555126
## 10     24.9284656
## 11     17.7105537
## 12     -19.7476888
## 13     -11.1824702
## 14     -7.2106130
## 15      5.9466123
## 16     -10.0773599
## 17     -1.7981701
## 18     -32.8075213
## 19     -12.8642936
## 20     -14.0985083
## 21     19.0059297
## 22     -18.5220484
## 23     -19.9167767
## 24      9.1433776
## 25     16.6556968
## 26      1.2258812
## 27     -2.5639313
## 28     -5.4797150
## 29      10.5348978
## 30     -3.9844677
## 31     -15.7405819
## 32     -28.7243775
## 33     -0.1576572
## 34     36.1632495
## 35     -2.1649987
## 36      8.5543146
## 37     -22.5591385
## 38      8.6700315
## 39      2.5373632
## 40     -4.4624425
## 41     -3.3604451
## 42      3.6352613
## 43     -2.9852467
## 44     -1.1517980
## 45      9.7132174
## 46     -13.1559296
## 47      0.7121896
## 48      3.1813897
## 49     -2.9641749

```

## 50	-6.9071589
## 51	16.8582269
## 52	-0.4488572
## 53	3.3103831
## 54	-7.2527054
## 55	4.0923659
## 56	-7.8280476
## 57	5.4796502
## 58	-8.5819209
## 59	-4.2601913
## 60	-3.7386242
## 61	-3.2658071
## 62	5.6878227
## 63	-3.8924849
## 64	-22.0236505
## 65	-5.1790142
## 66	-0.6045026
## 67	-22.0239682
## 68	-31.4651157
## 69	-19.5919984
## 70	-11.6263610
## 71	5.0606103
## 72	-20.7097482
## 73	-9.2454596
## 74	-4.8792831
## 75	10.9616612
## 76	-0.3632131
## 77	-3.3174283
## 78	-4.2045003
## 79	-1.3582302
## 80	2.4275044
## 81	-0.7852842
## 82	-1.3500113
## 83	-1.1188930
## 84	12.7728778
## 85	-4.3333447
## 86	3.4285498
## 87	-0.8866161
## 88	8.2348066
## 89	-15.1594969
## 90	0.6148278
## 91	-1.5688683
## 92	-12.0125554
## 93	6.2052389
## 94	0.9904026
## 95	-7.4450040
## 96	1.7470727
## 97	-2.0145420
## 98	-0.1837310
## 99	-3.3138086
## 100	-3.1325993
## 101	2.8564738
## 102	-18.3021779
## 103	11.2589245

```

## 104      6.7018982
## 105     -22.8377009
## 106      13.3016154
## 107     -3.4356506
## 108      1.9619453
## 109     -0.8013946
## 110      2.6854030
## 111      2.0542176
## 112     -3.2208176
## 113     -3.9086231
## 114    -30.7533142
## 115    -14.4015644
## 116    -14.6701989
## 117      8.7735098
## 118      5.3118987
## 119      0.3848501
## 120    -14.4151875
## 121      10.6030328
## 122    -17.1103215
## 123    -10.3507733
## 124    -22.1837368
## 125    -2.1376963
## 126     -4.6106077
## 127     -7.5501452
## 128      0.7250149
## 129    -2.3470336
## 130    -13.2199311
## 131      10.2022351
## 132    -17.8887602
## 133    -14.6916441
## 134     -5.1622556
## 135     -2.0749083
## 136    -10.7988828
## 137     -4.0873322
## 138     -2.7888184
## 139     -2.8374525
## 140      16.5254841
## 141      9.3704443
## 142    -11.5449304
## 143     -1.7728725
## 144      4.7211120
## 145    -26.2167107
## 146     -9.3463126
## 147    -25.2895116
## 148      6.8456729
## 149     -6.9695415
## 150      15.3507544
## 151      2.4675581
## 152     -1.1557629
## 153     -3.5286624
## 154    -17.1252421
## 155    -10.5846473
## 156    -44.5848565
## 157     -5.8681872

```

```

## 158      6.7787830
## 159     -31.8933122
## 160     -20.5525158
## 161     -15.1015479
## 162      -0.4073471
## 163     -31.3418411
## 164     -4.0739460
## 165     -29.5736065
## 166     -2.0837679
## 167     -1.5402912
## 168     -1.9674883
## 169      14.0252645
## 170     -10.6457890
## 171     -15.4244240
## 172      14.5283126
## 173     -0.7900406
## 174      34.0144409
## 175     -12.5305865
## 176      15.4632935
## 177     -8.7782278
## 178     -8.4541173
## 179      15.2118565
## 180     -11.5282429
## 181      2.9831634
## 182      2.5336264
## 183      1.2599940
## 184     -15.0456167
## 185      4.0707705
## 186     -13.1100566
## 187      7.4701007
## 188      14.9064938
## 189     -24.5046078
## 190     -3.5229480
## 191      3.0971708
## 192     -3.8311390
## 193     -9.5008279
## 194     -15.6868004
## 195      7.4372148
## 196     -18.5069903
## 197      4.8614793
## 198      5.1269299
## 199      0.8037897
## 200     -0.1412874
## 201     -7.4908271
## 202     -14.8832557
## 203     -2.9596786
## 204     12.7634178
## 205      9.8687786
## 206     -9.1361154
## 207     -9.1719022
## 208      2.9237508
## 209     -0.9063819
## 210     -8.4744941
## 211      6.5006728

```

```

## 212      -9.7874722
## 213       5.6538374
## 214       8.5461480
## 215      11.2338993
## 216     -13.1853211
## 217      36.8087608
## 218       1.2454669
## 219      26.7819500
## 220       3.1908343
## 221     -0.2041611
## 222       6.2091104
## 223     -13.9196757
## 224     -14.9314621
## 225      18.1019338
## 226       8.1552048
## 227     -14.1248528
## 228     -12.8967547
## 229     -24.1572577
## 230       2.8101289
## 231     -7.7913418
## 232     -5.9492138
## 233       6.0214319
## 234       0.6114309
## 235     -7.4205082
## 236     -8.9665613
## 237     -4.7322822
## 238     -7.8546391
## 239      37.9818445
## 240     -17.4193778
## 241       0.5711993
## 242     -41.5904060
## 243     -0.8425001
## 244     -13.9183403
## 245       3.0649725
## 246       1.6235141
## 247     -10.3022618
## 248       2.5077647
## 249       0.9081088
## 250      25.1654528
## 251     -1.1591735
## 252     -7.3969558
## 253     -14.6420167
## 254     -20.5585268
## 255     -22.9676921
## 256     -0.5835028
## 257       8.7075979
## 258     -16.7525326
## 259     -12.3989266
## 260       8.9349347
## 261     -35.1644935
## 262     -3.0459307
## 263     -9.8291570
## 264       7.0645417
## 265     -16.6006155

```

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## 266      9.9052296
## 267     -2.8746001
## 268     10.2975635
## 269     -1.7004164
## 270     -18.3571358
## 271     -11.0833426
## 272     18.2395366
## 273      7.0447097
## 274     61.0370335
## 275     12.7183658
## 276     13.4725909
## 277      2.2643078
## 278    -12.6124930
## 279     -0.4884965
## 280     74.9941152
## 281      8.6552989
## 282     -3.8958497
## 283    -14.8894579
## 284     -6.5559211
## 285      4.8131019
## 286     -3.6920071
## 287     15.9046088
## 288     -9.9466657
## 289     -8.1831206
## 290     -2.5684470
## 291     20.4558302
## 292     18.1809547
## 293      4.8737510
## 294     17.4198247
## 295    -13.7315611
## 296     -8.4087645
## 297      0.6161133
## 298      9.7673882
## 299     -5.5063069
## 300    -18.8447322
## 301      4.4271629
## 302     18.4851631
## 303     -7.8424657
## 304      6.3319636
## 305     -3.1515906
## 306     11.7577207
## 307    -16.3829899
## 308     13.9596084
## 309      7.2684875
## 310     -8.0119569
## 311      0.1110558
## 312     -3.3422756
## 313     37.6515652
## 314      6.6018646
## 315      9.6809068
## 316     -2.3592611
## 317      2.2040618
## 318    -10.0394227
## 319     -0.4673497

```

```

## 320      -6.3846755
## 321      -6.7545652
## 322      -7.9184957
## 323      -1.8299050
## 324      1.5036076
## 325      1.6379239
## 326      2.2794848
## 327      38.4142085
## 328      -23.0119325
## 329      -13.6860923
## 330      -13.2622904
## 331      -4.6157793
## 332      10.6300999
## 333      -34.3946283
## 334      -19.2547413
## 335      -11.0846056
## 336      -16.7031945
## 337      -13.6968280
## 338      -16.8722103
## 339      0.4386573
## 340      -21.3282728
## 341      7.4873943
## 342      -25.7857389
## 343      -12.2924665
## 344      -21.5854489
## 345      -9.1716086
## 346      -2.6655326
## 347      -7.1939361
## 348      -19.6193148
## 349      -10.7367284
## 350      -38.7007504
## 351      -4.8732060
## 352      1.5918735
## 353      -10.2478038
## 354      -2.8921650
## 355      -3.5393175
## 356      -21.2840991
## 357      -12.5699569
## 358      -16.0941939
## 359      10.7050249
## 360      8.7158931
## 361      -19.1017744
## 362      13.1049186
## 363      -7.6766388
## 364      6.2087232
## 365      7.6135487
## 366      -4.5912113
## 367      -7.0894165
## 368      -6.2792210
## 369      -4.9409753
## 370      8.6856341
## 371      -10.2587214
## 372      8.0507961
## 373      4.5778629

```

```

## 374      -15.7282836
## 375      -1.6318172
## 376       0.8526819
## 377       1.7054954
## 378      -10.3299449
## 379       37.9912628
## 380      -19.0253294
## 381      10.9561284
## 382       0.9072301
## 383      -13.7464332
## 384      14.8683643
## 385       9.0360548
## 386      -7.5446939
## 387      -17.0667935
## 388      -9.5209289
## 389      -21.2498472
## 390      -8.3048222
## 391      -8.5821521
## 392       9.7226291
## 393      -16.5138636
## 394       3.5979422
## 395      -1.5715042
## 396       1.8524772
## 397      -2.1618248
## 398      -11.5962445
## 399      -3.4089125
## 400      -7.2097835
## 401      -5.0111061
## 402      -13.3270310
## 403       5.9908414
## 404      10.0034756
## 405      -8.8283668
## 406      -1.5650772
## 407       5.2572954
## 408      -38.5289712
## 409      17.1050090
## 410      -45.3052836
## 411      -4.8492994
## 412       4.0124288
## 413      -13.4370647
## 414      -16.1603579
## 415      -27.7474701
## 416      10.1964895
## 417      -24.5331912
## 418       0.7983143
## 419       7.7900244
## 420       3.2888603
## 421       2.4599378
## 422       2.7220004
## 423       5.7371100
## 424      -11.1785125
## 425      -10.4504219
## 426      -5.3613585
## 427      5.6931984

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```

## 428      -12.3569652
## 429      10.5481568
## 430      -12.5918635
## 431      -13.7519102
## 432      2.7921082
## 433      13.0582267
## 434      -5.7379949
## 435      -14.1502616
## 436      6.4009620
## 437      5.6497083
## 438      -9.9935369
## 439      -8.3082825
## 440      6.7610798
## 441      -0.5104500
## 442      17.3735339
## 443      -15.1356335
## 444      -10.6634213
## 445      24.5289373
## 446      -10.7318729
## 447      14.0690214
## 448      0.7160629
## 449      -22.8506545
## 450      21.7472638
## 451      1.5449235
## 452      -3.6302907
## 453      14.9989434
## 454      1.0440101
## 455      -1.3936238
## 456      2.8227031
## 457      0.3220471
## 458      -3.8008871
## 459      -10.6698502
## 460      -13.9732237
## 461      -18.7559209
## 462      -2.8160588
## 463      -0.4615727
## 464      3.6308625
## 465      -18.7235680
## 466      6.6171858
## 467      -3.2159935
## 468      13.9973928
## 469      -3.7528369
## 470      -16.9233204
## 471      -9.7691614
## 472      -15.0792725
## 473      3.3876778
## 474      -2.0740880
## 475      -41.1046677
## 476      -17.4463513
## 477      -4.2192719
## 478      -8.2942707
## 479      4.6761054
## 480      -13.4978885
## 481      -27.2817559

```

```

## 482      -33.9352060
## 483      -9.0678709
## 484      -22.6790643
## 485      -14.7930203
## 486      -8.5206923
## 487      -17.0535184
## 488      -21.9921684
## 489      -23.4539181
## 490      -25.3757920
## 491      19.3596094
## 492      -10.6684291
## 493      -8.2221828
## 494      4.8454987
## 495      -5.4498958
## 496      -0.7746730
## 497      -4.8701118
## 498      -8.2536466
## 499      -0.4795884
## 500      -3.2448882
## 501      -5.9349694
## 502      19.1583658
## 503      -19.6565287
## 504      11.7493908
## 505      -15.6530384
## 506      13.2054209
## 507      -1.0348041
## 508      27.1400145
## 509      11.3220094
## 510      -9.9433483
## 511      -9.3325887
## 512      -2.5811704
## 513      26.6061303
## 514      -4.6806321
## 515      9.7167597
## 516      -7.8346774
## 517      -19.3977985
## 518      2.1405025
## 519      -22.6164350
## 520      3.8240032
## 521      -5.3138295
## 522      70.3170439
## 523      -21.9253488
## 524      32.8614635
## 525      -1.9014047
## 526      6.0997417
## 527      -18.2415321
## 528      -3.5592559
## 529      0.5297242
## 530      -23.0210443
## 531      -15.4561984
## 532      -8.2541620
## 533      -5.8898113
## 534      -24.0034357
## 535      0.5018013

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```

## 536      -11.1401188
## 537      -18.2640979
## 538      -9.1478342
## 539      14.5331770
## 540      4.6019527
## 541      -3.6180744
## 542      -11.9084599
## 543      -4.0402170
## 544      3.5664989
## 545      4.4002557
## 546      16.6303931
## 547      9.9573982
## 548      11.0816075
## 549      38.9514367
## 550      0.9040715
## 551      -34.7147115
## 552      7.2898509
## 553      6.4007014
## 554      -6.8382005
## 555      13.0568739
## 556      -25.6278679
## 557      -6.9288053
## 558      9.8922943
## 559      -1.5413530
## 560      -5.9360217
## 561      -22.4042075
## 562      -8.7289333
## 563      -9.7319550
## 564      -9.9606135
## 565      -26.1328068
## 566      -5.7390377
## 567      -7.0424178
## 568      -12.1556645
## 569      22.5934826
## 570      -13.1464650
## 571      1.8170543
## 572      -4.4774890
## 573      -25.6691201
## 574      12.7121404
## 575      -5.9275435
## 576      -7.6686038
## 577      -2.5543621
## 578      -34.7716724
## 579      -27.0362587
## 580      17.4857027
## 581      -0.3399883
## 582      -2.9028650
## 583      1.8710551
## 584      14.5547091
## 585      -8.3119830
## 586      3.2466551
## 587      -14.1110429
## 588      -11.2630678
## 589      -22.0285287

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```

## 590      -1.5544674
## 591     -10.4582660
## 592      29.8566833
## 593     -35.0272558
## 594      0.2598512

mutate(atlaspc2, PCH_SUPERCPTH_16_20 = PCH_SUPERCPTH_16_20) |>
select(PCH_SUPERCPTH_16_20)

##      PCH_SUPERCPTH_16_20
## 1      16.51542505
## 2      30.54981677
## 3      -4.51649887
## 4      32.12377610
## 5      -5.92115393
## 6      -1.92494095
## 7      0.59436029
## 8      18.09955735
## 9      49.00777732
## 10     33.74694950
## 11     -1.90787691
## 12     31.69608572
## 13     64.47690782
## 14     23.66512341
## 15     89.58867061
## 16     -3.16023211
## 17     35.31056016
## 18     -13.20971755
## 19     -6.40979486
## 20     10.95609599
## 21     567.54347430
## 22     92.58425762
## 23     -1.43603143
## 24     30.44394000
## 25     19.98870770
## 26     9.66137132
## 27     346.87119355
## 28     325.34127127
## 29     215.81397807
## 30     95.06712065
## 31     102.22260608
## 32     24.73234801
## 33     95.50281670
## 34     46.63734878
## 35     190.07681339
## 36     305.26945323
## 37     123.40514910
## 38     60.93941465
## 39     177.55145833
## 40     135.16938323
## 41     62.77950999
## 42     49.81288812
## 43     116.28829617
## 44     138.79272719
## 45     43.10420427

```

```

## 46      399.35340109
## 47      1773.46942242
## 48      249.48537418
## 49      221.69197032
## 50      306.74409612
## 51      33.00936575
## 52      35.00772691
## 53      310.31074150
## 54      193.94906123
## 55      49.04134389
## 56      144.83175955
## 57      168.42058976
## 58      194.32160348
## 59      4.44343100
## 60      16.74251508
## 61      37.68500762
## 62      21.48024960
## 63      7.16505482
## 64      192.41127587
## 65      33.04785015
## 66      15.08952519
## 67      28.43111290
## 68      21.36386265
## 69      -11.27392788
## 70      26.89547608
## 71      137.45738479
## 72      36.34056064
## 73      73.62640163
## 74      192.15649991
## 75      43.01723630
## 76      34.43058025
## 77      43.55023377
## 78      -8.55883696
## 79      -6.54989257
## 80      16.90095834
## 81      33.01313076
## 82      23.29279818
## 83      61.29540657
## 84      10.26681794
## 85      14.87177561
## 86      24.11425091
## 87      1.65474660
## 88      25.56928760
## 89      6.46651972
## 90      46.61016980
## 91      60.49947209
## 92      163.96232960
## 93      32.16653106
## 94      35.65037799
## 95      -2.48036666
## 96      26.91032689
## 97      -3.07960166
## 98      73.97526719
## 99      30.16167979

```

```

## 100      5.79843026
## 101     19.99922847
## 102     33.17044726
## 103     44.33589728
## 104     13.07629841
## 105      0.31099242
## 106     28.39021179
## 107     -8.80033964
## 108     46.57028976
## 109     -4.54474777
## 110     55.39118651
## 111     55.29989586
## 112      5.07454305
## 113     92.18277418
## 114     -1.90053188
## 115      0.62183652
## 116     52.04218399
## 117     47.62119654
## 118     20.04894511
## 119     -5.04135705
## 120     -7.56839872
## 121     29.03687816
## 122     49.93280482
## 123    -10.35077596
## 124     50.07423015
## 125     46.79345784
## 126     388.30283162
## 127      77.96343233
## 128    195.87972434
## 129     10.76173637
## 130     -4.54192518
## 131     14.79399536
## 132     24.95188020
## 133     25.71757772
## 134     26.45032929
## 135     29.30649766
## 136    102.50150208
## 137     59.52822595
## 138     39.87607875
## 139     36.36849734
## 140     33.47463726
## 141     56.24347634
## 142     36.56220483
## 143     18.66630358
## 144     26.38754647
## 145     37.72880975
## 146     51.79223335
## 147    108.40294236
## 148      2.88843646
## 149    138.24872399
## 150     22.60137583
## 151     22.96107937
## 152     31.17453554
## 153     45.33344959

```

```

## 154      14.26671375
## 155      30.05869580
## 156      61.62750851
## 157      35.96817774
## 158      18.52445416
## 159      45.94291284
## 160      4.98417295
## 161      13.19792868
## 162      32.79020730
## 163      10.13914360
## 164      116.15337761
## 165      0.60913795
## 166      -6.34099378
## 167      47.68956245
## 168      63.38752729
## 169      10.52093583
## 170      10.99900507
## 171      74.12618383
## 172      27.25368313
## 173      48.81494891
## 174      59.54099902
## 175      -2.43796146
## 176      34.42357737
## 177      33.79192643
## 178      -0.49360233
## 179      97.50602947
## 180      32.70764135
## 181      -2.16599770
## 182      53.80041745
## 183      35.24610022
## 184      52.91788794
## 185      12.83864447
## 186      1.37160701
## 187      33.05822664
## 188      43.63312295
## 189      48.08711642
## 190      53.97566442
## 191      28.29870382
## 192      35.35018235
## 193      32.73211158
## 194      17.79049774
## 195      -29.09144053
## 196      -1.04419562
## 197      19.84169424
## 198      -1.24439985
## 199      -6.16178303
## 200      12.01082503
## 201      0.91909768
## 202      -22.17897665
## 203      51.07414304
## 204      -41.16691063
## 205      -14.54650453
## 206      -17.78982347
## 207      59.34753837

```

```

## 208      37.23167086
## 209      36.90564221
## 210      31.79672662
## 211      49.76658380
## 212      45.46770139
## 213      65.52433519
## 214      100.70797663
## 215      196.62373750
## 216      48.82516937
## 217      187.29841341
## 218      16.56550341
## 219      127.55736673
## 220      124.36187249
## 221      262.31298122
## 222      259.86145410
## 223      46.33654584
## 224      201.60661472
## 225      98.10645860
## 226      31.09721546
## 227      110.37686148
## 228      301.20281283
## 229      308.38399628
## 230      134.00012078
## 231      156.37205163
## 232      51.25692938
## 233      300.52541370
## 234      186.41209274
## 235      124.71889906
## 236      258.82348917
## 237      691.45489071
## 238      147.35741951
## 239      1.98658318
## 240      0.93187706
## 241      50.85679897
## 242      -2.65067661
## 243      38.82049842
## 244      28.61213403
## 245      22.97526222
## 246      52.43527730
## 247      82.71761033
## 248      36.67703528
## 249      26.13513218
## 250      35.22339109
## 251      36.92054798
## 252      30.73370417
## 253      57.44832230
## 254      203.32200106
## 255      32.91848965
## 256      40.52784812
## 257      23.79355767
## 258      18.36749876
## 259      20.13861973
## 260      -0.14297548
## 261      -0.25306965

```

```

## 262      50.19932473
## 263      22.61963259
## 264      92.71617698
## 265      45.94891517
## 266      182.61341916
## 267      45.68809987
## 268      63.73457667
## 269      89.78937360
## 270      199.35716395
## 271      -3.67362392
## 272      97.71200873
## 273      76.30893807
## 274      26.87766027
## 275      45.59454330
## 276      74.47936398
## 277      41.59673675
## 278      16.51667852
## 279      20.62000379
## 280      37.25028404
## 281      -1.22246105
## 282      92.20830818
## 283      41.34429944
## 284      31.14958469
## 285      -2.33324695
## 286      20.79069842
## 287      17.68775298
## 288      23.28729709
## 289      78.63690725
## 290      192.29467530
## 291      100.75971095
## 292      38.73416032
## 293      34.83767691
## 294      43.10541816
## 295      27.80510015
## 296      35.77053356
## 297      0.61610910
## 298      24.52602857
## 299      25.99158026
## 300      46.07949256
## 301      25.76174672
## 302      196.21291456
## 303      299.34931736
## 304      98.94365531
## 305      96.58781845
## 306      46.68200165
## 307      67.81671086
## 308      46.51951137
## 309      103.24555662
## 310      116.19789012
## 311      333.81461179
## 312      350.27527503
## 313      160.19502170
## 314      55.82996125
## 315      33.52457475

```

```
## 316      167.16771260
## 317      73.26515080
## 318      56.73131466
## 319      221.78805030
## 320      111.72810443
## 321      133.80944619
## 322      50.67882080
## 323      25.96371549
## 324      52.25542074
## 325      21.27251990
## 326      41.61774919
## 327      73.01775870
## 328      63.30802744
## 329      41.91611864
## 330      174.76216385
## 331      36.96195639
## 332      55.57357773
## 333      51.39699656
## 334      33.22968966
## 335      78.11715772
## 336      52.71081557
## 337      39.72893477
## 338      259.54109338
## 339      55.22337901
## 340      1524.54802865
## 341      69.19310191
## 342      26.66376523
## 343      85.29956628
## 344      -0.67489438
## 345      76.57040042
## 346      2.20118689
## 347      303.04348278
## 348      299.01793487
## 349      147.70557291
## 350      36.22055392
## 351      64.41669373
## 352      148.57585959
## 353      168.91428956
## 354      52.94484517
## 355      34.33043469
## 356      51.80924372
## 357      100.96478943
## 358      16.98405346
## 359      35.61365558
## 360      6.26733761
## 361      30.18105238
## 362      -0.78515938
## 363      -5.86637347
## 364      7.51994465
## 365      -4.34350782
## 366      57.68952490
## 367      11.49270276
## 368      58.15381246
## 369      33.08262814
```

```

## 370      41.76387386
## 371      21.15072516
## 372      23.48662250
## 373      49.02915326
## 374      25.40434531
## 375      63.94697364
## 376      42.38025200
## 377      27.13187702
## 378      207.44018535
## 379      1.67777412
## 380      56.16544424
## 381      26.19735558
## 382      0.90722726
## 383      -1.98458417
## 384      54.16543422
## 385      113.59343398
## 386      47.92848983
## 387      33.96903469
## 388      60.44954762
## 389      55.64736259
## 390      48.85957683
## 391      0.55963113
## 392      99.93902066
## 393      45.00224960
## 394      82.44466080
## 395      41.57523728
## 396      69.75413837
## 397      95.67636205
## 398      -2.75587093
## 399      25.15613490
## 400      -0.07208118
## 401      74.97954782
## 402      25.44772712
## 403      85.20795449
## 404      129.57247555
## 405      2.56808171
## 406      42.73065375
## 407      18.87882750
## 408      10.70107266
## 409      0.37573067
## 410      18.13832790
## 411      22.85941905
## 412      -3.41702206
## 413      11.40495795
## 414      43.72510492
## 415      44.50505988
## 416      22.44054392
## 417      12.02104808
## 418      -2.80161974
## 419      7.48293313
## 420      -2.78695712
## 421      -3.56711450
## 422      17.82301813
## 423      -5.39311447

```

```

## 424      7.14972543
## 425      31.04817162
## 426      21.98692100
## 427      -1.35302326
## 428      26.08910397
## 429      28.97285010
## 430      195.40714782
## 431      36.90173447
## 432      83.46197506
## 433      70.48463638
## 434      69.56200794
## 435      47.85233584
## 436      67.48298549
## 437      218.83574113
## 438      53.01098464
## 439      61.30951713
## 440      96.02035659
## 441      297.95816805
## 442      54.58953287
## 443      -22.51513849
## 444      64.84724790
## 445      52.83097837
## 446      68.35655501
## 447      244.94473234
## 448      46.63073635
## 449      95.44500207
## 450      100.13250529
## 451      306.17971784
## 452      107.56552588
## 453      30.33213109
## 454      96.69900525
## 455      245.12229200
## 456      359.45126421
## 457      150.80512595
## 458      89.82145155
## 459      47.85680643
## 460      16.13614885
## 461      19.68995660
## 462      87.88893411
## 463      -11.52139737
## 464      30.74047743
## 465      0.78277525
## 466      10.88186987
## 467      27.09010791
## 468      48.13398257
## 469      -23.00227651
## 470      25.66220860
## 471      7.66179232
## 472      202.53010586
## 473      2.04498239
## 474      32.81202490
## 475      57.05421940
## 476      42.88130718
## 477      43.67110037

```

## 478	34.84004673
## 479	20.46059117
## 480	22.13508734
## 481	32.21499412
## 482	-9.91163756
## 483	13.66516607
## 484	-6.11029925
## 485	16.61969997
## 486	28.66744164
## 487	31.33193118
## 488	83.54785411
## 489	33.95564730
## 490	34.32356434
## 491	51.49489374
## 492	15.38661772
## 493	6.15265250
## 494	2.14946486
## 495	41.82516650
## 496	9.14785712
## 497	7.65728263
## 498	22.32847124
## 499	20.66000757
## 500	-7.53319710
## 501	25.42003770
## 502	31.70134361
## 503	17.73736614
## 504	2.30077997
## 505	8.96998687
## 506	-9.43566497
## 507	21.95517308
## 508	48.33002048
## 509	19.65626899
## 510	53.33971298
## 511	36.00110996
## 512	-17.56867809
## 513	23.48775511
## 514	42.97905857
## 515	41.06440699
## 516	22.88709261
## 517	53.14420218
## 518	206.42149946
## 519	30.58475601
## 520	29.78000395
## 521	-28.98537637
## 522	-14.84147662
## 523	50.57253489
## 524	33.69184728
## 525	13.57095539
## 526	30.58429294
## 527	22.63770190
## 528	44.92985495
## 529	34.03961636
## 530	71.45311927
## 531	23.29304581

```

## 532      -0.26114982
## 533      -5.88982066
## 534      -5.00428525
## 535      16.05411737
## 536      16.73208314
## 537      29.41518380
## 538      -5.90311375
## 539      195.49559625
## 540      23.97268676
## 541      28.50923688
## 542      71.02145827
## 543      52.06740824
## 544      22.26032295
## 545      -5.09068176
## 546      52.73028553
## 547      37.44673825
## 548      56.82108657
## 549      50.06755160
## 550      51.35609711
## 551      30.57057375
## 552      25.98430054
## 553      1.33399657
## 554      0.32809089
## 555      37.58502014
## 556      31.28297572
## 557      46.58713233
## 558      -4.76001427
## 559      23.07330240
## 560      17.57997920
## 561      -28.87052615
## 562      19.83008497
## 563      54.50531263
## 564      22.90375948
## 565      26.06667522
## 566      26.50813191
## 567      36.90116789
## 568      19.71927843
## 569      -1.92521091
## 570      56.18398933
## 571      11.36240460
## 572      85.07486654
## 573      32.14378206
## 574      4.66127917
## 575      3.47970795
## 576      56.96337440
## 577      130.98224336
## 578      -2.15751489
## 579      48.53332820
## 580      32.54797955
## 581      32.88001630
## 582      44.38470361
## 583      95.59241482
## 584      30.91966909
## 585      49.32048800

```

```

## 586      64.90786121
## 587      186.29653001
## 588      66.38175189
## 589      31.68515507
## 590      31.26070743
## 591      76.67274188
## 592      48.40763802
## 593      29.94548549
## 594      33.67980396

mutate(atlaspc2, PCH_CONVSPTH_16_20 = PCH_CONVSPTH_16_20) |>
  select(PCH_CONVSPTH_16_20)

```

```

##      PCH_CONVSPTH_16_20
## 1      -9.376894496
## 2       0.670459257
## 3      1.886046076
## 4     17.293556500
## 5    -13.291383385
## 6    -11.202313574
## 7    -3.027049456
## 8      2.586963093
## 9    -5.889824854
## 10     9.953694149
## 11   -11.870355903
## 12     2.120275978
## 13     -7.481746816
## 14    -7.203223807
## 15     1.044520987
## 16    -9.956001401
## 17    -9.912482421
## 18   -16.346710782
## 19     -5.254368141
## 20     -9.217739549
## 21   -22.341811569
## 22   -11.114961915
## 23     0.617385730
## 24     0.341486005
## 25     -0.009410248
## 26   -29.834374757
## 27    -1.297136242
## 28     0.587459917
## 29     2.232390955
## 30    -4.385126066
## 31     51.666947634
## 32     17.208806806
## 33    -5.002161253
## 34    18.219254766
## 35    11.141958662
## 36    18.203599749
## 37    -5.498380221
## 38     4.676046309
## 39     7.218513664
## 40   -11.633324735
## 41     13.354316012

