Chapter 2 Problem 10

a. To begin, load the Boston data set.

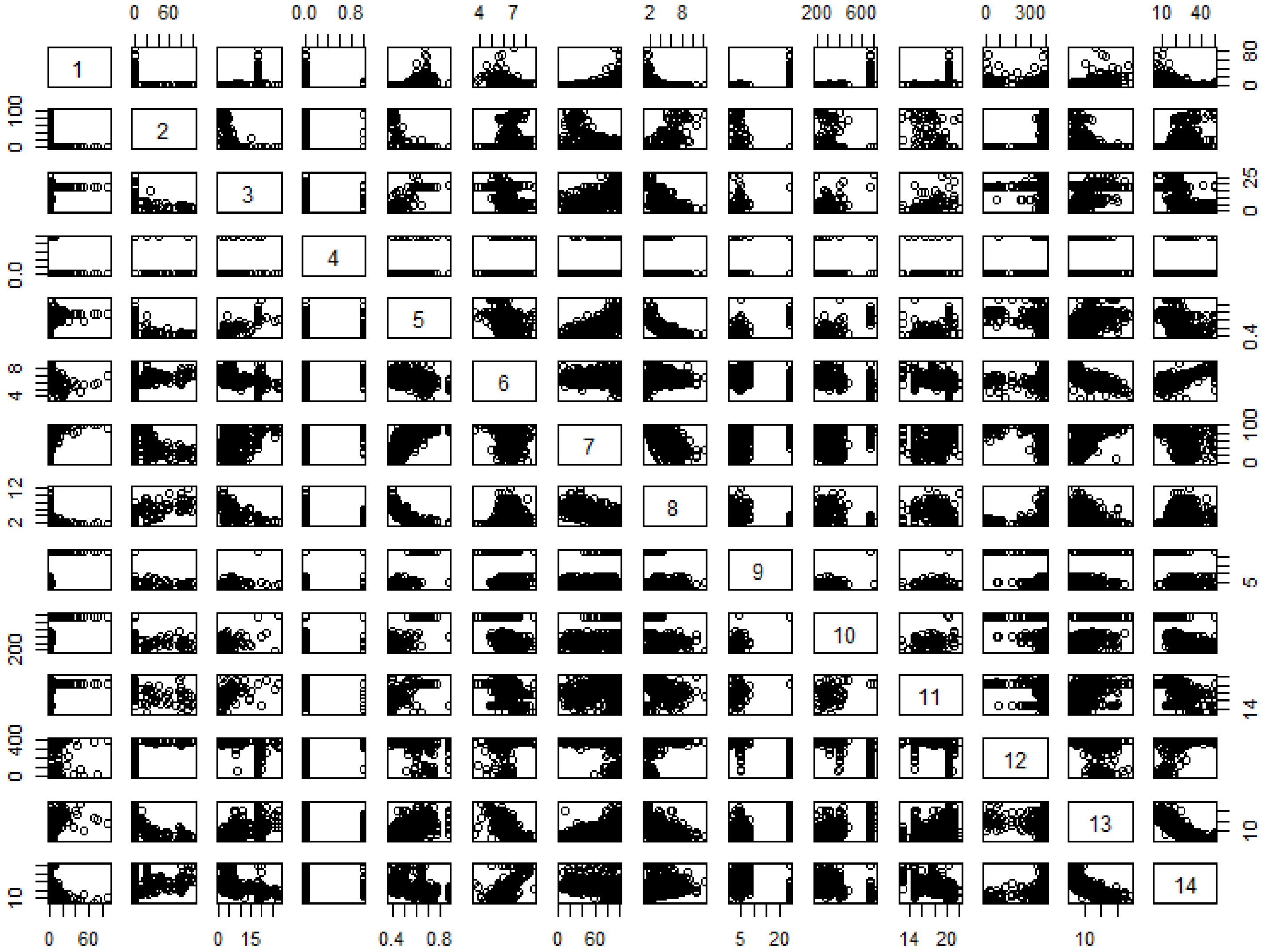
```
> library(MASS)
> Boston
> ?Boston #information
```

Number of rows: 506 (suburbs of Boston)
Number of columns: 14, representing:

