Summer Institute in Statistical Genetics
Module 6: Computing for Statistical Genetics

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2. Learning to Draw

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Graphics

R (and S-PLUS) can produce graphics in many formats, including:

- on screen
- PDF files for LaTeX or emailing to people
- PNG or JPEG bitmap formats for web pages (or on non-Windows platforms to produce graphics for MS Office). PNG is also useful for graphs of large data sets.
- On Windows, metafiles for Word, Powerpoint, and similar programs

Setting up a graph

Graphs should usually be designed on the screen and then may be replotted on eg a PDF file (for Word/Powerpoint you can just copy and paste)

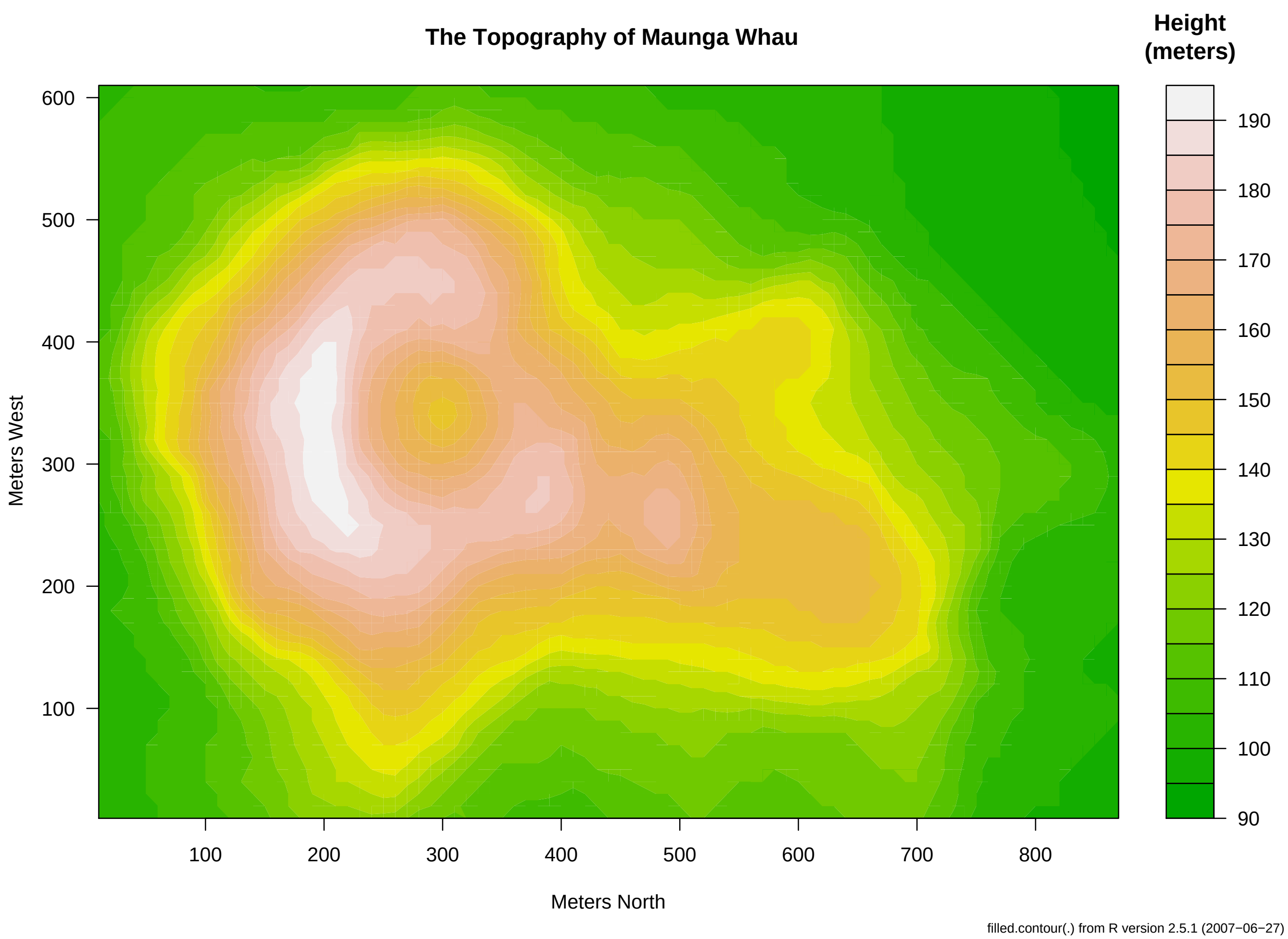
For printed graphs, you will get better results if you design the graph at the size it will end up, eg:

```
## on Windows
windows(height=4,width=6)
## on Unix
x11(height=4,width=6)
```

Word or LaTeX can rescale the graph, but when the graph gets smaller, so do the axis labels...