```

## 42	-4.072022060
## 43	11.696497309
## 44	-2.510333362
## 45	24.709538818
## 46	-9.899280828
## 47	1.268613268
## 48	4.896037611
## 49	1.380939357
## 50	-7.700377357
## 51	-14.339079349
## 52	14.696818450
## 53	2.577685309
## 54	10.684536165
## 55	11.781013927
## 56	9.160659307
## 57	-4.451803397
## 58	-8.900448450
## 59	14.121857445
## 60	2.827009147
## 61	-9.521282230
## 62	-11.926814444
## 63	5.005734245
## 64	-6.010655254
## 65	0.548992516
## 66	0.733753040
## 67	-9.696877089
## 68	-8.793223767
## 69	-2.055633661
## 70	2.093190067
## 71	-2.203246770
## 72	-10.151053911
## 73	3.657555283
## 74	0.578465669
## 75	10.838366122
## 76	-3.203635832
## 77	-2.012098045
## 78	6.939661759
## 79	-13.421230029
## 80	-20.015132142
## 81	1.406053115
## 82	-1.614837969
## 83	-8.784663140
## 84	-0.579100357
## 85	-4.651176633
## 86	-16.222883959
## 87	-2.977095527
## 88	2.981380481
## 89	-0.417098698
## 90	7.242625515
## 91	3.580038492
## 92	-27.034808203
## 93	-9.226291607
## 94	-5.635881305
## 95	-6.889947289

```

## 96      -1.626083324
## 97      -1.264031397
## 98      -7.202968845
## 99      -10.796125454
## 100      7.244125311
## 101      -0.182464516
## 102      -5.409823710
## 103      -3.213347842
## 104      -6.431010276
## 105      6.177133745
## 106      4.177273767
## 107      1.475683205
## 108      7.922395841
## 109      3.309166485
## 110      6.458905234
## 111      -2.000413126
## 112      2.853453573
## 113      14.394508231
## 114      11.421619203
## 115      0.804122750
## 116      3.498597620
## 117      -0.071807831
## 118      7.502717658
## 119      -4.153889513
## 120      -11.484992378
## 121      2.889935434
## 122      24.547355918
## 123      3.711848751
## 124      8.324253699
## 125      -3.796387535
## 126      -14.177077529
## 127      -11.299979005
## 128      -23.104695013
## 129      -14.827192492
## 130      6.688441192
## 131      -2.175552161
## 132      -15.529972280
## 133      3.613395258
## 134      16.966550507
## 135      -6.412424803
## 136      0.486281535
## 137      -3.626532863
## 138      -0.088509040
## 139      -12.638936566
## 140      -23.728776651
## 141      0.542684528
## 142      2.421657567
## 143      3.756960763
## 144      -2.099807793
## 145      13.041573403
## 146      8.359050338
## 147      19.303138853
## 148      -11.602901968
## 149      -3.657484454

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```

## 150      2.167819175
## 151     -10.116174007
## 152      6.680202723
## 153      5.902812440
## 154      7.180404097
## 155      3.281899670
## 156     -0.329699496
## 157     -9.354553441
## 158     14.516384937
## 159    -18.271967175
## 160     -0.609246174
## 161     -5.278580009
## 162      1.371107133
## 163      0.991372516
## 164     -4.987525899
## 165      7.926168910
## 166     11.064991194
## 167      2.649487263
## 168      4.568019129
## 169     15.544616221
## 170     13.311497986
## 171     14.291320835
## 172     16.823060093
## 173      9.764219144
## 174     -8.348791362
## 175      6.637575610
## 176      0.237362301
## 177    -16.038739175
## 178      1.693346386
## 179     -1.246984241
## 180    -10.422351790
## 181     -5.427129126
## 182     -5.353583271
## 183     -4.265956170
## 184    -20.709239496
## 185     -9.371198628
## 186    -12.883776772
## 187     17.065649817
## 188     -8.597099783
## 189     22.658007479
## 190    -8.308073413
## 191     -5.739731133
## 192      4.912364084
## 193    -30.868695465
## 194    -11.536929188
## 195     -5.455255318
## 196     -6.981546375
## 197     -0.535799103
## 198      6.709064534
## 199      4.078496296
## 200      7.963558823
## 201     -6.996128140
## 202     -3.970860349
## 203      6.016938962

```

```

## 204      1.938515242
## 205      8.517647170
## 206      3.759216955
## 207     -4.391476617
## 208     12.424404205
## 209     -4.219634405
## 210      1.415014371
## 211     -8.991403065
## 212     -20.495136365
## 213     -14.316810925
## 214     -2.209805523
## 215     -2.956437781
## 216     -14.627423454
## 217     -6.970037899
## 218     -5.334690753
## 219     -1.328070646
## 220     -6.219104855
## 221     -9.644306226
## 222      3.104967204
## 223     -2.442297857
## 224     -10.047144774
## 225     -14.280852825
## 226      7.777041509
## 227     -5.001696760
## 228      6.244447610
## 229     -12.918120969
## 230     -2.433298792
## 231      9.122461930
## 232      0.014786046
## 233      7.688432868
## 234      2.087486615
## 235     -1.685489221
## 236     -1.749157836
## 237      0.206759533
## 238      6.291520873
## 239     -18.410735571
## 240     -0.552420741
## 241     -5.344760302
## 242      1.243281585
## 243     -12.372443360
## 244     -11.357552974
## 245      1.191063367
## 246     -37.462450436
## 247     -17.372453739
## 248     -0.262718551
## 249     -7.619336269
## 250     -9.419739361
## 251     -6.045694796
## 252     -18.291433902
## 253      0.707837888
## 254     10.891910859
## 255      2.383163885
## 256     -4.812504107
## 257     -12.211762885

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```

## 258      2.775490283
## 259      3.823492135
## 260      -7.029673827
## 261      -10.940234523
## 262      -9.495271592
## 263      -1.665199979
## 264      -9.610989424
## 265      -2.700723888
## 266      -5.795518352
## 267      2.675426267
## 268      -3.247750348
## 269      -5.521002764
## 270      -10.718039388
## 271      6.206012267
## 272      -9.176040618
## 273      -5.968569867
## 274      -4.841760983
## 275      40.741396381
## 276      -3.033768245
## 277      -3.354605696
## 278      7.317996475
## 279      -5.011748862
## 280      10.855996518
## 281      -19.599675006
## 282      6.493787918
## 283      -14.208932813
## 284      -9.506783888
## 285      -11.757230163
## 286      -8.549090267
## 287      -15.937318943
## 288      -7.104449529
## 289      -3.810886758
## 290      -23.634728308
## 291      0.379853906
## 292      -17.246290116
## 293      -22.255748980
## 294      -8.744374491
## 295      -12.603866453
## 296      4.298117991
## 297      0.616109107
## 298      1.846030714
## 299      -5.506312182
## 300      -2.613670953
## 301      2.952021079
## 302      -4.005080232
## 303      17.586186632
## 304      -2.107079857
## 305      5.399492305
## 306      -8.645421185
## 307      -3.386573614
## 308      15.122461335
## 309      0.302997114
## 310      -7.028904409
## 311      0.111062625

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## 312      4.730692149
## 313     -7.234818022
## 314      4.495952481
## 315      7.561466870
## 316      6.867082599
## 317     -0.442826053
## 318      5.020643440
## 319     10.261793197
## 320     -7.722775437
## 321     25.628966557
## 322      0.452552773
## 323     -13.814299806
## 324     -1.879847633
## 325     -15.917718307
## 326     -20.898190174
## 327     -9.928984429
## 328     -4.984424137
## 329      9.925759365
## 330     126.554654040
## 331      1.724165110
## 332     14.353224955
## 333     -8.590491994
## 334     15.357406653
## 335     13.035883009
## 336    -15.160662884
## 337      8.232664674
## 338      97.481921630
## 339      0.094686857
## 340     71.257354658
## 341     -4.599548331
## 342     18.731285982
## 343     14.613303439
## 344     19.641600432
## 345      1.773213585
## 346     -7.261884372
## 347     22.352488576
## 348     29.769110833
## 349     12.148018453
## 350      5.814170470
## 351      8.820115495
## 352      3.355234006
## 353     13.318260297
## 354     11.232611894
## 355     -2.103534880
## 356     -5.394234861
## 357     21.432402436
## 358    -14.500541861
## 359     -2.275871794
## 360      9.802646452
## 361      3.247044861
## 362      0.368500515
## 363     -9.004162618
## 364     -8.385371771
## 365      0.168591246

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## 366      -1.086937103
## 367      -7.089411358
## 368      2.363612737
## 369      -2.780547502
## 370      3.697652740
## 371      -6.540873066
## 372      6.570643507
## 373      -6.833886818
## 374      4.562500444
## 375      -10.574375376
## 376      -8.410360860
## 377      -8.136967067
## 378      -11.655123830
## 379      -0.440506229
## 380      4.110290832
## 381      4.508757411
## 382      9.606138633
## 383      -4.404716652
## 384      4.963696439
## 385      -4.952941230
## 386      10.946367374
## 387      -20.645520754
## 388      4.445508277
## 389      11.963305508
## 390      -3.534060316
## 391      19.181789382
## 392      -9.202008434
## 393      -4.866254953
## 394      -8.012172029
## 395      23.863363662
## 396      12.037737253
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## 398      2.106340037
## 399      10.137393416
## 400      4.575734623
## 401      -5.465595247
## 402      4.145271851
## 403      -10.038333218
## 404      0.945222087
## 405      12.494031987
## 406      -11.454130564
## 407      -3.474458090
## 408      21.371059532
## 409      0.375725433
## 410      21.897188976
## 411      -5.439007822
## 412      -3.417022064
## 413      9.066824402
## 414      0.172043692
## 415      0.924176228
## 416      -12.542469049
## 417      3.874069991
## 418      4.791997051
## 419      8.041285202

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```

## 420      12.977324552
## 421      19.709785822
## 422      -7.790676933
## 423      5.118762815
## 424      3.625062155
## 425      0.976732998
## 426      1.062380693
## 427      4.449746991
## 428      -0.929988183
## 429      12.331193580
## 430      1.987424440
## 431      15.510843316
## 432      1.177235934
## 433      19.701968147
## 434      -2.661084034
## 435      -2.860303656
## 436      -14.476771899
## 437      -1.896695558
## 438      -4.368134601
## 439      8.883915791
## 440      6.254024910
## 441      12.968774614
## 442      7.309577261
## 443      -0.074171776
## 444      -12.727925965
## 445      -3.934821324
## 446      5.965583721
## 447      1.840822609
## 448      1.826901317
## 449      7.885643789
## 450      -1.742175914
## 451      3.617277997
## 452      1.526612427
## 453      1.303613312
## 454      2.840352978
## 455      14.227179934
## 456      17.581095264
## 457      0.322040955
## 458      -4.278074687
## 459      -0.682049752
## 460      -3.219880122
## 461      -4.941900290
## 462      -18.581456268
## 463      -0.305804555
## 464      -2.814706904
## 465      17.896826093
## 466      -7.947122936
## 467      -3.972852731
## 468      3.170071937
## 469      6.203758219
## 470      10.702421013
## 471      -5.621153681
## 472      0.843368352
## 473      -10.710641014

```

```

## 474      -0.616853387
## 475      -7.364632469
## 476      -16.820268006
## 477      -7.811046301
## 478      8.316746128
## 479      -4.580966047
## 480      -17.684829572
## 481      6.561333442
## 482      -8.243333214
## 483      5.221462553
## 484      -17.156141953
## 485      19.526101552
## 486      20.130959801
## 487      -2.797093624
## 488      20.617162326
## 489      -3.376257917
## 490      -2.862051202
## 491      -25.067044373
## 492      -7.690706707
## 493      -3.286805659
## 494      2.338980445
## 495      -5.449895509
## 496      -3.474676311
## 497      -0.235480929
## 498      -20.146687661
## 499      4.510056960
## 500      -0.128176078
## 501      -4.224694779
## 502      12.251772544
## 503      -2.498338557
## 504      18.214232972
## 505      4.066336285
## 506      -4.830694404
## 507      8.789129165
## 508      -13.974917352
## 509      0.438942994
## 510      5.524103693
## 511      -10.480281379
## 512      -19.095191826
## 513      -7.019272713
## 514      3.447381636
## 515      9.716759673
## 516      -7.834682461
## 517      8.832073127
## 518      -1.443375297
## 519      16.075342862
## 520      2.121965876
## 521      -11.489016118
## 522      -3.487000465
## 523      15.438943641
## 524      -14.437221470
## 525      5.966296460
## 526      -7.020685766
## 527      -5.215606919

```

```

## 528      -2.492728986
## 529      -16.509218110
## 530      -11.247795033
## 531      -3.066157233
## 532       7.338002933
## 533      -9.250895490
## 534      -3.607292117
## 535      -3.840869787
## 536     -13.225709318
## 537      -5.095529477
## 538      -8.041681681
## 539      -0.442342484
## 540     -23.550178427
## 541      -5.436594616
## 542     -10.417328085
## 543       7.269169368
## 544      1.573415141
## 545      15.247029882
## 546     -14.907413174
## 547      1.710593690
## 548      12.197198181
## 549     -13.914741883
## 550      17.178923721
## 551      16.147084281
## 552      10.437292535
## 553     -1.934830955
## 554      5.702819750
## 555      1.937990331
## 556     -4.805628303
## 557      11.685438227
## 558     -8.287426620
## 559     -12.215191525
## 560     -13.907540591
## 561      152.904795909
## 562     -9.732886272
## 563     -4.739133267
## 564     -3.403400232
## 565     -11.011763893
## 566     -12.989218294
## 567     -2.140598065
## 568      6.047630717
## 569     -13.463424782
## 570     -10.883257661
## 571      7.596522219
## 572      0.780263705
## 573      13.266094656
## 574      9.211766872
## 575      8.183325883
## 576      1.524280951
## 577     -8.882754694
## 578     -0.119127648
## 579     -14.688545387
## 580     -3.205103864
## 581      7.181516546

```

```

## 582      6.784522896
## 583     -16.692113670
## 584      5.463061989
## 585     -2.851731663
## 586      5.226924127
## 587     -6.895440815
## 588     -2.294975535
## 589      6.361079765
## 590     -8.714152185
## 591      2.275532586
## 592     -15.195635521
## 593     -11.972410764
## 594     -12.676897710

mutate(atlaspc2, PCH_SPECSPTH_16_20 = PCH_SPECSPTH_16_20) |>
select(PCH_SPECSPTH_16_20)

```

```

##      PCH_SPECSPTH_16_20
## 1     -2.66407436
## 2     -34.72509161
## 3     -16.84978920
## 4     -25.68037166
## 5     -14.10192422
## 6     -26.44370789
## 7     -15.50074028
## 8     -22.13215923
## 9      24.17315146
## 10    -15.08129995
## 11    120.70728177
## 12    -34.15195536
## 13    23.35768087
## 14    -7.01149693
## 15    -5.20565460
## 16    29.11968603
## 17    -18.04558994
## 18    -13.20971229
## 19    29.58643283
## 20    -4.89478271
## 21    -30.10762719
## 22    20.36516101
## 23    12.64454141
## 24    -35.07315397
## 25    -11.11947108
## 26    -13.23495991
## 27    -11.14841855
## 28    55.41314646
## 29    -16.89105331
## 30    -18.49935301
## 31      8.88909052
## 32    -14.46925028
## 33      9.97032609
## 34    36.86152558
## 35      0.49484540
## 36      8.07185419
## 37     11.70256528

```

```

## 38      -1.69893888
## 39       8.28381065
## 40     -14.48386064
## 41       2.71032811
## 42       2.70785069
## 43       2.45235075
## 44     -8.67452790
## 45    -15.60522185
## 46       2.72412668
## 47       3.17933477
## 48       5.25041607
## 49     -11.91767117
## 50     -28.81978573
## 51     -30.93744834
## 52     -11.01763779
## 53     -3.36884167
## 54     -15.08137756
## 55     -50.31954937
## 56       0.81307559
## 57       2.30785551
## 58     -29.14479414
## 59     -7.94249019
## 60     -18.92880994
## 61     -9.52127614
## 62     -4.33430520
## 63     -9.84061745
## 64     -51.26478736
## 65     -27.91525512
## 66       4.92577920
## 67     -30.43314558
## 68     -30.64922134
## 69     -33.45544246
## 70     -18.42434040
## 71     -8.29897877
## 72     -5.97203079
## 73     -29.98935523
## 74     -10.72996361
## 75       1.30387762
## 76     -26.79746318
## 77     -9.33669127
## 78     -18.71897218
## 79     -6.54989993
## 80     -25.18339120
## 81      13.80012835
## 82     -13.28697776
## 83     -31.44945003
## 84      22.51867070
## 85     -14.85381346
## 86     -14.07474875
## 87     -18.31315038
## 88     -12.82793235
## 89     -22.36815896
## 90      36.83617241
## 91     -10.65301918

```

```

## 92      5.58492869
## 93      2.27171218
## 94     -22.04250301
## 95     -18.50145487
## 96     -12.17994827
## 97     -13.62001280
## 98      2.56326004
## 99     -17.39739575
## 100    -22.27053998
## 101    34.99912886
## 102    -4.50705692
## 103    -37.08434818
## 104      7.22751816
## 105    -44.27167071
## 106    14.98920837
## 107    -21.82885912
## 108    30.28469672
## 109    -4.54473603
## 110    -14.52165423
## 111    11.81592250
## 112    -17.97816972
## 113    -23.12689033
## 114    47.14920659
## 115    -31.52124786
## 116    -4.97363399
## 117    10.71589348
## 118    -5.80775303
## 119    -22.30656537
## 120    10.91791697
## 121    -18.11121172
## 122    -57.16205800
## 123    34.47384329
## 124    -26.63037633
## 125    30.48305898
## 126    -12.10548957
## 127    -2.43923838
## 128    -9.59229838
## 129    2.85018771
## 130    14.54969220
## 131    -21.28411870
## 132    -10.74865372
## 133    53.93990059
## 134    51.74039199
## 135    -13.79566822
## 136    -4.75703211
## 137    -16.61025269
## 138    -7.77400266
## 139    -18.17890386
## 140    -4.66097592
## 141    3.76604864
## 142    -14.64862027
## 143    5.69469111
## 144    -15.74163795
## 145    3.29660732

```

## 146	19.05272254
## 147	27.35735227
## 148	-9.97262327
## 149	8.11286635
## 150	25.74499114
## 151	19.54548491
## 152	25.85352743
## 153	1.73340987
## 154	-3.31277329
## 155	-51.22799036
## 156	35.76711186
## 157	-32.01591113
## 158	-20.98369923
## 159	-2.70471762
## 160	14.82644844
## 161	108.38711958
## 162	-33.60489635
## 163	10.13914360
## 164	13.52352478
## 165	14.98187306
## 166	-22.79681595
## 167	-1.54029397
## 168	14.37126702
## 169	-17.10929813
## 170	-12.58827996
## 171	-33.66621807
## 172	-35.21630877
## 173	-14.96289181
## 174	-40.17212674
## 175	-13.27819103
## 176	-11.09552145
## 177	33.79192643
## 178	-11.54987189
## 179	48.12952210
## 180	-37.79329749
## 181	-38.85374670
## 182	-17.97310437
## 183	14.16878874
## 184	27.43157499
## 185	5.10373600
## 186	-4.96412314
## 187	-11.29451860
## 188	11.71465209
## 189	23.40592171
## 190	-2.01548474
## 191	-51.88798607
## 192	0.04143315
## 193	-0.45091833
## 194	13.07888004
## 195	-5.45525047
## 196	15.44843844
## 197	83.50759735
## 198	31.67412937
## 199	-33.70125628

```
## 200      34.76302873
## 201      0.91909275
## 202     -30.51694344
## 203     -39.57034411
## 204     -35.65131393
## 205      19.63489857
## 206      38.53937924
## 207     -21.77484773
## 208     -6.43295313
## 209     -6.75861232
## 210      64.74591205
## 211      33.12584600
## 212      3.23513506
## 213     -10.52738204
## 214     -16.89435216
## 215     -23.09755251
## 216      32.28904369
## 217     -4.23386220
## 218     -6.74759936
## 219     -26.85655792
## 220     -8.90570673
## 221      1.90051883
## 222     -5.91856151
## 223      13.81731855
## 224     -17.74365364
## 225     -9.20119972
## 226      22.90365054
## 227     -9.57485869
## 228     -21.33277852
## 229      12.30559218
## 230     -10.85709491
## 231      1.50477406
## 232      0.83795603
## 233     -8.21292812
## 234     -13.78899998
## 235     -12.03437661
## 236     -5.90292804
## 237      0.16850926
## 238      5.68908488
## 239     -12.58293032
## 240      11.02505550
## 241     -49.71440034
## 242     -2.65068606
## 243     -27.88545325
## 244      1.05238522
## 245     -43.04304232
## 246      42.27292345
## 247      49.49623031
## 248      2.50777204
## 249     -26.61228714
## 250     -18.75906793
## 251      1.76527121
## 252     -26.46228628
## 253     -1.35496140
```

```

## 254      34.80976714
## 255      -5.55790971
## 256      -18.58487626
## 257      -15.27018305
## 258      -19.67919770
## 259       0.11551644
## 260      -50.07148962
## 261      19.69632313
## 262      3.36297942
## 263      2.73364233
## 264      -39.14225506
## 265      -2.70072322
## 266      -24.63641841
## 267      74.82571509
## 268      -8.62287304
## 269      -8.97658312
## 270      -25.16070901
## 271      -44.95635353
## 272      -19.53581295
## 273      -15.15960430
## 274      -52.42087958
## 275      -2.93695924
## 276      -26.45911147
## 277      -23.58271148
## 278      -32.03193564
## 279      -3.50399318
## 280      2.93771018
## 281      -40.73347490
## 282      -35.93056394
## 283      -52.88522868
## 284      -21.31025019
## 285      -36.80386724
## 286      -13.82615211
## 287      -21.54150097
## 288      -34.24676798
## 289      -12.55535264
## 290      -35.04562997
## 291       0.37985548
## 292      -19.07174285
## 293      19.85571541
## 294      19.25451514
## 295      -24.68628260
## 296      -3.02104419
## 297      -32.92259902
## 298      -7.98909848
## 299      -31.27731778
## 300      -26.96025372
## 301      -16.15883292
## 302      -40.75741843
## 303      149.59333753
## 304      -0.52816117
## 305      -13.50135804
## 306      -30.15143037
## 307      -13.62375177

```

```

## 308      9.88963652
## 309      1.62277644
## 310      3.39027728
## 311      2.24108268
## 312      4.23038468
## 313     -32.65540287
## 314     -26.33492683
## 315      38.66014427
## 316      15.60141045
## 317     -9.19178599
## 318     11.68117730
## 319     -16.51725820
## 320     -17.34678481
## 321      2.53437368
## 322     -33.03163667
## 323      5.53351320
## 324     21.80433510
## 325     52.45688009
## 326     -21.32346857
## 327     -53.86192873
## 328      15.27625153
## 329      4.86413642
## 330     -0.62768631
## 331     14.13496193
## 332     -7.80825660
## 333      0.93133604
## 334     -21.48965218
## 335     -0.96071618
## 336     52.71081557
## 337      4.79670476
## 338     -5.82103949
## 339     -33.04089778
## 340     -14.49747241
## 341     -10.42717916
## 342     -12.17978887
## 343     -15.22952838
## 344     -10.60740820
## 345     -15.91885751
## 346     -14.83234549
## 347      0.76087397
## 348     -14.49616067
## 349     -11.23883132
## 350      36.22055392
## 351     -41.70681163
## 352     -0.56965425
## 353     -2.95457792
## 354     -49.01838588
## 355     -8.84720716
## 356     -32.52922231
## 357     -6.98589183
## 358     -18.11116034
## 359     -25.48700029
## 360     -37.37818069
## 361     -34.90947430

```

## 362	32.28644959
## 363	-0.63673127
## 364	-3.23205056
## 365	-28.25763087
## 366	-39.35018132
## 367	-38.05960958
## 368	-23.31936566
## 369	-1.28486767
## 370	-31.26599781
## 371	-3.07941894
## 372	-22.82086445
## 373	5.41764381
## 374	-28.34037648
## 375	57.38909733
## 376	16.01355097
## 377	-12.82385370
## 378	2.48006016
## 379	1.67778389
## 380	108.22059658
## 381	2.82747790
## 382	-36.93297746
## 383	-1.98458093
## 384	19.90645314
## 385	-4.95293798
## 386	-0.43275117
## 387	59.48695180
## 388	-3.73026659
## 389	159.41226565
## 390	-13.16524779
## 391	-19.55229284
## 392	-7.17117127
## 393	45.00224960
## 394	-21.40845766
## 395	-15.72903573
## 396	17.52209766
## 397	56.54108706
## 398	62.07355277
## 399	3.35473687
## 400	-0.07208118
## 401	-0.01168131
## 402	0.35817641
## 403	-7.76204746
## 404	4.02502393
## 405	-61.53696701
## 406	21.10479480
## 407	38.69197026
## 408	-3.13656321
## 409	-44.23570714
## 410	-16.94252116
## 411	1.35902222
## 412	60.97162989
## 413	28.73461867
## 414	-30.31510072
## 415	28.44895039

```

## 416      -2.04756229
## 417      -14.45665293
## 418      -44.45807269
## 419      -27.44901485
## 420      -22.22956712
## 421      -3.56712267
## 422      -18.66195037
## 423      41.91032174
## 424      9.38201090
## 425      -34.10149485
## 426      -12.76175398
## 427      47.97046869
## 428      3.91959670
## 429      -3.27036104
## 430      -11.53811841
## 431      43.74682586
## 432      -11.50311088
## 433      15.07711706
## 434      -18.87622406
## 435      -1.43178091
## 436      -33.00680379
## 437      -15.15389545
## 438      42.81025233
## 439      27.03124905
## 440      -32.94040264
## 441      -16.14452690
## 442      54.58953385
## 443      16.22728610
## 444      -23.07128059
## 445      1.88731352
## 446      16.16601593
## 447      9.50625783
## 448      -18.53847551
## 449      -28.68898219
## 450      -16.61146475
## 451      -8.60956795
## 452      3.78276068
## 453      -18.54241807
## 454      1.90430484
## 455      -15.48025041
## 456      -5.05844748
## 457      10.35425755
## 458      -6.30607969
## 459      -11.62581637
## 460      -3.21987261
## 461      -20.20669803
## 462      -26.18648491
## 463      17.97146558
## 464      -6.81769889
## 465      -5.93607554
## 466      -17.43564730
## 467      8.93438338
## 468      -5.73292227
## 469      44.37073154

```

```

## 470      -2.26272801
## 471      1.50969091
## 472      -13.56283306
## 473      -36.22188343
## 474      -32.23876728
## 475      4.70281293
## 476      -42.84747439
## 477      -4.21927263
## 478      -14.91488320
## 479      -8.70354665
## 480      -4.03671428
## 481      -0.83875561
## 482      12.61045548
## 483      -35.04847485
## 484      -43.66617742
## 485      20.93894372
## 486      -15.03093871
## 487      -17.91754058
## 488      60.60437444
## 489      6.04822163
## 490      -55.22547763
## 491      51.49489374
## 492      -7.69070860
## 493      -23.68913143
## 494      16.07893934
## 495      -17.26865373
## 496      22.57247306
## 497      4.86099338
## 498      -67.37907432
## 499      -13.36549946
## 500      -27.84287421
## 501      -24.74797443
## 502      251.20357250
## 503      -7.04944574
## 504      -7.30929402
## 505      1.70532107
## 506      -32.07675036
## 507      -8.24324499
## 508      27.14001211
## 509      11.48567279
## 510      -19.29488841
## 511      -9.33259107
## 512      9.90842921
## 513      -40.89475443
## 514      -20.56719530
## 515      -5.95706488
## 516      115.05241207
## 517      -14.88407134
## 518      2.14050250
## 519      -34.70762199
## 520      -30.78399789
## 521      57.81027373
## 522      -29.03455888
## 523      33.84226161

```

```

## 524      -41.23435566
## 525      -9.06398415
## 526      37.11349913
## 527      -26.41738325
## 528      -33.74635003
## 529      25.66213889
## 530      -34.68452709
## 531      10.96373878
## 532      2.58854153
## 533      12.93222006
## 534      9.99503668
## 535      7.19377751
## 536      28.86551627
## 537      22.22544917
## 538      -20.37956049
## 539      -18.88355770
## 540      -7.02048738
## 541      54.21108226
## 542      1.63561273
## 543      14.05055345
## 544      0.86476878
## 545      -24.07254355
## 546      37.45724934
## 547      8.23930587
## 548      161.36848279
## 549      0.04503440
## 550      -15.91327378
## 551      -51.03603361
## 552      -35.86254329
## 553      1.33400678
## 554      0.32809089
## 555      -16.07717607
## 556      -26.32077737
## 557      68.79730184
## 558      -4.76001814
## 559      -11.74575122
## 560      -5.93601274
## 561      -43.09642092
## 562      -3.69794664
## 563      1.16419149
## 564      -7.06104303
## 565      -5.44999095
## 566      -10.20182404
## 567      -13.94783960
## 568      -16.51759003
## 569      -15.93589327
## 570      -19.67680857
## 571      4.19874077
## 572      -15.39434919
## 573      32.14378206
## 574      56.99190760
## 575      37.97294748
## 576      -34.59858786
## 577      -11.77762036

```

```

## 578      160.91328511
## 579      -66.99259373
## 580      -45.77582982
## 581      -8.00614465
## 582      -14.34805604
## 583       3.90847633
## 584     -16.91635844
## 585     -0.45300333
## 586      16.93466962
## 587     -20.47319009
## 588     -0.17095124
## 589     -1.23612740
## 590      20.32231054
## 591     -15.87012857
## 592     -37.51257684
## 593     -26.90566207
## 594      75.45473575

mutate(atlaspc2, PCH_SNAPSPTH_17_23 = PCH_SNAPSPTH_17_23) |>
select(PCH_SNAPSPTH_17_23)

```

```

##      PCH_SNAPSPTH_17_23
## 1      3.39574075
## 2     -2.99234033
## 3     -6.83735704
## 4     -4.09431648
## 5      4.53637838
## 6     12.43699074
## 7     -2.30500865
## 8      8.84546280
## 9     -6.75190210
## 10     14.70357990
## 11     -5.49335194
## 12      7.37758398
## 13      6.60395432
## 14     -0.66083485
## 15      6.50310469
## 16      5.71973896
## 17      0.78607303
## 18      5.88990259
## 19      2.39160466
## 20      0.85851246
## 21      8.95672035
## 22      5.30743980
## 23     12.90557194
## 24      7.18904829
## 25     11.10718632
## 26     -5.03497887
## 27      7.92563057
## 28     13.76066303
## 29     22.16687393
## 30      2.06194949
## 31     14.13780689
## 32     15.14154816
## 33      9.02354431

```

```

## 34      3.65922999
## 35      5.34744453
## 36      9.79098892
## 37      9.39050388
## 38      7.71818781
## 39      10.83230782
## 40      -0.29009572
## 41      14.41715336
## 42      11.82999229
## 43      9.87582493
## 44      10.45685577
## 45      10.52009010
## 46      22.99387360
## 47      20.13890266
## 48      12.46262169
## 49      10.04724026
## 50      4.31324768
## 51      8.58337307
## 52      15.64630890
## 53      15.56848717
## 54      6.82930040
## 55      2.79635286
## 56      -0.99263138
## 57      11.20543766
## 58      9.83506775
## 59      17.84786224
## 60      22.15851021
## 61      11.65198612
## 62      23.07081795
## 63      18.54633141
## 64      24.33510017
## 65      11.99177837
## 66      43.46316528
## 67      16.90695763
## 68      -3.66331983
## 69      22.97482300
## 70      19.79741859
## 71      13.04616642
## 72      -6.53784084
## 73      14.82347012
## 74      -3.10944891
## 75      1.63432193
## 76      -0.88033092
## 77      1.74496675
## 78      2.45824814
## 79      -13.19069099
## 80      -0.30096617
## 81      5.35355568
## 82      -4.69903708
## 83      2.69585490
## 84      11.63844872
## 85      0.07276759
## 86      -10.36203003
## 87      5.49181604