1. crim-per capita crime rate by town.
2. zn-proportion of residential land zoned for lots over 25,000 sq.ft.
3. indus-proportion of non-retail business acres per town.
4. chas-Charles River dummy variable (= 1 if tract bounds river; 0 otherwise).
5. nox-nitrogen oxides concentration (parts per 10 million).
6. rm-average number of rooms per dwelling.
7. age-proportion of owner-occupied units built prior to 1940.
8. dis-weighted mean of distances to five Boston employment centres.
9. rad-index of accessibility to radial highways.
10. tax-full-value property-tax rate per \$10,000.
11. ptratio-pupil-teacher ratio by town.
12. black-*1000(Bk - 0.63)^2* where *Bk* is the proportion of blacks by town.
13. lstat-lower status of the population (percent).
14. medv-median value of owner-occupied homes in \$1000s.

b. Make some pairwise scatterplots of the predictors. Describe your findings.

```
> pairs(Boston,1:14)
```



c. Are any of the predictors associated with per capita crime rate? If so, explain the relationship.

As age of town increases, crime rate increases.
Crime rates are higher when in closer proximity to employment centers.

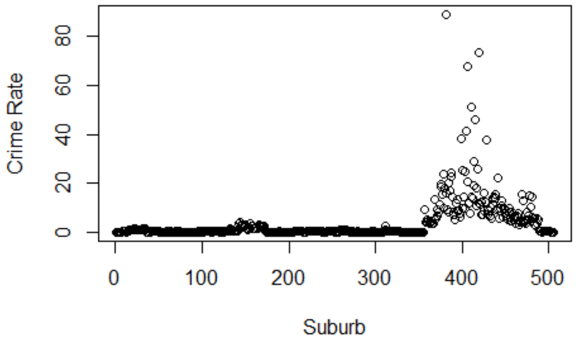
There are some peaks of crime rate in the following:
Low proportion in residential-zoned lots
When tract does not bound Charles River
High access to radial highways
Etc.

d. Do any of the suburbs of Boston appear to have particularly high crime rates? Tax rates? Pupil-teacher ratios? Comment on the range of each predictor.

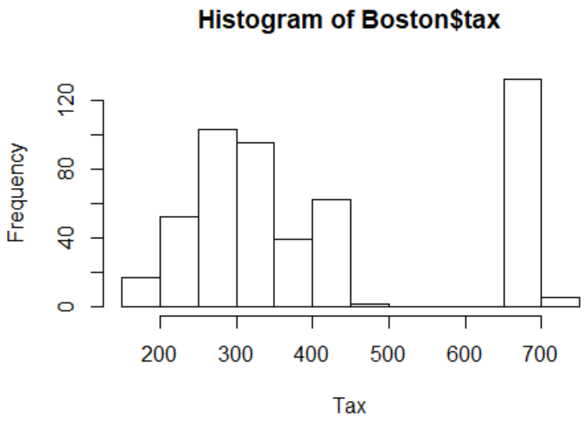
```
> summary(Boston)
```

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

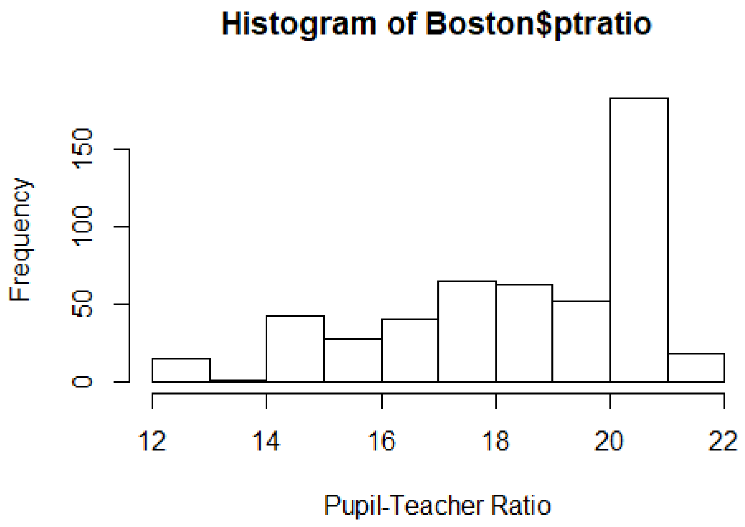
The range of the crime predictor is 88.97%, so the data is very spread out. Given that the maximum crime rate is 88.98% and the mean value is 3.61%, at least one suburb has a significantly higher crime rate than others. Out of curiosity, here is the plot of crime rate with each suburb:



I observed a histogram of Boston property tax rates since a regular plot did not help as much. The two peaks indicate that the tax is bimodal which suggests we have two different groups of suburbs. One group pays a high tax while the other pays a medium tax. There is not a major differentiation like in the crime predictor. The range is 513, so again, the data for tax rates is spread out.



Finally, we observe pupil-teacher ratios with a histogram. There is one obvious peak, though some cities have very low pupil-teacher ratios comparatively. The range is 9.4.



e. How many of the suburbs in this data set bound the Charles River?

We need to identify the amount of observations whose value for chas = 1. The following command gives us 35 towns bounding the Charles River.

```
        > count <- nrow(Boston[Boston$chas==1,])
```

f. What is the median pupil-teacher ratio among the towns in the data set?

19.05 (refer to the summary table).

g. Which suburb has the lowest median value of owner-occupied houses (medv)? What are the values of the other predictors for that suburb, and how do these values compare to the overall ranges for those predictors? Comment on your findings.

```
        #use which.min/which.max to find min/max values
        > Min <- Boston[which.min(Boston$medv),]
        > View(Min)
```

This returns observation **399**.
Now, we analyze how suburb 399 compares with the whole data set.

```
`> sapply(Boston[,1:14], quantile) #whole data set

          crim    zn indus chas   nox     rm     age       dis rad tax ptratio    black  lstat
0%    0.006320   0.0  0.46    0 0.385 3.5610   2.900  1.129600   1 187   12.60   0.3200  1.730
25%   0.082045   0.0  5.19    0 0.449 5.8855  45.025  2.100175   4 279   17.40 375.3775  6.950
50%   0.256510   0.0  9.69    0 0.538 6.2085  77.500  3.207450   5 330   19.05 391.4400 11.360
75%   3.677083  12.5 18.10    0 0.624 6.6235  94.075  5.188425  24 666   20.20 396.2250 16.955
100% 88.976200 100.0 27.74    1 0.871 8.7800 100.000 12.126500  24 711   22.00 396.9000 37.970
       medv
0%    5.000
25%  17.025
50%  21.200
75%  25.000
100% 50.000

> View(Min) #solely suburb 399

crim: 38.3518
zn: 0
indus: 18.1
```

```
chas: 0
nox: 0.693
rm: 5.453
age: 100
dis: 1.4896
rad: 24
tax: 666
ptratio: 20.2
black: 396.9
lstat: 30.59
medv: 5
```

From observation 399, these predictors are at or above the 75th percentile when compared to the entire Boston data set: crim, indus, nox, age, rad, tax, ptratio, lstat

h. In this data set, how many of the suburbs average more than seven rooms per dwelling? More than eight rooms per dwelling? Comment on the suburbs that average more than eight rooms per dwelling.

```
> count7rooms <- nrow(Boston[Boston$rm>7,])
> count8rooms <- nrow(Boston[Boston$rm>81,])
```

There are 64 suburbs with more than 7 rooms per house on average, and there are 13 suburbs with more than 8 rooms per house on average.

```
> sapply(Boston[Boston$rm > 8,], mean)
```

```
       crim          zn       indus        chas         nox          rm         age         dis 
  0.7187954  13.6153846   7.0784615   0.1538462   0.5392385   8.3485385  71.5384615   3.4301923 
        rad         tax     ptratio       black       lstat        medv 
  7.4615385 325.0769231  16.3615385 385.2107692   4.3100000  44.2000000 
```

We compare the above table with the one given by `> sapply(Boston[,1:14], quantile).`
Crime rate is above the 50th percentile.
There is a lower pupil-teacher ratio.
There is a small percentage of people in the lower status.
The median value of homes is much higher.