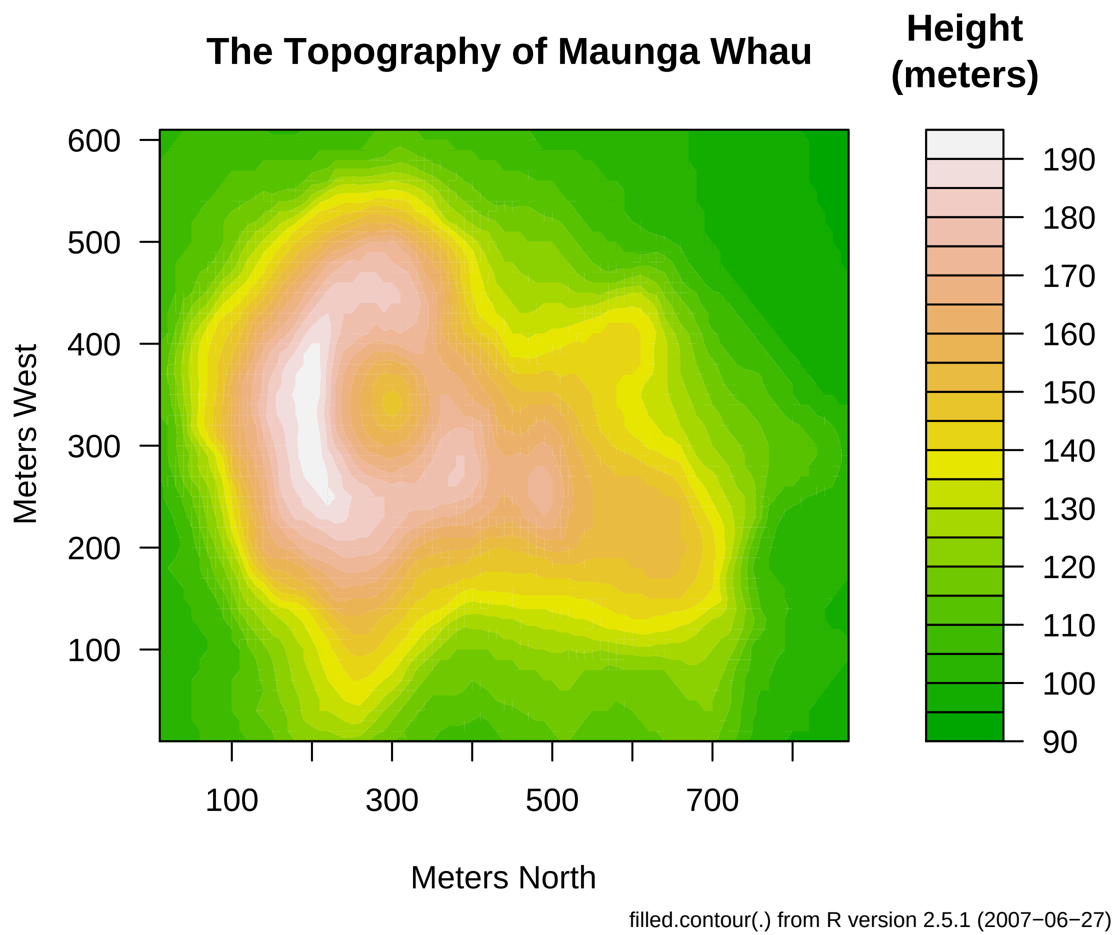
Setting up a graph

Created at full-page size



Setting up a graph

Created at 5x6 inches



Finishing a graph

After you have the right commands to draw the graph you can produce it in another format: eg

```
## start a PDF file
pdf("picture.pdf",height=4,width=6)
## your drawing commands here
...
### close the PDF file
dev.off()
```

Drawing

Usually use `plot()` to create a graph and then `lines()`, `points()`, `legend()`, `text()`, and other commands to annotate it.

`plot()` is a `generic function`: it does appropriate things for different types of input

```
## scatterplot
plot(salary$year, salary$salary)
## boxplot
plot(salary$rank, salary$salary)
## stacked barplot
plot(salary$field, salary$rank)
```

and others for other types of input.

Formula interface

The `plot()` command can be written

```
plot(salary~rank, data=salary)
```

introducing the *formula* system that is also used for regression models. The variables in the formula are automatically looked up in the `data=` argument.

Designing graphs

Two important aspects of designing a graph

- It should have something to say

- It should be legible

Having something to say is your problem; software can help with legibility.

Designing graphs

Important points

- Axes need labels (with units, large enough to read)
- Color can be very helpful (but not if the graph is going to be printed in black and white).
- Different line or point styles usually should be labelled.
- Points plotted on top of each other won't be seen

After these are satisfied, it can't hurt to have the graph look nice.

Options for `plot()`

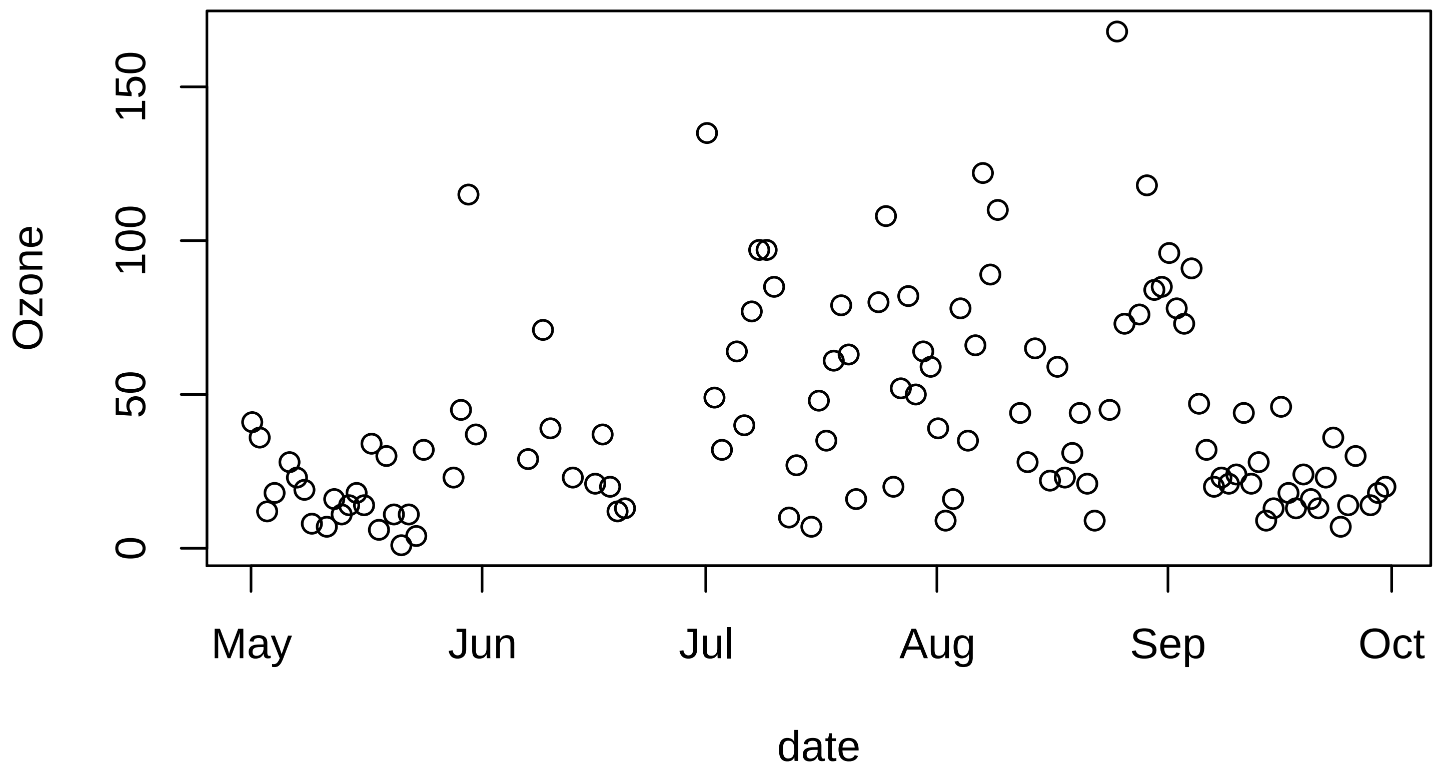
Set up a data set: daily ozone concentrations in New York, summer 1973

```
data(airquality)
names(airquality)
airquality$date<-with(airquality, ISOdate(1973,Month,Day))
```