```

## 88	-6.40462303
## 89	-1.24734759
## 90	5.62489986
## 91	-1.41783917
## 92	0.84184605
## 93	-1.63782704
## 94	-0.15607955
## 95	-1.87185395
## 96	0.89228082
## 97	5.89364958
## 98	-0.20340464
## 99	5.08036661
## 100	4.83094263
## 101	4.24966717
## 102	1.05357909
## 103	2.73396492
## 104	-1.20032883
## 105	-4.10869265
## 106	12.54003239
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## 110	10.06645393
## 111	5.05714130
## 112	4.00693417
## 113	2.42841053
## 114	7.21599483
## 115	14.76469421
## 116	0.38275081
## 117	16.45486641
## 118	10.64798164
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## 121	8.71026134
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## 123	5.33458853
## 124	11.30865002
## 125	16.76038170
## 126	1.91561615
## 127	-4.43237209
## 128	12.16834545
## 129	4.20714045
## 130	16.68542671
## 131	9.40735435
## 132	4.97969770
## 133	7.35300541
## 134	-7.65592670
## 135	9.79800797
## 136	5.15669441
## 137	20.10767555
## 138	17.20288277
## 139	16.94244957
## 140	39.53746033
## 141	20.02263260

```

## 142      27.63641357
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## 144      11.56176472
## 145      14.37483788
## 146      5.90326405
## 147      12.61281109
## 148      23.53500175
## 149      8.53435135
## 150      6.19558048
## 151      7.37840414
## 152      19.55409050
## 153      11.79344654
## 154      12.78380966
## 155      25.53667259
## 156      7.24758911
## 157      21.57718468
## 158      9.67547131
## 159      -3.28242397
## 160      6.37324238
## 161      7.70011425
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## 163      0.80736864
## 164      16.49569702
## 165      12.16410542
## 166      14.73378658
## 167      17.14375687
## 168      7.35637474
## 169      10.02823544
## 170      19.37163353
## 171      22.00585175
## 172      14.23157215
## 173      10.08672333
## 174      33.00944901
## 175      11.55241585
## 176      11.94468498
## 177      10.44172955
## 178      14.62490368
## 179      2.59879947
## 180      13.46784115
## 181      14.22802258
## 182      46.60715866
## 183      2.78609848
## 184      3.94724274
## 185      18.08997154
## 186      11.92001534
## 187      -1.41826022
## 188      0.61565191
## 189      -5.07548237
## 190      14.55058002
## 191      18.82832718
## 192      4.37950897
## 193      3.21281695
## 194      15.18318748
## 195      9.63823700

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## 196	14.57416439
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## 198	-0.09251536
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## 200	14.02792740
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## 203	-10.02357578
## 204	13.83657932
## 205	-9.31438255
## 206	0.85906500
## 207	8.59684467
## 208	1.91991198
## 209	6.07735491
## 210	-14.73699093
## 211	-2.10829377
## 212	0.50024718
## 213	16.07783127
## 214	5.14287519
## 215	8.80986023
## 216	10.51371574
## 217	7.93879700
## 218	6.85566425
## 219	4.53181696
## 220	11.14325523
## 221	10.78524399
## 222	17.07106400
## 223	17.65208435
## 224	38.88736725
## 225	17.42160606
## 226	16.01580238
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## 229	8.26967239
## 230	6.06620789
## 231	8.62724209
## 232	12.49193954
## 233	16.83466911
## 234	11.54673767
## 235	10.91919708
## 236	3.87478781
## 237	7.43073606
## 238	7.49472761
## 239	3.21603537
## 240	13.05577755
## 241	10.60568714
## 242	29.10820198
## 243	12.64082146
## 244	5.92238712
## 245	5.81586504
## 246	3.99785161
## 247	12.74998283
## 248	26.87776756
## 249	13.00655270

## 250	15.24543762
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## 252	22.00787735
## 253	0.44663414
## 254	14.39987850
## 255	1.06107700
## 256	-2.82925987
## 257	9.84608841
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## 260	10.03199100
## 261	2.50519586
## 262	5.87515450
## 263	-2.66496158
## 264	20.64437103
## 265	15.02913475
## 266	20.17621613
## 267	5.94343233
## 268	3.06561351
## 269	4.80572653
## 270	27.36599159
## 271	6.71977806
## 272	14.13987732
## 273	6.00908470
## 274	13.55860233
## 275	21.36568069
## 276	2.67821670
## 277	8.57797432
## 278	-0.81008232
## 279	13.03390217
## 280	35.55558777
## 281	6.09772873
## 282	5.71126509
## 283	9.39315414
## 284	10.51527882
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## 286	9.11928177
## 287	10.48705292
## 288	4.04437304
## 289	-0.35741243
## 290	15.21190262
## 291	0.38928378
## 292	-6.77536869
## 293	13.88448334
## 294	-10.02722359
## 295	9.80892849
## 296	-0.10536308
## 297	41.88519287
## 298	14.09937000
## 299	28.92459488
## 300	-4.07172346
## 301	0.84301323
## 302	-6.65683079
## 303	11.31737900

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## 304      -2.41859674
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## 306       5.50591278
## 307       5.63420057
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## 311      1.40292263
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## 313     -0.45945489
## 314      5.68490267
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## 317      4.97768021
## 318      3.55799508
## 319     11.04611969
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## 321     18.56005096
## 322      9.78075218
## 323     10.38420486
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## 325      2.75814319
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## 327     63.11169434
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## 332     13.61700153
## 333     -1.78938210
## 334     -1.74236095
## 335     11.63073158
## 336     29.93440437
## 337      0.84836042
## 338      4.41662121
## 339      7.72684240
## 340      2.18265676
## 341     11.91084099
## 342     12.58115673
## 343      9.17013836
## 344     -0.10262012
## 345      9.28556538
## 346      9.29975986
## 347      7.28793955
## 348     -0.73106438
## 349      2.45934534
## 350     11.67191410
## 351      8.63719559
## 352      4.20243549
## 353      7.05923748
## 354     31.62648010
## 355      0.53424984
## 356     -0.95137876
## 357      9.82146168

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## 358      0.77822894
## 359     -4.31785631
## 360    -11.74693394
## 361     -9.76593304
## 362      5.78211355
## 363     -7.28171968
## 364      2.22584224
## 365     -5.85626507
## 366      6.99727249
## 367     -5.48634434
## 368     -4.62182283
## 369      3.42008662
## 370     -4.50873184
## 371     13.00019550
## 372     -1.51780808
## 373     -2.92642474
## 374      7.81020880
## 375     16.58377647
## 376     16.74866295
## 377     10.16740608
## 378      57.69583130
## 379      8.45930481
## 380      8.57825375
## 381     17.61345863
## 382     10.91195869
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## 385      3.99544978
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## 396     22.85034561
## 397     17.67764091
## 398     27.84487915
## 399     11.70793056
## 400     -1.03218496
## 401     25.26266479
## 402     11.20062923
## 403     17.46315384
## 404     11.61153698
## 405     15.80156898
## 406     17.38976288
## 407      5.87509871
## 408      1.96777833
## 409      7.93158531
## 410     3.07342219
## 411     12.57319736

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```

## 412      0.61547935
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## 414      3.38116264
## 415      15.17901707
## 416      -2.76694608
## 417      4.24084520
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## 431      9.40990353
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## 435      22.55143356
## 436      29.92908287
## 437      12.40990925
## 438      7.68202400
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## 440      13.55150890
## 441      2.89205909
## 442      19.88762665
## 443      3.06970716
## 444      12.23830509
## 445      15.28936195
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## 447      10.03915501
## 448      15.43141270
## 449      8.25668144
## 450      2.67614913
## 451      9.91698265
## 452      9.54180527
## 453      19.54950905
## 454      9.38832474
## 455      7.35114765
## 456      -6.78764391
## 457      20.34013367
## 458      19.77317810
## 459      11.70918846
## 460      -0.70389885
## 461      1.29418457
## 462      5.55688906
## 463      11.38757610
## 464      -2.26886725
## 465      7.90233517

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```

## 466      -0.56378198
## 467      -1.71001136
## 468      10.13410473
## 469      -6.41731739
## 470      6.57206821
## 471      -2.15006089
## 472      -1.82113099
## 473      -5.05241442
## 474      1.91810989
## 475      13.08179283
## 476      -1.16774523
## 477      -4.70241642
## 478      -5.84726095
## 479      2.77396894
## 480      0.54271472
## 481      -0.17525624
## 482      -15.39937878
## 483      12.90776157
## 484      -4.77295923
## 485      5.45146227
## 486      8.47294331
## 487      4.90198278
## 488      -0.37993681
## 489      -4.55093670
## 490      9.08816814
## 491      26.00881195
## 492      5.78906155
## 493      8.81494904
## 494      31.46523094
## 495      5.65101242
## 496      8.04889870
## 497      10.50867748
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## 499      17.23491287
## 500      16.21567535
## 501      33.91323090
## 502      16.73945236
## 503      0.13901883
## 504      24.94648933
## 505      14.48230934
## 506      16.08256912
## 507      26.83061790
## 508      18.22765732
## 509      14.37018204
## 510      31.30147171
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## 512      3.24511981
## 513      32.02876663
## 514      10.98227978
## 515      9.35673428
## 516      74.64083862
## 517      18.69211197
## 518      16.48252678
## 519      34.14896393

```

```

## 520      3.40617394
## 521      36.93972015
## 522      14.25437450
## 523      19.95170212
## 524      16.71194839
## 525      16.04031372
## 526      16.58509636
## 527      23.68268013
## 528      2.34691525
## 529      18.59071732
## 530      19.53836441
## 531      14.69435120
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## 533      -0.58789855
## 534      11.31486130
## 535      6.93827248
## 536      9.11147690
## 537      10.93626785
## 538      8.11567020
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## 540      3.96907258
## 541      1.03689516
## 542      3.87644601
## 543      29.30318069
## 544      8.57382107
## 545      5.14624786
## 546      14.38078213
## 547      2.69447327
## 548      -18.55408096
## 549      6.49982595
## 550      16.14798737
## 551      -3.14330721
## 552      7.56419373
## 553      1.38923371
## 554      6.93019295
## 555      1.51009119
## 556      17.68194962
## 557      13.76377583
## 558      -0.04381015
## 559      2.30770850
## 560      9.40977859
## 561      -0.42163488
## 562      2.76302075
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## 564      4.58960295
## 565      -1.43679571
## 566      7.93626833
## 567      4.83993959
## 568      1.80709374
## 569      8.78467274
## 570      5.27596140
## 571      10.87668324
## 572      4.91527748
## 573      11.44066525

```

```

## 574      -1.42818058
## 575      10.16794205
## 576      15.22427940
## 577      17.56909943
## 578      13.49627209
## 579      15.19492435
## 580      -3.50019121
## 581      14.49812126
## 582      12.04676342
## 583      4.78192759
## 584      38.39988327
## 585      -3.25179172
## 586      21.52538300
## 587      23.41023445
## 588      9.14954472
## 589      29.93756485
## 590      38.08540344
## 591      14.33442783
## 592      13.00773430
## 593      6.19929171
## 594      10.35099602

mutate(atlaspc2, PCH_WICSPTH_16_22 = PCH_WICSPTH_16_22) |>
select(PCH_WICSPTH_16_22)

##      PCH_WICSPTH_16_22
## 1      -20.4221193
## 2      -7.3536209
## 3      -8.1640348
## 4      -34.5263194
## 5      -8.1722998
## 6      -9.4945766
## 7      -7.1801952
## 8      7.6496762
## 9      -20.0199382
## 10     -32.7861114
## 11     -8.5869486
## 12     -15.8930975
## 13     -1.7831437
## 14     -26.7456184
## 15     -1.4275310
## 16     -11.6022071
## 17     -10.2723181
## 18     -24.3031316
## 19     -26.4731933
## 20     -12.4658904
## 21     -17.0874984
## 22     -10.7990828
## 23     -10.3705133
## 24     -13.6314882
## 25     30.3970784
## 26     -20.6059602
## 27     -8.1799080
## 28     -4.3049411
## 29     -1.7288408

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```

## 30      -24.8182468
## 31       12.2546060
## 32     -25.3220013
## 33     -19.4325650
## 34      11.9569450
## 35     -23.9023974
## 36      5.7903069
## 37     -23.6267521
## 38     -25.1691741
## 39     -18.8563170
## 40      -4.6238955
## 41      -6.6699623
## 42     -12.2180480
## 43     -13.7512894
## 44     -19.7262975
## 45     -23.0055534
## 46     -27.8124180
## 47     -17.3367607
## 48      -7.4751179
## 49      -2.3502339
## 50     -18.5210284
## 51      3.4849237
## 52     -10.8249561
## 53      5.6181276
## 54     -22.6980320
## 55     -31.2346574
## 56     -14.7987851
## 57     -15.8901638
## 58      0.1361245
## 59     -17.1874592
## 60      21.3447799
## 61      -4.4718189
## 62      -2.4982407
## 63      -8.9209817
## 64      -6.7895506
## 65     -20.1742911
## 66     -17.0405231
## 67     -18.6584160
## 68     -31.9210923
## 69     -10.5179196
## 70     -32.1039874
## 71     -24.9729963
## 72      3.7231234
## 73      12.7254331
## 74      -4.9992657
## 75     -23.0374606
## 76     -11.5938078
## 77      -7.0881232
## 78     -29.4745175
## 79      -3.4519306
## 80     -13.3490972
## 81      -2.6879723
## 82     -14.0465377
## 83      -0.9719124

```

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## 84      -10.0823423
## 85      -14.2272230
## 86      -3.6987875
## 87      -10.6534689
## 88      -12.7528924
## 89      -17.1202426
## 90      -8.4609084
## 91      1.1122162
## 92      -6.3084899
## 93      -3.8037481
## 94      -6.9135145
## 95      -22.9713689
## 96      -5.7710837
## 97      -19.0687122
## 98      -10.9398873
## 99      -1.4371387
## 100     -8.9101174
## 101     7.1295423
## 102     6.3356436
## 103     -2.1135510
## 104     -0.6587048
## 105     -11.0390044
## 106     -17.0507475
## 107     -28.4384005
## 108     -10.8685495
## 109     -30.2504501
## 110     -13.2485513
## 111     -8.0190461
## 112     -32.5103989
## 113     -8.1872208
## 114     -32.8839664
## 115     -42.1420799
## 116     7.5973787
## 117     -14.5104101
## 118     -15.1289581
## 119     -27.3911281
## 120     -7.9023466
## 121     -3.6860443
## 122     -10.9879980
## 123     -29.4494380
## 124     -13.1527423
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## 126     -10.8032866
## 127     -3.6255377
## 128     -5.5096663
## 129     -9.7850178
## 130     -28.1043415
## 131     -22.1792032
## 132     -24.4979925
## 133     -23.7773974
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## 135     6.0066849
## 136     -8.5670438
## 137     -4.1142259

```

```

## 138      29.9413915
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## 140     -31.4063007
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## 146    -12.0890481
## 147     -8.3480825
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## 149    -26.5185429
## 150    -13.4487449
## 151     -5.1098478
## 152     -8.1931690
## 153     -8.9371413
## 154     -8.4307090
## 155    -44.3611400
## 156    -16.5922188
## 157    -30.7732077
## 158     -2.5144893
## 159    -16.7565567
## 160    -42.1996031
## 161    -34.9428053
## 162    -15.0293403
## 163     11.3661305
## 164     16.1069970
## 165    -10.9800811
## 166    -26.3828803
## 167    -20.4302773
## 168      3.2250090
## 169    -10.6568560
## 170    -18.2526122
## 171    -30.3475089
## 172      1.3583540
## 173    -17.8799963
## 174    -12.0333217
## 175    -17.4116102
## 176     -6.9356553
## 177    -21.3438002
## 178    -12.3528443
## 179    -18.5941830
## 180    -12.6438944
## 181     -2.3023836
## 182     -3.1529043
## 183     -1.3403693
## 184      2.5609325
## 185    -11.2248221
## 186    -11.1399716
## 187    -18.9034606
## 188    -27.4846053
## 189    -24.4531174
## 190    -23.0958039
## 191    -10.0137722

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## 192      -22.3638904
## 193      -37.8843202
## 194      -3.6422569
## 195      13.4186632
## 196      5.5721200
## 197      -0.5139931
## 198      6.3379090
## 199      -39.5591501
## 200      -3.3769893
## 201      -22.7066265
## 202      -48.3068453
## 203      -56.5776638
## 204      33.0039985
## 205      -4.6225509
## 206      -14.5933258
## 207      -11.0357278
## 208      -20.0830154
## 209      -4.9951032
## 210      7.8077919
## 211      48.3277275
## 212      -12.4495139
## 213      -30.5066158
## 214      -35.9450060
## 215      -24.0094461
## 216      -1.6375315
## 217      -35.7148010
## 218      -31.1654229
## 219      -28.2415072
## 220      -22.5811276
## 221      -30.7637820
## 222      -31.0409547
## 223      -23.5955797
## 224      -22.2118965
## 225      -48.1862848
## 226      -11.0944708
## 227      -70.1067739
## 228      -0.9167754
## 229      -4.4963967
## 230      -14.1311536
## 231      -25.3938131
## 232      -25.1041631
## 233      -1.9233891
## 234      -4.0589086
## 235      6.5581414
## 236      -4.3227407
## 237      -23.2015850
## 238      -19.3085405
## 239      -25.0021205
## 240      -16.4991121
## 241      -46.1567398
## 242      -16.4532026
## 243      -43.1337607
## 244      -35.3365928
## 245      0.7723650

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```

## 246      -54.3900509
## 247      -23.4569127
## 248      189.8107989
## 249      -31.5299224
## 250      -16.4667776
## 251      -18.2664648
## 252      -8.7020840
## 253      -6.4840129
## 254      74.1197307
## 255      -35.5682357
## 256      -9.4179498
## 257      4.1573688
## 258      -15.4473941
## 259      -44.8016733
## 260      -15.3345840
## 261      -19.4971403
## 262      -17.3862491
## 263      -26.0460021
## 264      -17.4968397
## 265      7.5896581
## 266      -2.4254463
## 267      3.0646214
## 268      -12.2723876
## 269      -17.8334035
## 270      -22.5613006
## 271      -18.6162551
## 272      -23.2508737
## 273      -2.4516326
## 274      31.6652651
## 275      -6.0630898
## 276      -7.4096101
## 277      -3.7905163
## 278      1802.4853341
## 279      -6.1235701
## 280      -11.8654207
## 281      7.5237464
## 282      -14.8720214
## 283      -58.1285108
## 284      -10.7767189
## 285      -4.5920957
## 286      24.6931679
## 287      -18.0636525
## 288      -20.3718943
## 289      -6.4997486
## 290      7.7979910
## 291      -2.8120316
## 292      -10.6219885
## 293      11.6088817
## 294      1.5399990
## 295      22.6711221
## 296      8.2882710
## 297      -26.7618831
## 298      -1.5164253
## 299      0.7724131

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## 300      -21.5718944
## 301      -1.1338352
## 302      -5.5105316
## 303      -31.5102481
## 304      -33.5049782
## 305      -28.1553607
## 306      -23.2240547
## 307      -17.9336677
## 308      -8.4357344
## 309      22.4407898
## 310      -27.1684971
## 311      -18.7627545
## 312      -3.4753660
## 313      -28.4208803
## 314      -17.4962376
## 315      -14.7983323
## 316      -26.5732681
## 317      -9.1154873
## 318      -15.8752656
## 319      -18.8691548
## 320      -9.7793774
## 321      -25.2189972
## 322      -2.4093498
## 323      -1.4801279
## 324      -11.2706884
## 325      6.5126159
## 326      -7.5893246
## 327      -18.8655278
## 328      7.2850377
## 329      -4.9842812
## 330      -33.2317841
## 331      4.4791407
## 332      13.7225278
## 333      -12.4971142
## 334      -3.7542255
## 335      -0.3914167
## 336      -39.1248035
## 337      -17.0248421
## 338      -31.1085631
## 339      -13.8677429
## 340      -18.5745302
## 341      -21.0050436
## 342      3.8342841
## 343      -3.7999237
## 344      -18.7728587
## 345      -11.0796827
## 346      2.0976446
## 347      -0.6113997
## 348      -28.2582793
## 349      -2.4010831
## 350      2.6309016
## 351      10.2045068
## 352      -38.6649846
## 353      23.4531445

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```
## 354      10.9130800
## 355      10.7535356
## 356      18.5877788
## 357     -24.3988505
## 358     -35.3201377
## 359      -9.2861258
## 360     -35.3733386
## 361     -26.9964876
## 362     -15.5424084
## 363     -35.2689074
## 364     -20.9698889
## 365      -7.5201315
## 366     -30.4371895
## 367     -20.4714419
## 368     -26.2457294
## 369     -20.9419350
## 370      -5.2956890
## 371     -17.0462404
## 372     -19.4388119
## 373     -14.7185312
## 374      -6.2923675
## 375     -15.6737037
## 376     -15.7200321
## 377      -4.2974481
## 378     -24.1650911
## 379     -12.1220147
## 380     -14.8945396
## 381      -3.7826368
## 382     -18.5718028
## 383     -39.8219297
## 384      37.9301282
## 385     -20.2268223
## 386     -41.6878767
## 387     -32.6983658
## 388     -23.3940229
## 389     -25.0089267
## 390     -14.7947205
## 391     -21.6005941
## 392     -24.5073748
## 393     -38.9788208
## 394      -7.6153404
## 395     -14.9731722
## 396      -5.9677414
## 397     -22.9850761
## 398     -13.2295936
## 399     -14.5389814
## 400     -18.5625317
## 401     -5.2163679
## 402     -23.0230300
## 403      -6.2421252
## 404     -8.8923382
## 405     -20.1982924
## 406     -36.0461201
## 407     -23.4908894
```

```

## 408      1.1105668
## 409     21.7907289
## 410      6.4987233
## 411     27.4839116
## 412     -8.5342244
## 413    -23.5433977
## 414     17.5528013
## 415    -19.5065624
## 416      4.4337301
## 417    -23.4963285
## 418    -18.7752131
## 419      1.0660517
## 420    -31.7623908
## 421     42.3172132
## 422    -26.6878253
## 423    -13.0464721
## 424    -18.4441077
## 425     -0.7353730
## 426      1.8337779
## 427    -28.1181147
## 428    -30.1477962
## 429    -16.9345633
## 430    -11.1802468
## 431    -24.2948689
## 432    -43.2923751
## 433     -3.3674884
## 434    -19.1134619
## 435     -49.6915872
## 436      0.3233212
## 437    -16.4871920
## 438     -5.9980260
## 439     -6.6716707
## 440    -28.7082172
## 441    -41.1047494
## 442    -21.2471400
## 443    -13.9198655
## 444    -32.7374622
## 445      4.9128275
## 446    -12.2098997
## 447    -27.3533164
## 448     -8.7485540
## 449    -61.0949450
## 450    -14.7748782
## 451    -21.5313392
## 452    -25.9894111
## 453     -6.4432703
## 454    -19.7025101
## 455    -19.8893325
## 456    -67.0771703
## 457     -0.6497115
## 458    -34.9997812
## 459    -17.6570543
## 460    -13.0119722
## 461    -17.5821257

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```

## 462      5.3692621
## 463     -42.6491926
## 464      2.1716551
## 465      9.2296498
## 466     -20.4974881
## 467     -30.4600777
## 468     -16.3607394
## 469     -27.6516704
## 470     -15.7882020
## 471     -27.5833687
## 472      10.2341531
## 473     -21.0994933
## 474     -24.3906210
## 475     -31.3864385
## 476      9.6983483
## 477     37.4388421
## 478     -26.7036434
## 479     -7.3166677
## 480     -18.7896325
## 481     -8.8128370
## 482     -9.9103807
## 483     -9.6428975
## 484      1.5987930
## 485     -15.5466427
## 486     -10.7599140
## 487     -16.8919666
## 488     -21.4620613
## 489     -21.7260196
## 490     -28.7100538
## 491     23.7025801
## 492     -23.3568216
## 493     -16.1034330
## 494     -24.2297695
## 495     -17.9678940
## 496      -5.4547611
## 497     -6.8034913
## 498     -17.9617536
## 499      0.8137699
## 500     -35.4448537
## 501      1.1202804
## 502     -31.7060448
## 503     -5.6215420
## 504     -17.8777018
## 505     -7.0320231
## 506     -32.2028678
## 507     -1.3097447
## 508     -24.3182230
## 509     -18.0707283
## 510      9.1590629
## 511     -50.0740693
## 512     -17.8670400
## 513      13.5178761
## 514     -0.5629217
## 515     -6.8284330

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## 516      -8.0145010
## 517      -34.5356153
## 518      11.1594635
## 519      -28.4659651
## 520      95.2618126
## 521      -81.8214841
## 522      -20.4472486
## 523      -3.2433083
## 524      2.1540418
## 525      0.2243176
## 526      -18.0566158
## 527      -11.3865776
## 528      -10.9287895
## 529      19.7105498
## 530      -58.7345299
## 531      -6.5195837
## 532      -17.0791126
## 533      -38.8053328
## 534      -26.0913660
## 535      -9.4758030
## 536      -21.6445523
## 537      -21.4601649
## 538      -20.7409331
## 539      -51.0942260
## 540      -93.1174968
## 541      -14.6367064
## 542      -83.4334605
## 543      -3.9257737
## 544      -20.9637872
## 545      -75.0305228
## 546      -48.3503154
## 547      -13.6824986
## 548      -0.3458292
## 549      -17.9039283
## 550      25.4707048
## 551      19.3770097
## 552      -7.6679263
## 553      -0.8155591
## 554      58.5184563
## 555      -8.0527070
## 556      -14.4104936
## 557      1.2963130
## 558      -15.0788147
## 559      -17.4337714
## 560      -7.0212684
## 561      -33.6785482
## 562      -23.2960715
## 563      -26.5417841
## 564      -25.9631039
## 565      -6.9547416
## 566      -33.5994251
## 567      -20.8866925
## 568      -16.4631565
## 569      -32.6366853

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## 570      -29.7622049
## 571      -17.8080807
## 572       9.1796373
## 573     -20.6219749
## 574      15.5486284
## 575      43.3059606
## 576     -1.8019437
## 577     -8.9238678
## 578    -35.7238139
## 579    -23.2808495
## 580   -13.7302869
## 581   -31.6729437
## 582   -39.0105640
## 583    -4.6230280
## 584    -4.4907109
## 585   -34.6075321
## 586    -8.2796065
## 587     2.7841759
## 588   -14.3370808
## 589    -2.0032909
## 590    -8.2345708
## 591   -12.1077195
## 592    -9.2489424
## 593   -14.5287548
## 594   -12.8141307

mutate(atlaspc2, PCH_FFRPTH_16_20 = PCH_FFRPTH_16_20) |>
select(PCH_FFRPTH_16_20)

##      PCH_FFRPTH_16_20
## 1      -0.082217810
## 2       2.132723912
## 3      -3.050058848
## 4       7.466878513
## 5       2.554422868
## 6      15.238194594
## 7      17.360082207
## 8      16.087377144
## 9       3.753566313
## 10      4.968951206
## 11      2.681228625
## 12      8.989863453
## 13      2.541064523
## 14      3.002646973
## 15      1.787364216
## 16     14.021007239
## 17      3.472288658
## 18     -2.689679643
## 19     -5.736484480
## 20      6.109128374
## 21     10.810955199
## 22     10.048144227
## 23      0.910728405
## 24      4.465115866
## 25      2.902945071

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## 26      -1.086177468
## 27      5.602449832
## 28      5.662300108
## 29      10.095634229
## 30      12.609730999
## 31      -12.439702858
## 32      6.567431904
## 33      6.181041657
## 34      13.135925782
## 35      7.374752446
## 36      6.678069422
## 37      -0.907198894
## 38      9.350406482
## 39      1.470980300
## 40      -0.299450654
## 41      7.448801563
## 42      8.570278337
## 43      7.981149232
## 44      3.106261952
## 45      3.591881005
## 46      11.394217192
## 47      -0.609887834
## 48      9.431873989
## 49      -0.337395156
## 50      9.239844993
## 51      4.663099865
## 52      -0.119679725
## 53      11.390203219
## 54      4.140427085
## 55      7.781310675
## 56      6.835674825
## 57      3.197974668
## 58      0.688972268
## 59      -0.271032142
## 60      -3.291362904
## 61      4.089286463
## 62      -6.382188282
## 63      6.510479839
## 64      -2.529572573
## 65      -3.993059228
## 66      -0.623798876
## 67      13.259303699
## 68      -4.740816067
## 69      0.371368146
## 70      17.930036780
## 71      15.551034010
## 72      3.798361650
## 73      -9.040265033
## 74      6.778013420
## 75      9.379964767
## 76      -4.601727518
## 77      1.769659620
## 78      -7.371289366
## 79      11.173397385

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## 80      10.748271317
## 81      9.112338068
## 82      3.261448946
## 83      10.161334768
## 84      11.121589623
## 85      1.074750238
## 86      -11.918921398
## 87      -2.106477042
## 88      -0.648478633
## 89      7.953921524
## 90      4.134324852
## 91      4.001303890
## 92      -10.546095370
## 93      3.186491931
## 94      10.148590965
## 95      25.708904157
## 96      2.133551481
## 97      18.409531734
## 98      8.542556147
## 99      13.600940318
## 100     12.369761177
## 101     13.521993145
## 102     4.808733628
## 103     11.860329316
## 104     9.720155019
## 105     -1.857893329
## 106     -1.409005669
## 107     0.553472705
## 108     6.284891563
## 109     5.296011785
## 110     13.016420420
## 111     22.605173117
## 112     8.435989077
## 113     6.454179924
## 114     11.916294179
## 115     5.775212252
## 116     3.142495931
## 117     -4.903199536
## 118     18.689892737
## 119     15.076994942
## 120     7.836870593
## 121     3.168633522
## 122     12.509960790
## 123     17.664607453
## 124     0.049492388
## 125     16.681979487
## 126     7.763384904
## 127     10.712179664
## 128     -2.150013492
## 129     6.867767129
## 130     -15.297761181
## 131     -4.677393790
## 132     -6.654556507
## 133     3.101721435

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## 134      7.770166510
## 135      0.025134726
## 136      1.239959817
## 137      1.982044080
## 138      6.212217225
## 139      14.077493113
## 140      4.120260408
## 141      3.349419411
## 142      -1.787456758
## 143      2.148658011
## 144      0.387817491
## 145      10.891942514
## 146      11.314300298
## 147      8.089583698
## 148      10.303811063
## 149      2.106600002
## 150      12.922320460
## 151      0.552278041
## 152      2.535820794
## 153      5.076767857
## 154      10.610177633
## 155      -7.951414977
## 156      15.230901356
## 157      10.576523792
## 158      2.176249290
## 159      -8.110012217
## 160      1.902657312
## 161      -1.549399487
## 162      7.560074023
## 163      -13.344683033
## 164      10.739474244
## 165      -0.788208070
## 166      -3.613706506
## 167      1.220264363
## 168      7.491792077
## 169      -1.979731223
## 170      -1.488379478
## 171      4.994578521
## 172      21.193988366
## 173      3.461816636
## 174      -0.794505130
## 175      -1.262522497
## 176      -2.417666315
## 177      1.777433400
## 178      9.825575484
## 179      4.239293247
## 180      -7.726720716
## 181      5.583225979
## 182      15.350321087
## 183      3.153808116
## 184      5.866229328
## 185      0.875544274
## 186      -18.288346938
## 187      -1.105379070

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## 188      -2.760004773
## 189       0.058854504
## 190      -2.982440784
## 191       7.066169325
## 192       4.285617511
## 193       3.696959507
## 194       7.832954259
## 195      13.245908353
## 196      -0.1444597823
## 197      13.126428912
## 198      14.481005379
## 199      12.293828707
## 200       9.185993352
## 201      16.445108329
## 202       6.355395058
## 203      22.164890314
## 204       2.085381849
## 205       4.615794070
## 206      -2.573724722
## 207      15.674516767
## 208       9.050157385
## 209       0.484744328
## 210      -1.152456972
## 211       4.542941465
## 212       3.563429330
## 213       8.845516146
## 214       5.216365370
## 215      -3.442796053
## 216       2.469790351
## 217       0.475948678
## 218       0.614435344
## 219      -5.800119966
## 220       4.670664077
## 221       0.396548166
## 222       8.558984606
## 223      11.677893715
## 224      -7.401470675
## 225       7.819001277
## 226       6.325942698
## 227      -0.722732786
## 228      -2.919954618
## 229      -5.132038279
## 230      -0.707880144
## 231       2.397122032
## 232      -1.270162174
## 233       4.260476409
## 234       2.910545050
## 235       4.868813240
## 236       4.711216409
## 237       1.679971955
## 238      -4.394054484
## 239     -12.411524344
## 240       5.604645210
## 241       5.755271678

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## 242      23.659941886
## 243      22.569685462
## 244     -11.698698881
## 245      19.027902334
## 246      6.041930628
## 247      8.800033319
## 248     21.901131974
## 249      4.234739375
## 250     -5.715795629
## 251     12.726643753
## 252      2.507110920
## 253     20.110050159
## 254      7.847820073
## 255     -7.212665619
## 256      3.928165545
## 257     -0.193546225
## 258      1.457854247
## 259      6.220120487
## 260     -3.079957878
## 261      6.547868965
## 262      1.871308015
## 263     10.365001839
## 264     -4.088013448
## 265     11.713989164
## 266      2.927113262
## 267      4.596582030
## 268      3.663121249
## 269      2.868358449
## 270     -12.687495251
## 271      0.870086972
## 272      3.978078353
## 273     12.404748465
## 274      9.497150257
## 275      1.515461915
## 276     10.453430089
## 277     -0.208011463
## 278     -5.758562595
## 279     -2.199994553
## 280      0.192706352
## 281     27.650977642
## 282     -10.096119593
## 283      1.041305501
## 284     12.413942152
## 285      9.311639516
## 286      1.334065897
## 287      3.234879408
## 288      2.394343001
## 289      2.242971659
## 290     -4.165680759
## 291     10.563324796
## 292     -10.271434564
## 293      0.085695298
## 294     14.018953488
## 295     10.176804151

```

