Conceptual

1.

(a)

Obs.	X1	X2	X3	Distance(0, 0, 0)	Y
1	0	3	0	3	Red
2	2	0	0	2	Red
3	0	1	3	$\sqrt{10}$ ~ 3.2	Red
4	0	1	2	$\sqrt{5}$ ~ 2.2	Green
5	-1	0	1	$\sqrt{2}$ ~ 1.4	Green
6	1	1	1	$\sqrt{3}$ ~ 1.7	Red

(b) Green. Observation #5 is the closest neighbor for K = 1.

(c) Red. Observations #2, 5, 6 are the closest neighbors for K = 3. 2 is Red,
5 is Green, and 6 is Red.

(d) Small. A small K would be flexible for a non-linear decision boundary,
whereas a large K would try to fit a more linear boundary because it takes more points into consideration.

hw1_solution

Applied

1

(a)

```
library(readr)
college <- read.csv("C:/Users/jzz0121/Desktop/STAT6000/datasets/College.csv")
```

(b)

```
fix(college)
rownames(college) <- college[, 1]
college <- college[, -1]
fix(college)
```

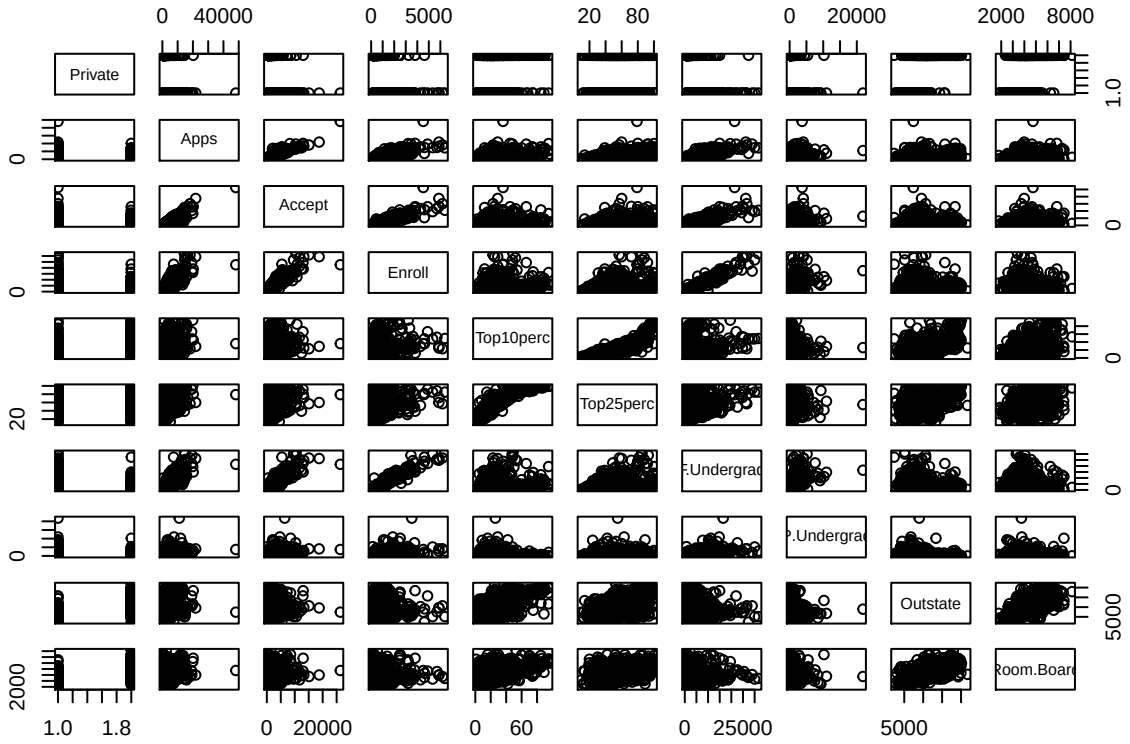
(c)

```
# i.
summary(college)
```

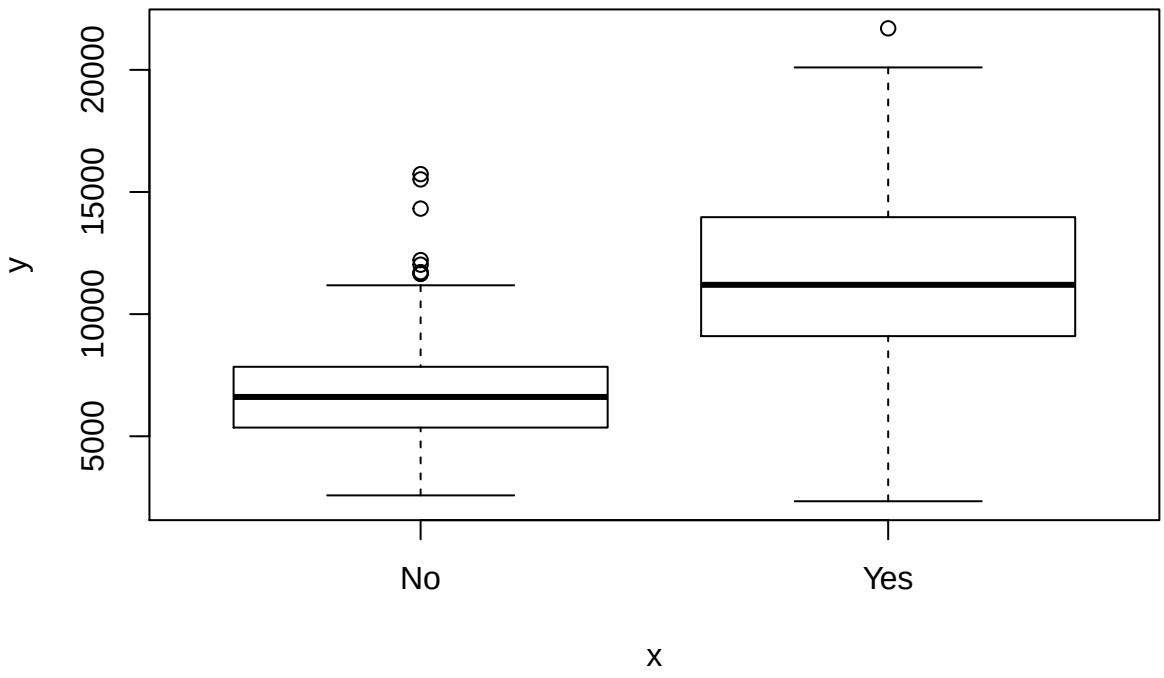
```
##  Private        Apps           Accept          Enroll       Top10perc
##  No :212   Min.   :   81   Min.   :   72   Min.   :  35   Min.   : 1.00
##  Yes:565   1st Qu.:  776   1st Qu.:  604   1st Qu.: 242   1st Qu.:15.00
##            Median : 1558   Median : 1110   Median : 434   Median :23.00
##            Mean   : 3002   Mean   : 2019   Mean   : 780   Mean   :27.56
##            3rd Qu.: 3624   3rd Qu.: 2424   3rd Qu.: 902   3rd Qu.:35.00
##            Max.   :48094   Max.   :26330   Max.   :6392   Max.   :96.00
##    Top25perc      F.Undergrad     P.Undergrad         Outstate
##  Min.   :  9.0   Min.   :  139   Min.   :    1.0   Min.   : 2340
##  1st Qu.: 41.0   1st Qu.:  992   1st Qu.:   95.0   1st Qu.: 7320
##  Median : 54.0   Median : 1707   Median :  353.0   Median : 9990
##  Mean   : 55.8   Mean   : 3700   Mean   :  855.3   Mean   :10441
##  3rd Qu.: 69.0   3rd Qu.: 4005   3rd Qu.:  967.0   3rd Qu.:12925
##  Max.   :100.0   Max.   :31643   Max.   :21836.0   Max.   :21700
##    Room.Board       Books           Personal          PhD
##  Min.   :1780   Min.   :  96.0   Min.   : 250   Min.   :  8.00
##  1st Qu.:3597   1st Qu.: 470.0   1st Qu.: 850   1st Qu.: 62.00
##  Median :4200   Median : 500.0   Median :1200   Median : 75.00
##  Mean   :4358   Mean   : 549.4   Mean   :1341   Mean   : 72.66
##  3rd Qu.:5050   3rd Qu.: 600.0   3rd Qu.:1700   3rd Qu.: 85.00
##  Max.   :8124   Max.   :2340.0   Max.   :6800   Max.   :103.00
##     Terminal       S.F.Ratio      perc.alumni        Expend
##  Min.   : 24.0   Min.   : 2.50   Min.   : 0.00   Min.   : 3186
##  1st Qu.: 71.0   1st Qu.:11.50   1st Qu.:13.00   1st Qu.: 6751
##  Median : 82.0   Median :13.60   Median :21.00   Median : 8377
##  Mean   : 79.7   Mean   :14.09   Mean   :22.74   Mean   : 9660
##  3rd Qu.: 92.0   3rd Qu.:16.50   3rd Qu.:31.00   3rd Qu.:10830
```

```
##  Max.   :100.0   Max.   :39.80   Max.   :64.00   Max.   :56233
##    Grad.Rate
##  Min.   : 10.00
##  1st Qu.: 53.00
##  Median : 65.00
##  Mean   : 65.46
##  3rd Qu.: 78.00
##  Max.   :118.00
```

```
# ii.
pairs(college[,1:10])
```