All these graphs were designed at 4in×6in and stored as PDF files

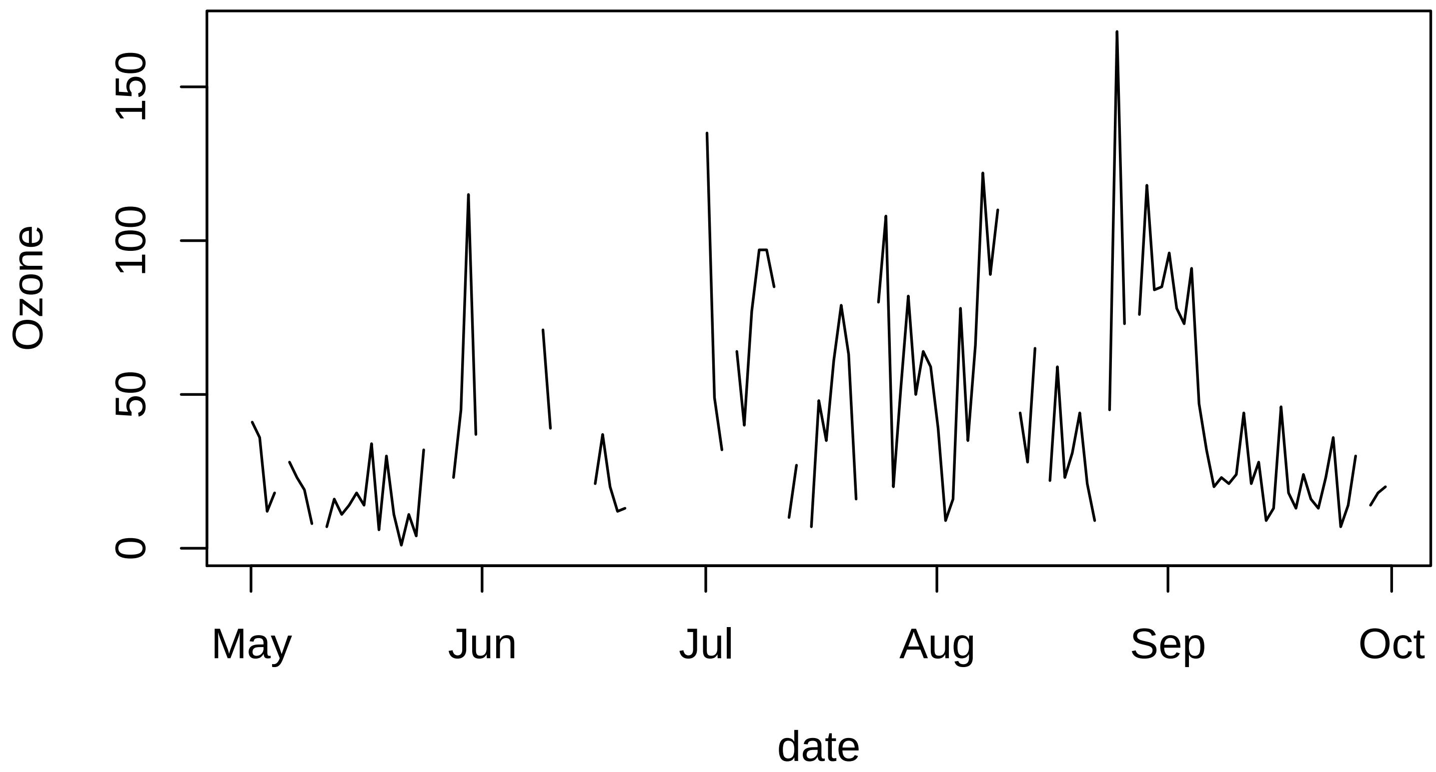
Options for `plot()`

```
plot(Ozone~date, data=airquality)
```



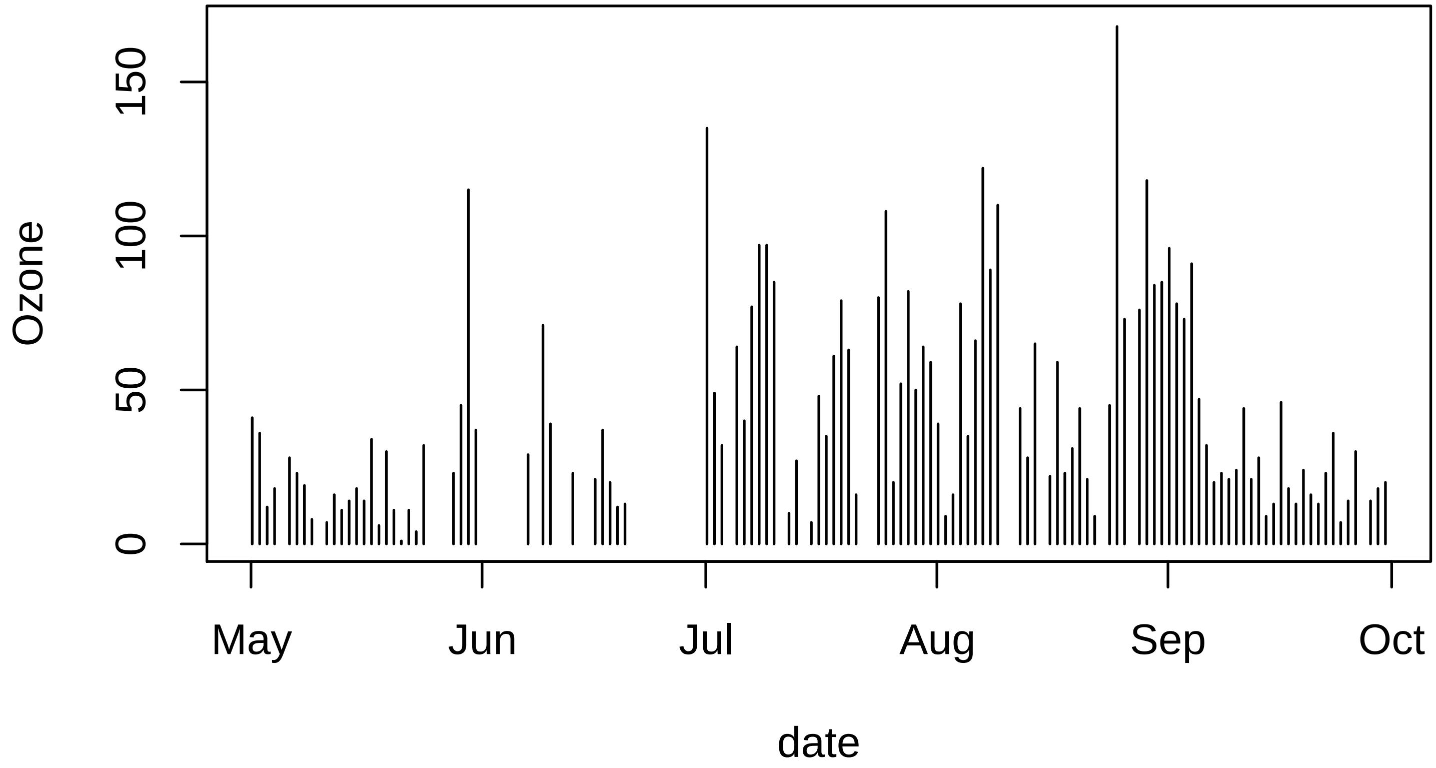
Options for `plot()`

```
plot(Ozone~date, data=airquality,type="l")
```