```

## 296      10.084221130
## 297      4.897646394
## 298     -10.272769866
## 299      1.183506645
## 300     19.376793916
## 301      0.069423832
## 302     15.544034742
## 303    -11.908243433
## 304    -1.803450194
## 305      2.254468440
## 306    -2.211999275
## 307      2.327257860
## 308      6.121128837
## 309      3.686180327
## 310      7.047578274
## 311      4.833280581
## 312      1.334202651
## 313    -5.994057885
## 314     10.182796423
## 315    -11.452127097
## 316    -4.503180917
## 317      2.963491345
## 318     11.523644912
## 319      3.338026602
## 320      2.717747317
## 321    -1.644736269
## 322    -5.598812214
## 323      5.397727576
## 324    -0.803292575
## 325      8.946453674
## 326      4.275757540
## 327     13.247994434
## 328    -1.124414849
## 329    -1.275732201
## 330      1.216904850
## 331      0.053378965
## 332    -4.111882397
## 333     42.339061571
## 334      0.696852741
## 335      2.205461230
## 336      1.807214510
## 337    -18.833923153
## 338      4.666084667
## 339      1.870934341
## 340      1.766600233
## 341     14.757067578
## 342      6.059789121
## 343    -4.042026560
## 344    -12.298047361
## 345    -2.546475564
## 346    -7.532254253
## 347     11.853818163
## 348      5.472900299
## 349    -3.421653767

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## 350      6.171904371
## 351      0.511332889
## 352     -9.964649012
## 353      4.756160272
## 354     -9.652836178
## 355      4.320437146
## 356     -3.394115123
## 357      3.875306404
## 358     -7.138234757
## 359      5.238110948
## 360      5.318525007
## 361     -0.178339742
## 362      7.811074679
## 363     -0.600159219
## 364     -0.871859179
## 365     -2.065977741
## 366     -2.307557989
## 367     -10.805832832
## 368      0.033015563
## 369     -6.197263252
## 370      0.726964902
## 371     -4.254217036
## 372     -2.280278910
## 373     -2.799215789
## 374     16.424776986
## 375     15.328217826
## 376      8.268318826
## 377     -11.238830675
## 378     10.845781981
## 379     -7.206686519
## 380      8.038986702
## 381     12.430372741
## 382     -8.579770456
## 383     13.697882378
## 384      8.116021987
## 385      6.701615791
## 386     5.588159912
## 387      3.424864501
## 388      2.789320189
## 389     -1.378608567
## 390      1.554344175
## 391      0.559628552
## 392      1.556324567
## 393     -7.793449881
## 394      7.910671549
## 395      2.688955331
## 396      8.713007992
## 397     -4.454904045
## 398      1.987745610
## 399      3.208827776
## 400     27.327513372
## 401     -11.199190575
## 402     -0.744666987
## 403      5.699485248

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## 404      9.609346514
## 405      6.783216674
## 406      7.316285371
## 407      -7.594187386
## 408      -0.964735590
## 409      -3.941511898
## 410      6.913172486
## 411      1.148639761
## 412      5.781357791
## 413      -3.449035004
## 414      -4.183258480
## 415      -14.367370421
## 416      0.599798923
## 417      -5.603595942
## 418      -5.578717169
## 419      -1.393072491
## 420      4.690966912
## 421      14.373877005
## 422      -8.801921111
## 423      -22.088447449
## 424      14.265137680
## 425      -0.367733866
## 426      3.137392352
## 427      11.626849672
## 428      -4.165805865
## 429      5.140913184
## 430      5.742048794
## 431      14.084779137
## 432      1.815186095
## 433      7.456976973
## 434      -1.700200866
## 435      19.880267611
## 436      5.275023029
## 437      -3.037430960
## 438      -2.242982037
## 439      2.448696760
## 440      -1.144912472
## 441      -0.741285723
## 442      1.974849115
## 443      12.599715590
## 444      2.987053293
## 445      -2.357993413
## 446      6.128558455
## 447      2.323933016
## 448      -10.022047856
## 449      3.151540240
## 450      -3.237824148
## 451      17.733254803
## 452      7.934077350
## 453      -3.123659827
## 454      -5.590316581
## 455      8.369378574
## 456      -0.749228279
## 457      18.025942294

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## 458      3.032522577
## 459      3.080996506
## 460      10.098497264
## 461      9.328722693
## 462      23.519578388
## 463      5.682780259
## 464      4.126557184
## 465      4.550350393
## 466      0.870865027
## 467      -4.872858127
## 468      4.167269400
## 469      10.893457750
## 470      -0.759084649
## 471      -2.707693807
## 472      16.357729933
## 473      -4.874735554
## 474      5.617181972
## 475      -18.799633266
## 476      23.532797583
## 477      8.551498895
## 478      9.611916216
## 479      2.832209608
## 480      5.016420659
## 481      7.424678335
## 482      -1.929120909
## 483      6.684154082
## 484      -15.775410650
## 485      1.330646275
## 486      8.855598406
## 487      3.095560821
## 488      5.540013299
## 489      1.638534730
## 490      3.325819845
## 491      -3.270873701
## 492      5.608084939
## 493      2.325335507
## 494      8.340340172
## 495      5.733456407
## 496      16.029611032
## 497      8.266683919
## 498      6.447232372
## 499      7.269452352
## 500      10.444698447
## 501      15.901565082
## 502      7.938717432
## 503      5.911047362
## 504      1.546281105
## 505      2.773429337
## 506      4.595430602
## 507      6.153446792
## 508      8.726632555
## 509      18.472855471
## 510      12.509604327
## 511      9.924205437

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```

## 512      27.953091196
## 513      1.441872701
## 514      4.068488413
## 515      21.472125033
## 516      21.350995375
## 517      6.239814651
## 518      0.283400546
## 519      -8.846720606
## 520      2.121965876
## 521      13.623400612
## 522      1.979961029
## 523      4.396963660
## 524      -1.683335967
## 525      5.694473245
## 526      9.415348393
## 527      5.494791421
## 528      0.599096309
## 529      8.680770538
## 530      13.648930112
## 531      3.469459063
## 532      -1.817687958
## 533      -9.981564370
## 534      -3.008573472
## 535      -2.865628120
## 536      1.605510643
## 537      0.771290655
## 538      8.761339044
## 539      4.766615190
## 540      -2.888062214
## 541      10.517938086
## 542      13.175970687
## 543      1.755147733
## 544      8.761356604
## 545      -1.855133196
## 546      3.237937175
## 547      7.179972383
## 548      22.267294003
## 549      7.943322767
## 550      30.257973944
## 551      8.058413029
## 552      10.541059595
## 553      4.656426037
## 554      -2.979426574
## 555      5.747169322
## 556      5.289608122
## 557      -2.275247215
## 558      -2.185960689
## 559      -5.491520717
## 560      8.412723527
## 561      -18.709172743
## 562      -5.336485757
## 563      1.042379797
## 564      -5.109132882
## 565      -2.994159861

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```

## 566      -6.159644939
## 567       0.002019645
## 568      -7.442579596
## 569      -1.925210977
## 570      -0.912779580
## 571       5.637307745
## 572      17.507840237
## 573      16.097751583
## 574      8.933158690
## 575      3.479708259
## 576      3.118697203
## 577     -0.894349478
## 578     -12.678209830
## 579     -1.854080369
## 580     14.138530521
## 581      3.812516864
## 582      6.311135937
## 583     -5.799231770
## 584     27.069088444
## 585     18.426594035
## 586     -3.636451225
## 587     -4.567824290
## 588     11.748940578
## 589      2.936984341
## 590     -1.554477433
## 591      4.400871068
## 592     15.258153209
## 593     -11.015587876
## 594     -7.031773146

mutate(atlaspc2, PCH_FSRPTH_16_20 = PCH_FSRPTH_16_20) |>
select(PCH_FSRPTH_16_20)

```

```

##      PCH_FSRPTH_16_20
## 1     -5.53692430
## 2      0.59489169
## 3      5.41615894
## 4     -9.52393436
## 5     -3.38988501
## 6     -0.34308525
## 7     -1.25140984
## 8     -7.84743494
## 9     -0.66148549
## 10    -8.44702656
## 11    -5.92804476
## 12    -7.03805389
## 13    -4.81750855
## 14    -2.09186277
## 15      1.56537181
## 16      0.71336107
## 17   -12.90936786
## 18   -11.71333065
## 19    -5.97245799
## 20    -0.19822819
## 21    -5.88457477

```

```

## 22      -6.27567105
## 23     -12.11378750
## 24      2.87821860
## 25      9.26807295
## 26     -2.16799187
## 27     -0.50432224
## 28      8.75201977
## 29      1.95117784
## 30      3.35926937
## 31     -0.31279499
## 32     -3.06514730
## 33      0.39929743
## 34     -0.06935804
## 35      2.16509950
## 36     -4.83288629
## 37      17.84007273
## 38     -4.97162829
## 39      4.21456845
## 40     -1.91716616
## 41      3.35531322
## 42      4.64533278
## 43      3.51781684
## 44     -1.65074328
## 45     -2.40122777
## 46     -2.47922359
## 47     -1.05517901
## 48     -1.37073134
## 49      1.28036133
## 50     -6.36106808
## 51      22.58278608
## 52      0.04002445
## 53      0.42021186
## 54      2.33038998
## 55     -0.63910506
## 56     -1.60534658
## 57     -1.87986558
## 58      0.83240439
## 59      2.75523069
## 60      3.68850230
## 61      2.12897814
## 62     -7.93578343
## 63      9.03285866
## 64      4.35069920
## 65     -3.24904710
## 66     -4.57189170
## 67     -6.48219664
## 68     -13.12902214
## 69     -10.16484657
## 70      22.20899652
## 71     -3.40399048
## 72     -3.75960741
## 73      0.29119596
## 74     -1.22987193
## 75      1.18100851

```

```

## 76      -1.55170834
## 77       3.25779986
## 78      -5.86938905
## 79      -6.54989767
## 80       7.77154625
## 81      -6.89080471
## 82      -0.62340238
## 83      -6.55990481
## 84      -0.32379391
## 85       1.00599058
## 86       2.24166095
## 87      -1.26544976
## 88      -10.85866810
## 89       1.58209139
## 90      11.16596044
## 91       6.37237609
## 92      -12.01255431
## 93      -4.23373644
## 94      -0.24405729
## 95      -0.78437868
## 96      -2.33459653
## 97       4.31824662
## 98       0.28750424
## 99      -14.11731068
## 100     -1.63051251
## 101     13.82279660
## 102     -2.85566637
## 103     2.63886884
## 104     1.52421790
## 105     6.06653742
## 106     5.32683602
## 107     11.95545007
## 108     -8.34622878
## 109     16.30181096
## 110     2.32546820
## 111     -3.14191533
## 112     -2.95375591
## 113     -3.90861548
## 114     -11.24333964
## 115     -11.30372002
## 116     3.33201489
## 117     5.37269963
## 118     3.32488314
## 119     0.78943141
## 120     5.20669985
## 121     -15.84551733
## 122     2.79081315
## 123     -7.54923183
## 124     0.04948190
## 125     -0.71939990
## 126     -6.07168633
## 127     -0.37856436
## 128     -4.58950267
## 129     -9.22804658

```

```

## 130      -7.83358059
## 131       6.14716839
## 132       6.25160590
## 133      -0.47357530
## 134       0.85918683
## 135      -1.05917091
## 136       5.06432562
## 137       5.29863106
## 138      13.09000126
## 139      14.48847272
## 140      -0.32738511
## 141       2.16277339
## 142       5.83571114
## 143       1.76076443
## 144       7.31853917
## 145     -13.18689238
## 146      -3.67031623
## 147       6.29949231
## 148      10.17257217
## 149      -7.01005852
## 150      -2.42399945
## 151       2.46756444
## 152      13.46413355
## 153       2.70694062
## 154      -2.93656872
## 155       0.69060486
## 156     -16.39955813
## 157       4.88974054
## 158      -1.22961856
## 159      27.70006131
## 160       7.54476687
## 161       3.79435136
## 162      -2.18577505
## 163       5.29785689
## 164       4.08616228
## 165      -2.82072116
## 166       2.97857303
## 167       6.33648969
## 168       9.01892521
## 169       3.59190599
## 170       5.88722060
## 171       5.67657725
## 172     -7.71135238
## 173      -2.06195864
## 174       2.79151640
## 175      -0.84727607
## 176       2.93005809
## 177      -3.44261986
## 178      18.64224415
## 179     -10.65202694
## 180      -7.66426452
## 181     -12.35703713
## 182     -10.28308868
## 183      -3.61224294

```

```

## 184      -3.88018648
## 185       8.14984746
## 186        2.35579475
## 187     -6.00829192
## 188     -5.23175281
## 189      17.59858620
## 190     -5.52747385
## 191      5.38822005
## 192     -3.15477246
## 193     -7.26934775
## 194     -7.73077225
## 195     -1.74761681
## 196     -1.04420027
## 197     -1.78467050
## 198      3.54956023
## 199     -2.71793874
## 200     -1.99052391
## 201      5.84198155
## 202      8.72054417
## 203      6.14389963
## 204     -0.19386453
## 205     19.32415848
## 206     -4.51251464
## 207      0.10774759
## 208    -19.66926529
## 209     -0.22467165
## 210     -1.15245966
## 211    -10.30928166
## 212     -2.26091585
## 213     -4.63515556
## 214      3.35308130
## 215     -4.06228611
## 216    -19.50337030
## 217      0.05416667
## 218     -8.42279030
## 219      4.71901599
## 220     -0.70941656
## 221     -3.97956801
## 222      2.22602726
## 223     -5.64091598
## 224      9.84438132
## 225     -3.86009058
## 226      3.15846484
## 227     10.51797730
## 228     -2.70368805
## 229     -9.14393246
## 230     -3.46629385
## 231      0.43629616
## 232     -3.33876479
## 233    -13.65919520
## 234     -3.37366232
## 235     -3.11957155
## 236     -7.54962508
## 237     -1.17184198

```

```
## 238      -2.90799927
## 239      -6.88181480
## 240      -3.90732159
## 241      -8.45442745
## 242       0.29929644
## 243      -6.85205163
## 244      -2.91910659
## 245       3.84576522
## 246      43.46849886
## 247      -6.25198599
## 248     14.15637891
## 249      -8.96334089
## 250      -2.14498827
## 251       0.21793059
## 252      -6.28822779
## 253      -4.93193113
## 254     10.82919312
## 255      0.77243965
## 256      -0.78956367
## 257      -6.54800525
## 258       5.98721725
## 259      -0.81148519
## 260     19.27366242
## 261       9.52604350
## 262      -2.63895370
## 263      3.34846593
## 264      -2.40654635
## 265      -8.10623626
## 266      -0.02790335
## 267      -5.49960740
## 268      -9.39074860
## 269      -4.45748622
## 270     26.39524508
## 271      5.86365166
## 272       2.68975480
## 273       0.74797266
## 274      8.13436564
## 275      -2.93696984
## 276     -16.44909757
## 277      -8.08632907
## 278      -3.96393638
## 279      -7.46958512
## 280      -9.70376778
## 281      4.42197546
## 282      -0.84492191
## 283      -4.54670921
## 284      -5.85333040
## 285      1.86337725
## 286      3.06714633
## 287      5.29957565
## 288      -3.32322396
## 289      -1.43166236
## 290      -2.56844394
## 291      -2.66195608
```

```

## 292      -10.54299312
## 293      -2.45784904
## 294       7.54588831
## 295     -11.59113685
## 296     -1.48169035
## 297    -21.97118025
## 298    -3.61887673
## 299    -5.50631005
## 300   -13.43437763
## 301      1.29773978
## 302     -8.23208193
## 303      1.52949048
## 304     -2.00182549
## 305      6.03133367
## 306      6.01315624
## 307      0.28071746
## 308     -9.76258833
## 309      4.75928583
## 310      1.62580613
## 311      0.11106892
## 312     -9.82859908
## 313     -11.29715048
## 314      6.60186463
## 315     -5.49845881
## 316     -0.51766264
## 317      2.78211985
## 318     -5.08104465
## 319      0.96670938
## 320     -1.31505583
## 321     -6.36671152
## 322      14.09425249
## 323     -1.00190721
## 324     -5.92348422
## 325     -12.34337103
## 326      0.43812673
## 327     -3.47429650
## 328      1.70575180
## 329     -6.40592773
## 330      3.20225921
## 331     -5.59125068
## 332     -11.70148847
## 333     -15.00518969
## 334     -8.37988798
## 335     -6.33540527
## 336     -5.33715702
## 337      0.24033649
## 338      3.20182920
## 339     -3.75300659
## 340     -7.20500632
## 341     -0.74004695
## 342      0.37052224
## 343     -8.36834823
## 344     -1.48241008
## 345     -7.31000232

```

```

## 346      -5.92844906
## 347       6.25691620
## 348      -6.32810808
## 349      -4.38880450
## 350      -8.78087769
## 351      -8.27995065
## 352     -16.05470771
## 353      1.43086041
## 354      5.08454914
## 355     -3.25010596
## 356     -0.93199705
## 357     -3.80703793
## 358     -3.41796237
## 359      1.84294263
## 360      1.35917104
## 361      7.70931999
## 362      2.47541983
## 363      0.04159288
## 364      4.66737854
## 365     10.08089089
## 366     -0.12701786
## 367     -6.46163204
## 368      5.17443049
## 369      7.38149242
## 370      0.57865136
## 371      2.26265631
## 372     -4.81240102
## 373      5.79300590
## 374     -9.29658182
## 375     19.44708731
## 376     -8.14176647
## 377      8.19733806
## 378     -4.06121100
## 379     11.84555364
## 380      7.00224105
## 381     -1.41219946
## 382     10.80010130
## 383     -0.13524711
## 384      0.59020799
## 385     -1.42915222
## 386      1.63961155
## 387    -10.98402670
## 388      1.79341034
## 389      4.15795411
## 390     -3.95708181
## 391      0.55962854
## 392     -1.60068920
## 393     -7.62819585
## 394      6.09858863
## 395     -0.68064686
## 396     -1.67997213
## 397      4.68684194
## 398    -10.72670051
## 399     -2.28774109

```

```

## 400      -13.02569206
## 401      -0.01168254
## 402       9.76676123
## 403      -1.51360645
## 404      -4.47477235
## 405       0.04592656
## 406       3.08324475
## 407      1.21929474
## 408      5.87399066
## 409     -13.25554511
## 410       4.58381295
## 411     10.43332858
## 412       2.54488752
## 413       2.42032245
## 414      5.39840970
## 415      27.41306475
## 416      -8.57772771
## 417      -6.05385390
## 418      -2.80162839
## 419       3.95365121
## 420       3.96394744
## 421      -7.75985239
## 422      -3.31329495
## 423       4.80958292
## 424      -3.95725363
## 425       8.01546104
## 426      -1.39264847
## 427     -16.76661494
## 428       2.97055375
## 429       8.52593326
## 430       1.00546717
## 431       7.34340063
## 432      -0.52436944
## 433       0.06706584
## 434       0.77917340
## 435      -9.83682713
## 436       0.48979667
## 437      -5.17590773
## 438      -0.90716593
## 439       5.22632003
## 440      -2.86883452
## 441       4.85882222
## 442       1.44095468
## 443     -16.20155256
## 444       4.00672625
## 445     -13.61727972
## 446      -4.21093909
## 447       0.35848542
## 448      -6.62321555
## 449      -1.54821741
## 450      -3.63991118
## 451      -7.32792755
## 452       3.78276072
## 453      3.06877715

```

```

## 454      3.06792146
## 455      0.48817087
## 456      3.87593352
## 457     -11.48054783
## 458     -1.13355382
## 459     -7.27624196
## 460     -6.06634839
## 461     -4.84277243
## 462     -3.14001088
## 463     -3.82760213
## 464     -1.24610017
## 465     -6.75238351
## 466      5.94281674
## 467     -8.01519879
## 468     -0.81852911
## 469     14.07069953
## 470     -0.90053851
## 471      0.63081933
## 472     -4.46417556
## 473     -0.20600504
## 474      2.89283231
## 475     -0.91011970
## 476    -18.90520342
## 477      0.65093669
## 478    11.11710095
## 479      0.05134469
## 480     -3.47388309
## 481     -0.83875599
## 482     -3.69865074
## 483      2.21053345
## 484     -7.64947238
## 485      4.02797898
## 486      5.10356017
## 487    -14.74461171
## 488      5.29849752
## 489     -0.82581829
## 490     -8.31883887
## 491    31.02260647
## 492     -2.04958638
## 493     -2.53276786
## 494      2.05272905
## 495      7.26272211
## 496      1.20983709
## 497     -0.51365483
## 498    -16.37431947
## 499      5.91097508
## 500      1.02925795
## 501    13.80706832
## 502     -0.56283791
## 503      6.91625811
## 504      8.70364922
## 505     -0.24439429
## 506     -7.84682059
## 507      5.94933120

```

```
## 508      -11.82224838
## 509      -0.71378573
## 510      2.22646761
## 511      -9.33258791
## 512      -19.06743545
## 513      5.01736161
## 514      -10.01318385
## 515      -2.71421107
## 516      1.02736943
## 517      -4.85008349
## 518      13.18270743
## 519      -4.38056265
## 520      12.31869412
## 521      -11.98187676
## 522      -3.92371335
## 523      31.05388220
## 524      -4.50582276
## 525      0.67774370
## 526      0.16408780
## 527      -7.40164788
## 528      -1.38269475
## 529      2.23360114
## 530      -5.38203174
## 531      -15.03766388
## 532      2.58853826
## 533      -10.37125254
## 534      -5.00429218
## 535      0.82568213
## 536      -8.30045973
## 537      -17.87113260
## 538      -13.40359531
## 539      -1.50146423
## 540      1.24435542
## 541      -0.04837347
## 542      -5.72668013
## 543      -2.67686246
## 544      -0.60027089
## 545      -13.83233081
## 546      -15.09992918
## 547      -1.25536766
## 548      0.28015366
## 549      4.54144281
## 550      4.50778640
## 551      -0.83247465
## 552      -4.58789046
## 553      1.33400117
## 554      0.32808837
## 555      0.25243032
## 556      3.00883537
## 557      2.61099164
## 558      -16.94187820
## 559      8.77335458
## 560      -4.55271633
## 561      9.06519170
```

```

## 562      -2.07816637
## 563       0.10488430
## 564      -0.42091687
## 565      -2.27184478
## 566       4.33419794
## 567       0.19178171
## 568      -6.88500295
## 569       9.21965856
## 570      -3.05821627
## 571       1.25572701
## 572      -1.39943068
## 573      -6.77975833
## 574      -2.64067521
## 575       6.98749926
## 576      -3.35485359
## 577      -2.73135939
## 578       0.28854597
## 579      -6.85196792
## 580     -13.13603680
## 581       1.52281138
## 582       3.17490372
## 583      -9.77135053
## 584       0.77369359
## 585       1.11465389
## 586      -1.05528684
## 587      -0.64595681
## 588      -0.17094259
## 589       6.01259537
## 590       6.84940896
## 591       0.06979283
## 592      -1.06157517
## 593      -0.73608544
## 594      -3.97647383

mutate(atlaspc2, PCH_PC_DIRSALES_12_17 = PCH_PC_DIRSALES_12_17) |>
  select(PCH_PC_DIRSALES_12_17)

##      PCH_PC_DIRSALES_12_17
## 1      79.01234568
## 2      88.97058824
## 3      36.06557377
## 4      -7.78443114
## 5     -15.63342318
## 6     158.21917808
## 7      12.73996510
## 8     -40.96385542
## 9     -38.72549020
## 10     74.69879518
## 11     -32.69230769
## 12     123.78048780
## 13     -70.00964320
## 14     723.56687898
## 15     -44.74885845
## 16     -33.96226415
## 17     -50.83586626

```

```

## 18      0.20790021
## 19      350.45161290
## 20      441.91919192
## 21      10.30927835
## 22      50.88757396
## 23      105.00000000
## 24      -22.75862069
## 25      473.17073171
## 26      54.56431535
## 27      831.78294574
## 28      318.20568928
## 29      28.05970149
## 30      47.09208848
## 31      55.94087550
## 32      484.43396226
## 33      199.79797980
## 34      1910.49250535
## 35      -41.57872520
## 36      -2.07197383
## 37      -9.87611539
## 38      1214.57737852
## 39      -24.86033520
## 40      130.58752271
## 41      502.22061308
## 42      119.68805932
## 43      24.20147420
## 44      41.13718253
## 45      26.46036551
## 46      586.55676411
## 47      334.60837887
## 48      959.90453461
## 49      174.12451362
## 50      6.46031338
## 51      -21.23552124
## 52      254.12810070
## 53      682.68122164
## 54      393.65183246
## 55      1066.41550054
## 56      53.17810352
## 57      865.42688081
## 58      83.78951835
## 59      91.23505976
## 60      20.53571429
## 61      -32.85795779
## 62      -28.57142857
## 63      40.16393443
## 64      248.88888889
## 65      252.94117647
## 66      -17.80366057
## 67      132.30464326
## 68      -17.80538302
## 69      46.84479818
## 70      528.20037106
## 71      428.45528455

```

```

## 72          68.36323691
## 73          0.00000000
## 74          26.74418605
## 75          277.77777778
## 76          41.96185286
## 77          8.00000000
## 78          72.72727273
## 79          288.77551020
## 80          -56.66666667
## 81          118.62745098
## 82          127.90697674
## 83          18.45637584
## 84          9.36170213
## 85          21.45178765
## 86          402.19780220
## 87          -7.74058577
## 88          90.31719533
## 89          34.64566929
## 90          13.26530612
## 91          44.84781812
## 92          -18.00000000
## 93          77.46478873
## 94          185.82089552
## 95          1007.14285714
## 96          -6.94896851
## 97          -30.12589928
## 98          32.14285714
## 99          124.83069977
## 100         305.71428571
## 101         43.21608040
## 102         1147.16981132
## 103         -52.33644860
## 104         775.10917031
## 105         -20.00000000
## 106         -49.15254237
## 107         68.60465116
## 108         117.64705882
## 109         0.00000000
## 110         -58.82352941
## 111         -24.77064220
## 112         103.12500000
## 113         -87.16216216
## 114         -32.50000000
## 115         101.37931034
## 116         -3.55329949
## 117         -60.00000000
## 118         118.18181818
## 119         -0.80000000
## 120         -42.65232975
## 121         414.58333333
## 122         0.00000000
## 123         595.23809524
## 124         1600.00000000
## 125         -55.55555556

```

```

## 126      181.95388953
## 127      110.17262639
## 128      -2.13963964
## 129      6.01626016
## 130      15.69767442
## 131      -30.41474654
## 132      76.06084868
## 133      -6.03248260
## 134      -6.04534005
## 135      72.65135699
## 136      269.17562724
## 137      100.63694268
## 138      103.09951060
## 139      147.56097561
## 140      -19.39218524
## 141      -14.01000715
## 142      -79.30622010
## 143      32.69129288
## 144      52.49343832
## 145      -39.36170213
## 146      7.34299517
## 147      -3.36134454
## 148      -54.00000000
## 149      285.52631579
## 150      -49.49748744
## 151      134.07407407
## 152      -51.23318386
## 153      6.59340659
## 154      -5.22151899
## 155      137.08920188
## 156      -70.12847966
## 157      126.06837607
## 158      -9.10990389
## 159      21.33333333
## 160      -31.85840708
## 161      29.30555556
## 162      284.82490272
## 163      -15.43209877
## 164      66.21983914
## 165      22.11302211
## 166      68.69158879
## 167      -10.88607595
## 168      31.14035088
## 169      -12.33123312
## 170      -71.16060961
## 171      -64.45366528
## 172      47.22222222
## 173      40.21739130
## 174      498.92761394
## 175      5.96026490
## 176      40.02624672
## 177      37.68115942
## 178      -52.35404896
## 179      149.06250000

```

```

## 180      -50.17301038
## 181      23.34004024
## 182      -81.81818182
## 183      -34.20074349
## 184      -47.82608696
## 185      -53.84615385
## 186      -31.25000000
## 187      8.07453416
## 188      73.42657343
## 189      172.78287462
## 190      20.42553191
## 191      112.85714286
## 192      -17.09401709
## 193      84.65909091
## 194      222.40437158
## 195      -42.85714286
## 196      136.05015674
## 197      -10.81967213
## 198      -30.61224490
## 199      -84.54545455
## 200      32.72727273
## 201      72.07792208
## 202      63.33333333
## 203      400.00000000
## 204      199.31506849
## 205      -13.14655172
## 206      -25.58139535
## 207      230.43478261
## 208      34.78260870
## 209      86.19094813
## 210      56.96629213
## 211      -15.49364614
## 212      103.46820809
## 213      5.00000000
## 214      169.05882353
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## 216      254.05797101
## 217      -26.27291242
## 218      312.41526935
## 219      99.31153184
## 220      136.69600542
## 221      99.28360725
## 222      16.22562674
## 223      52.97176820
## 224      180.64516129
## 225      133.20440345
## 226      -30.94736842
## 227      0.00000000
## 228      21.87500000
## 229      68.88086643
## 230      -41.05827194
## 231      65.25950292
## 232      -8.25471698
## 233      8.89887640

```

```

## 234      221.85863874
## 235      40.81967213
## 236      156.83090705
## 237      8.62068966
## 238      192.70666037
## 239      -16.48793566
## 240      74.15787683
## 241      47.40484429
## 242      15.71428571
## 243      0.64377682
## 244      35.57446809
## 245      230.93980993
## 246      85.15625000
## 247      -13.78708551
## 248      47.60213144
## 249      20.86190010
## 250      36.28808864
## 251      20.23217247
## 252      9.87903226
## 253      78.67142465
## 254      78.80184332
## 255      652.56410256
## 256      197.66081871
## 257      46.26256281
## 258      -16.12903226
## 259      -21.74721190
## 260      51.93798450
## 261      29.40298507
## 262      104.53527436
## 263      73.53603604
## 264      -0.47318612
## 265      -48.87218045
## 266      -14.68531469
## 267      -14.93506494
## 268      149.73958333
## 269      -44.84797297
## 270      -65.20787746
## 271      -12.85008237
## 272      70.30567686
## 273      -7.78341794
## 274      120.95671982
## 275      -10.85080148
## 276      4.74214582
## 277      60.57507987
## 278      -42.60869565
## 279      160.36866359
## 280      45.45454545
## 281      -43.27731092
## 282      17.02702703
## 283      36.40776699
## 284      73.77690802
## 285      48.07692308
## 286      180.34682081
## 287      216.50485437

```

```

## 288      170.34482759
## 289      137.30769231
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## 292      134.18719212
## 293      27.85388128
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## 296      73.66071429
## 297      297.29729730
## 298      -18.45102506
## 299      34.18367347
## 300      91.30434783
## 301      86.66666667
## 302      88.45188285
## 303      9.22643030
## 304      38.49802372
## 305      93.57834420
## 306      43.45344274
## 307      62.70827022
## 308      129.25577417
## 309      557.66423358
## 310      53.74015748
## 311      236.73239437
## 312      283.01886792
## 313      67.05202312
## 314      99.79312128
## 315      139.12024987
## 316      438.11320755
## 317      69.58981612
## 318      279.98610146
## 319      273.81386861
## 320      427.55798090
## 321      663.87559809
## 322      104.79069767
## 323      -70.77464789
## 324      1313.15789474
## 325      6.01671309
## 326      761.32075472
## 327      -4.17362270
## 328      5.61056106
## 329      203.04386750
## 330      0.00000000
## 331      51.76678445
## 332      31.92090395
## 333      124.72035794
## 334      38.49416755
## 335      -5.16147636
## 336      96.85658153
## 337      -34.52768730
## 338      89.37198068
## 339      40.64297800
## 340      0.00000000
## 341      20.99009901

```