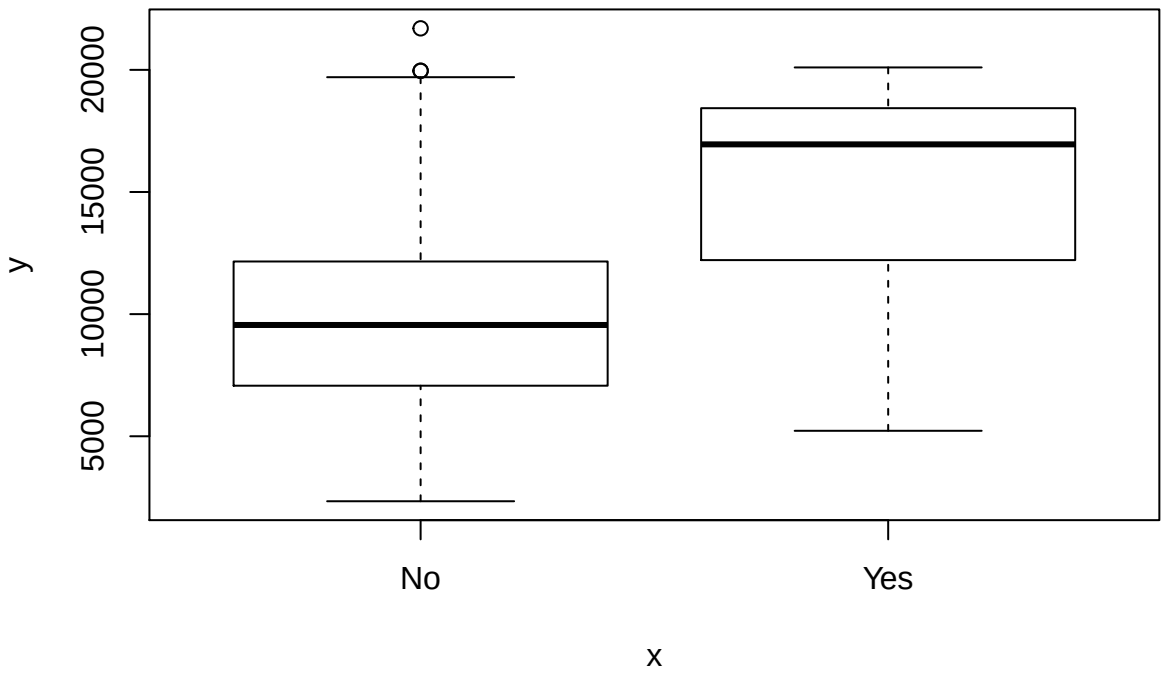

```
# iii.
plot(college$Private, college$Outstate)
```



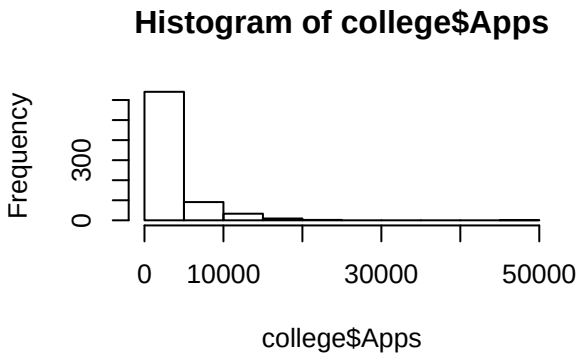

```
# iv.
Elite <- rep("No", nrow(college))
Elite[college$Top10perc > 50] <- "Yes"
Elite <- as.factor(Elite)
college <- data.frame(college, Elite)
summary(college$Elite)
```

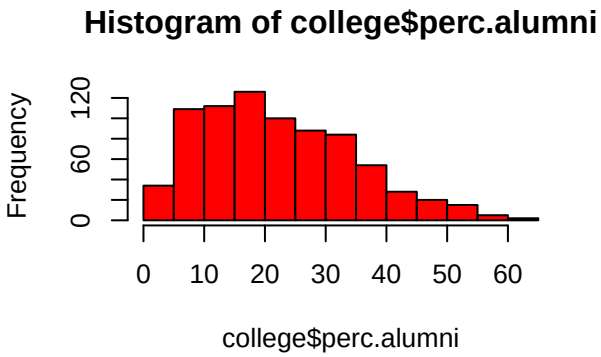
```
##  No Yes
## 699  78
```

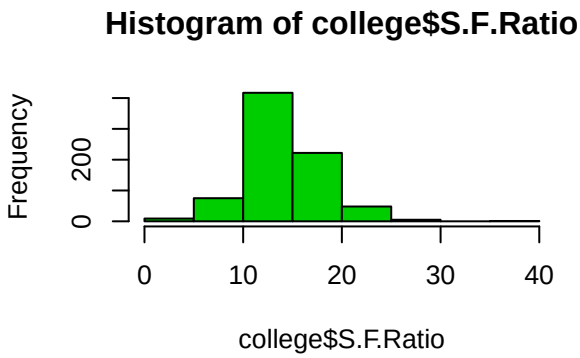
```
plot(college$Elite, college$Outstate)
```

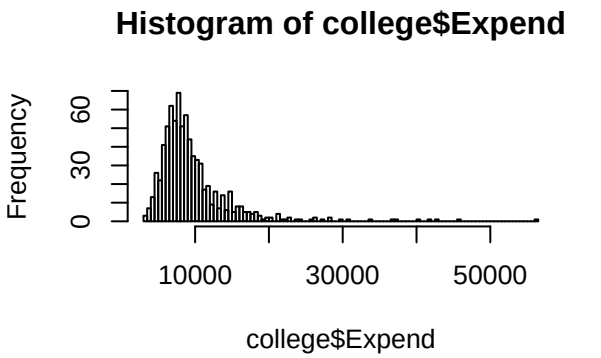



```
# v.
par(mfrow=c(2,2))
hist(college$Apps)
hist(college$perc.alumni, col=2)
hist(college$S.F.Ratio, col=3, breaks=10)
hist(college$Expend, breaks=100)
```