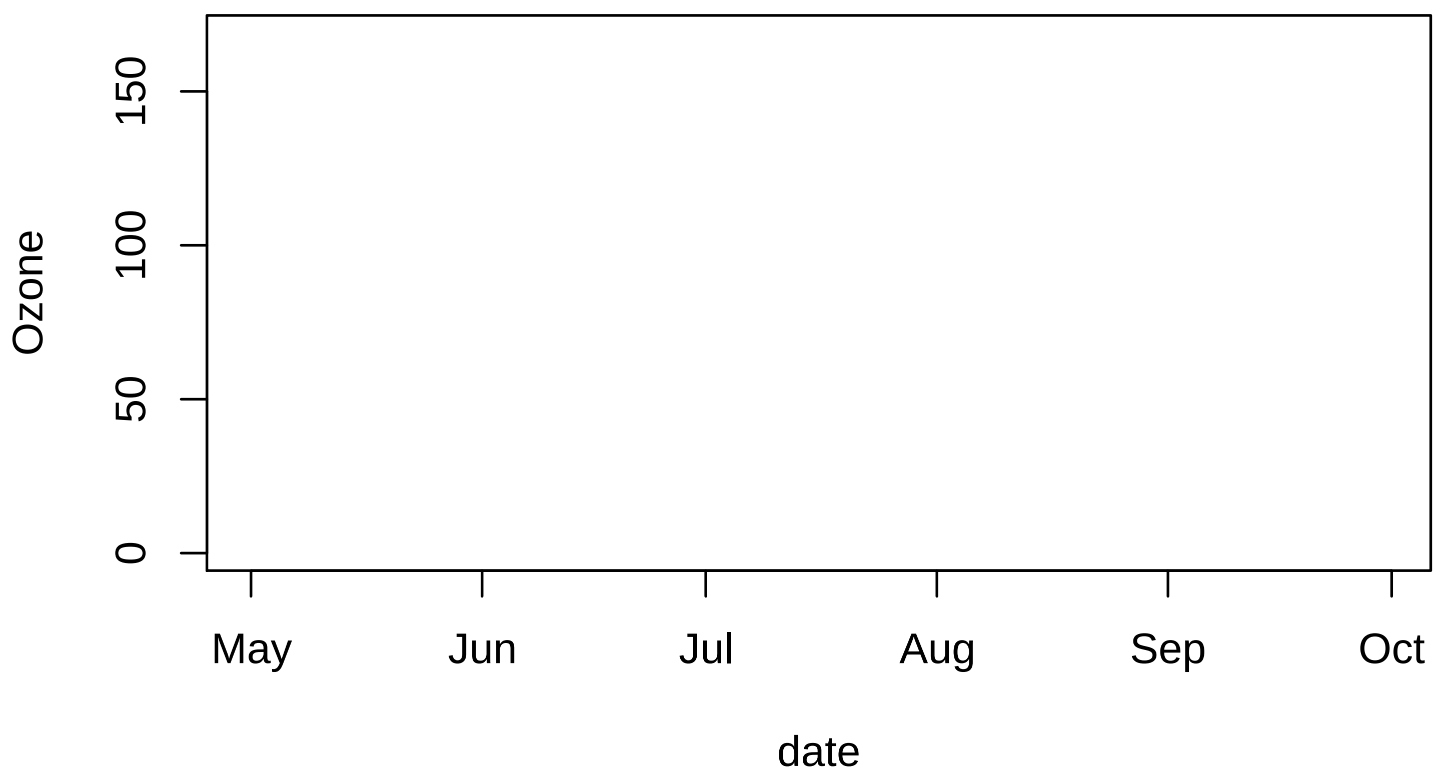
Options for `plot()`

```
plot(Ozone~date, data=airquality,type="h")
```



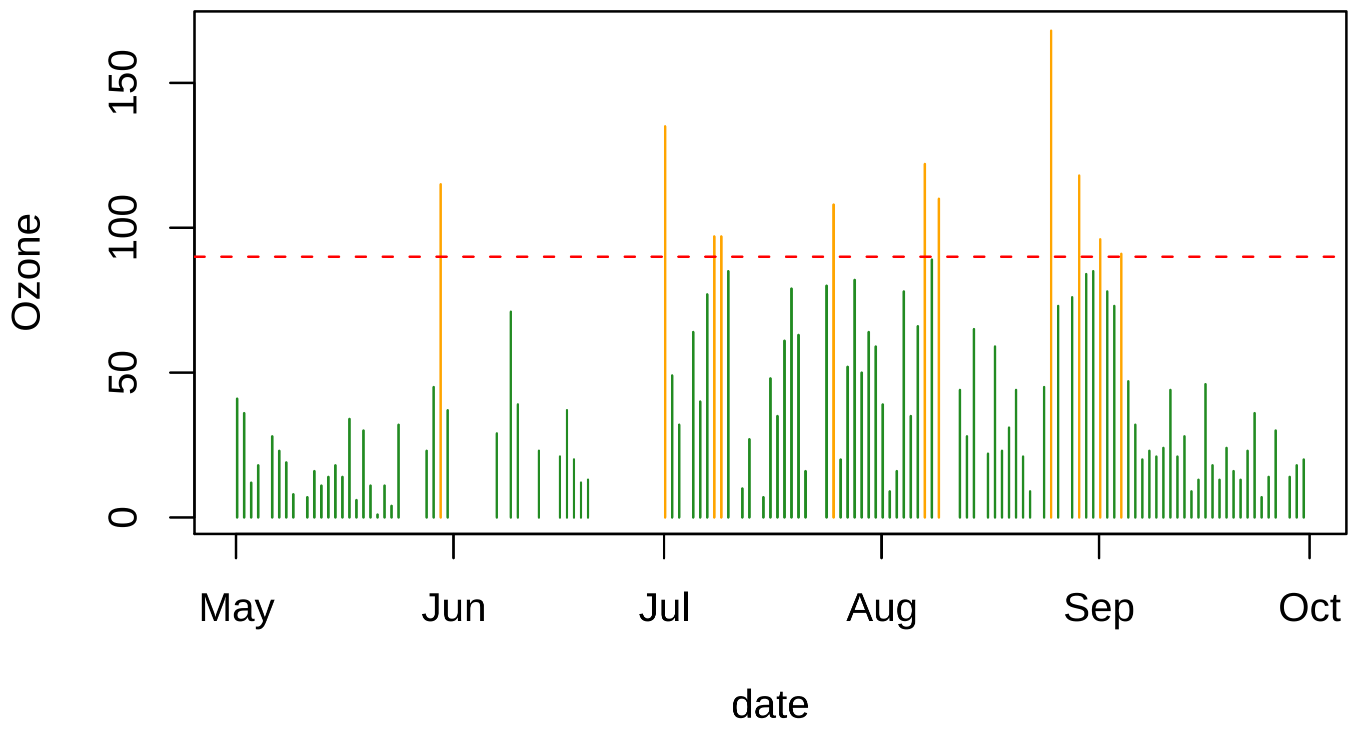
Options for `plot()`

```
plot(Ozone~date, data=airquality,type="n")
```