```

## 342      68.08585503
## 343      31.43459916
## 344      261.65803109
## 345      -3.34479112
## 346      77.84090909
## 347      70.41053447
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## 349      65.98360656
## 350      49.89185292
## 351      215.46803653
## 352      -17.03703704
## 353      209.34913890
## 354      -23.16043426
## 355      207.44863014
## 356      0.43859649
## 357      204.92125984
## 358      48.21092279
## 359      39.26380368
## 360      295.94594595
## 361      53.01204819
## 362      93.85964912
## 363      314.78260870
## 364      -22.57462687
## 365      -13.21428571
## 366      469.67370441
## 367      140.10282776
## 368      167.36842105
## 369      -23.52941176
## 370      -34.64566929
## 371      -36.76470588
## 372      67.84313725
## 373      582.56880734
## 374      -68.25726141
## 375      256.00000000
## 376      -6.45161290
## 377      228.57142857
## 378      -76.76767677
## 379      22.32620321
## 380      46.17940199
## 381      35.93155894
## 382      146.17940199
## 383      41.03194103
## 384      59.94291151
## 385      110.43478261
## 386      30.94629156
## 387      57.24020443
## 388      20.54140127
## 389      17.69759450
## 390      91.25248509
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## 392      8.88888889
## 393      -17.83625731
## 394      1.98412698
## 395      83.52534562

```

## 396	85.28006947
## 397	-16.01532567
## 398	0.11668611
## 399	253.20855615
## 400	35.20000000
## 401	0.07347539
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## 403	-29.30374904
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## 405	51.30568356
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## 407	-17.43589744
## 408	139.72602740
## 409	316.92307692
## 410	492.43243243
## 411	-10.61007958
## 412	4.77732794
## 413	87.28787411
## 414	-40.90909091
## 415	-31.13207547
## 416	-5.94059406
## 417	87.55506608
## 418	166.32595116
## 419	302.03679369
## 420	39.35052531
## 421	6.13718412
## 422	76.52898422
## 423	-67.22365039
## 424	-2.23438212
## 425	-11.02871568
## 426	-39.76884686
## 427	941.95338513
## 428	35.33558075
## 429	812.59899208
## 430	157.52293578
## 431	69.00072939
## 432	145.20817935
## 433	-17.15145436
## 434	160.07822686
## 435	9.05644482
## 436	192.50197316
## 437	235.77981651
## 438	-38.46153846
## 439	294.94186047
## 440	1293.57541899
## 441	-70.58823529
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## 443	56.44067797
## 444	124.87930480
## 445	17.26618705
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## 447	65.86941927
## 448	71.24582870
## 449	162.22775358

```

## 450      -13.66711773
## 451      -0.08298755
## 452      103.50378788
## 453      27.52941176
## 454      232.37250554
## 455      21.72797263
## 456      94.44444444
## 457      -55.75268817
## 458      18.62999481
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## 460      53.50877193
## 461      -23.82608696
## 462      51.95195195
## 463      -59.12698413
## 464      -2.25118483
## 465      -24.10714286
## 466      -30.57119871
## 467      79.26829268
## 468      -88.24101069
## 469      156.88073394
## 470      -7.81250000
## 471      17.20720721
## 472      280.43478261
## 473      37.47826087
## 474      -44.28571429
## 475      -53.54330709
## 476      169.76744186
## 477      21.94092827
## 478      631.49606299
## 479      -37.46556474
## 480      43.56617647
## 481      892.45283019
## 482      101.66666667
## 483      33.56643357
## 484      -25.96685083
## 485      46.34146341
## 486      128.92561983
## 487      110.52631579
## 488      101.98675497
## 489      10.73318216
## 490      -28.40375587
## 491      -48.00000000
## 492      -16.08695652
## 493      -53.40909091
## 494      -89.12037037
## 495      -31.46853147
## 496      -37.50000000
## 497      66.96035242
## 498      259.74025974
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## 501      4.16666667
## 502      -17.32673267
## 503      -41.05960265

```

## 504	76.21951220
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## 507	-31.84615385
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## 510	-4.90797546
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## 512	-61.90476190
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## 515	-54.86284289
## 516	361.53846154
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## 518	38.29787234
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## 522	-45.45454545
## 523	-31.25000000
## 524	-44.56721915
## 525	614.04958678
## 526	-35.55555556
## 527	10.52631579
## 528	757.49385749
## 529	-48.25174825
## 530	7.14285714
## 531	-21.66666667
## 532	57.73710483
## 533	374.54545455
## 534	-34.79359730
## 535	126.28062361
## 536	-45.83602324
## 537	-32.57142857
## 538	37.43409490
## 539	63.93144638
## 540	52.54041570
## 541	705.93406593
## 542	55.69620253
## 543	395.36507937
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## 549	0.00000000
## 550	0.00000000
## 551	0.00000000
## 552	0.00000000
## 553	0.00000000
## 554	0.00000000
## 555	295.23809524
## 556	135.49883991
## 557	-1.65484634

```

## 558      199.51456311
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## 561     -40.49751244
## 562      74.87666034
## 563      13.08056872
## 564      94.13008990
## 565     174.49297972
## 566     147.46963563
## 567     -31.66157872
## 568      7.43398393
## 569     523.87706856
## 570      89.13043478
## 571      6.37989367
## 572     -50.66666667
## 573     14.14141414
## 574     -23.85321101
## 575      67.02127660
## 576      28.24175824
## 577      37.15549507
## 578      31.65938865
## 579     -8.41784990
## 580     14.47368421
## 581     103.63036304
## 582      77.35849057
## 583     -57.94947994
## 584     -11.79883946
## 585      70.45075125
## 586      30.90803260
## 587      9.24242424
## 588      84.75894246
## 589     -14.49399657
## 590      44.06229721
## 591      30.45454545
## 592      58.71559633
## 593     135.67839196
## 594     110.14492754

cor(atlaspc2)

##          PCH_LACCESS_POP_15_19 PCH_GROCPTH_16_20
## PCH_LACCESS_POP_15_19      1.000000000 -0.084206775
## PCH_GROCPTH_16_20     -0.084206775  1.000000000
## PCH_SUPERCPTH_16_20      0.018425037  0.008091590
## PCH_CONVSPTH_16_20     -0.001400242 -0.119616952
## PCH_SPECSPTH_16_20      0.006932067 -0.063737757
## PCH_SNAPSPTH_17_23     -0.004985344  0.098718445
## PCH_WICSPTH_16_22     -0.032020566 -0.005017603
## PCH_FFRPTH_16_20     -0.109084416  0.061274962
## PCH_FSRPTH_16_20      0.141752309  0.013515837
## PCH_PC_DIRSALES_12_17   -0.041513549  0.050895256
##          PCH_SUPERCPTH_16_20 PCH_CONVSPTH_16_20 PCH_SPECSPTH_16_20
## PCH_LACCESS_POP_15_19      0.018425037 -0.001400242  0.006932067
## PCH_GROCPTH_16_20      0.008091590 -0.119616952 -0.063737757
## PCH_SUPERCPTH_16_20      1.000000000  0.147948020 -0.007705825

```

```

## PCH_CONVSPTH_16_20          0.147948020    1.000000000    0.026224555
## PCH_SPECSPTH_16_20         -0.007705825    0.026224555    1.000000000
## PCH_SNAPSPTH_17_23          0.037958390   -0.007140006    0.040959877
## PCH_WICSPTH_16_22          -0.022902150    0.023093921   -0.039133197
## PCH_FFRPTH_16_20           -0.016784759   -0.043905615    0.034036418
## PCH_FSRPTH_16_20            -0.029449275    0.080128354    0.047073748
## PCH_PC_DIRSALES_12_17       0.067257365    0.020570372   -0.025135601
##                               PCH_SNAPSPTH_17_23 PCH_WICSPTH_16_22 PCH_FFRPTH_16_20
## PCH_LACCESS_POP_15_19        -0.004985344   -0.032020566   -0.10908442
## PCH_GROCPTH_16_20            0.098718445   -0.005017603    0.06127496
## PCH_SUPERCPTH_16_20           0.037958390   -0.022902150   -0.01678476
## PCH_CONVSPTH_16_20            -0.007140006    0.023093921   -0.04390562
## PCH_SPECSPTH_16_20             0.040959877   -0.039133197    0.03403642
## PCH_SNAPSPTH_17_23           1.000000000   -0.020451183    0.02622866
## PCH_WICSPTH_16_22            -0.020451183    1.000000000   -0.02190272
## PCH_FFRPTH_16_20              0.026228664   -0.021902718    1.000000000
## PCH_FSRPTH_16_20              0.048516764    0.007131612   -0.08847977
## PCH_PC_DIRSALES_12_17        -0.048479520   -0.032939935    0.05535931
##                               PCH_FSRPTH_16_20 PCH_PC_DIRSALES_12_17
## PCH_LACCESS_POP_15_19          0.141752309   -0.04151355
## PCH_GROCPTH_16_20              0.013515837    0.05089526
## PCH_SUPERCPTH_16_20            -0.029449275    0.06725736
## PCH_CONVSPTH_16_20              0.080128354    0.02057037
## PCH_SPECSPTH_16_20              0.047073748   -0.02513560
## PCH_SNAPSPTH_17_23              0.048516764   -0.04847952
## PCH_WICSPTH_16_22              0.007131612   -0.03293993
## PCH_FFRPTH_16_20              -0.088479766    0.05535931
## PCH_FSRPTH_16_20              1.000000000   -0.03822234
## PCH_PC_DIRSALES_12_17        -0.038222337    1.000000000
mshapiro.test(t(atlaspc2[,1:9]))

```

```

##
## Shapiro-Wilk normality test
##
## data: Z
## W = 0.13286, p-value < 2.2e-16
atlaspc2_long <- atlaspc2 |>
  pivot_longer(cols = c("PCH_GROCPTH_16_20", "PCH_SUPERCPTH_16_20", "PCH_CONVSPTH_16_20", "PCH_SPECSPTH_16_20"),
                names_to = "sources",
                values_to = "food")
atlaspc2_long

## # A tibble: 5,346 x 3
##      PCH_LACCESS_POP_15_19 sources          food
##      <dbl> <chr>          <dbl>
## 1      -1.32 PCH_GROCPTH_16_20     -9.38
## 2      -1.32 PCH_SUPERCPTH_16_20     16.5 
## 3      -1.32 PCH_CONVSPTH_16_20    -9.38
## 4      -1.32 PCH_SPECSPTH_16_20    -2.66
## 5      -1.32 PCH_SNAPSPTH_17_23     3.40 
## 6      -1.32 PCH_WICSPTH_16_22    -20.4 
## 7      -1.32 PCH_FFRPTH_16_20    -0.0822
## 8      -1.32 PCH_FSRPTH_16_20    -5.54 

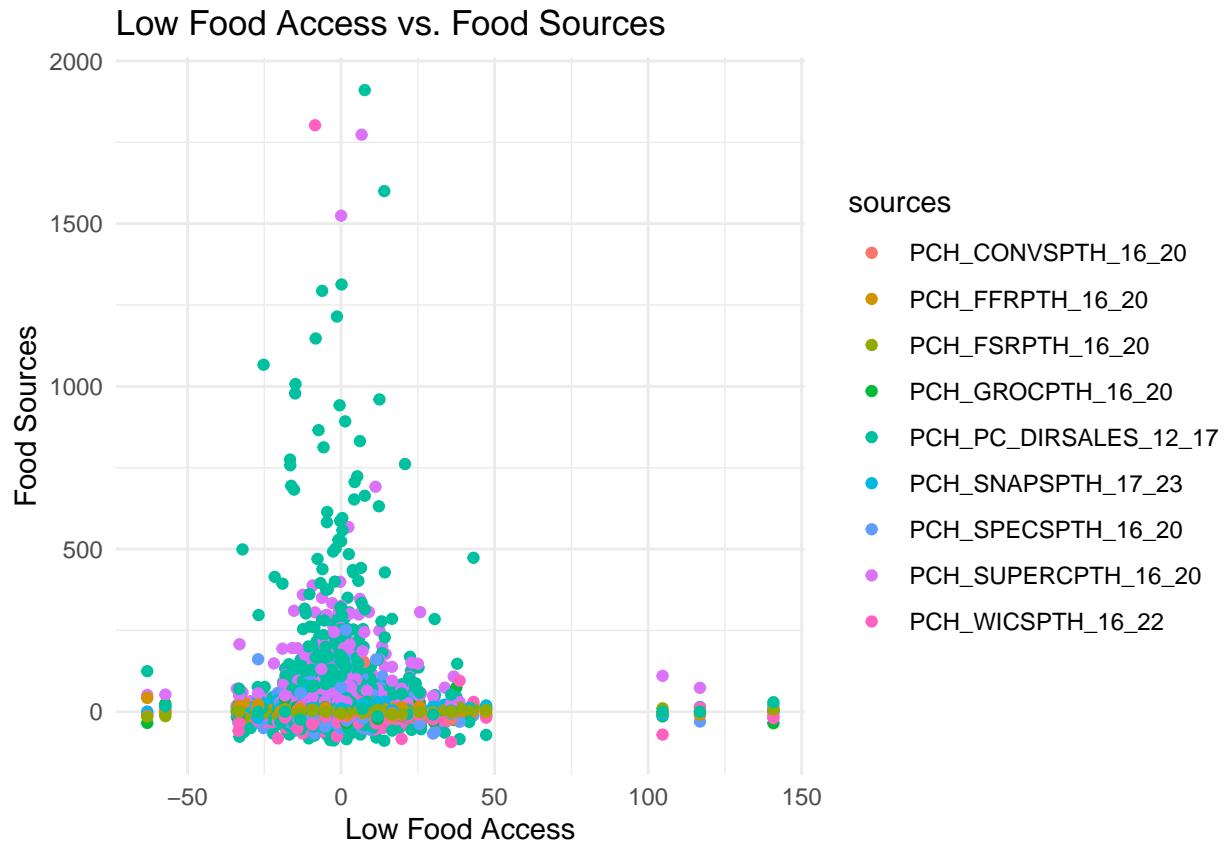
```

```

##  9          -1.32 PCH_PC_DIRSALES_12_17  79.0
## 10          -8.19 PCH_GROCPTH_16_20      -2.09
## # i 5,336 more rows

options(repr.plot.width = NULL, repr.plot.height = NULL)
ggplot(atlaspc2_long, aes(x = PCH_LACCESS_POP_15_19, y = food, color = sources)) +
  geom_point() +
  labs(title = "Low Food Access vs. Food Sources",
       x = "Low Food Access",
       y = "Food Sources") +
  theme_minimal()

```



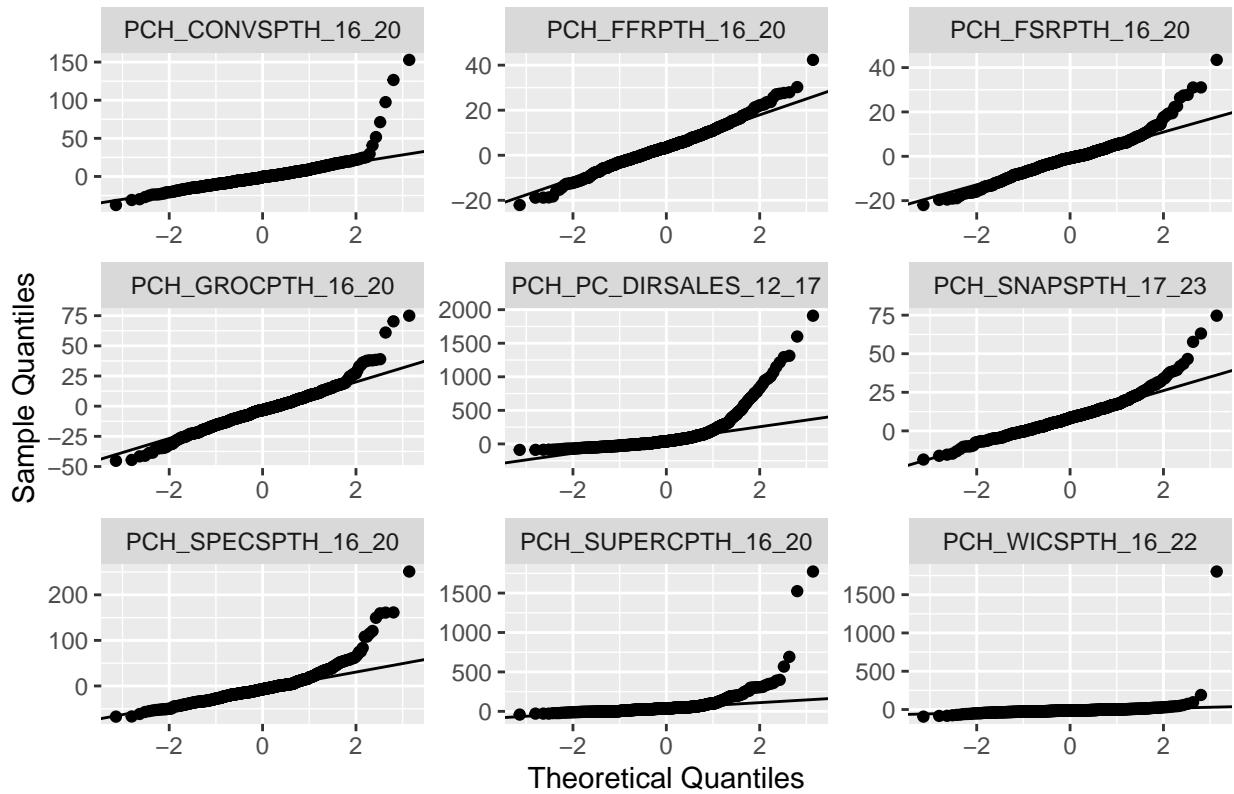
```

options(repr.plot.width = 8, repr.plot.height = 3)

ggplot(atlaspc2_long, aes(sample = food)) +
  stat_qq() +
  stat_qq_line() +
  facet_wrap(~sources, scales = "free") +
  labs(title = "Q-Q Plots for Food Sources",
       x = "Theoretical Quantiles", y = "Sample Quantiles")

```

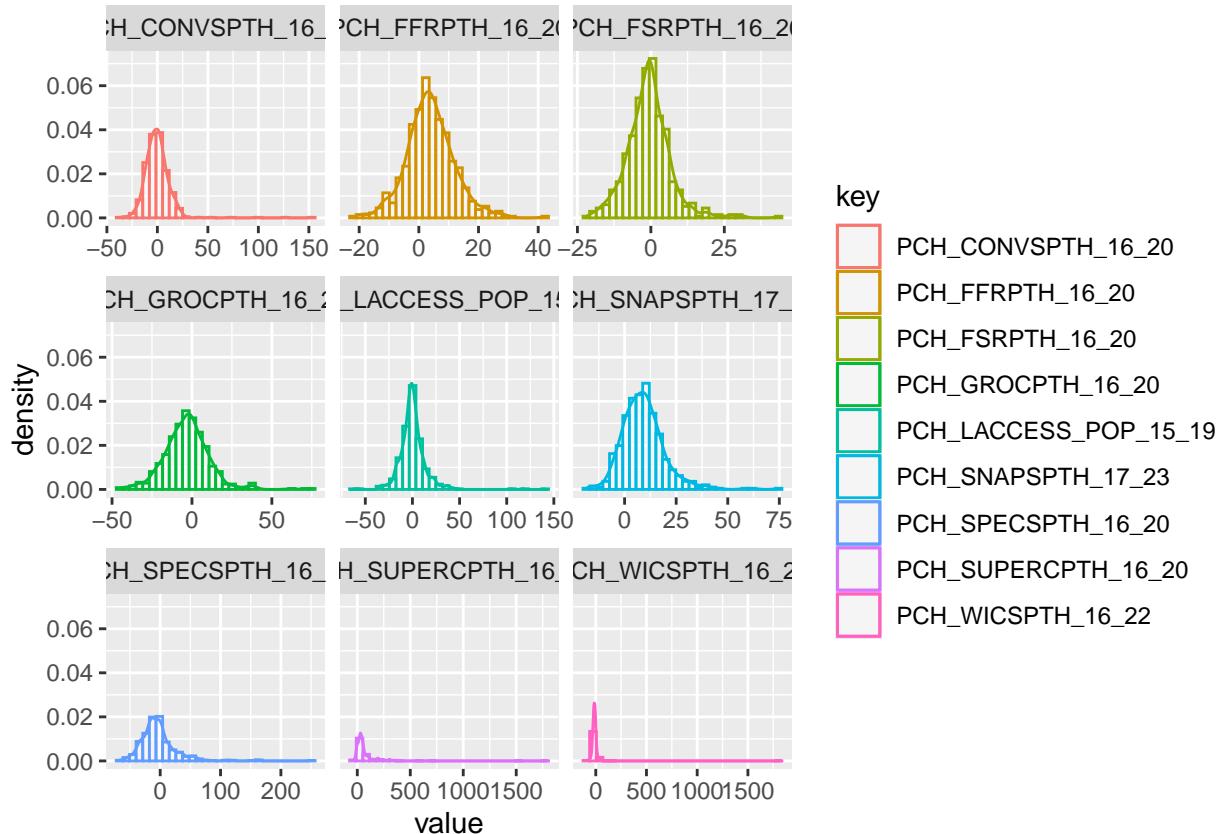
## Q–Q Plots for Food Sources



```
options(repr.plot.width = 8, repr.plot.height = 3)

d <- gather(atlaspct2[,c(1:9)])
ggplot(d,aes(x = value, color=key)) +
  facet_wrap(~key,scales = "free_x") +
  geom_histogram(aes(y=after_stat(density)), alpha=0.5,
                 position="identity",fill="white")+
  geom_density(alpha=.2)

## `stat_bin()` using `bins = 30`. Pick better value `binwidth`.
```



```
pcmodel <- lm(PCH_LACCESS_POP_15_19 ~ ., data = atlaspc2)
pcmodel
```

```
##
```

```
## Call:
```

```
## lm(formula = PCH_LACCESS_POP_15_19 ~ ., data = atlaspc2)
```

```
##
```

```
## Coefficients:
```

	(Intercept)	PCH_GROCPHTH_16_20	PCH_SUPERCPHTH_16_20
	0.811170	-0.087606	0.003371
PCH_CONVSPTH_16_20	-0.030915	PCH_SPECSPTH_16_20	PCH_SNAPSPTH_17_23
		-0.001288	-0.006356
PCH_WICSPTH_16_22	-0.006885	PCH_FFRPTH_16_20	PCH_FSRPTH_16_20
		-0.171426	0.275960
PCH_PC_DIRSALES_12_17	-0.001984		

```
predict(pcmodel, newdata=data.frame(PCH_GROCPHTH_16_20=1, PCH_SUPERCPHTH_16_20=1, PCH_CONVSPTH_16_20=1, P
```

```
##           1
## 0.7840411
```

```
summary(pcmodel)
```

```
##
```

```
## Call:
```

```
## lm(formula = PCH_LACCESS_POP_15_19 ~ ., data = atlaspc2)
```

```
##
```

```

## Residuals:
##      Min     1Q Median     3Q    Max
## -55.850 -6.839 -1.093  4.933 135.044
##
## Coefficients:
##                               Estimate Std. Error t value Pr(>|t|)
## (Intercept)               0.811170  0.987088  0.822 0.411537
## PCH_GROCPTH_16_20        -0.087606  0.043835 -1.999 0.046120 *
## PCH_SUPERCPTH_16_20       0.003371  0.005105  0.660 0.509348
## PCH_CONVSPTH_16_20        -0.030915  0.044485 -0.695 0.487365
## PCH_SPECSPTH_16_20        -0.001288  0.019792 -0.065 0.948144
## PCH_SNAPSPTH_17_23        -0.006356  0.059314 -0.107 0.914704
## PCH_WICSPTH_16_22         -0.006885  0.007928 -0.868 0.385538
## PCH_FFRPTH_16_20          -0.171426  0.076598 -2.238 0.025598 *
## PCH_FSRPTH_16_20           0.275960  0.082413  3.348 0.000865 ***
## PCH_PC_DIRSALES_12_17     -0.001984  0.002735 -0.726 0.468319
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
##
## Residual standard error: 14.85 on 584 degrees of freedom
## Multiple R-squared:  0.03932,   Adjusted R-squared:  0.02451
## F-statistic: 2.656 on 9 and 584 DF,  p-value: 0.005046

```

```
confint(pcmodel)
```

```

##                               2.5 %      97.5 %
## (Intercept)             -1.127503890  2.749844070
## PCH_GROCPTH_16_20        -0.173699347 -0.001512995
## PCH_SUPERCPTH_16_20       -0.006655960  0.013397398
## PCH_CONVSPTH_16_20        -0.118284205  0.056455076
## PCH_SPECSPTH_16_20        -0.040160353  0.037584775
## PCH_SNAPSPTH_17_23        -0.122850914  0.110139426
## PCH_WICSPTH_16_22         -0.022456220  0.008686580
## PCH_FFRPTH_16_20          -0.321867890 -0.020984265
## PCH_FSRPTH_16_20           0.114097906  0.437821843
## PCH_PC_DIRSALES_12_17    -0.007355228  0.003386331

```

```
anova(pcmodel)
```

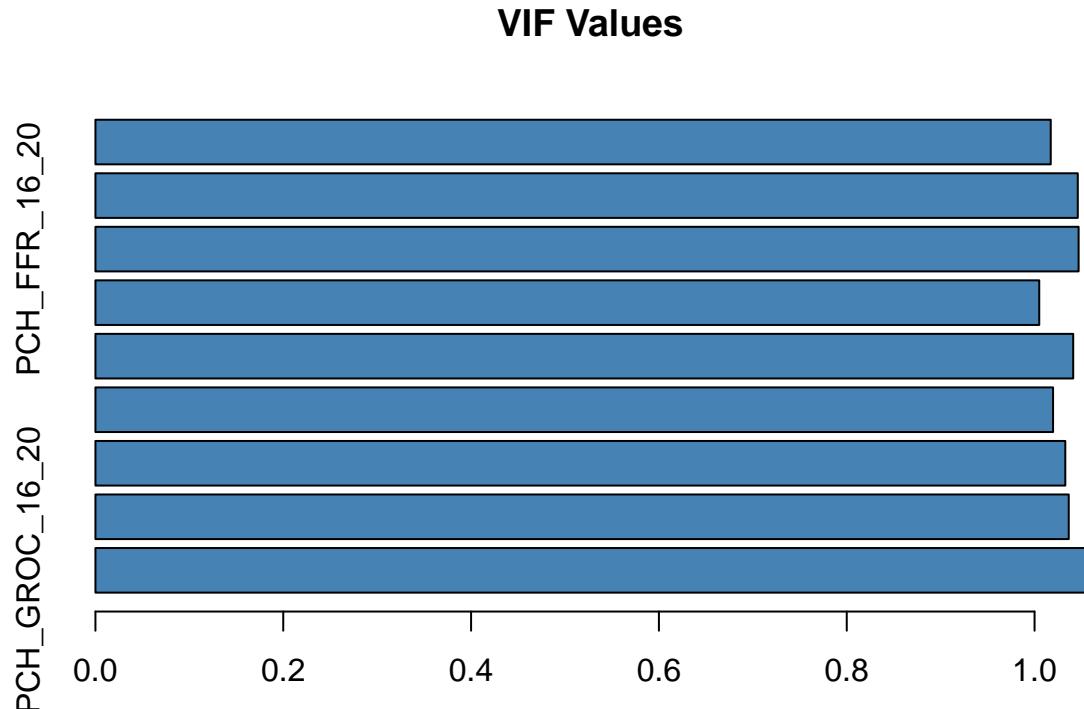
```

## Analysis of Variance Table
##
## Response: PCH_LACCESS_POP_15_19
##                               Df Sum Sq Mean Sq F value    Pr(>F)
## PCH_GROCPTH_16_20          1   951   951.05  4.3105 0.0383149 *
## PCH_SUPERCPTH_16_20         1    49    48.97  0.2219 0.6377481
## PCH_CONVSPTH_16_20          1    29    28.54  0.1293 0.7192410
## PCH_SPECSPTH_16_20          1     1     0.54  0.0024 0.9607049
## PCH_SNAPSPTH_17_23          1     1     0.86  0.0039 0.9503561
## PCH_WICSPTH_16_22           1   133   133.48  0.6050 0.4369922
## PCH_FFRPTH_16_20            1  1485  1485.09  6.7309 0.0097133 **
## PCH_FSRPTH_16_20            1  2509  2508.65 11.3701 0.0007957 ***
## PCH_PC_DIRSALES_12_17       1   116   116.19  0.5266 0.4683191
## Residuals                  584 128852  220.64
##
## ---
## Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

Assumptions: testing linearity, independence, homoskedasticity, etc.

```
#create vector of VIF values
vif_values <- vif(model)
barplot(vif_values, main = "VIF Values", horiz = TRUE, col = "steelblue") #create horizontal bar chart
#add vertical line at 5 as after 5 there is severe correlation
abline(v = 5, lwd = 3, lty = 2)
```



```
# independent variables
data_x <- atlas2[,1:3]
# independent variables correlation matrix
var <- cor(data_x)
## or solve independent variables inverse correlation matrix
var_inv <- ginv(var)
# rename the row names and column names
colnames(var_inv) <- colnames(data_x)
rownames(var_inv) <- colnames(data_x)
var_inv

##          PCH_LACCESS_POP_15_19 PCH_GROC_16_20 PCH_SUPER_C_16_20
## PCH_LACCESS_POP_15_19      1.016762202   0.13018761   -0.006190331
## PCH_GROC_16_20              0.130187605   1.01787972    0.034018141
## PCH_SUPER_C_16_20            -0.006190331   0.03401814    1.001248013

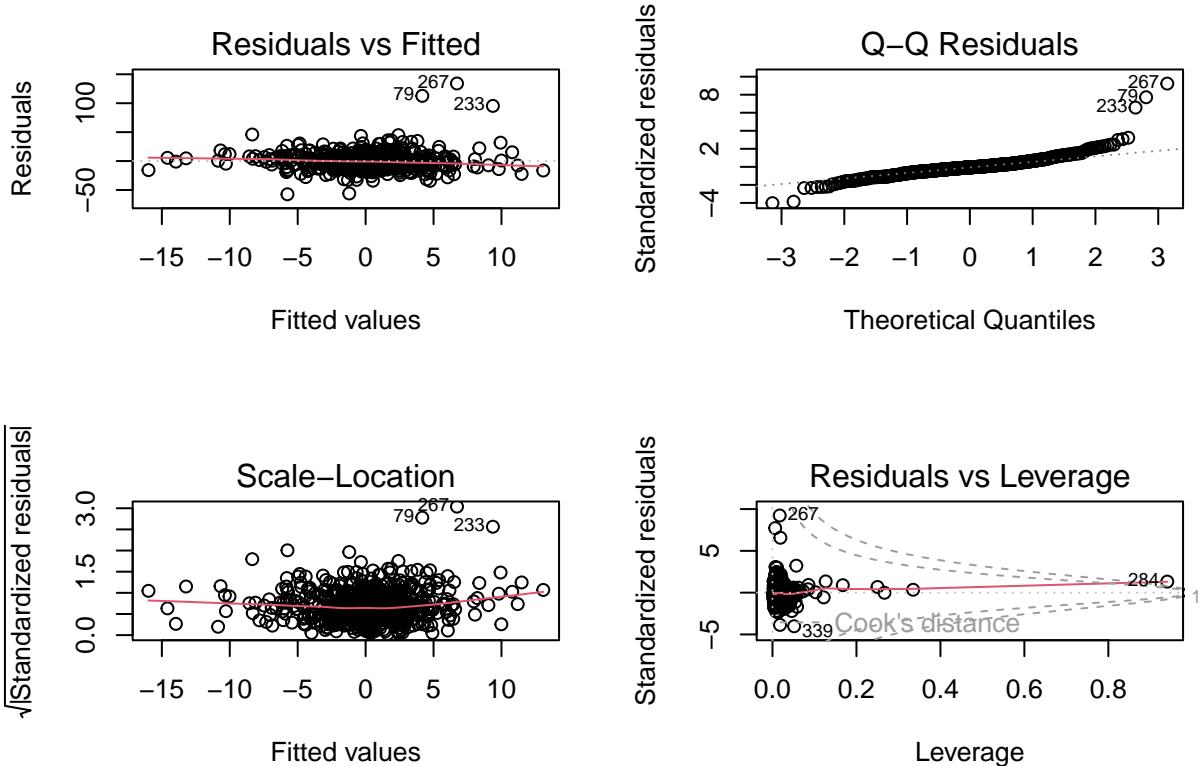
model.arg <- augment(model, se_fit = TRUE)
head(model.arg)

## # A tibble: 6 x 17
```

```

##   PCH_LACCESS_POP_15_19 PCH_GROC_16_20 PCH_SUPERC_16_20 PCH_CONVS_16_20
##   <dbl>           <dbl>           <dbl>           <dbl>
## 1      -1.32            0             28.6            0
## 2     -8.19            0             33.3            2.82
## 3    -0.0797          5.61           -5.26           1.09
## 4      10.3             0             33.3            18.4
## 5     -3.73           -2.17            0            -7.83
## 6     -4.41            4.55            0            -9.46
## # i 13 more variables: PCH_SPECS_16_20 <dbl>, PCH_SNAPS_17_23 <dbl>,
## # PCH_WICS_16_22 <dbl>, PCH_FFR_16_20 <dbl>, PCH_FSR_16_20 <dbl>,
## # PCH_DIRSALES_12_17 <dbl>, .fitted <dbl>, .se.fit <dbl>, .resid <dbl>,
## # .hat <dbl>, .sigma <dbl>, .cooksdi <dbl>, .std.resid <dbl>
par(mfrow = c(2, 2))
plot(model)