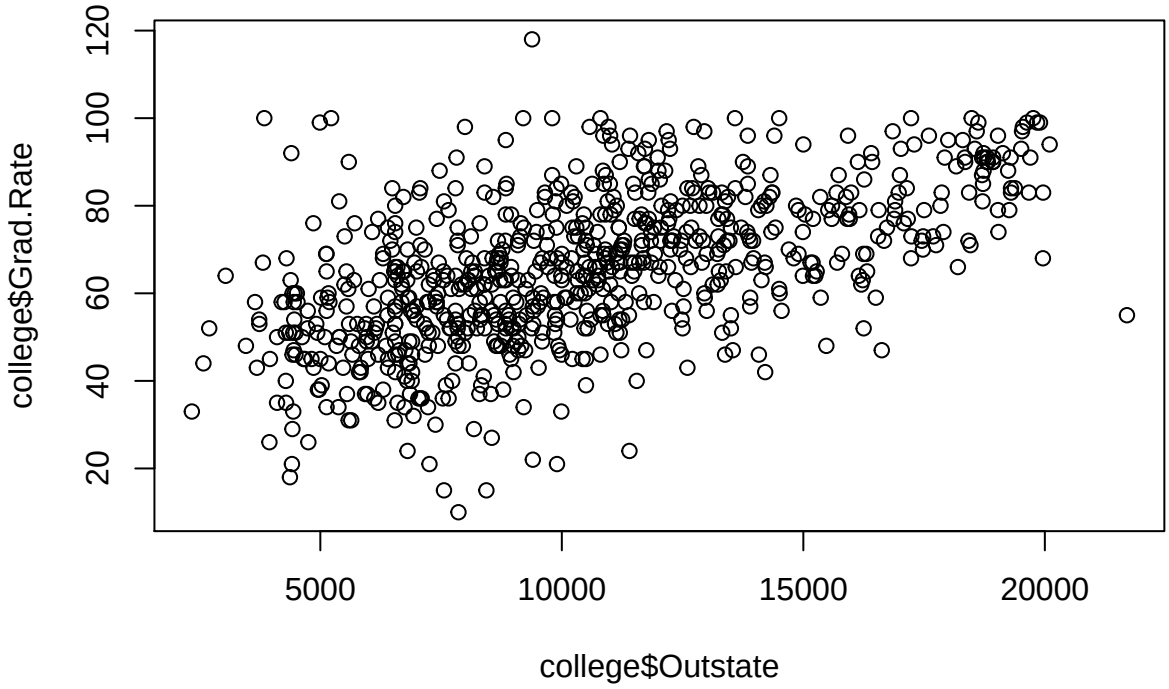




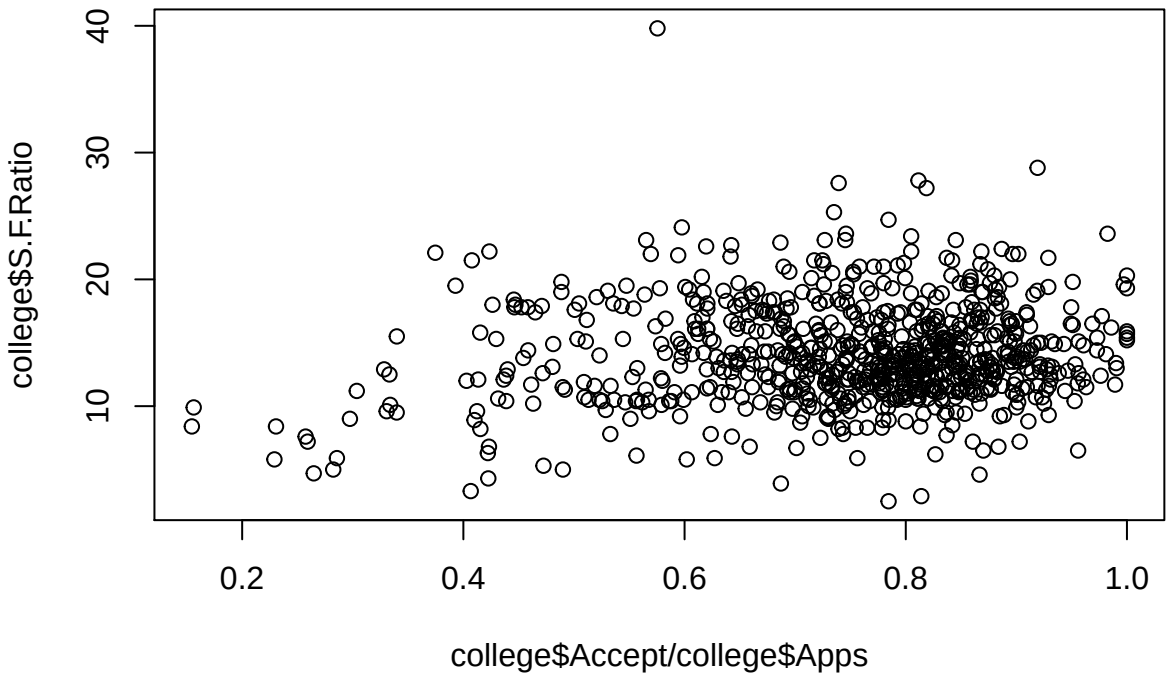




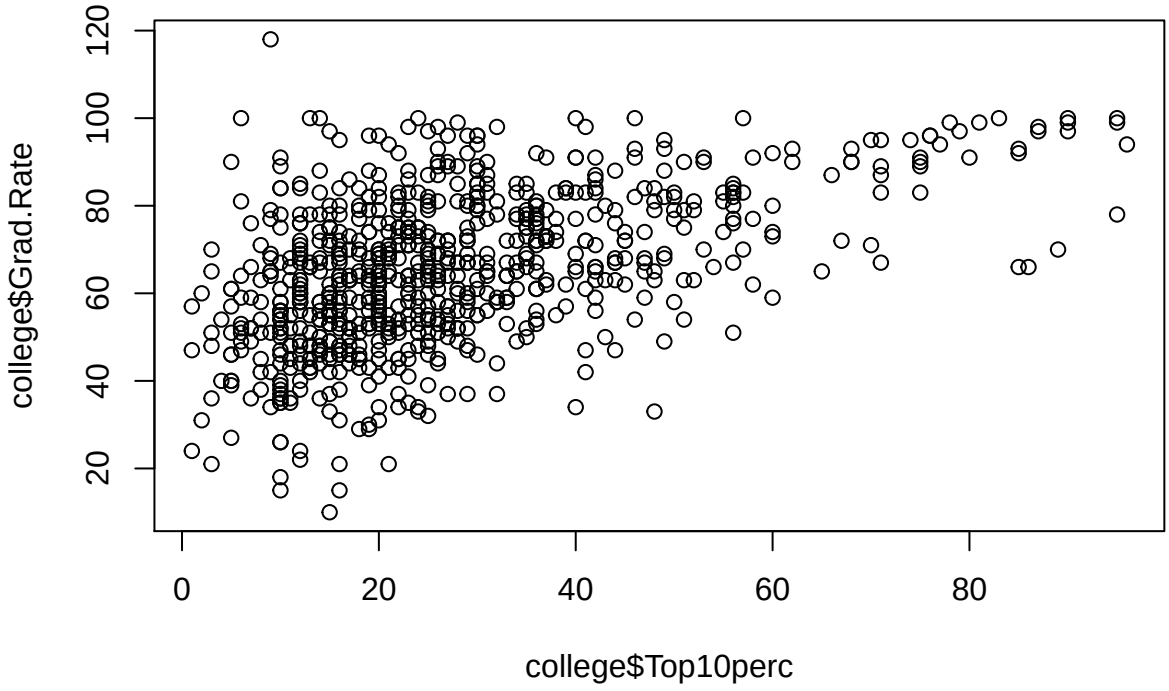

```
# vi.
par(mfrow=c(1,1))
# High tuition correlates to high graduation rate.
plot(college$Outstate, college$Grad.Rate)
```




```
# Colleges with low acceptance rate tend to have low S:F ratio.
plot(college$Accept / college$Apps, college$S.F.Ratio)
```




```
# Colleges with the most students from top 10% perc don't necessarily have
# the highest graduation rate. Also, rate > 100 is erroneous!
plot(college$Top10perc, college$Grad.Rate)
```