Options for `plot()`

```
bad<-ifelse(airquality$Ozone>=90, "orange","forestgreen")
plot(Ozone~date, data=airquality,type="h",col=bad)
abline(h=90,lty=2,col="red")
```



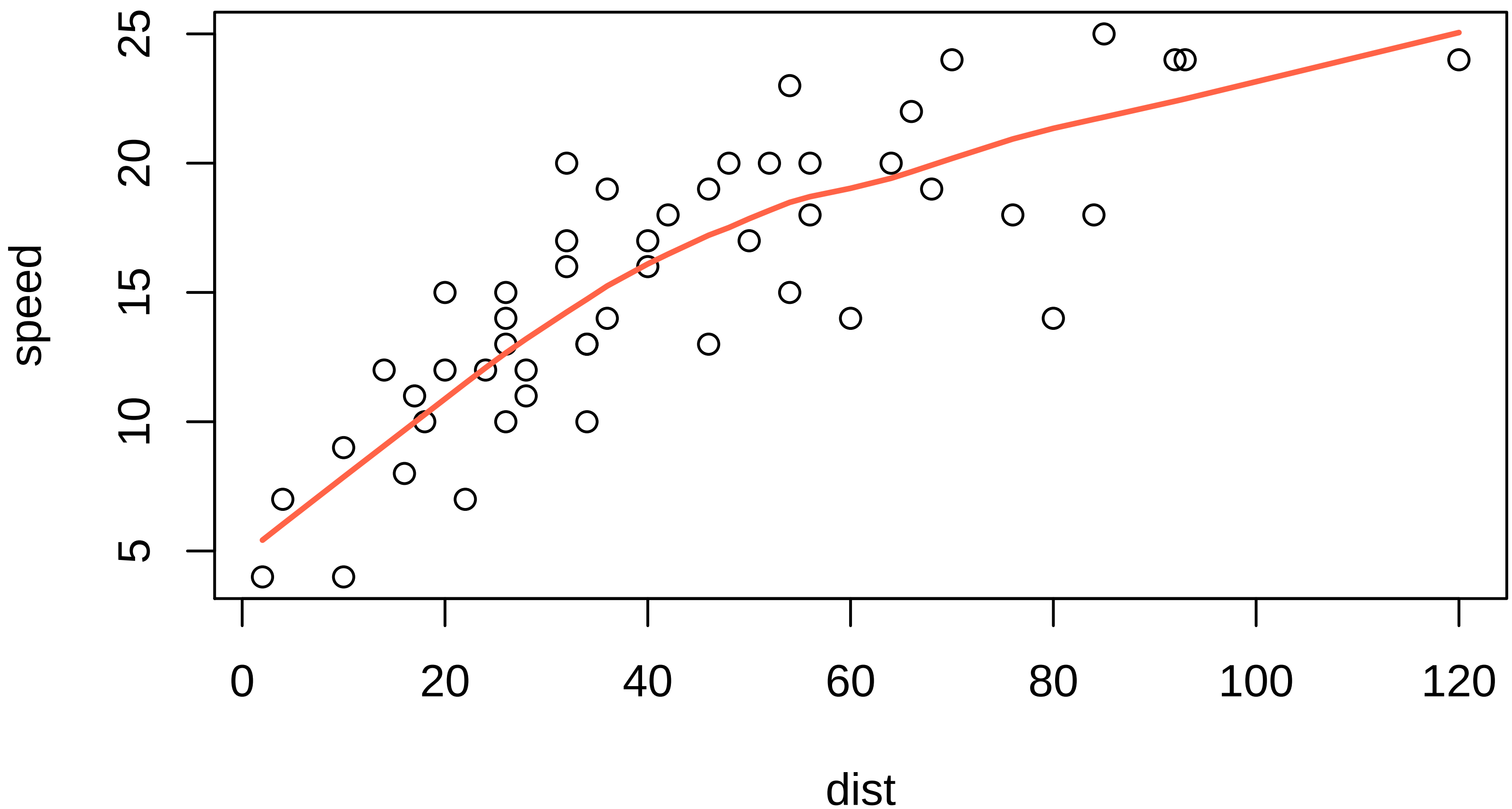
Notes

- `type=` controls how data are plotted. `type="n"` is not as useless as it looks: it can set up a plot for latter additions.
- Colors can be specified by name (the `colors()` function gives all the names), by red/green/blue values (#rrggbb with six base-sixteen digits) or by position in the standard palette of 8 colors.
- `abline` draws a single straight line on a plot
- `ifelse()` selects between two vectors based on a logical variable.
- `lty` specifies the line type: 1 is solid, 2 is dashed, 3 is dotted, then it gets more complicated.