```

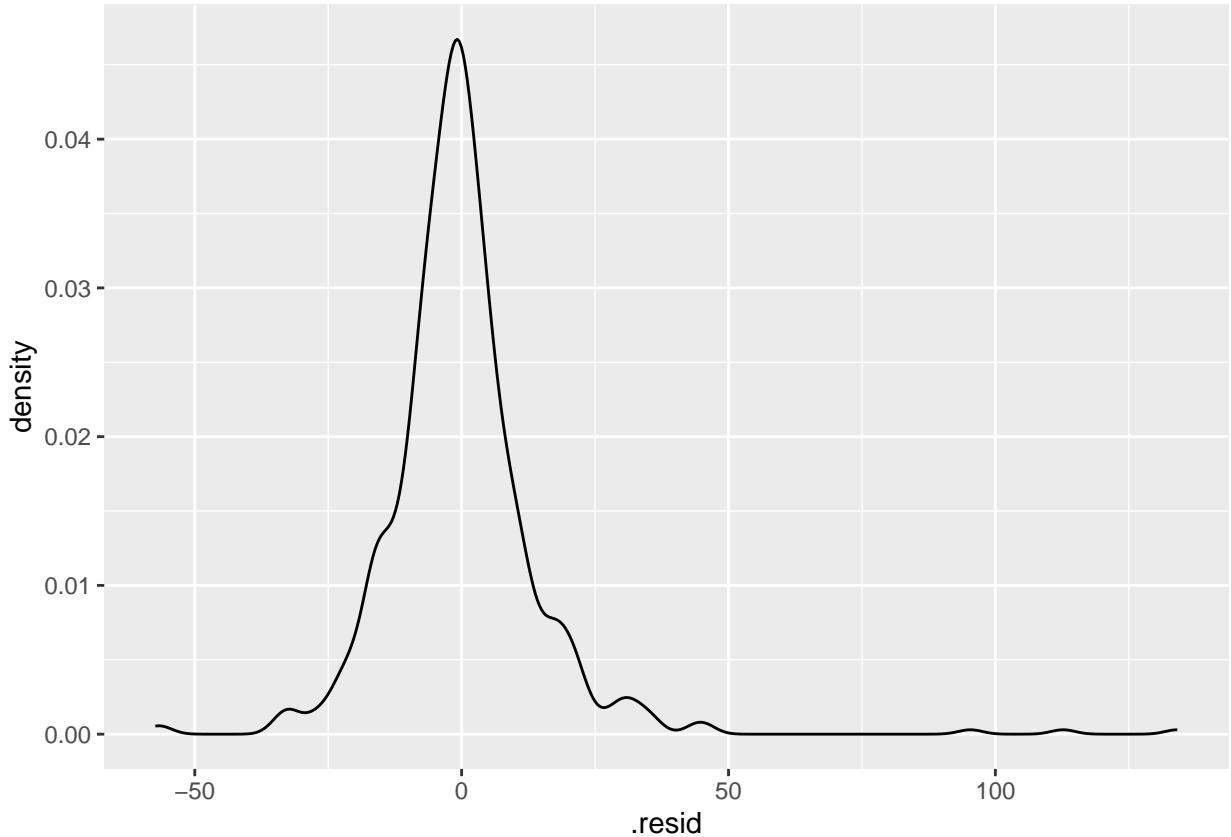


```

mshapiro.test(t(model.arg$resid))

##
##  Shapiro-Wilk normality test
##
##  data:  Z
##  W = 0.82313, p-value < 2.2e-16
ggplot(model.arg) +
  geom_density(aes(x=.resid))

```



```

# Add observations indices and
# drop some columns (.se.fit, .sigma) for simplification
model.arg %>%
  mutate(index = 1:nrow(model.arg)) %>%
  filter(index %in% c(6,76,131))

## # A tibble: 3 x 18
##   PCH_LACCESS_POP_15_19 PCH_GROC_16_20 PCH_SUPERC_16_20 PCH_CONVS_16_20
##   <dbl>           <dbl>           <dbl>           <dbl>
## 1 -4.41            4.55            0             -9.46
## 2 -0.875           -7.14           33.3           7.27
## 3  4.47             0              50            -1.69
## # i 14 more variables: PCH_SPECS_16_20 <dbl>, PCH_SNAPS_17_23 <dbl>,
## #   PCH_WICS_16_22 <dbl>, PCH_FFR_16_20 <dbl>, PCH_FSR_16_20 <dbl>,
## #   PCH_DIRSALES_12_17 <dbl>, .fitted <dbl>, .se.fit <dbl>, .resid <dbl>,
## #   .hat <dbl>, .sigma <dbl>, .cooksrd <dbl>, .std.resid <dbl>, index <int>

# again for model2
vif_values2 <- vif(model2)
barplot(vif_values2, main = "VIF Values", horiz = TRUE, col = "steelblue")
abline(v = 5, lwd = 3, lty = 2)
data_x2 <- atlas3[,1:3]
var2 <- cor(data_x2)
var_inv2 <- ginv(var2)
colnames(var_inv2) <- colnames(data_x2)
rownames(var_inv2) <- colnames(data_x2)
var_inv2

```

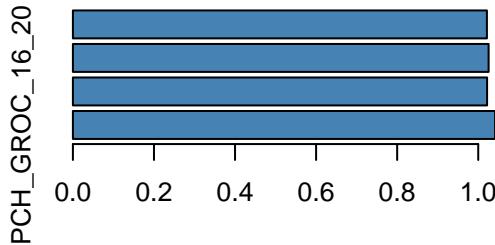
```

##          PCH_LACCESS_POP_15_19 PCH_GROC_16_20 PCH_CONVS_16_20
## PCH_LACCESS_POP_15_19           1.02068363    0.1373672    0.06337882
## PCH_GROC_16_20                  0.13736716    1.0289901    0.11154921
## PCH_CONVS_16_20                 0.06337882    0.1115492    1.01443818
model2.arg <- augment(model2, se_fit = TRUE)
head(model2.arg)

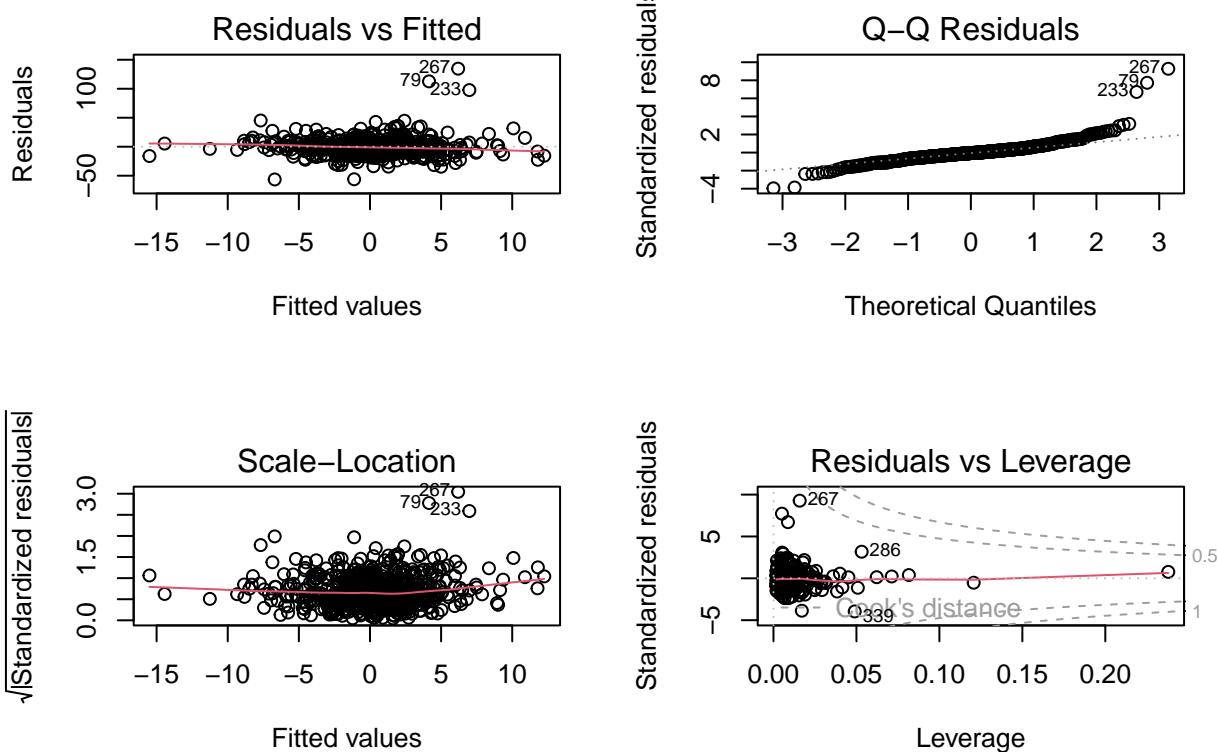
## # A tibble: 6 x 12
##   PCH_LACCESS_POP_15_19 PCH_GROC_16_20 PCH_CONVS_16_20 PCH_FFR_16_20
##   <dbl>             <dbl>             <dbl>             <dbl>
## 1 -1.32              0                 0               10.3
## 2 -8.19              0                 2.82            4.31
## 3 -0.0797             5.61              1.09            -3.81
## 4 10.3                0                 18.4             8.45
## 5 -3.73              -2.17             -7.83            9.01
## 6 -4.41              4.55              -9.46            17.5
## # i 8 more variables: PCH_FSR_16_20 <dbl>, .fitted <dbl>, .se.fit <dbl>,
## #   .resid <dbl>, .hat <dbl>, .sigma <dbl>, .cooks.d <dbl>, .std.resid <dbl>
par(mfrow = c(2, 2))

```

### VIF Values

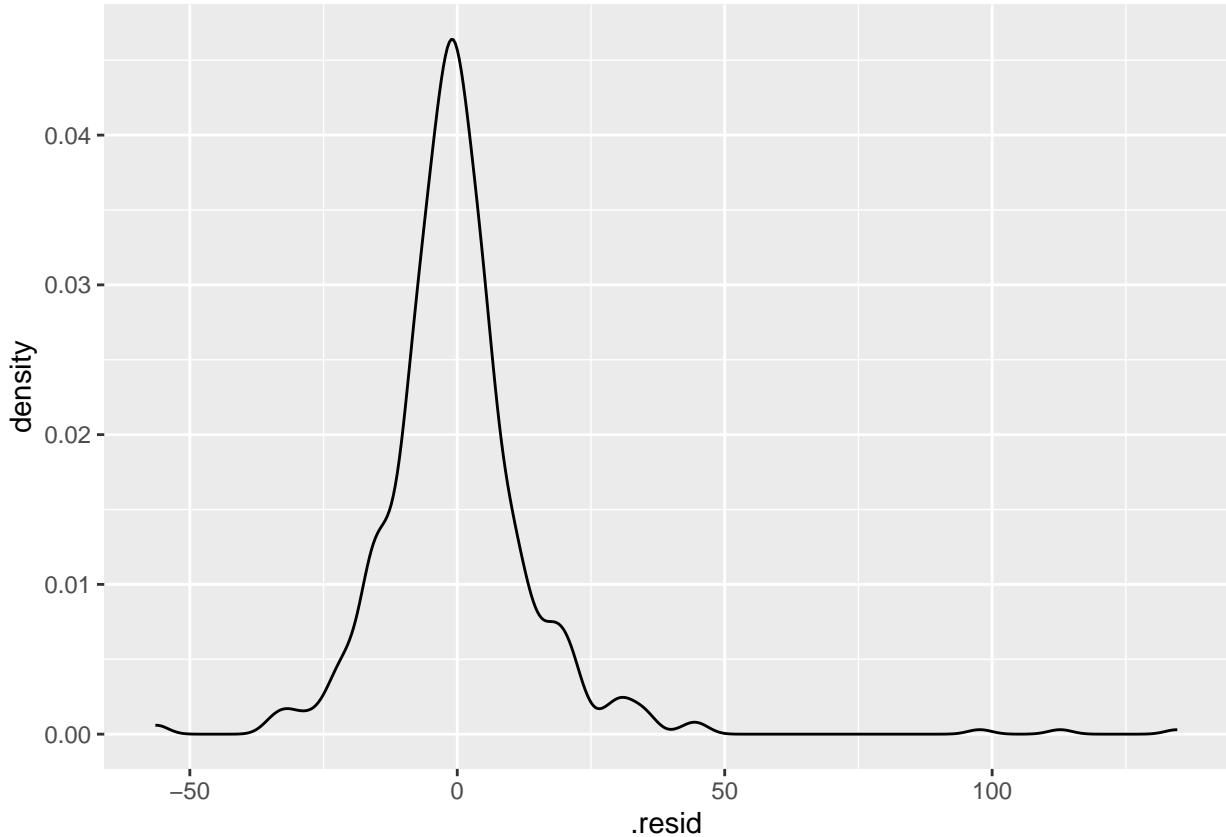


```
plot(model2)
```



```
mshapiro.test(t(model2.arg$resid))
```

```
##
## Shapiro-Wilk normality test
##
## data: Z
## W = 0.82107, p-value < 2.2e-16
ggplot(model2.arg) +
  geom_density(aes(x=.resid))
```



```

model2.arg %>%
  mutate(index = 1:nrow(model2.arg)) %>%
  filter(index %in% c(6,76,131))

## # A tibble: 3 x 13
##   PCH_LACCESS_POP_15_19 PCH_GROC_16_20 PCH_CONVS_16_20 PCH_FFR_16_20
##   <dbl>             <dbl>             <dbl>             <dbl>
## 1 -4.41              4.55             -9.46            17.5
## 2 -0.875             -7.14             7.27            23.9
## 3  4.47               0                -1.69            19.2
## # i 9 more variables: PCH_FSR_16_20 <dbl>, .fitted <dbl>, .se.fit <dbl>,
## #   .resid <dbl>, .hat <dbl>, .sigma <dbl>, .cooks.d <dbl>, .std.resid <dbl>,
## #   index <int>

# again for pcmodel
pcvif_values <- vif(pcmodel)
barplot(pcvif_values, main = "VIF Values", horiz = TRUE, col = "steelblue")
abline(v = 5, lwd = 3, lty = 2)
pcdata_x <- atlaspca2[,1:3]
pcvar <- cor(pcdata_x)
pcvar_inv <- ginv(pcvar)
colnames(pcvar_inv) <- colnames(pcdata_x)
rownames(pcvar_inv) <- colnames(pcdata_x)
pcvar_inv

##                               PCH_LACCESS_POP_15_19 PCH_GROCPHTH_16_20
## PCH_LACCESS_POP_15_19           1.00751187      0.084995097

```

```

## PCH_GROCPTH_16_20          0.08499510    1.007235782
## PCH_SUPERCPTH_16_20        -0.01925119   -0.009716176
##                               PCH_SUPERCPTH_16_20
## PCH_LACCESS_POP_15_19      -0.019251188
## PCH_GROCPTH_16_20          -0.009716176
## PCH_SUPERCPTH_16_20         1.000433323

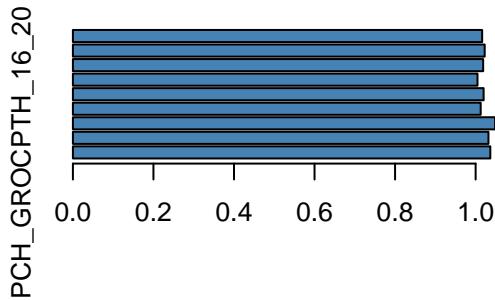
pcmodel.arg <- augment(pcmodel, se_fit = TRUE)
head(pcmodel.arg)

## # A tibble: 6 x 17
##   PCH_LACCESS_POP_15_19 PCH_GROCPTH_16_20 PCH_SUPERCPTH_16_20 PCH_CONVSPTH_16_20
##   <dbl>                <dbl>                <dbl>                <dbl>
## 1 -1.32                 -9.38                16.5               -9.38
## 2 -8.19                 -2.09                30.5               0.670
## 3 -0.0797                6.44                -4.52               1.89
## 4 10.3                  -0.907               32.1               17.3
## 5 -3.73                 -7.97                -5.92              -13.3
## 6 -4.41                 2.53                -1.92              -11.2
## # i 13 more variables: PCH_SPECSPTH_16_20 <dbl>, PCH_SNAPSPTH_17_23 <dbl>,
## # PCH_WICSPTH_16_22 <dbl>, PCH_FFRPTH_16_20 <dbl>, PCH_FSRPTH_16_20 <dbl>,
## # PCH_PC_DIRSALES_12_17 <dbl>, .fitted <dbl>, .se.fit <dbl>, .resid <dbl>,
## # .hat <dbl>, .sigma <dbl>, .cooksdi <dbl>, .std.resid <dbl>

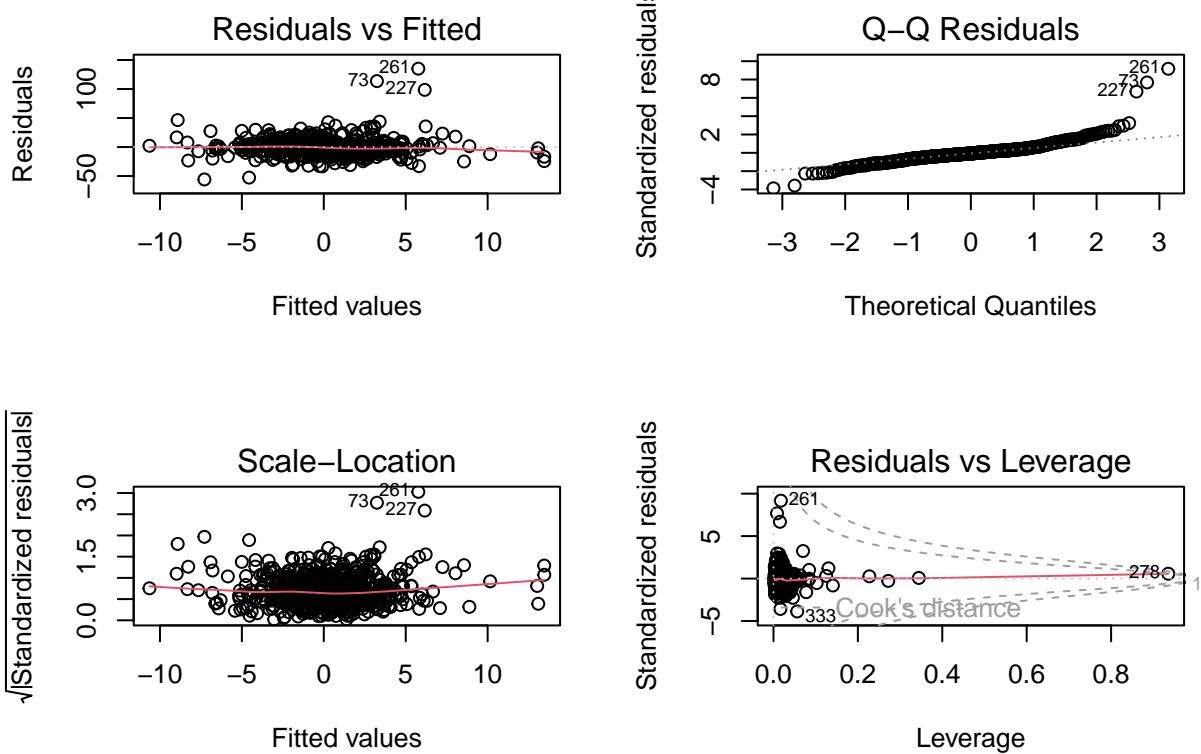
par(mfrow = c(2, 2))

```

### VIF Values



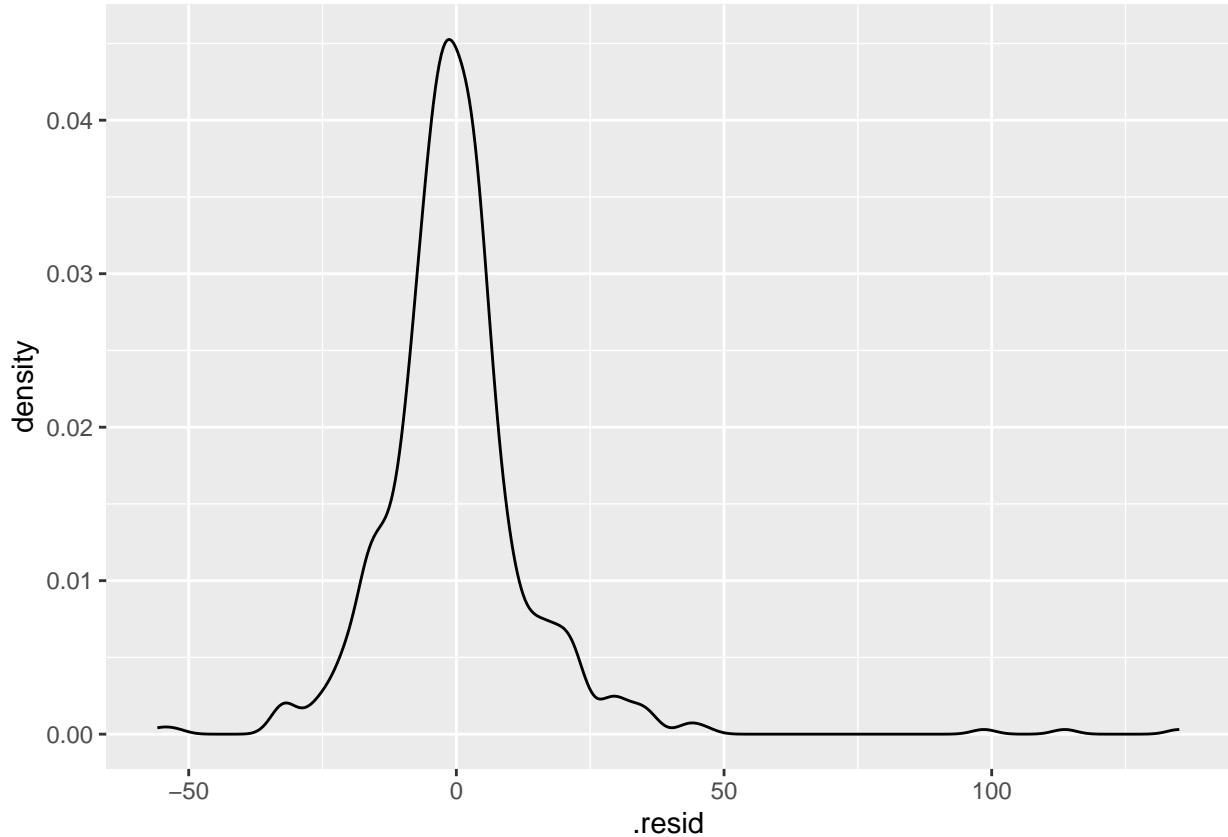
```
plot(pcmodel)
```



```
mshapiro.test(t(pcmodel.arg$resid))

##
##  Shapiro-Wilk normality test
##
## data: Z
## W = 0.82102, p-value < 2.2e-16

ggplot(pcmodel.arg) +
  geom_density(aes(x=.resid))
```



```

pcmodel.arg %>%
  mutate(index = 1:nrow(pcmodel.arg)) %>%
  filter(index %in% c(6,76,131))

## # A tibble: 3 x 18
##   PCH_LACCESS_POP_15_19 PCH_GROCPTH_16_20 PCH_SUPERCPTH_16_20 PCH_CONVSPTH_16_20
##   <dbl>                <dbl>                <dbl>                <dbl>
## 1 -4.41                 2.53                -1.92               -11.2
## 2 -2.67                -0.363               34.4                -3.20
## 3 -2.61                 10.2                 14.8                -2.18
## # i 14 more variables: PCH_SPECSPTH_16_20 <dbl>, PCH_SNAPSPTH_17_23 <dbl>,
## # PCH_WICSPTH_16_22 <dbl>, PCH_FFRPTH_16_20 <dbl>, PCH_FSRPTH_16_20 <dbl>,
## # PCH_PC_DIRSALES_12_17 <dbl>, .fitted <dbl>, .se.fit <dbl>, .resid <dbl>,
## # .hat <dbl>, .sigma <dbl>, .cooksrd <dbl>, .std.resid <dbl>, index <int>

```

For models 1 and 2 and the per capita model, the VIF looks to be slightly higher than 1, suggesting moderate multicollinearity. The Residual v. Fitted Plot suggests linearity because there is a horizontal line without any distinct patterns. The Normal Q-Q Plot suggests that the residuals are normally distributed because they follow the red line. The Scale-Location suggests that we have homoscedasticity because there is a horizontal line with equally spread points.

Results, interpretation, and insights:

Comparing the first and second models, the first model's Shapiro-Wilk test had a W of 0.12859 with a significant p-value, so we cannot say that the data are multivariate normal. The second model's W is much closer to 1 at 0.747533 with a significant p-value, so we can say that the data are multivariate normal.

In the first model, the intercept for grocery stores was -.109 with a p-value of .00842, the intercept for

convenience stores was -.072 with a p-value of .09752, the intercept for fast food was -.267 with a p-value of 8.33e-05, and the intercept for full-service restaurants was .140 with a p-value of .06602. (I need coding help to fix the summary of model 2.)

The first model had a residual standard error of 14.65 on 590 df, an adjusted R^2 of .04206—very low. Its F-statistic was 3.922 with a p-value of 7.339e-05. (Need to fix code for second model)

For the per capita variables, the model's Shapiro-Wilk test had a W of 0.13286 with a significant p-value, so we cannot say that the data are multivariate normal. The intercept for grocery stores was -.088 with a p-value of .046, the intercept for fast food was -.171 with a p-value of .026, and the intercept for full service restaurants was .276 with a p-value of .000865. The first model had a residual standard error of 14.85 on 584 df, an adjusted R^2 of .0245—very low. Its F-statistic was 2.656 with a p-value of .005. I am deciding not to try a second model for the per capita variables for now to focus on the homework 3 problems, especially because of the coding error I had earlier.

\*\*\* HOMEWORK 3 PROBLEMS START HERE \*\*\*

1. Variable Selection (R) Consider a dataset with a large number of predictor variables. Perform the following variable selection methods: Best Subset Selection, Sequential Selection Methods, Ridge, Lasso, Principal Components Regression, Partial Least Squares. Compare and contrast them for variable selection on the same dataset. Discuss the selected variables and their performance.

Best Subset Selection: I need coding help here. R is not running the summary of my data because it is in list form; I tried unlisting but it did not work.

```
install.packages("leaps",repos = "http://cran.us.r-project.org")

## Installing package into 'C:/Users/harip/AppData/Local/R/win-library/4.5'
## (as 'lib' is unspecified)

## package 'leaps' successfully unpacked and MD5 sums checked

## Warning: cannot remove prior installation of package 'leaps'

## Warning in file.copy(savedcopy, lib, recursive = TRUE): problem copying
## C:\Users\harip\AppData\Local\R\win-library\4.5\00LOCK\leaps\libs\x64\leaps.dll
## to C:\Users\harip\AppData\Local\R\win-library\4.5\leaps\libs\x64\leaps.dll:
## Permission denied

## Warning: restored 'leaps'

##
## The downloaded binary packages are in
## C:\Users\harip\AppData\Local\Temp\RtmpS6DxXm\downloaded_packages

install.packages("glmnet",repos = "http://cran.us.r-project.org")

## Installing package into 'C:/Users/harip/AppData/Local/R/win-library/4.5'
## (as 'lib' is unspecified)

## package 'glmnet' successfully unpacked and MD5 sums checked

## Warning: cannot remove prior installation of package 'glmnet'

## Warning in file.copy(savedcopy, lib, recursive = TRUE): problem copying
## C:\Users\harip\AppData\Local\R\win-library\4.5\00LOCK\glmnet\libs\x64\glmnet.dll
## to C:\Users\harip\AppData\Local\R\win-library\4.5\glmnet\libs\x64\glmnet.dll:
## Permission denied

## Warning: restored 'glmnet'

##
## The downloaded binary packages are in
```

```

##  C:\Users\harip\AppData\Local\Temp\RtmpS6DxXm\downloaded_packages
library(MASS)
library(leaps)
library(glmnet)

## Loading required package: Matrix

##
## Attaching package: 'Matrix'

## The following objects are masked from 'package:tidyverse':
##
##     expand, pack, unpack

## Loaded glmnet 4.1-10

Y <- as.numeric(atlas2[,1])
X <- as.matrix(atlas2[,-1])

Y <- Y - mean(Y)
Y

## [1] -1.54955140 -8.42069617 -0.31177433 10.07001313 -3.96253697
## [6] -4.63784639 -0.02331065 -19.01504890 22.85461625 11.07688626
## [11] -10.53748599 -0.56003359 6.07112130 5.04149684 0.35615298
## [16] 9.49653157 1.97278293 -3.97360746 1.88305720 6.25111350
## [21] 2.13741454 11.01591596 -2.74741522 13.26399430 42.89198884
## [26] 4.41279515 5.87820824 -0.19596140 -3.41769472 -1.41945890
## [31] -16.79631606 2.28695258 7.07438144 7.46880397 -6.24996129
## [36] -8.73679343 -16.55705634 -1.58497504 14.25566682 -1.50904289
## [41] -2.00114325 -8.59137431 3.31988462 1.34578499 -4.17591563
## [46] -0.54371822 6.46370562 12.26215371 1.93530377 8.84354695
## [51] -4.65690604 6.90383777 -15.56608573 -19.32853690 -25.47346870
## [56] -10.47300616 -7.58239308 0.37886706 -19.05877486 -6.05604402
## [61] -11.97629348 -9.22649089 -10.46015826 -0.20760735 3.74072369
## [66] 7.47980985 -5.40384475 -4.79450313 3.45786532 -3.54116288
## [71] -2.00949863 1.86794671 3.52407774 -6.75043574 -0.72298277
## [76] -1.10681507 14.01112470 -3.88822404 116.63695344 4.27314433
## [81] 12.93036660 -2.90132037 -5.78159228 1.81493148 1.00338873
## [86] -14.84337035 -15.89561359 3.70482596 0.86282846 -4.46914378
## [91] -2.78720490 5.39839085 -3.23085967 0.97212097 4.83406409
## [96] 6.42107304 -10.72987071 2.43071469 -0.80083612 1.51884493
## [101] -15.08095447 -5.72086803 2.26877054 10.04851350 -3.92543307
## [106] 2.43061575 -7.38814202 -8.51007072 -9.83180514 -16.85493079
## [111] 0.97421321 3.26750382 -3.53996531 -3.26686088 -1.42556134
## [116] -3.36134020 3.05429467 5.15452489 -3.73525969 18.03687676
## [121] 0.32666018 -2.72431770 -17.94923965 4.36290273 -18.17609397
## [126] 0.03645372 -21.86427108 -15.14158908 0.15794247 13.83246716
## [131] 4.23857030 -9.48423282 1.20300826 -16.11195174 10.48587521
## [136] 4.90376052 -2.84615532 -27.38164130 -5.68699876 1.48640272
## [141] -4.13112394 -2.07373623 -0.66742614 -0.50564343 37.58550462
## [146] 13.44430932 -3.17268506 11.24370393 1.42393991 -6.63918964
## [151] 9.98732480 11.46509274 36.45784959 30.67425355 16.34264764
## [156] 18.77668198 -4.14752070 8.68066510 -2.39690343 8.86146363
## [161] 7.10744628 -17.07832900 22.50458154 4.14260062 -3.50864473
## [166] 9.64985761 13.17238339 30.23374375 30.21066865 9.83492288