2

```
## mark ? as NA
Auto <- read.csv("C:/Users/jzz0121/Desktop/STAT6000/datasets/Auto.csv", header=T, na.strings="?")
summary(Auto)  ## notice there are NA in horsepower
```

```
##       mpg          cylinders      displacement     horsepower
##  Min.   : 9.00   Min.   :3.000   Min.   : 68.0   Min.   : 46.0
##  1st Qu.:17.50   1st Qu.:4.000   1st Qu.:104.0   1st Qu.: 75.0
##  Median :23.00   Median :4.000   Median :146.0   Median : 93.5
##  Mean   :23.52   Mean   :5.458   Mean   :193.5   Mean   :104.5
##  3rd Qu.:29.00   3rd Qu.:8.000   3rd Qu.:262.0   3rd Qu.:126.0
##  Max.   :46.60   Max.   :8.000   Max.   :455.0   Max.   :230.0
##                                                  NA's   :5
##      weight      acceleration        year           origin
##  Min.   :1613   Min.   : 8.00   Min.   :70.00   Min.   :1.000
##  1st Qu.:2223   1st Qu.:13.80   1st Qu.:73.00   1st Qu.:1.000
##  Median :2800   Median :15.50   Median :76.00   Median :1.000
##  Mean   :2970   Mean   :15.56   Mean   :75.99   Mean   :1.574
##  3rd Qu.:3609   3rd Qu.:17.10   3rd Qu.:79.00   3rd Qu.:2.000
##  Max.   :5140   Max.   :24.80   Max.   :82.00   Max.   :3.000
##
##              name
##  ford pinto    :  6
```

```
##  amc matador   :  5
##  ford maverick :  5
##  toyota corolla:  5
##  amc gremlin   :  4
##  amc hornet    :  4
##  (Other)       :368
```

```
Auto <- na.omit(Auto)
dim(Auto)
```

```
## [1] 392   9
```

```
summary(Auto)
```

```
##       mpg          cylinders      displacement     horsepower
##  Min.   : 9.00   Min.   :3.000   Min.   : 68.0   Min.   : 46.0
##  1st Qu.:17.00   1st Qu.:4.000   1st Qu.:105.0   1st Qu.: 75.0
##  Median :22.75   Median :4.000   Median :151.0   Median : 93.5
##  Mean   :23.45   Mean   :5.472   Mean   :194.4   Mean   :104.5
##  3rd Qu.:29.00   3rd Qu.:8.000   3rd Qu.:275.8   3rd Qu.:126.0
##  Max.   :46.60   Max.   :8.000   Max.   :455.0   Max.   :230.0
##
##      weight      acceleration        year           origin
##  Min.   :1613   Min.   : 8.00   Min.   :70.00   Min.   :1.000
##  1st Qu.:2225   1st Qu.:13.78   1st Qu.:73.00   1st Qu.:1.000
##  Median :2804   Median :15.50   Median :76.00   Median :1.000
##  Mean   :2978   Mean   :15.54   Mean   :75.98   Mean   :1.577
##  3rd Qu.:3615   3rd Qu.:17.02   3rd Qu.:79.00   3rd Qu.:2.000
##  Max.   :5140   Max.   :24.80   Max.   :82.00   Max.   :3.000
##
##                  name
##  amc matador       :  5
##  ford pinto        :  5
##  toyota corolla    :  5
##  amc gremlin       :  4
##  amc hornet        :  4
##  chevrolet chevette:  4
##  (Other)           :365
```

(a)

quantitative: mpg, cylinders, displacement, horsepower, weight, acceleration, year.

qualitative: name, origin

(b)

```
# apply the range function to the first seven columns of Auto
sapply(Auto[, 1:7], range)
```

```
##       mpg cylinders displacement horsepower weight acceleration year
## [1,]  9.0         3           68         46   1613          8.0   70
## [2,] 46.6         8          455        230   5140         24.8   82
```

(c)

```
sapply(Auto[, 1:7], mean)
```

```
##          mpg    cylinders displacement   horsepower       weight
##    23.445918     5.471939   194.411990   104.469388  2977.584184
## acceleration         year
##    15.541327    75.979592
```

```
sapply(Auto[, 1:7], sd)
```

```
##          mpg    cylinders displacement   horsepower       weight
##     7.805007     1.705783   104.644004    38.491160   849.402560
## acceleration         year
##     2.758864     3.683737
```

(d)

```
newAuto <- Auto[-(10:85),]

sapply(newAuto[, 1:7], range)
```

```
##       mpg cylinders displacement horsepower weight acceleration year
## [1,] 11.0         3           68         46   1649          8.5   70
## [2,] 46.6         8          455        230   4997         24.8   82
```

```
sapply(newAuto[, 1:7], mean)
```

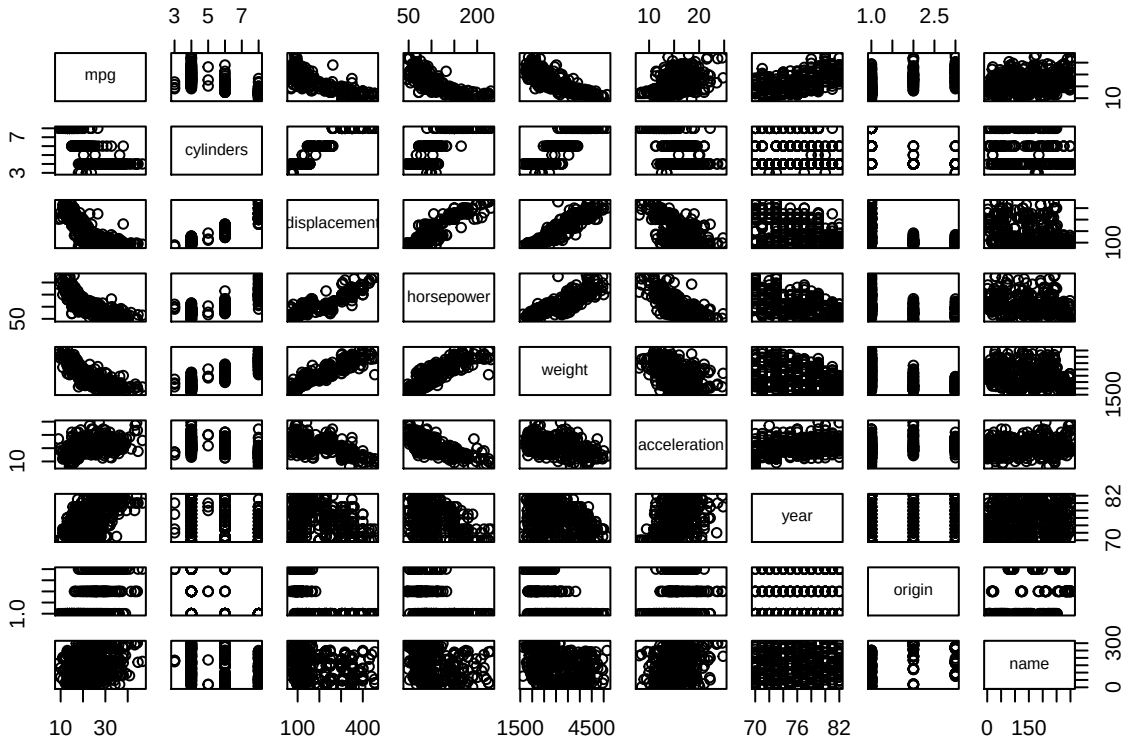
```
##          mpg    cylinders displacement   horsepower       weight
##    24.404430     5.373418   187.240506   100.721519  2935.971519
## acceleration         year
##    15.726899    77.145570
```

```
sapply(newAuto[, 1:7], sd)
```

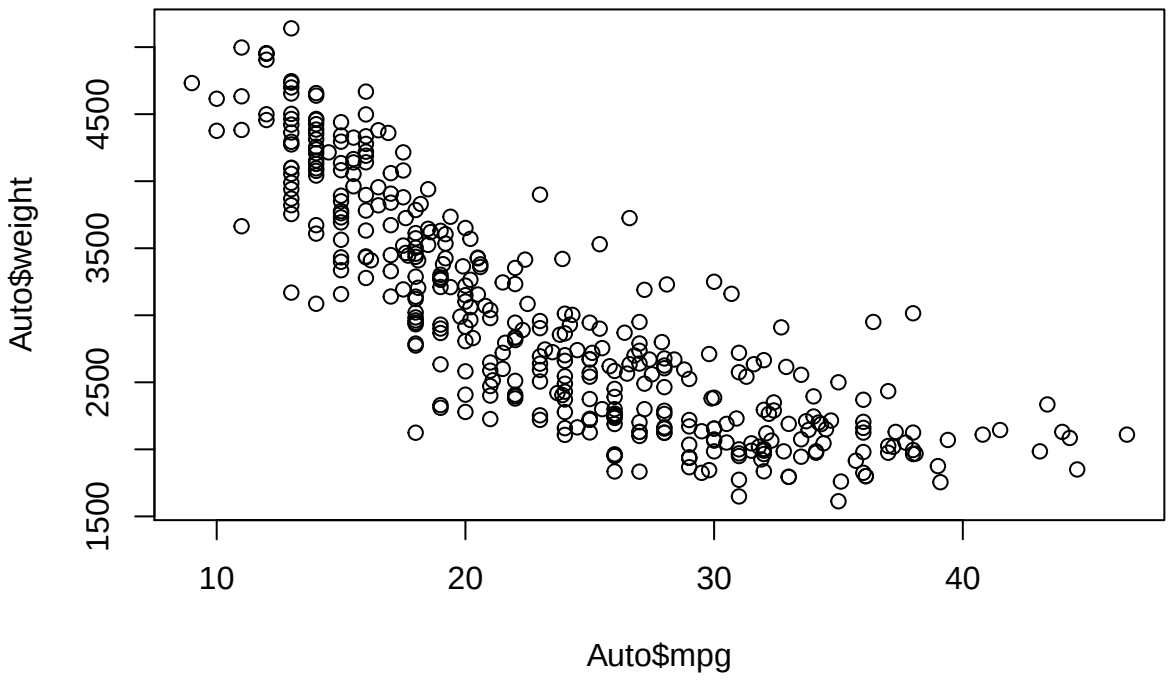
```
##          mpg    cylinders displacement   horsepower       weight
##     7.867283     1.654179    99.678367    35.708853   811.300208
## acceleration         year
##     2.693721     3.106217
```