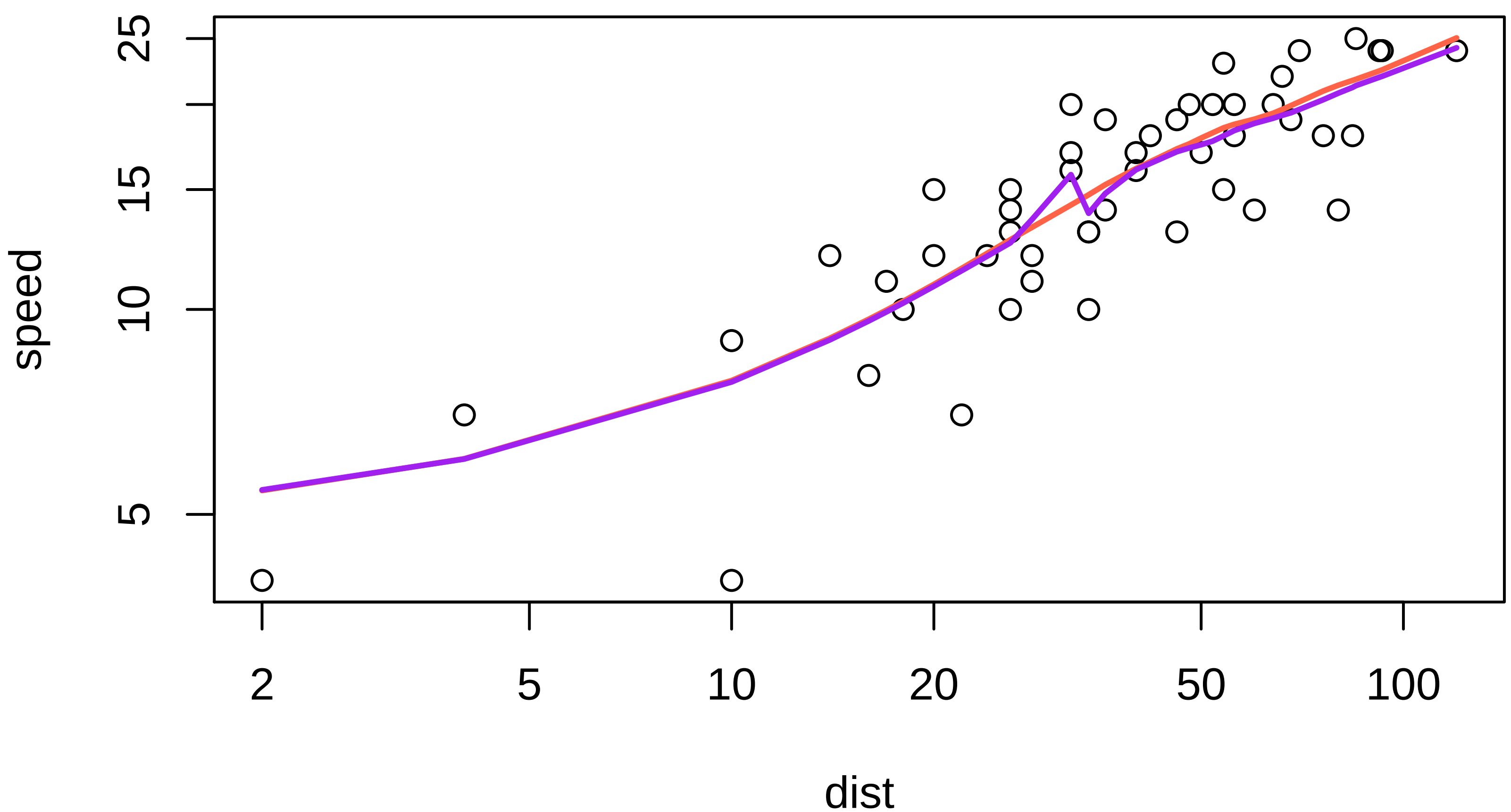
Adding to a plot

```
data(cars)
plot(speed~dist,data=cars)
with(cars, lines(lowess(dist,speed), col="tomato", lwd=2))
plot(speed~dist,data=cars, log="xy")
with(cars, lines(lowess(dist,speed), col="tomato", lwd=2))
with(cars, lines(supsmu(dist,speed), col="purple", lwd=2))
legend(2,25, legend=c("lowess","supersmoother"),bty="n", lwd=2,
  col=c("tomato","purple"))
```