```

```

## [171] -18.74587051 20.93605622 18.18497666 -0.03438764 -1.86255840
## [176] 47.00863084 33.52925309 -13.17245856 -8.08730975 -32.34263793
## [181] -9.08797351 1.79182943 -7.85287324 2.70580825 -3.89236251
## [186] -29.71892921 -0.23209563 -10.74391261 -11.33706561 -0.99475185
## [191] -1.25733021 41.49313172 10.48341283 4.84253320 5.65083608
## [196] -4.27124826 -6.43146077 18.07390984 21.04268845 5.60056409
## [201] -5.86247197 24.98252114 -2.70318905 -6.17452136 1.54212233
## [206] -6.30469409 -2.62831560 3.99684247 -2.28159205 5.19331797
## [211] 19.73551949 3.42283305 -5.81308356 -9.12596313 -7.95384637
## [216] -4.94127551 15.63862237 1.57324346 -11.48762218 22.21607980
## [221] -1.63353912 -12.61595145 1.22568628 6.80469521 2.94190511
## [226] 5.75197085 -2.63461534 -2.66750208 -2.69036690 13.15810498
## [231] -18.42299453 2.29692301 104.46146973 2.53805884 -1.00861213
## [236] -1.21594146 -3.34197584 -4.71548740 -0.95021078 -3.31259290
## [241] 0.78328689 -0.34271289 10.98403939 1.38646420 -5.35296098
## [246] 4.97937640 11.99350556 0.37435743 -0.25070663 -1.52267555
## [251] -7.35531655 10.69061765 20.56641587 -9.51251689 -0.22489200
## [256] -6.59277192 -15.55067245 -3.64592591 13.90726575 6.25516137
## [261] 4.02297982 -1.61295489 -2.56740681 12.76264008 -0.28235161
## [266] 9.02572640 140.58162507 2.19562610 -0.48302073 2.01098927
## [271] -0.18641880 3.87363967 12.53957375 -6.63154546 -9.11359683
## [276] 3.26718768 -6.29280749 -6.66860334 -1.15818003 -0.68760217
## [281] 3.48517379 -9.85498992 10.24212941 -8.72534553 -13.39809981
## [286] 37.31947526 2.64532622 -3.27864782 1.19126769 -17.78131858
## [291] 5.12548598 5.74516162 -8.22423640 -0.35657939 -13.30803577
## [296] -4.55630437 -8.91800300 -15.94113341 -17.20382110 -10.21511260
## [301] 5.02028617 -6.52220193 -27.09105292 37.32330140 12.77078923
## [306] 1.94744738 -11.85329524 -10.67189113 -0.76454822 3.82929715
## [311] -11.17945090 5.71314486 -0.69660575 -3.76367251 0.20860677
## [316] -2.27654329 -3.16603318 -6.46731797 12.33593282 -16.17960158
## [321] 9.44767293 -6.29586021 -2.58474151 -2.91238943 -0.21068321
## [326] 3.82855138 7.47281464 9.17081364 -9.59036246 -0.07357489
## [331] -11.48701087 20.56862267 -6.37878362 -4.37653199 6.32566317
## [336] -11.99015609 22.90294274 -2.25161139 -63.36934844 -0.40052188
## [341] 2.26524385 -0.38219709 -4.32259456 -0.23209563 7.51370868
## [346] -0.23209563 17.71827515 6.45703038 16.92393693 -10.27622691
## [351] -0.50449238 -12.11335555 -0.32807889 5.53381642 24.75442895
## [356] -17.46907798 -0.78492901 -22.11463538 4.81697997 -7.64600268
## [361] -7.30424539 4.07063826 -1.67890683 4.64539584 9.14020356
## [366] -5.28906051 13.71781548 -2.62922565 7.51463517 -1.23456672
## [371] -6.93676320 -7.91100541 -13.12242786 -8.50043670 -12.63381377
## [376] 5.70410165 7.21418580 -0.65310580 -4.86486474 2.45927152
## [381] 1.56376346 -0.24266475 13.99254617 -33.32357207 3.53983482
## [386] 6.70313701 7.83973607 -17.24345580 -0.69699461 0.64619216
## [391] -18.27722350 8.70542916 -10.36892501 -5.27675668 2.60017380
## [396] 2.10753783 -11.48915092 -3.95127216 3.62798079 -19.09945480
## [401] 16.31523332 19.67610749 -14.22137538 9.34257325 -0.55067701
## [406] 20.35429009 -4.10603682 9.81895932 5.19690713 -2.27632919
## [411] 30.33983048 -7.10416833 7.49666318 -16.10685245 -12.09821883
## [416] -2.82770387 -3.08485309 -10.77156821 24.07968530 -12.57123176
## [421] -11.01321880 17.67212685 6.21099433 4.96295079 -11.71806136
## [426] 4.52594336 -6.27925960 -4.65404407 -22.34643165 8.68512639
## [431] 2.38191136 -21.22278205 -0.71790189 14.15624436 -5.94324103
## [436] 0.69451013 -16.12832252 0.45653954 -34.18491164 11.65935811

```

```

## [441] 13.42434033 -7.57146922 -5.98938361 0.13188013 0.08421844
## [446] -6.40509645 -4.92631093 23.81460389 -6.54357043 5.29483231
## [451] -57.46896926 3.57145699 7.33366021 9.95165166 -6.37980882
## [456] 4.67221984 25.49358186 22.00375756 -2.44427887 1.04753932
## [461] -2.51468149 -12.69204036 22.71488961 2.84761914 0.61881873
## [466] 16.85270509 1.69908294 4.17731818 -2.12667230 -9.84707633
## [471] -15.28257743 -15.88211528 3.23586496 -2.64141623 -0.44919093
## [476] 21.36890992 0.28122434 -5.66956226 -1.53124229 -17.08127967
## [481] 25.79296311 -4.39741985 -11.54728023 12.07805070 -4.64399425
## [486] 4.28692731 1.09807404 -2.59531442 -7.45187799 -3.17637221
## [491] -22.35397330 -3.20806948 -5.29680577 -1.61590627 3.08164724
## [496] 9.23127278 10.10591897 -27.53666106 -13.35114947 13.81649217
## [501] -12.63875762 -4.17324511 -12.42715541 -8.94462386 2.81432518
## [506] -16.47215644 -4.19690267 1.32880279 -2.85365907 -25.11243430
## [511] -13.01414767 -22.82818786 -9.67447940 -15.20773402 -10.89677707
## [516] 3.12274703 1.00602421 -31.83578101 -8.89415542 -16.50019637
## [521] -4.58781854 -10.54717818 -6.53425113 2.56547030 -9.71062556
## [526] 38.34921464 -20.82062522 -9.20293990 -2.36076370 -2.62551538
## [531] -4.76356259 -18.09618751 -25.90262023 -16.77194396 -3.03036777
## [536] -33.63630477 2.44652399 -2.79529945 -5.08324186 -15.40027896
## [541] -11.53592578 -4.21706787 -19.92559425 -2.56557528 -14.48502341
## [546] 35.58666047 4.18550929 19.47993668 -6.95899573 -8.20762626
## [551] -1.56706384 -0.46068603 -1.67821566 -27.27751342 -18.51480476
## [556] -1.03106484 -0.25513626 -1.62324217 -5.77376643 1.16532441
## [561] -0.07948170 8.13243016 -3.02140013 -5.28878013 -5.22633639
## [566] -3.79084746 7.24946317 0.17408412 5.14595279 -3.16138998
## [571] -0.48855874 5.36254414 -0.86312047 1.31964787 -0.23209563
## [576] 0.49766126 11.18550500 1.94988307 -5.16826335 -13.50440208
## [581] 6.85215434 -1.90402917 -6.66172639 11.14138707 29.71829423
## [586] -5.49116985 -1.28135208 -9.58393470 16.38340958 1.84773072
## [591] -33.41437331 8.14972695 6.75352963 -5.30637113 11.67494305
## [596] 1.40130051 2.92557796 25.33718690 1.49714562 -0.23209563

X <- t(t(X) - colMeans(X))

cor(atlas2)

##                                     PCH_LACCESS_POP_15_19 PCH_GROC_16_20 PCH_SUPERC_16_20
## PCH_LACCESS_POP_15_19                      1.00000000 -0.12825303  0.01054011
## PCH_GROC_16_20                           -0.12825303  1.00000000 -0.03476868
## PCH_SUPERC_16_20                          0.01054011 -0.03476868  1.00000000
## PCH_CONVS_16_20                           -0.04837386 -0.10194873  0.08313836
## PCH_SPECS_16_20                          -0.01327074 -0.03113158 -0.03446943
## PCH_SNAPS_17_23                           -0.07170763  0.14143289 -0.01624929
## PCH_WICS_16_22                           -0.04365784 -0.00269269 -0.03008571
## PCH_FFR_16_20                            -0.17928865  0.14941098 -0.09015193
## PCH_FSR_16_20                            0.04399629  0.08591949 -0.11639025
## PCH_DIRSALES_12_17                         -0.04141853  0.05904253  0.06667660
##                                         PCH_CONVS_16_20 PCH_SPECS_16_20 PCH_SNAPS_17_23
## PCH_LACCESS_POP_15_19                      -0.048373860 -0.01327074 -0.071707633
## PCH_GROC_16_20                            -0.101948734 -0.03113158  0.141432885
## PCH_SUPERC_16_20                          0.083138361 -0.03446943 -0.016249294
## PCH_CONVS_16_20                           1.000000000  0.03017534  0.001181517
## PCH_SPECS_16_20                          0.030175344  1.00000000  0.078258999
## PCH_SNAPS_17_23                           0.001181517  0.07825900  1.000000000

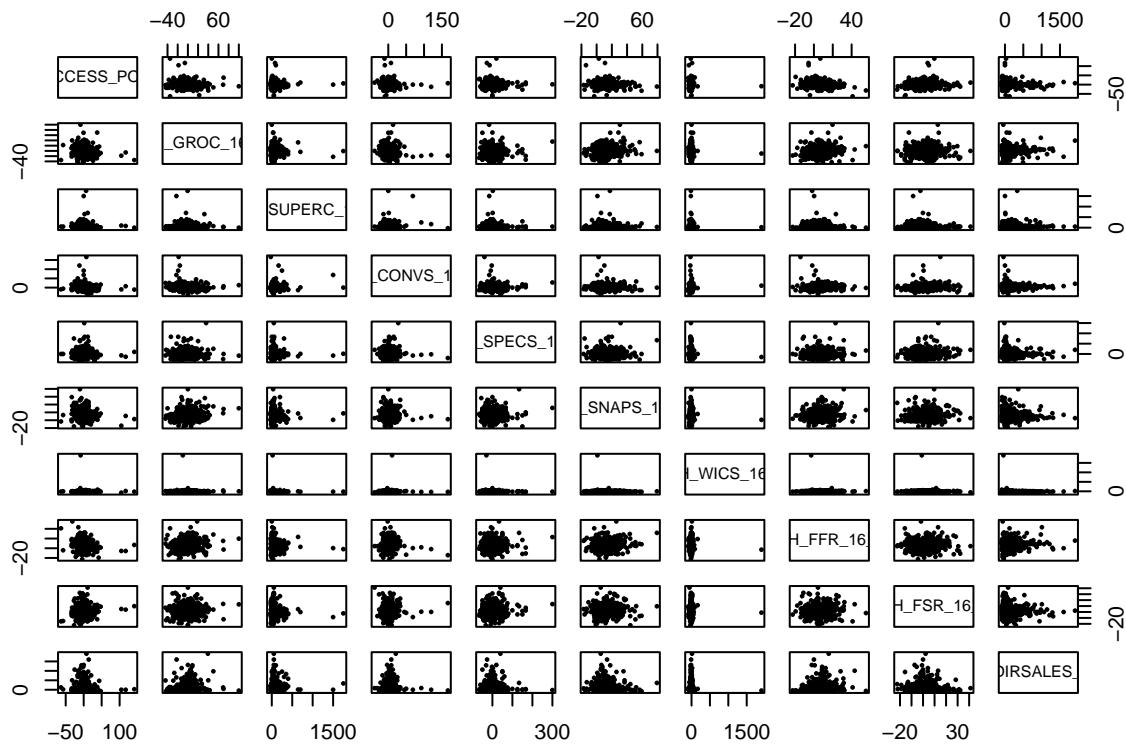
```

```

## PCH_WICS_16_22          0.018046555   -0.03976880   -0.031334023
## PCH_FFR_16_20           -0.012903865    0.06940831    0.095304847
## PCH_FSR_16_20           0.095275731    0.06975211    0.090492833
## PCH_DIRSALES_12_17      0.026334746   -0.01929969   -0.036825560
##                                     PCH_WICS_16_22 PCH_FFR_16_20 PCH_FSR_16_20
## PCH_LACCESS_POP_15_19   -0.043657843   -0.17928865   0.043996289
## PCH_GROC_16_20          -0.002692690    0.14941098   0.085919490
## PCH_SUPERC_16_20         0.030085712   -0.09015193   -0.116390245
## PCH_CONVS_16_20          0.018046555   -0.01290386   0.095275731
## PCH_SPECBS_16_20         -0.039768796    0.06940831   0.069752112
## PCH_SNAPS_17_23          0.031334023    0.09530485   0.090492833
## PCH_WICS_16_22           1.000000000   -0.01633849   0.005264114
## PCH_FFR_16_20            -0.016338491    1.00000000   0.063304297
## PCH_FSR_16_20            0.005264114    0.06330430   1.000000000
## PCH_DIRSALES_12_17       -0.029665757    0.06431184   -0.024182203
##                                     PCH_DIRSALES_12_17
## PCH_LACCESS_POP_15_19   -0.04141853
## PCH_GROC_16_20           0.05904253
## PCH_SUPERC_16_20          0.06667660
## PCH_CONVS_16_20           0.02633475
## PCH_SPECBS_16_20          -0.01929969
## PCH_SNAPS_17_23           -0.03682556
## PCH_WICS_16_22            -0.02966576
## PCH_FFR_16_20              0.06431184
## PCH_FSR_16_20              -0.02418220
## PCH_DIRSALES_12_17        1.000000000

plot(atlas2,pch=16,cex=.5)

```



```

# need help here: this code is not running properly even after I tried unlisting each variable
atlas2$PCH_LACCESS_POP_15_19 <- unlist(atlas2$PCH_LACCESS_POP_15_19)
atlas2$PCH_GROC_16_20 <- unlist(atlas2$PCH_GROC_16_20)
atlas2$PCH_SUPERC_16_20 <- unlist(atlas2$PCH_SUPERC_16_20)
atlas2$PCH_CONVS_16_20 <- unlist(atlas2$PCH_CONVS_16_20)
atlas2$PCH_SPECS_16_20 <- unlist(atlas2$PCH_SPECS_16_20)
atlas2$PCH_SNAPS_17_23 <- unlist(atlas2$PCH_SNAPS_17_23)
atlas2$PCH_WICS_16_22 <- unlist(atlas2$PCH_WICS_16_22)
atlas2$PCH_FFR_16_20 <- unlist(atlas2$PCH_FFR_16_20)
atlas2$PCH_FSR_16_20 <- unlist(atlas2$PCH_FSR_16_20)
atlas2$PCH_DIRSALES_12_17 <- unlist(atlas2$PCH_DIRSALES_12_17)
atlas2$X <- unlist(atlas2$X)
atlas2$Y <- unlist(atlas2$Y)
#fit <- lm(atlas2~., data=atlas2)
#summary(fit)

#fit0 <- lm(atlas2~1, data=atlas2)
#summary(fit0)

#fit_bsub <- regsubsets(x=atlas2[,2:9], y=atlas2[,1])
#summary(fit_bsub)

#fit_bsub$rss

```

Sequential Selection Methods Error: no terms component or attribute

```

# forward step-wise via BIC
#fit_forw <- stepAIC(atlas2, scope=PCH_LACCESS_POP_15_19~PCH_GROC_16_20+PCH_SUPERC_16_20+PCH_CONVS_16_20
#                                direction="forward", data=atlas2, k=log(nrow(atlas2)))
#summary(fit_forw)
#trying again with atlas2_long
#fit_forw <- stepAIC(atlas2_long, scope=PCH_LACCESS_POP_15_19~PCH_GROC_16_20+PCH_SUPERC_16_20+PCH_CONVS_
#                                #direction="forward", data=atlas2_long, k=log(nrow(atlas2_long)))
#summary(fit_forw)

# backward step-wise via BIC
#fit_back <- stepAIC(fit, direction="backward", data=atlas2, k=log(nrow(atlas2)))
#summary(fit_back)

```

Ridge Line 516 error: error in evaluating the argument ‘a’ in selecting a method for function ‘solve’: non-conformable arrays

```

lam <- 1*nrow(atlas2)

beta_ls <- solve(t(X)%%X)%%t(X)%%Y
#beta_r <- solve(t(X)%%X + diag(rep(lam,8)))%%t(X)%%Y
#cbind(beta_ls,beta_r)

# coefficient paths

lambdas <- exp(seq(log(.01),log(100*nrow(atlas2)),1=100))
betasr <- matrix(0,length(lambdas),8)
#for(i in 1:length(lambdas))
#{ 
#  betasr[i,] = solve(t(X)%%X + diag(rep(lambdas[i],8)))%%t(X)%%Y
#}

#betasr

#plot(c(1,length(lambdas)),range(betasr),type="n",ylab="Coefficients",xlab="Lambda Index")
#for(j in 1:8)
#{ 
#  lines(betasr[length(lambdas):1,j],col=j)
#}
#legend(0,20,legend=names(atlas2)[2:9],col=1:8,lty=rep(1,8))

```

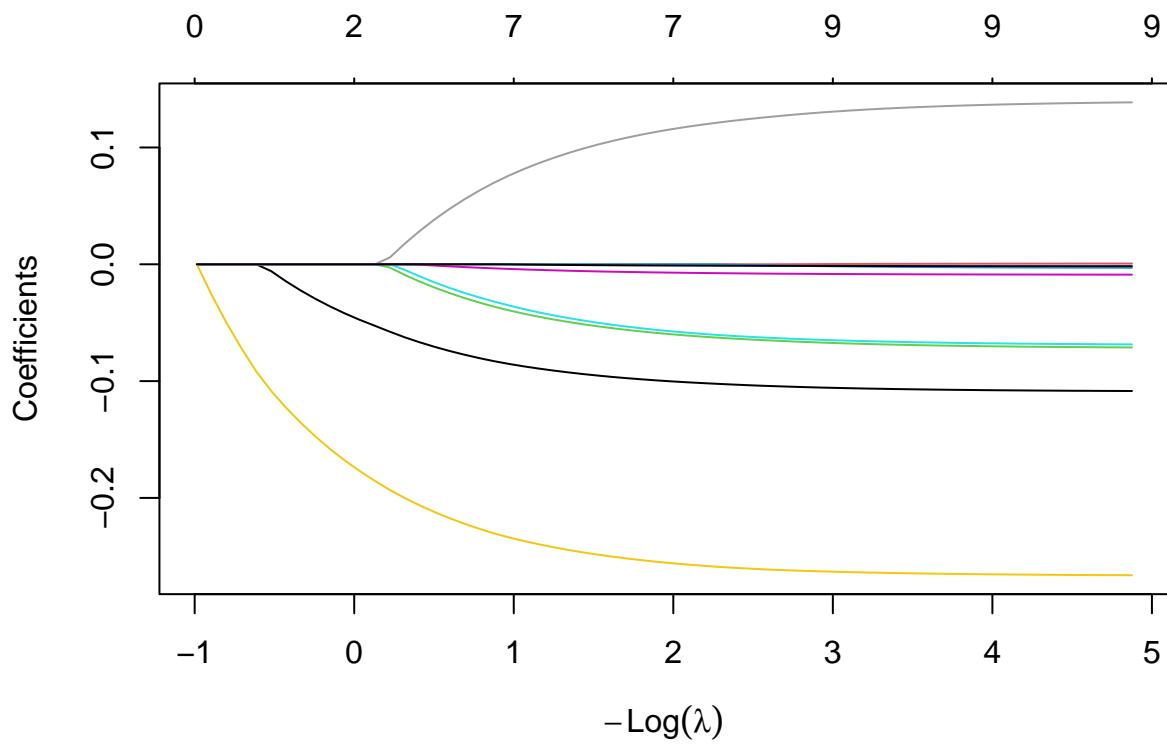
Lasso

Here the lasso paths do not cross over at all, so the order of the coefficients does not change. Supercenters, specialized food stores, and direct farm sales went to zero. The MSE is not changing much with lambda as it did in the example in class. Any log lambda less than or equal to 1 would include all the variables selected by lasso: grocery stores, convenience stores, SNAPs accepting stores, WICS accepting stores, fast food restaurants, and full-service restaurants. These are four more variables than were significant in the original linear regression.

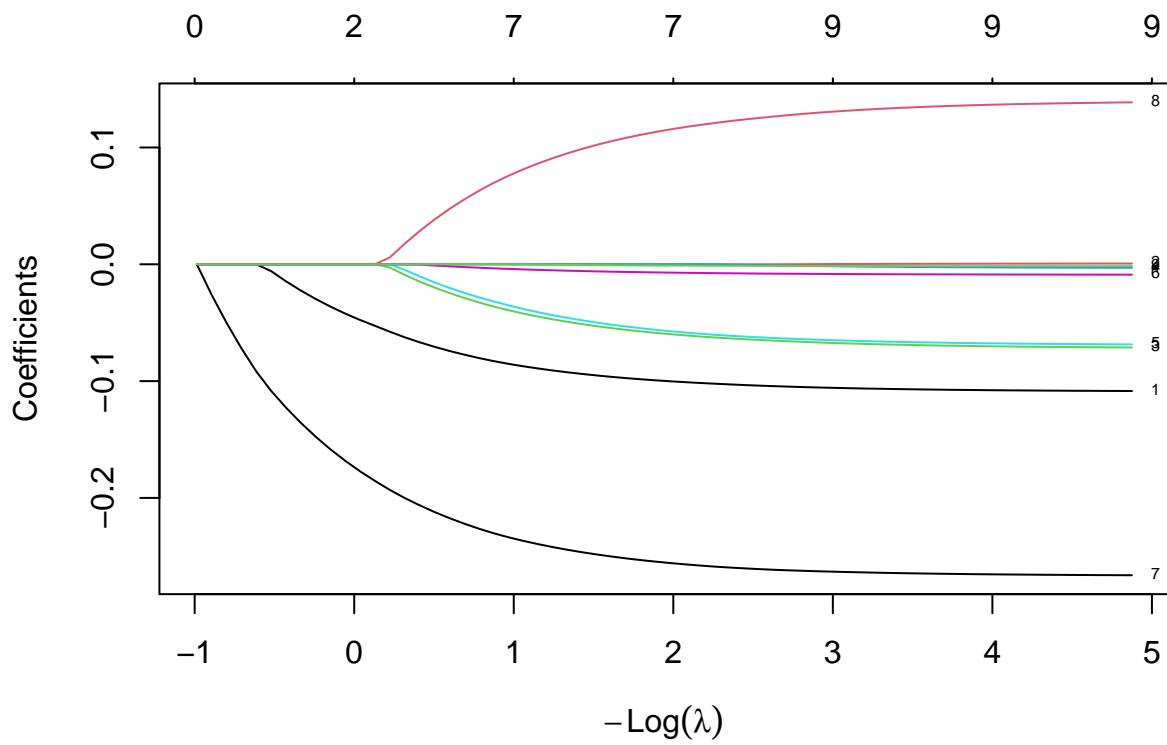
```

fitl <- glmnet(x=X,y=Y,family="gaussian",alpha=1)
plot(fitl,col=1:8)
legend(0,19,legend=names(atlas2)[2:9],col=1:8,lty=rep(1,8),cex=.8)

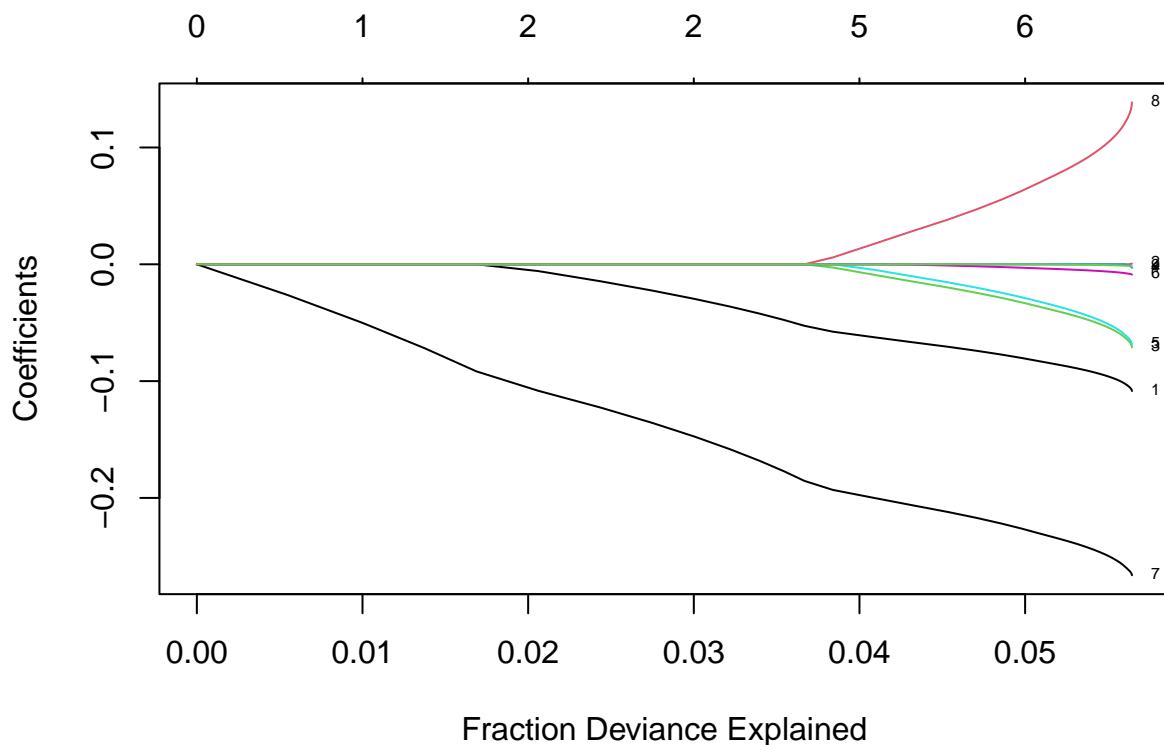
```



```
plot(fitl, xvar = "lambda", label = TRUE)
```



```
plot(fit1, xvar = "dev", label = TRUE)
```

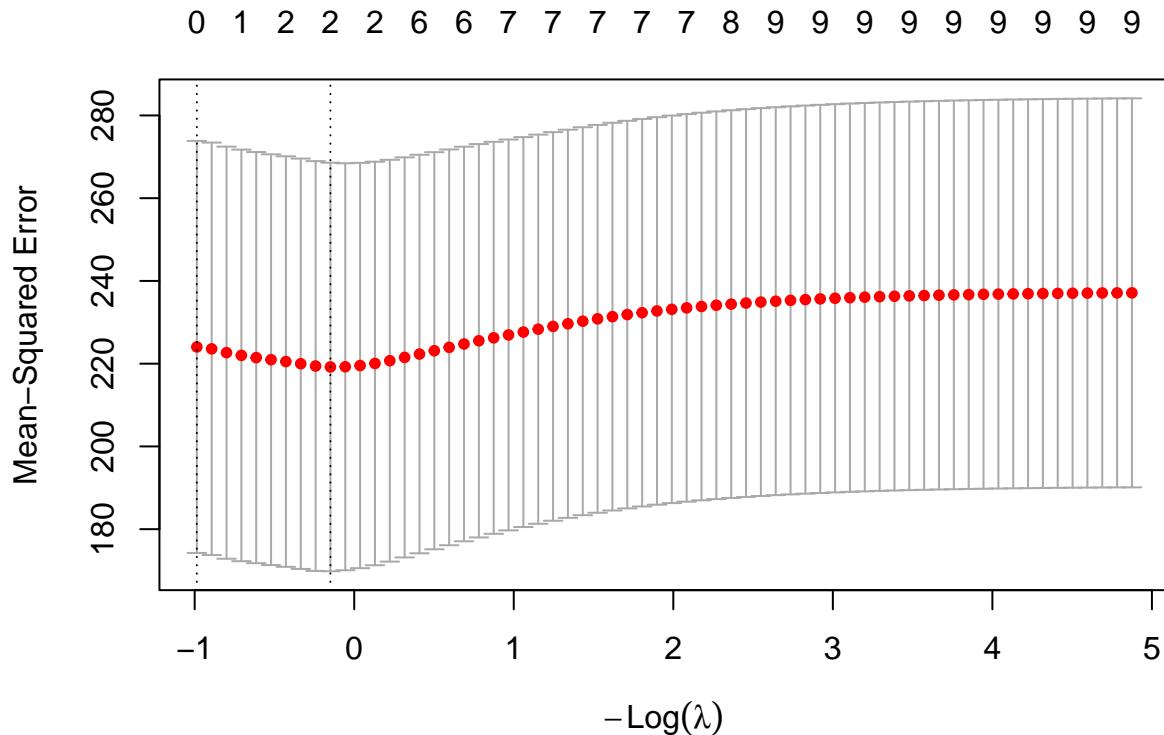


```

cvfit <- cv.glmnet(X, Y)
print(cvfit)

##
## Call: cv.glmnet(x = X, y = Y)
##
## Measure: Mean-Squared Error
##
##      Lambda Index Measure      SE Nonzero
## min   1.161     10    219.2 49.37      2
## 1se   2.681      1    224.1 49.79      0
plot(cvfit)

```



```

cvfit$lambda.min

## [1] 1.160708
coef(cvfit, s = "lambda.min")

## 10 x 1 sparse Matrix of class "dgCMatrix"
##                               lambda.min
## (Intercept)      -4.081030e-16
## PCH_GROC_16_20   -3.622669e-02
## PCH_SUPERC_16_20 .
## PCH_CONVS_16_20 .
## PCH_SPECS_16_20 .
## PCH_SNAPS_17_23 .
## PCH_WICS_16_22 .
## PCH_FFR_16_20    -1.583812e-01
## PCH_FSR_16_20   .
## PCH_DIRSALES_12_17 .

predict(cvfit, newx = X[1:5,], s = "lambda.min")

##      lambda.min
## [1,] -0.5998997
## [2,]  0.3418452
## [3,]  1.4245265
## [4,] -0.3139099
## [5,] -0.3235812

```

```

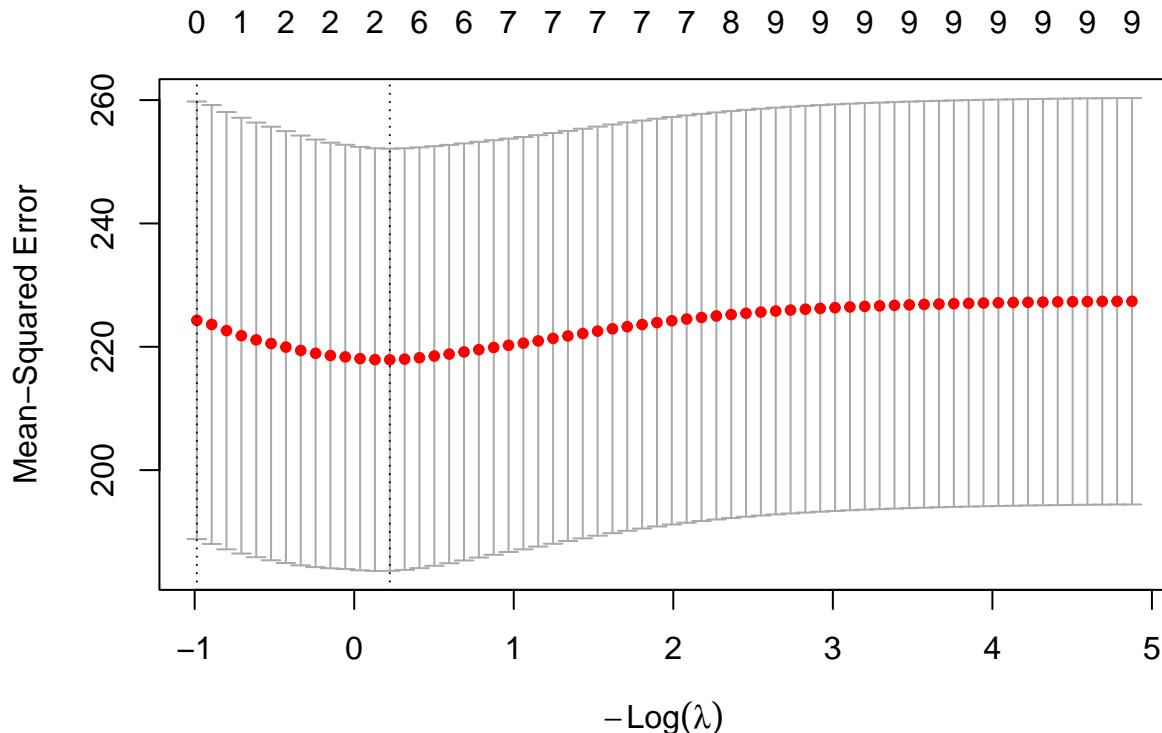
Y[1:5]

## [1] -1.5495514 -8.4206962 -0.3117743 10.0700131 -3.9625370
cvfit2 <- cv.glmnet(X, Y, type.measure = "mse", nfolds = 5)
print(cvfit2)

##
## Call: cv.glmnet(x = X, y = Y, type.measure = "mse", nfolds = 5)
##
## Measure: Mean-Squared Error
##
##      Lambda Index Measure      SE Nonzero
## min  0.800     14   217.9 34.22        4
## 1se  2.681      1   224.3 35.47        0
cvfit2$lambda.min

## [1] 0.8000313
plot(cvfit2)