(e)

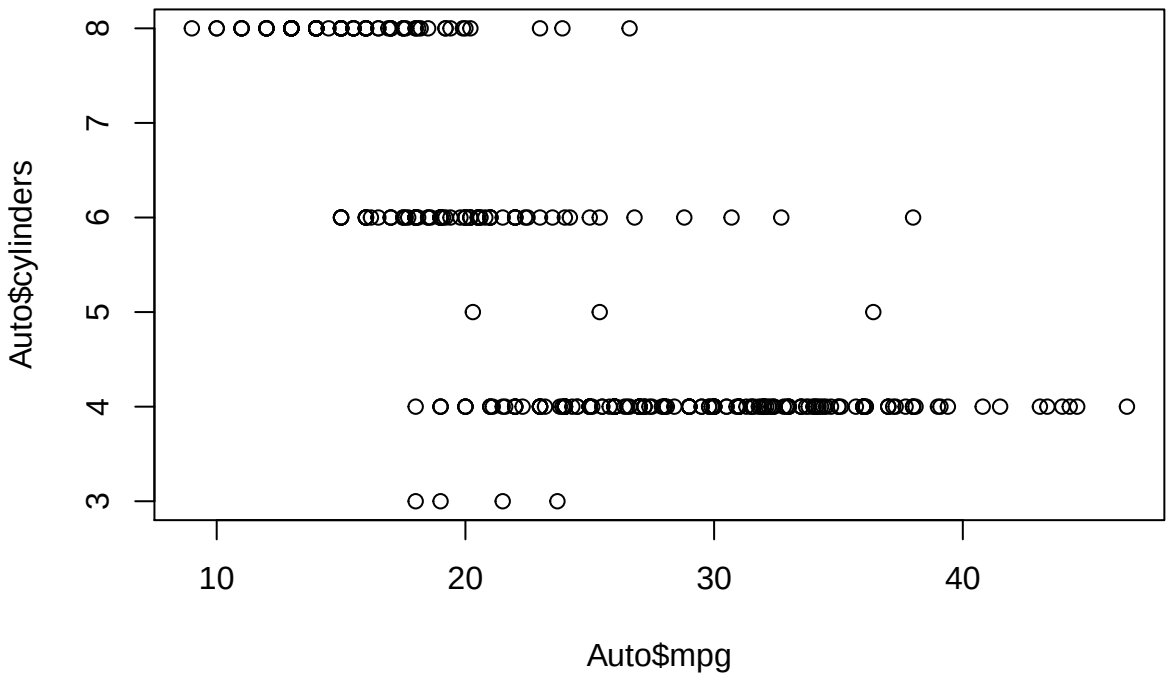
```
pairs(Auto)
```



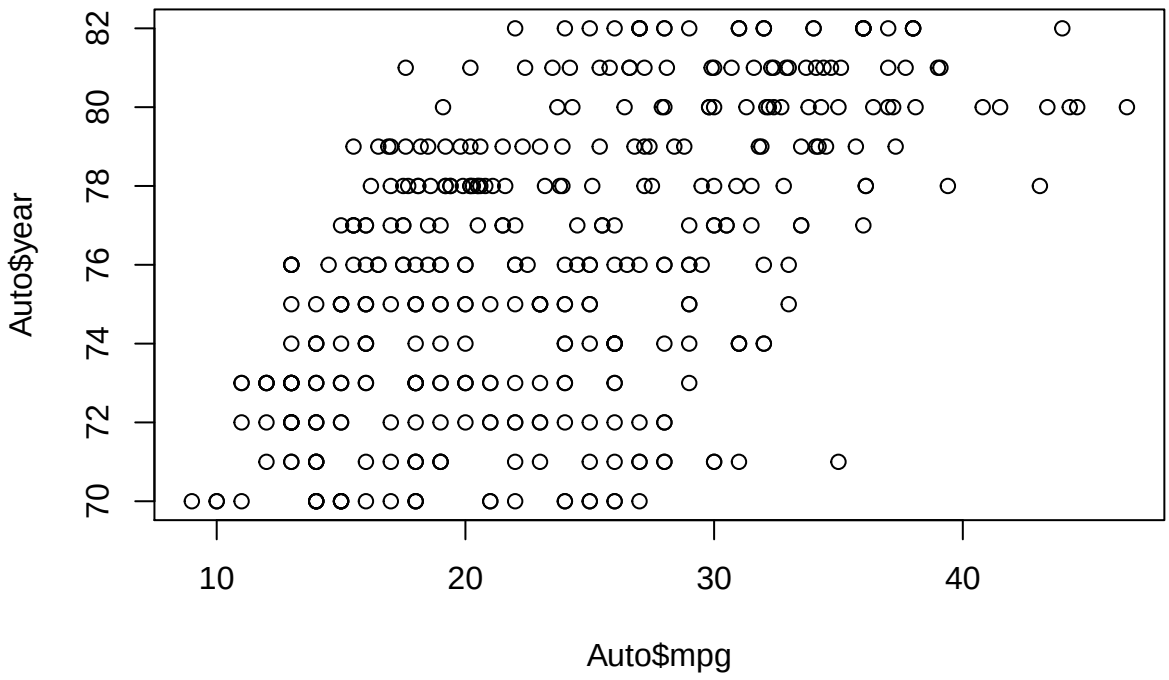

```
# Heavier weight correlates with lower mpg.
plot(Auto$mpg, Auto$weight)
```




```
# More cylinders, less mpg.
plot(Auto$mpg, Auto$cylinders)
```




```
# Cars become more efficient over time.
plot(Auto$mpg, Auto$year)
```



(f) See pairs plot in (e). All of the predictors show some correlation with mpg. The name predictor has too little observations per name though, so using this as a predictor is likely to result in overfitting the data and will not generalize well.

3

(a) 506 rows, 14 columns.

14 features, 506 housing values in Boston suburbs

```
library(MASS)
# ?Boston
dim(Boston)
```

```
## [1] 506  14
```

(b)