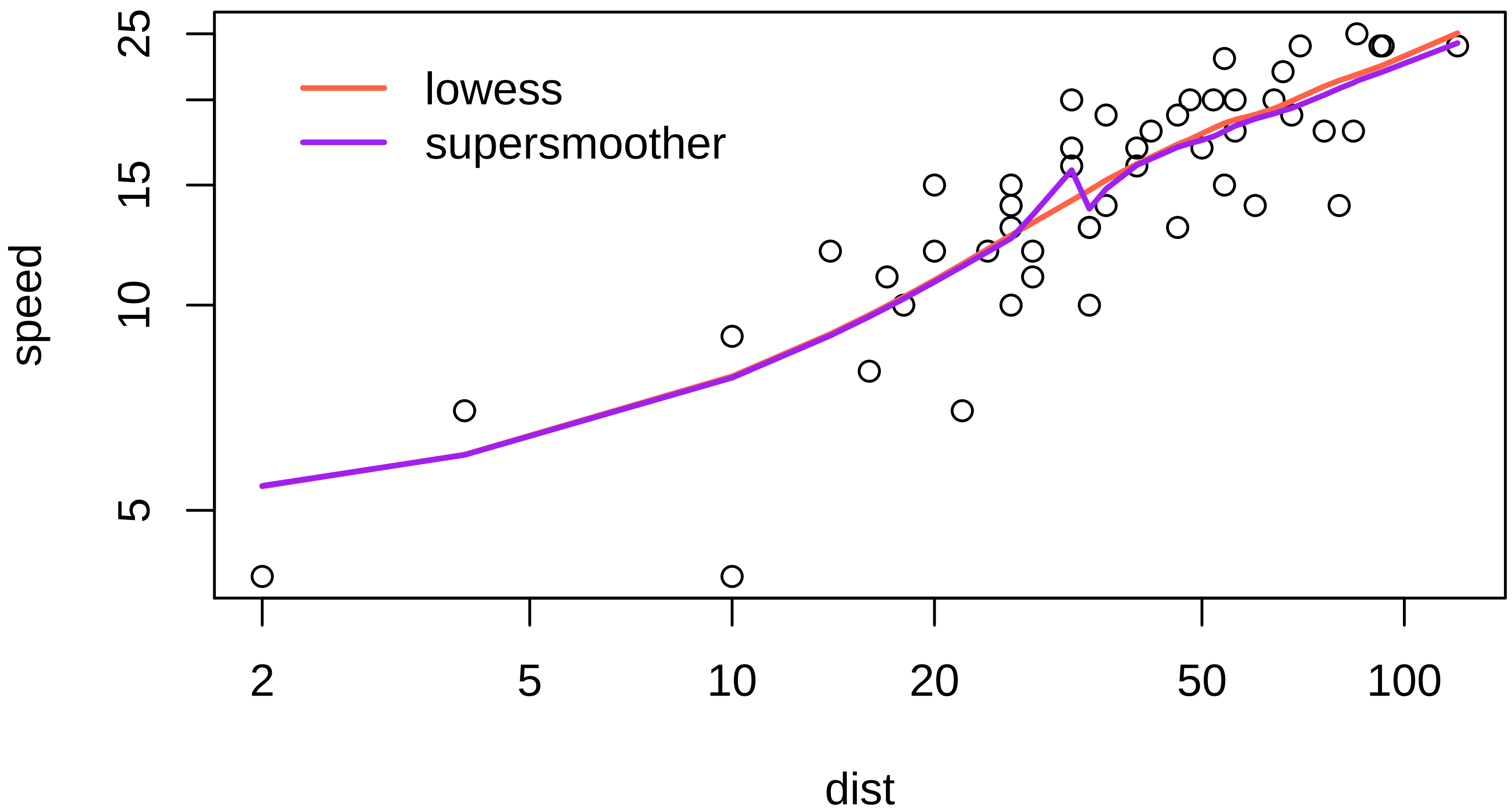
Adding to a plot



Adding to a plot



Adding to a plot

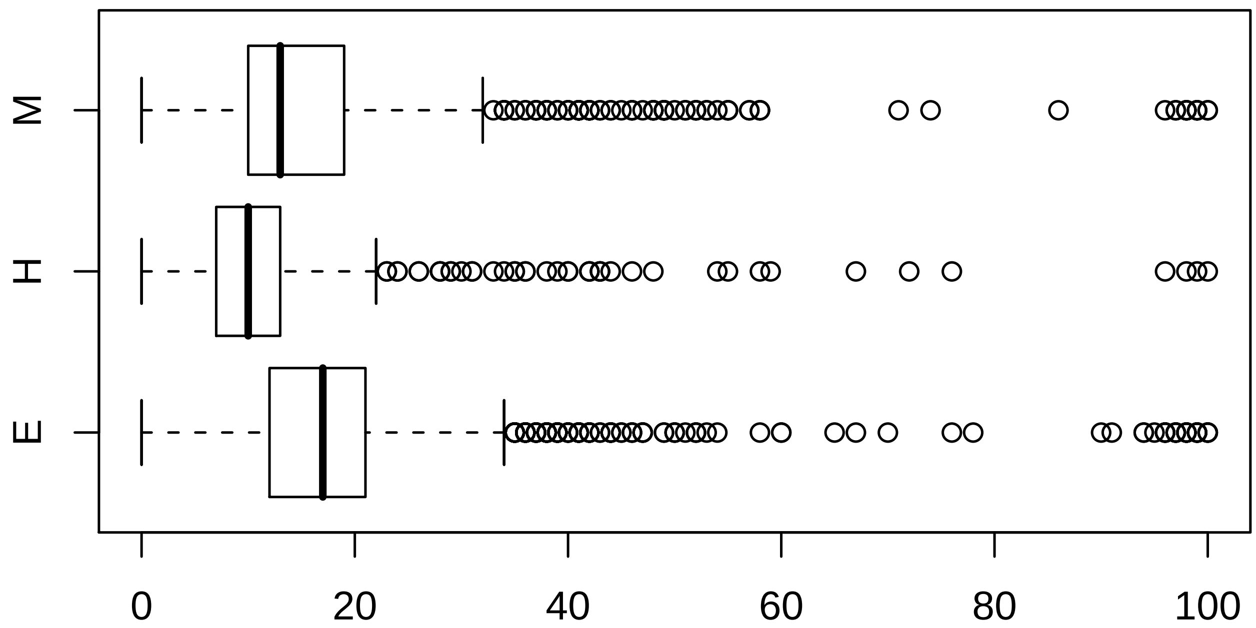


Notes

- `lines` adds lines to an existing plot (`points()` adds points).
- `lowess()` and `supsmu()` are scatterplot smoothers. They draw smooth curves that fit the relationship between y and x locally.
- `log="xy"` asks for both axes to be logarithm (`log="x"` would just be the x-axis)
- `legend()` adds a legend

Boxplots

```
data(api, package="survey")
boxplot(mobility~stype,data=apipop, horizontal=TRUE)
```



Notes

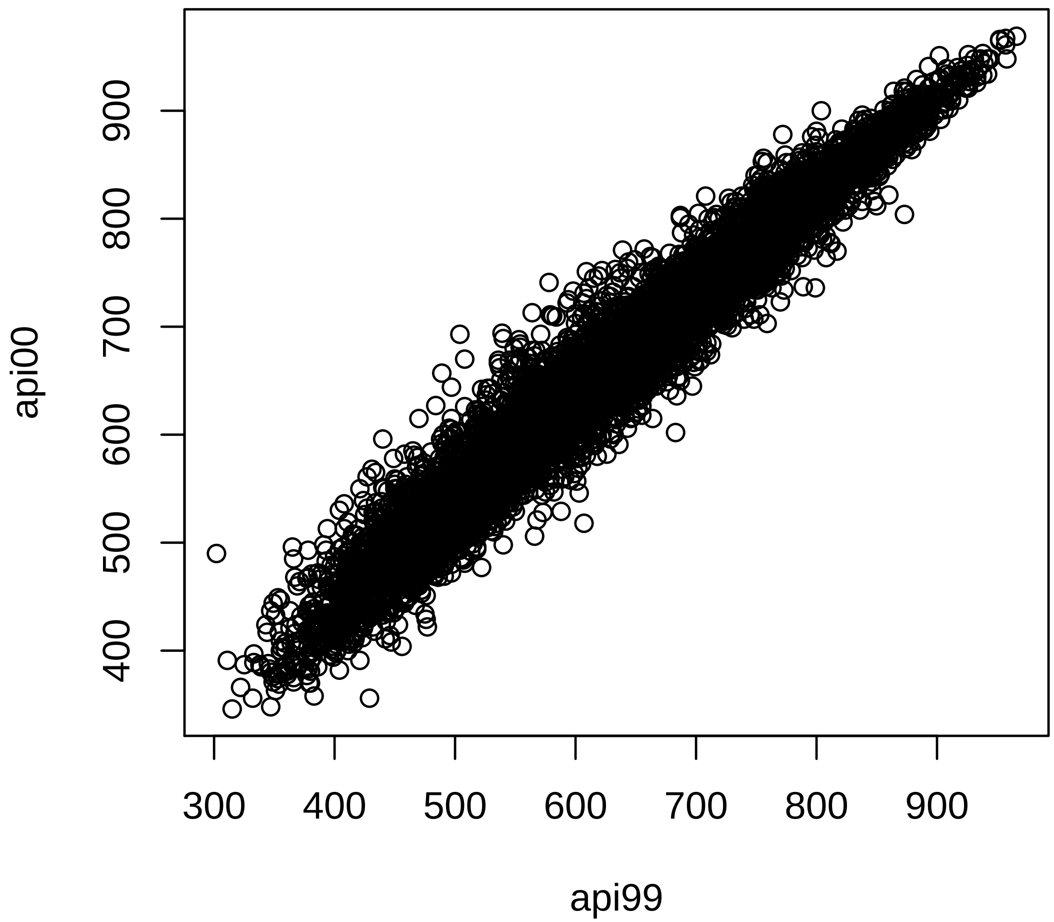
- `boxplot` computes and draws boxplots.
- `horizontal=TRUE` turns a boxplot sideways
- `xlab` and `ylab` are general options for x and y axis labels.