```



Principal Components Regression Error in lambdas, so tried to partially run the ridge section. Then error in line 616: error in evaluating the argument 'x' in selecting a method for function 'mean': object 'fit' not found  
(This would hopefully fix itself after the best subset portion is fixed.)

```

svdx = svd(X)
svdx$d

```

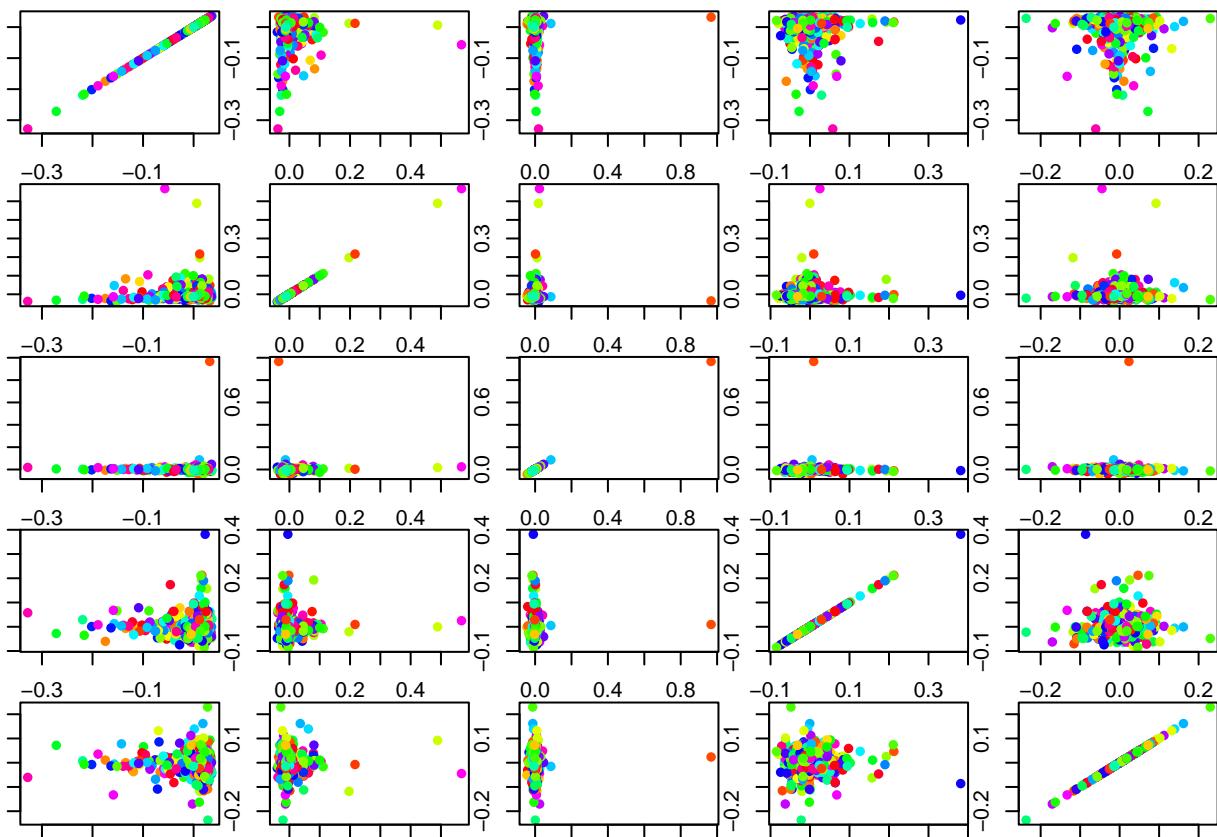
```

## [1] 5485.2502 2935.3203 1966.5020 787.5126 379.3500 335.9742 255.3708
## [8] 215.6719 191.0439
svdx$v

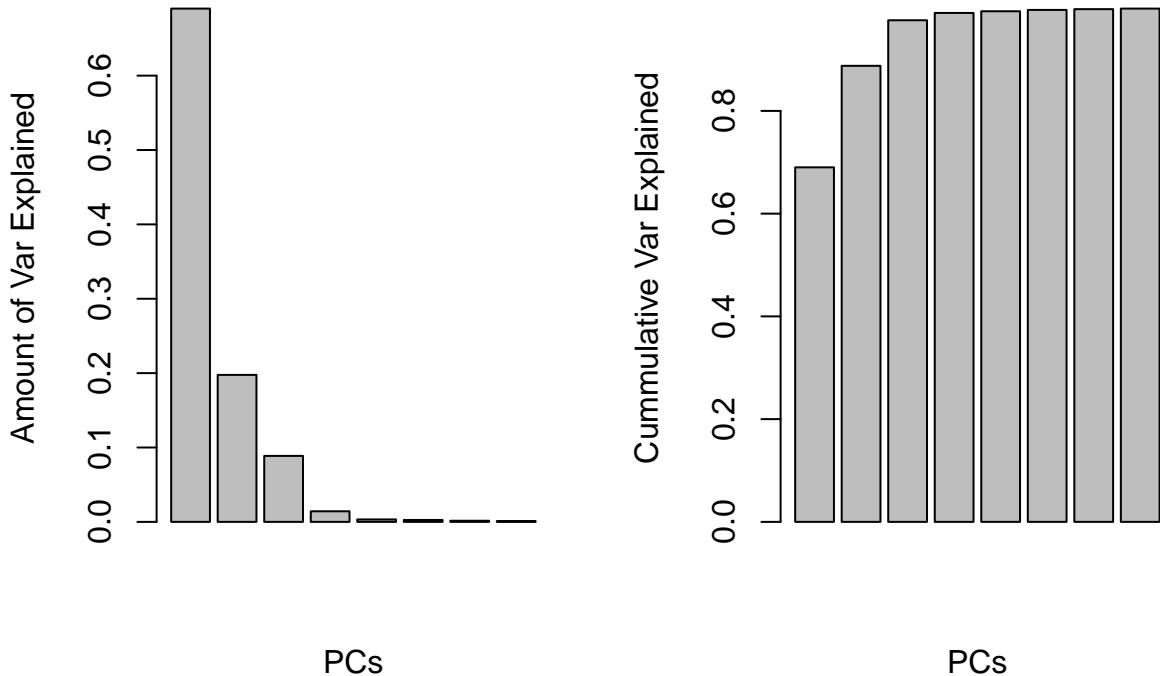
## [,1]      [,2]      [,3]      [,4]      [,5]
## [1,] -0.0038933753 -0.005138437 -0.0005040145 -0.017682233 -0.887783723
## [2,] -0.0502320909  0.998009582  0.0334506377  0.010050905 -0.009911546
## [3,] -0.0017865017  0.009531256  0.0041066886  0.019352641  0.406713802
## [4,]  0.0029360868 -0.009206351 -0.0201141715  0.998648747 -0.015494105
## [5,]  0.0017662523 -0.001117619 -0.0045850525  0.027989848 -0.172380265
## [6,]  0.0125176939 -0.033116383  0.9991582325  0.019827022 -0.003207317
## [7,] -0.0025127925 -0.007343337 -0.0022440839  0.020350290 -0.123154390
## [8,]  0.0009810497 -0.007716170 -0.0001883104  0.017729878 -0.034404540
## [9,] -0.9986404146 -0.050630630  0.0107744348  0.002729105  0.003117598
##      [,6]      [,7]      [,8]      [,9]
## [1,] -0.373714107 -0.239768946  0.1090362430  0.0494499727
## [2,]  0.005467566  0.002183143 -0.0067812568 -0.0074000194
## [3,] -0.905703613 -0.069369938  0.0158804068  0.0934614689
## [4,]  0.018361259 -0.034239598  0.0175445251  0.0120564970
## [5,] -0.136562202  0.952681809  0.1837840548  0.0971996844
## [6,]  0.002875377  0.004091646 -0.0008159195  0.0006051756
## [7,] -0.073831261  0.145281372 -0.9744817620  0.0904497138
## [8,] -0.124722801  0.088262018 -0.0640794816 -0.9853878937
## [9,]  0.002713956  0.002305803  0.0026430539 -0.0009684370

par(mar=c(1,1,1,1))
layout(matrix(1:25,5,5))
mycols = rainbow(length(Y))
orY = order(Y)
for(i in 1:5)
{
  for(j in 1:5)
  {
    plot(svdx$u[,i],svdx$u[,j],type="p",pch=16,col=mycols[orY])
  }
}

```



```
#amount of variance explained
varex = 0; cumvarex = 0;
for(i in 1:8)
{
  varex[i] = svdx$d[i]^2/sum(svdx$d^2)
  cumvarex[i] = sum(varex)
}
par(mfrow=c(1,2))
par(mar=c(5,4,4,2))
barplot(varex,ylab="Amount of Var Explained",xlab="PCs")
barplot(cumvarex,ylab="Cummulative Var Explained",xlab="PCs")
```



```

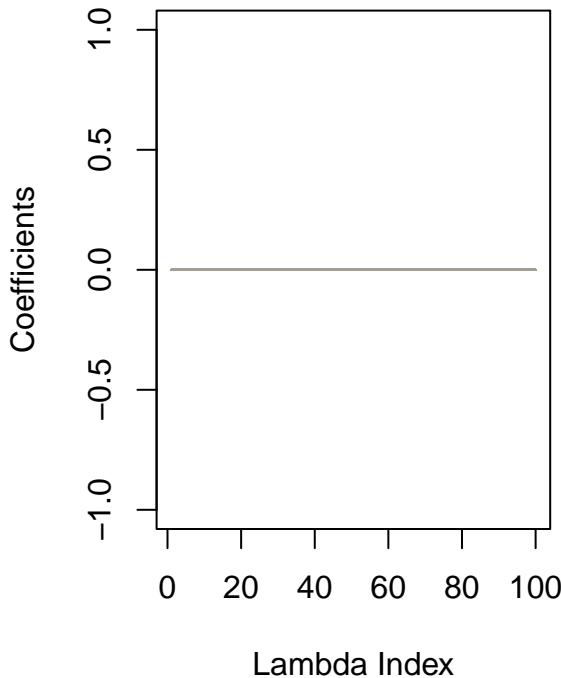
# ridge paths again

plot(c(1,length(lambdas)),range(betasmr),type="n",ylab="Coefficients",xlab="Lambda Index")
for(j in 1:8)
{
  lines(betasmr[length(lambdas):1,j],col=j)
}
legend(0,20,legend=names(atlas2)[2:9],col=1:9,lty=rep(1,9))

# pc regression

betapcr <- diag(svdx$d) %*% t(svdx$u) %*% Y
ypcr <- svdx$u[,1:2] %*% t(svdx$u[,1:2]) %*% Y
#mean((predict(fit)-atlas2[,1])^2)
#mean((ypcr-Y)^2)
#mse_pcr <- NULL
#for(i in 1:8){
#  ypcr <- svdx$u[,1:i] %*% t(svdx$u[,1:i]) %*% Y
#  mse_pcr <- c(mse_pcr, mean((ypcr-Y)^2))
#}
#mse_pcr

```



Partial Least Squares From the PLS method, there are high correlations for every entry on the diagonal except for the second and third. These are supercenters and convenience stores. This model chooses all other variables, which is three more than the four included in the original regression.

```

plsfunc <- function(x,y)
{
  p <- ncol(x)
  n <- nrow(x)
  M <- t(x) %*% y
  Z <- NULL; V <- NULL; P <- NULL;
  for(k in 1:p){
    svdm <- svd(M)
    z <- x %*% svdm$u
    z <- z*as.numeric(1/sqrt(t(z) %*% z))
    V <- cbind(V,svdm$u)
    P <- t(x) %*% z/as.numeric(t(z) %*% z)
    P <- cbind(P,p);
    Z <- cbind(Z,z);
    M <- M - P %*% solve(t(P) %*% P) %*% t(P) %*% M;
  }
  return(list(Z=Z,V=V))
}

plsx <- plsfunc(X,Y)

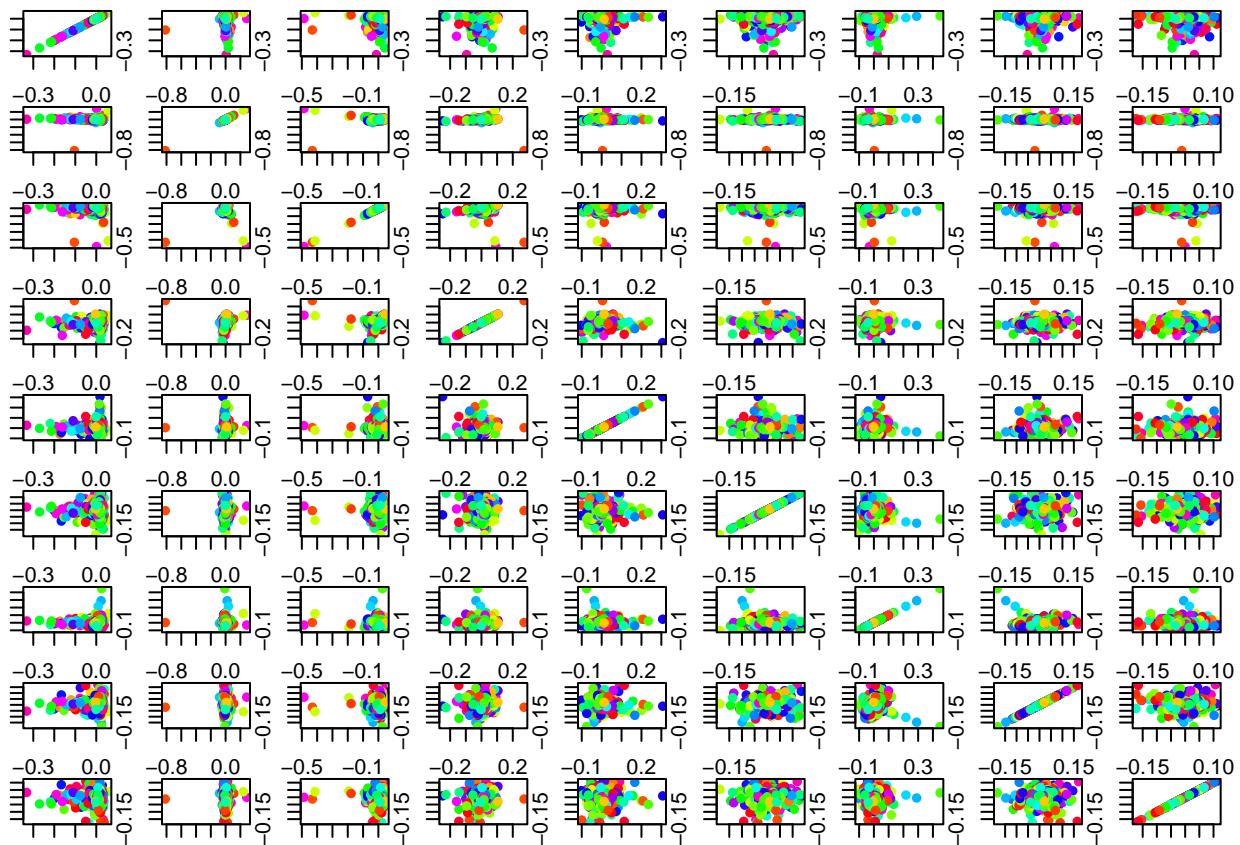
# scatterplots of PLS components

```

```

par(mar=c(1,1,1,1))
layout(matrix(1:81,9,9))
mycols <- rainbow(length(Y))
orY <- order(Y)
for(i in 1:9)
{
  for(j in 1:9)
  {
    plot(plsx$Z[,i],plsx$Z[,j],type="p",pch=16,col=mycols[orY])
  }
}

```



```

betapls = t(plsx$Z) %*% Y

cbind(betapcr,betapls)

##          [,1]      [,2]
## [1,]  82163.287 18.9041081
## [2,] 16750.307 22.8618721
## [3,] -31848.270 24.1716572
## [4,] -4810.084 64.8951570
## [5,] 15479.250 27.4537198
## [6,] 13252.838 32.3496279
## [7,] -3989.039  9.4936885
## [8,] 10473.297  3.0996293
## [9,] -6608.012  0.7131445

```

Compare and contrast variable selection across methods:

The selected variables and their performance:

2. Model Assessment (R) Choose a dataset and split into training/validation sets. Implement linear regression models (degrees 1 to 10) in R. You have developed multiple linear regression models for a dataset, but you are unsure which model to choose. Use the following model assessment techniques:
  - A. Bias-Variance Tradeoff: Explain the concept of bias-variance tradeoff in the context of model selection. Evaluate the bias and variance of your models and discuss how they relate to model complexity.
  - B. Information Criteria: Calculate and compare the Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), and F statistic for your models. Interpret the results and recommend the best model based on these criteria.

The concept of bias-variance trade-off is that when you choose between estimators, you are choosing between reducing bias or reducing variance. The expected prediction error and therefore the mean squared error both include terms for squared bias and variance. Regularizing the model through different methods of shrinking, dampening, or controlling the estimates will reduce variance while increasing bias. As long as the increase in bias is smaller than the decrease in variance, this is a helpful tradeoff to make.

```
# L1 regularization

fit1 <- lm(Y~X-1,data=atlas2)
lam <- .01
fitl <- glmnet(x=X,y=Y,family="gaussian",lambda=lam,alpha=1)
cbind(fit1$coef,as.matrix(fitl$beta))

##                                     s0
## XPCH_GROC_16_20      -0.1089863758 -0.1083396753
## XPCH_SUPERC_16_20     0.0007047547  0.0006070183
## XPCH_CONVS_16_20     -0.0718614173 -0.0709547145
## XPCH_SPECS_16_20     -0.0032387185 -0.0029274202
## XPCH_SNAPS_17_23     -0.0692429375 -0.0683904389
## XPCH_WICS_16_22      -0.0089636422 -0.0088316445
## XPCH_FFR_16_20       -0.2667555927 -0.2660301396
## XPCH_FSR_16_20       0.1400872946  0.1382014447
## XPCH_DIRSALES_12_17  -0.0016519904 -0.0016076121

# model complexity and prediction error

n = 100
p = 50
Btrue = matrix(0,p,1)
Btrue[1:10] = rnorm(10)*.75
Btrue[11:20] = rnorm(10)*.5

Xtr = scale(matrix(rnorm(n*p),n,p))
Ytr = Xtr%*%Btrue + matrix(rnorm(n),n,1)
Xts = scale(matrix(rnorm(n*p),n,p))
Yts = Xts%*%Btrue + matrix(rnorm(n),n,1)

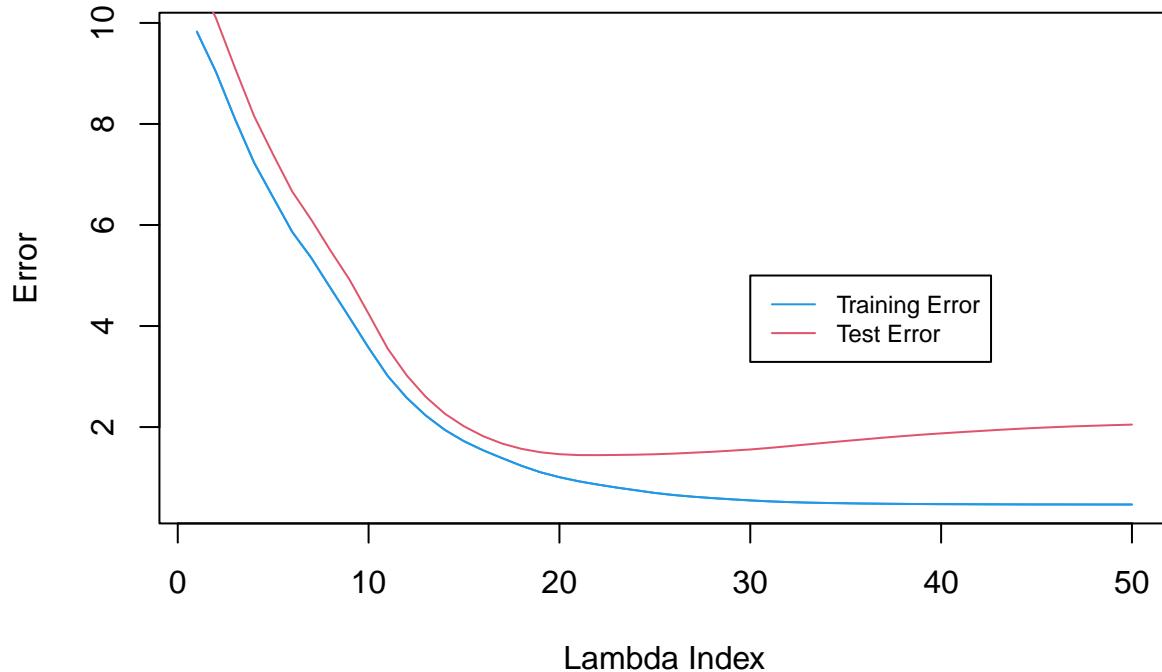
fit = glmnet(x=Xtr,y=Ytr,family="gaussian",standardize=FALSE,nlambda=50,lambda.min.ratio=.001)
Yhtr = predict(fit,newx=Xtr)
MSEtr = apply((Yhtr-Ytr%*%matrix(1,1,length(fit$lambda)))^2,2,mean)
Yhts = predict(fit,newx=Xts)
MSEts = apply((Yhts-Yts%*%matrix(1,1,length(fit$lambda)))^2,2,mean)

plot(1:length(fit$lambda),MSEtr,type="l",col=4,xlab="Lambda Index",ylab="Error")
```

```

lines(1:length(fit$lambda),MSEtr,col=4)
lines(1:length(fit$lambda),MSEts,col=2)
legend(30,5,legend=c("Training Error", "Test Error"),col=c(4,2),lty=c(1,1),cex=.75)

```



3. Cross-Validation (R) Explain the concept of cross-validation and its importance in model assessment. Compare k-fold cross-validation and leave-one-out cross-validation. Perform cross-validation on your models to assess their predictive performance: A. K-Fold Cross-Validation: Implement K-fold cross-validation (choose an appropriate value of K) on your models and calculate the mean squared error (MSE) for each fold. Report the average MSE and discuss its significance. B. Leave-One-Out Cross-Validation (LOOCV): Apply LOOCV to evaluate the performance of your models. Compare the results with K-fold cross-validation and discuss the pros and cons of each method.

Cross-validation is a nonparametric method to validate the data by reusing the data efficiently. Ideally there would be enough data to set aside a training set without affecting estimation accuracy, but we use cross-validation when there is not enough data. K-fold cross-validation randomly splits the data into K parts of about the same size and fits a model for each part using all the other parts. For each model, we find the prediction error on the kth part. Then we average all of the errors to find an estimate of the prediction error. This is a direct estimate of the error outside the sample. Leave-One-Out cross-validation uses all observations but one and repeats the process n times so that each observation was excluded one time. This method gives an approximately unbiased prediction error, but the variance can be high because the training sets are alike. It can also take a long time to run. In comparison, k-fold cross-validation usually has a low variance but could have a large bias. If the error is much higher for smaller training sets, then 5-fold or 10-fold cross-validation could give too-high prediction errors.

The average training error for 5-fold CV is 1.044289 compared to the testing error of 1.40464. LOO cross-validation gives a training error of 0.8705967 and a testing error of 1.253238. Here it appears that 5-fold is better because the difference between the training and testing errors is smaller.

```

install.packages("leaps",repos = "http://cran.us.r-project.org")

## Warning: package 'leaps' is in use and will not be installed
install.packages("glmnet",repos = "http://cran.us.r-project.org")

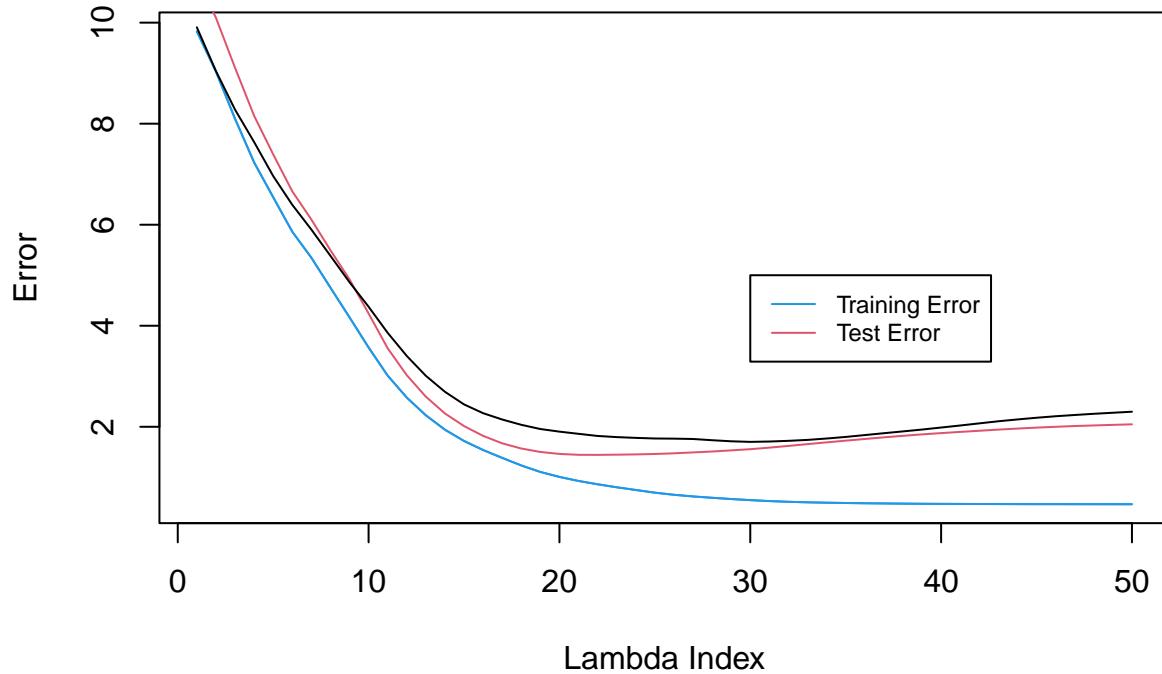
## Warning: package 'glmnet' is in use and will not be installed

library(MASS)
library(leaps)
library(glmnet)

fold = 5
sam = sample(1:n,n)
CVerrs = NULL
for(i in 1:fold)
{
  ind = sam[((i-1)*n/fold + 1):(i*n/fold)]
  Xin = Xtr[-ind,]; Yin = Ytr[-ind]
  Xout = Xtr[ind,]; Yout = Ytr[ind]
  fit = glmnet(x=Xin,y=Yin,family="gaussian",standardize=FALSE,nlambda=50,lambda.min.ratio=.001)
  Yh = predict(fit,newx=Xout)
  CVerrs = cbind(CVerrs,apply((Yh-Yout%*%matrix(1,1,length(fit$lambda)))^2,2,mean))
}
CVerr = apply(CVerrs,1,mean)

plot(1:length(fit$lambda),MSEtr,type="l",col=4,xlab="Lambda Index",ylab="Error")
lines(1:length(fit$lambda),MSEtr,col=4)
lines(1:length(fit$lambda),MSEts,col=2)
legend(30,5,legend=c("Training Error","Test Error"),col=c(4,2),lty=c(1,1),cex=.75)
lines(1:length(fit$lambda),CVerr,col=1)

```



```

# test error
fit = glmnet(x=Xtr,y=Ytr,family="gaussian",standardize=FALSE,nlambda=50,lambda.min.ratio=.001)
optlam = fit$lambda[which.min(CVerr)]
optlam

## [1] 0.03001812

fit = glmnet(x=Xtr,y=Ytr,family="gaussian",standardize=FALSE,lambda=optlam)
Yhtr = predict(fit,newx=Xtr)
TRerr = mean( (Yhtr - Ytr)^2 )
Yhts = predict(fit,newx=Xts)
TSerr = mean( (Yhts - Yts)^2 )
sum(fit$beta!=0)

## [1] 43
TRerr

## [1] 0.5472661
TSerr

## [1] 1.556642

#now LOO
fold = n
sam = sample(1:n,n)
CVerrs = NULL
for(i in 1:fold)
{

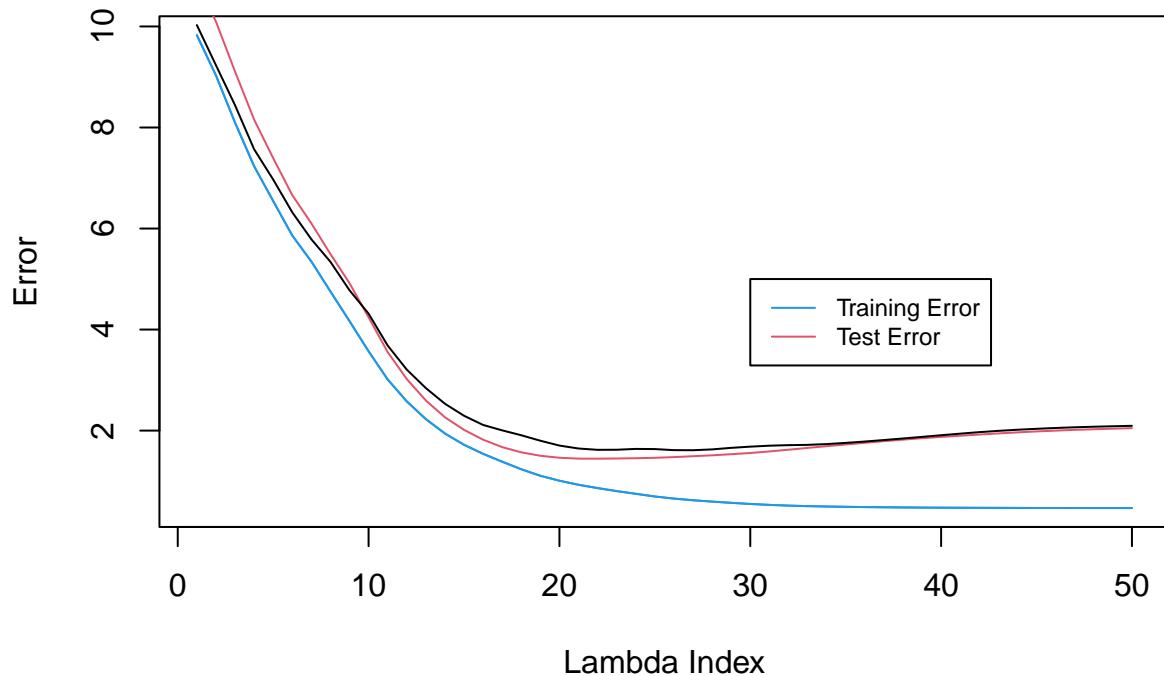
```

```

ind = sam[((i-1)*n/fold + 1):(i*n/fold)]
Xin = Xtr[-ind,]; Yin = Ytr[-ind]
Xout = Xtr[ind,]; Yout = Ytr[ind]
fit = glmnet(x=Xin,y=Yin,family="gaussian",standardize=FALSE,nlambda=50,lambda.min.ratio=.001)
Yh = predict(fit,newx=Xout)
CVerrs = cbind(CVerrs,apply((Yh-Yout%*%matrix(1,1,length(fit$lambda)))^2,2,mean))
}
CVerr = apply(CVerrs,1,mean)

plot(1:length(fit$lambda),MSEtr,type="l",col=4,xlab="Lambda Index",ylab="Error")
lines(1:length(fit$lambda),MSEtr,col=4)
lines(1:length(fit$lambda),MSEts,col=2)
legend(30,5,legend=c("Training Error","Test Error"),col=c(4,2),lty=c(1,1),cex=.75)
lines(1:length(fit$lambda),CVerr,col=1)

```



```

fit = glmnet(x=Xtr,y=Ytr,family="gaussian",standardize=FALSE,nlambda=50,lambda.min.ratio=.001)
optlam = fit$lambda[which.min(CVerr)]
optlam

## [1] 0.04582019

fit = glmnet(x=Xtr,y=Ytr,family="gaussian",standardize=FALSE,lambda=optlam)
Yhtr = predict(fit,newx=Xtr)
TRerr = mean( (Yhtr - Ytr)^2 )
Yhts = predict(fit,newx=Xts)
TSerr = mean( (Yhts - Yts)^2 )
sum(fit$beta!=0)

```

```
## [1] 38
TRerr
## [1] 0.6212778
TSerr
## [1] 1.492408
```