X correlates with: a, b, c

crim: age, dis, rad, tax, ptratio

zn: indus, nox, age, lstat

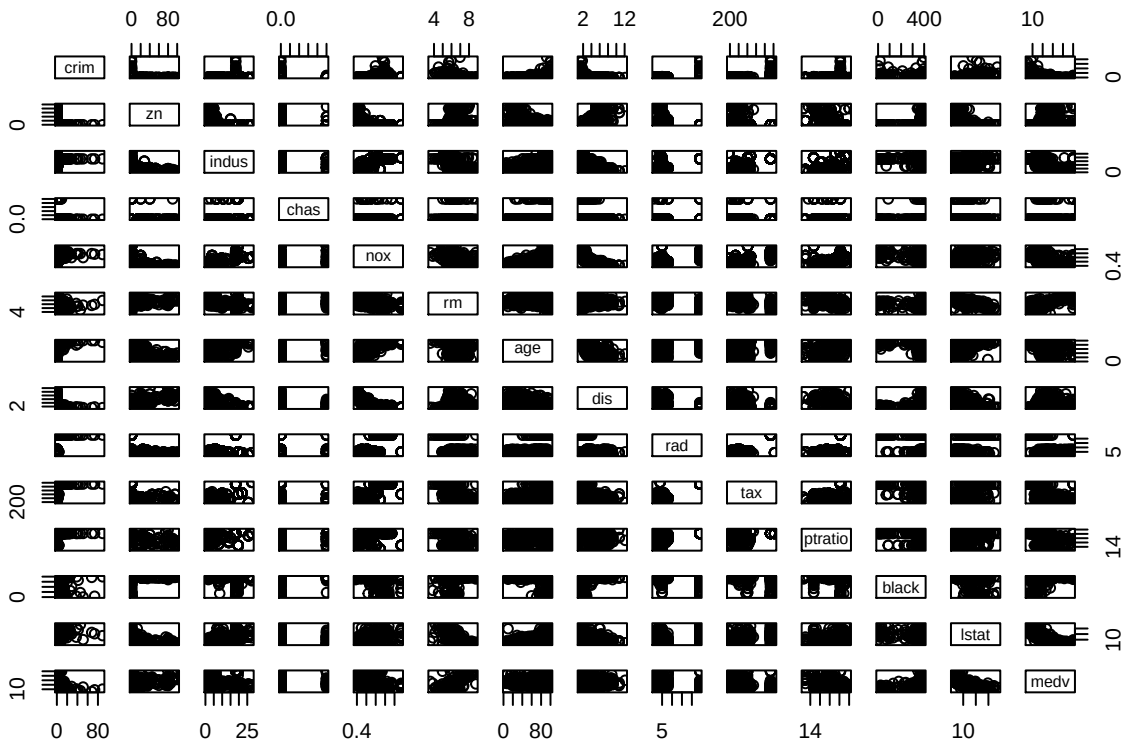
indus: age, dis

nox: age, dis

dis: lstat

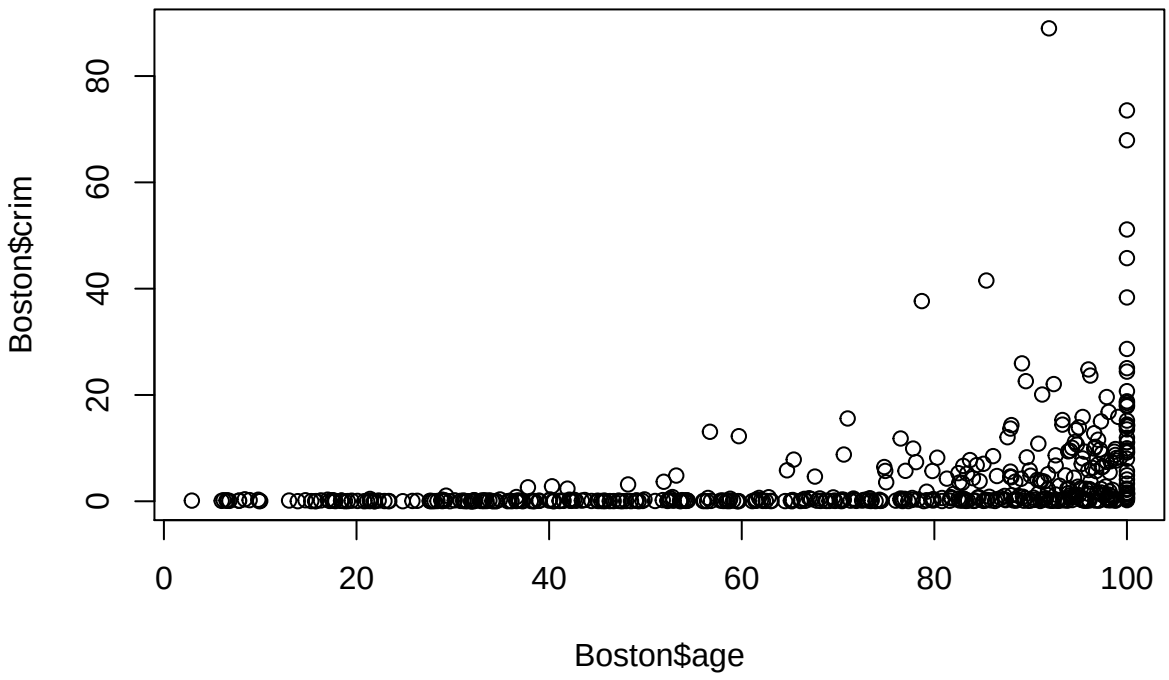
lstat: medv

```
pairs(Boston)
```

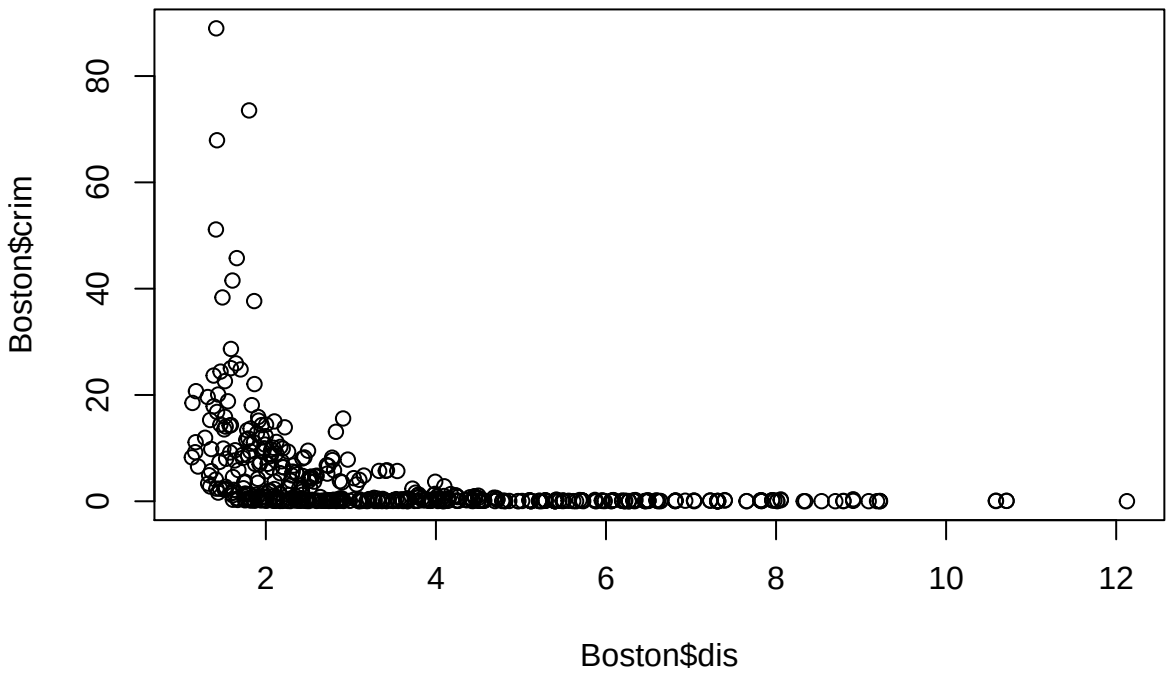


(c)

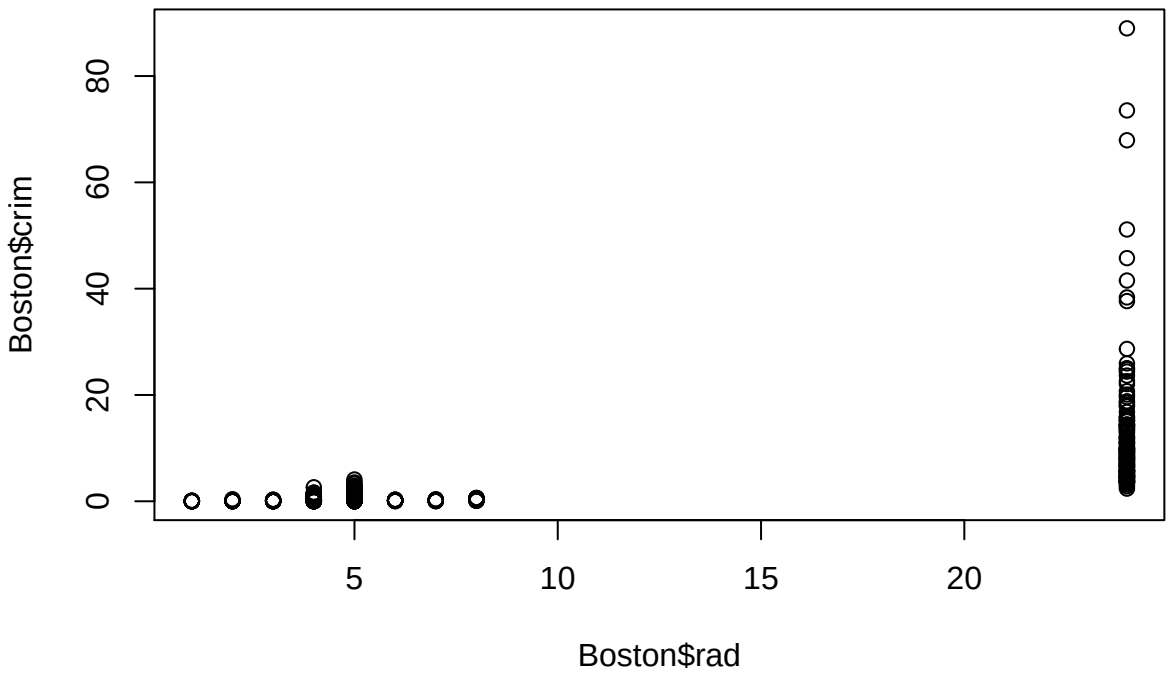
```
# Older homes, more crime
plot(Boston$age, Boston$crim)
```



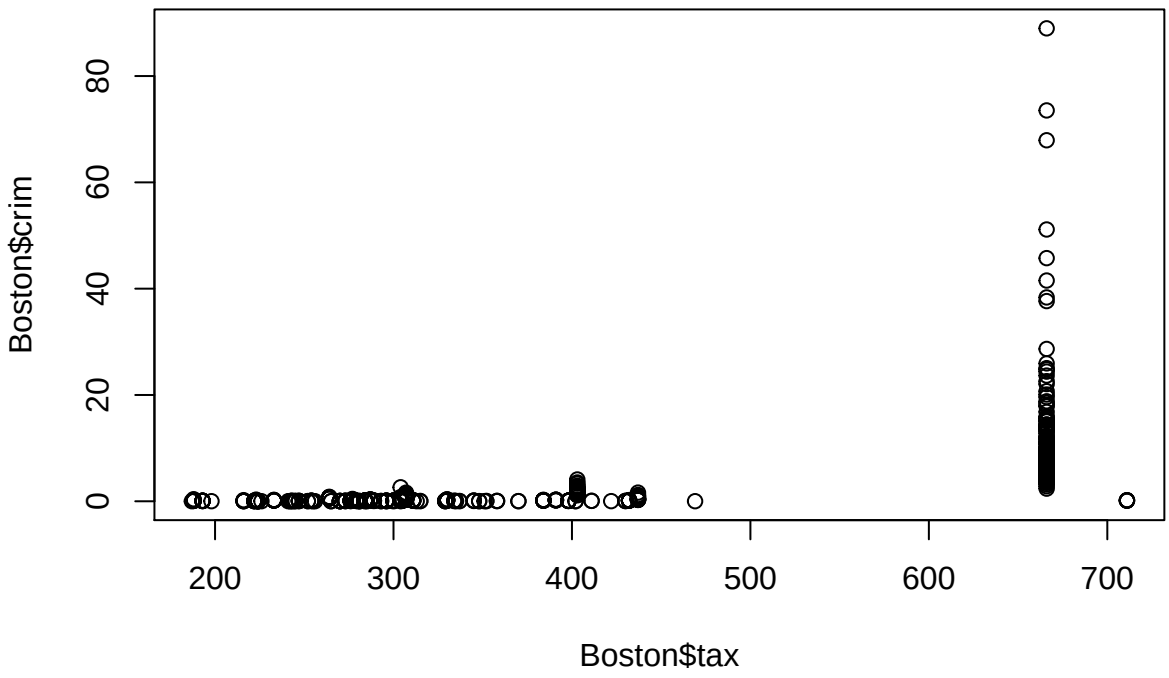

```
# Closer to work-area, more crime
plot(Boston$dis, Boston$crim)
```



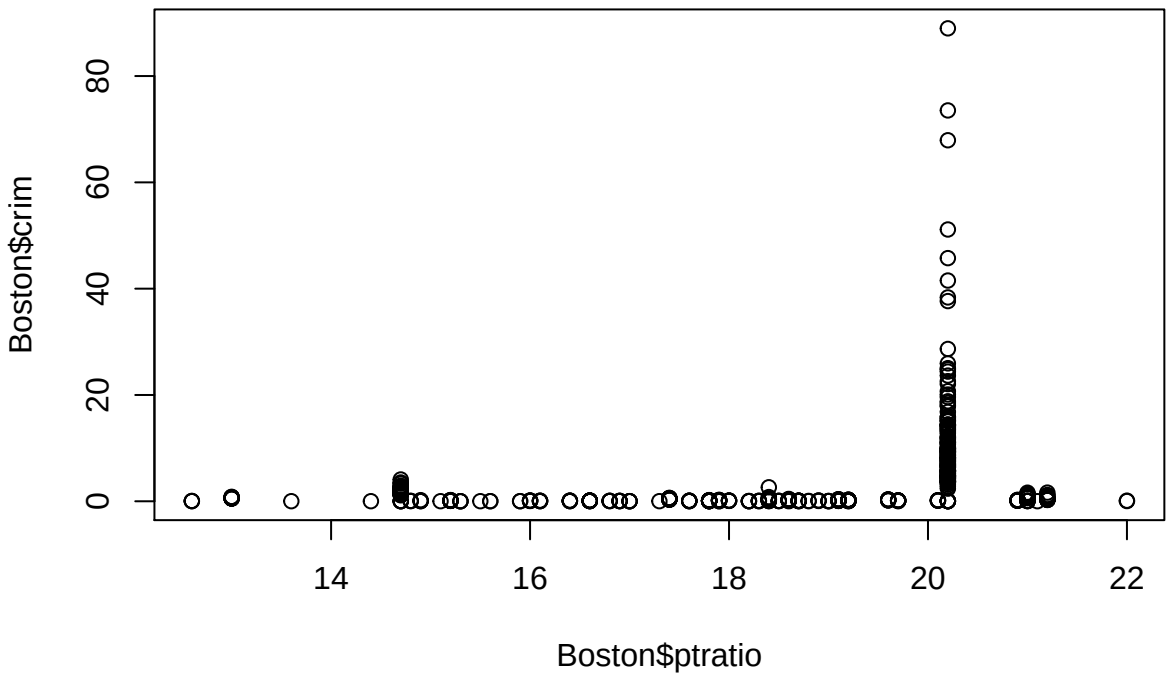

```
# Higher index of accessibility to radial highways, more crime
plot(Boston$rad, Boston$crim)
```




```
# Higher tax rate, more crime
plot(Boston$tax, Boston$crim)
```

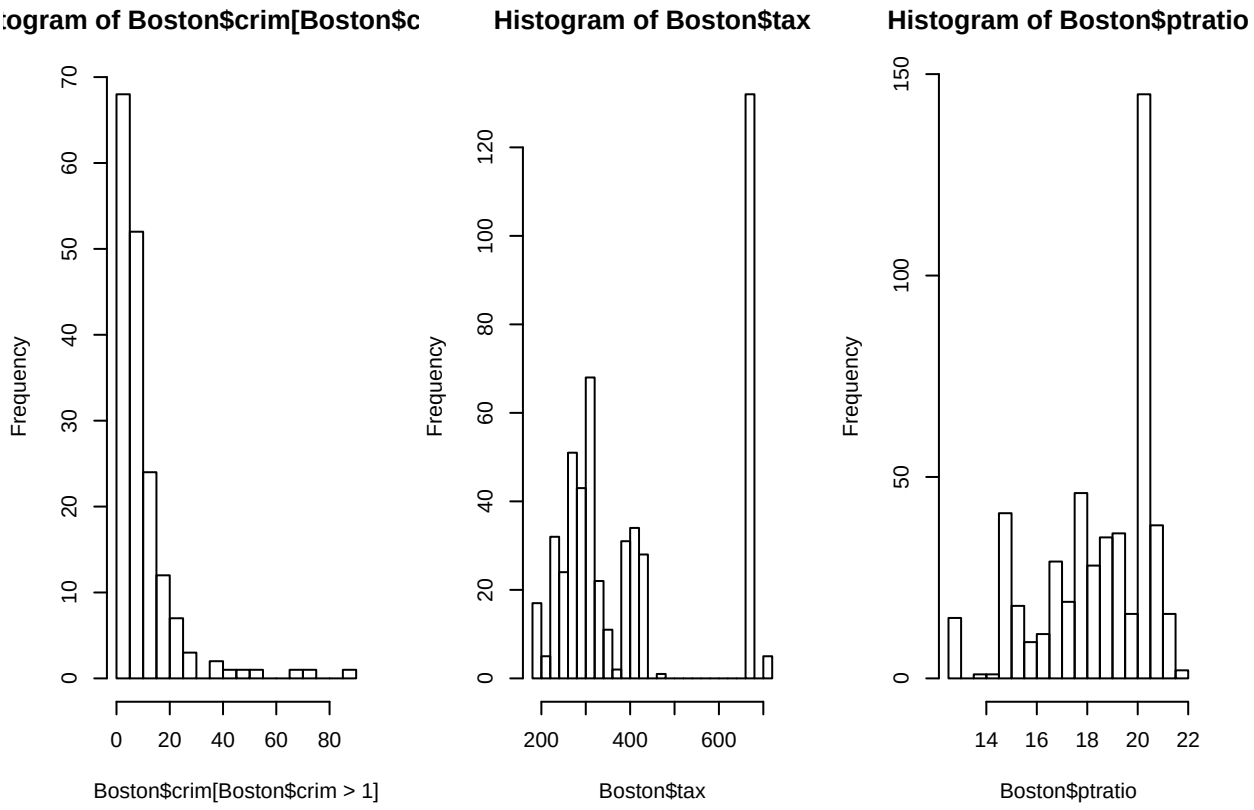



```
# Higher pupil:teacher ratio, more crime
plot(Boston$ptratio, Boston$crim)
```



(d)

```
par(mfrow=c(1,3))
hist(Boston$crim[Boston$crim>1], breaks=25)
# most cities have low crime rates, but there is a long tail: 18 suburbs appear
# to have a crime rate > 20, reaching to above 80
hist(Boston$tax, breaks=25)
# there is a large divide between suburbs with low tax rates and a peak at 660-680
hist(Boston$ptratio, breaks=25)
```




```
# a skew towards high ratios, but no particularly high ratios
```

(e)

```
# 35 suburbs
dim(subset(Boston, chas == 1))
```

```
## [1] 35 14
```

```
table(Boston$chas)
```

```
##
##   0   1
## 471  35
```

(f)

```
median(Boston$ptratio)
```

```
## [1] 19.05
```

(g)

```r
subset(Boston, medv == min(Boston$medv))
```

```
##        crim zn indus chas   nox    rm age    dis rad tax ptratio  black
## 399 38.3518  0  18.1    0 0.693 5.453 100 1.4896  24 666    20.2 396.90
## 406 67.9208  0  18.1    0 0.693 5.683 100 1.4254  24 666    20.2 384.97
##     lstat medv
## 399 30.59    5
## 406 22.98    5
```

```r
summary(Boston)
```

```
##       crim                zn             indus            chas        
##  Min.   : 0.00632   Min.   :  0.00   Min.   : 0.46   Min.   :0.00000  
##  1st Qu.: 0.08204   1st Qu.:  0.00   1st Qu.: 5.19   1st Qu.:0.00000  
##  Median : 0.25651   Median :  0.00   Median : 9.69   Median :0.00000  
##  Mean   : 3.61352   Mean   : 11.36   Mean   :11.14   Mean   :0.06917  
##  3rd Qu.: 3.67708   3rd Qu.: 12.50   3rd Qu.:18.10   3rd Qu.:0.00000  
##  Max.   :88.97620   Max.   :100.00   Max.   :27.74   Max.   :1.00000  
##       nox               rm             age              dis        
##  Min.   :0.3850   Min.   :3.561   Min.   :  2.90   Min.   : 1.130  
##  1st Qu.:0.4490   1st Qu.:5.886   1st Qu.: 45.02   1st Qu.: 2.100  
##  Median :0.5380   Median :6.208   Median : 77.50   Median : 3.207  
##  Mean   :0.5547   Mean   :6.285   Mean   : 68.57   Mean   : 3.795  
##  3rd Qu.:0.6240   3rd Qu.:6.623   3rd Qu.: 94.08   3rd Qu.: 5.188  
##  Max.   :0.8710   Max.   :8.780   Max.   :100.00   Max.   :12.127  
##       rad              tax           ptratio          black       
##  Min.   : 1.000   Min.   :187.0   Min.   :12.60   Min.   :  0.32  
##  1st Qu.: 4.000   1st Qu.:279.0   1st Qu.:17.40   1st Qu.:375.38  
##  Median : 5.000   Median :330.0   Median :19.05   Median :391.44  
##  Mean   : 9.549   Mean   :408.2   Mean   :18.46   Mean   :356.67  
##  3rd Qu.:24.000   3rd Qu.:666.0   3rd Qu.:20.20   3rd Qu.:396.23  
##  Max.   :24.000   Max.   :711.0   Max.   :22.00   Max.   :396.90  
##      lstat            medv      
##  Min.   : 1.73   Min.   : 5.00  
##  1st Qu.: 6.95   1st Qu.:17.02  
##  Median :11.36   Median :21.20  
##  Mean   :12.65   Mean   :22.53  
##  3rd Qu.:16.95   3rd Qu.:25.00  
##  Max.   :37.97   Max.   :50.00
```

```r
# Not the best place to live, but certainly not the worst.
```

(h)

```r
dim(subset(Boston, rm > 7))
```

```
## [1] 64 14
```

```r
# 64
dim(subset(Boston, rm > 8))
```

```
## [1] 13 14
```

```
# 13
summary(subset(Boston, rm > 8))
```

```
##       crim               zn             indus             chas
##  Min.   :0.02009   Min.   : 0.00   Min.   : 2.680   Min.   :0.0000
##  1st Qu.:0.33147   1st Qu.: 0.00   1st Qu.: 3.970   1st Qu.:0.0000
##  Median :0.52014   Median : 0.00   Median : 6.200   Median :0.0000
##  Mean   :0.71879   Mean   :13.62   Mean   : 7.078   Mean   :0.1538
##  3rd Qu.:0.57834   3rd Qu.:20.00   3rd Qu.: 6.200   3rd Qu.:0.0000
##  Max.   :3.47428   Max.   :95.00   Max.   :19.580   Max.   :1.0000
##       nox               rm             age              dis
##  Min.   :0.4161   Min.   :8.034   Min.   : 8.40   Min.   :1.801
##  1st Qu.:0.5040   1st Qu.:8.247   1st Qu.:70.40   1st Qu.:2.288
##  Median :0.5070   Median :8.297   Median :78.30   Median :2.894
##  Mean   :0.5392   Mean   :8.349   Mean   :71.54   Mean   :3.430
##  3rd Qu.:0.6050   3rd Qu.:8.398   3rd Qu.:86.50   3rd Qu.:3.652
##  Max.   :0.7180   Max.   :8.780   Max.   :93.90   Max.   :8.907
##       rad              tax           ptratio          black
##  Min.   : 2.000   Min.   :224.0   Min.   :13.00   Min.   :354.6
##  1st Qu.: 5.000   1st Qu.:264.0   1st Qu.:14.70   1st Qu.:384.5
##  Median : 7.000   Median :307.0   Median :17.40   Median :386.9
##  Mean   : 7.462   Mean   :325.1   Mean   :16.36   Mean   :385.2
##  3rd Qu.: 8.000   3rd Qu.:307.0   3rd Qu.:17.40   3rd Qu.:389.7
##  Max.   :24.000   Max.   :666.0   Max.   :20.20   Max.   :396.9
##      lstat            medv
##  Min.   :2.47   Min.   :21.9
##  1st Qu.:3.32   1st Qu.:41.7
##  Median :4.14   Median :48.3
##  Mean   :4.31   Mean   :44.2
##  3rd Qu.:5.12   3rd Qu.:50.0
##  Max.   :7.44   Max.   :50.0
```

```
# compare with summary(Boston)
# relatively lower crime (comparing range), lower lstat (comparing range)
```