Large data sets

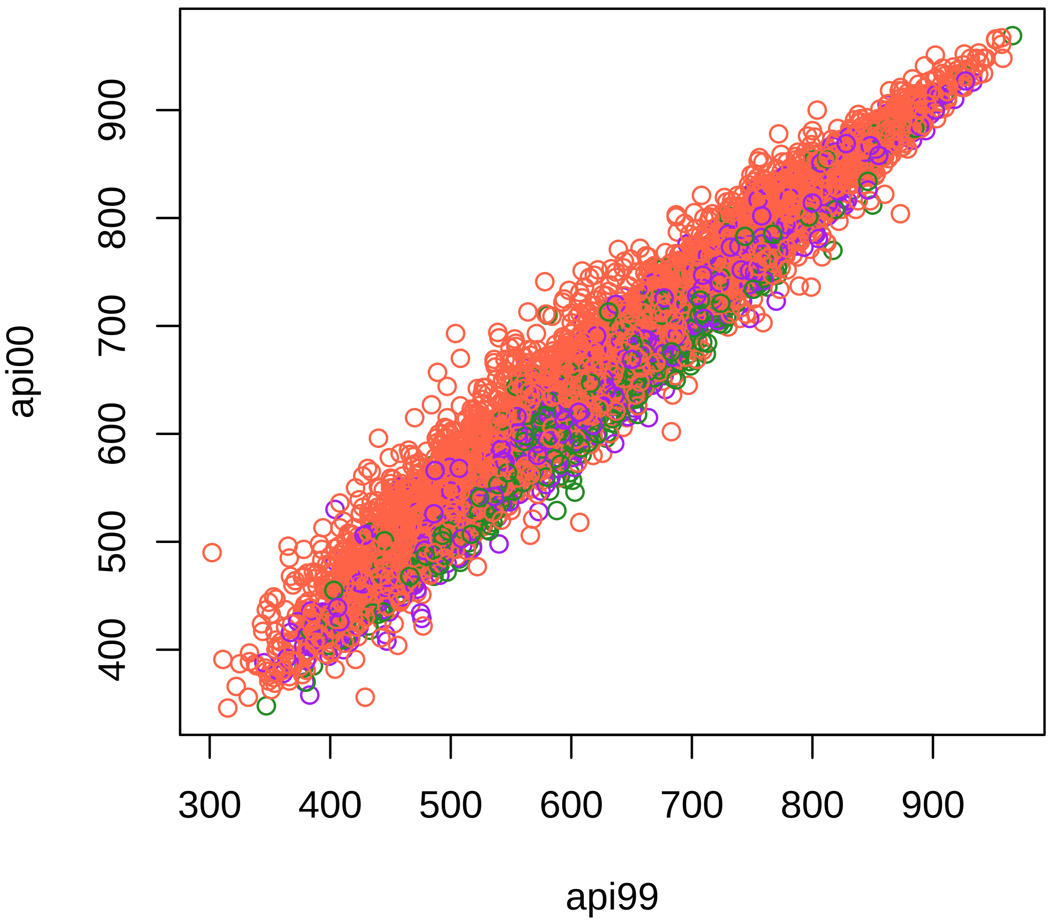
Scatterplots quickly get crowded. For example, the California Academic Performance Index is reported on 6194 schools

```
> plot(api00~api99,data=apipop)
> colors<-c("tomato","forestgreen","purple")[apipop$stype]
> plot(api00~api99,data=apipop,col=colors)
```

Large data sets



Large data sets



Density plots

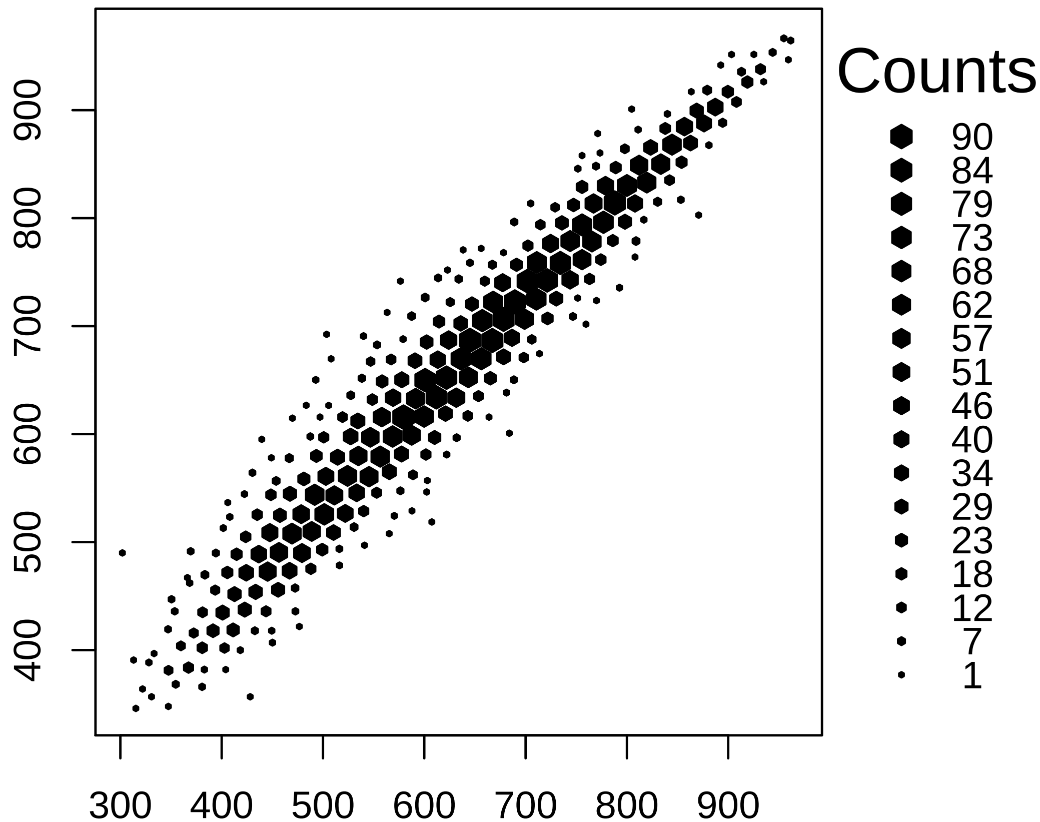
For a single large scatterplot some form of aggregation is useful

```
library(hexbin)
with(apipop, plot(hexbin(api99,api00), style="centroids"))
```

`hexbin` is in the `hexbin` package from the Bioconductor project. It computes the number of points in each hexagonal bin.

The `style=centroids` plot puts a filled hexagon with size depending on the number of points at the centroid of the points in the bin.

Density plots

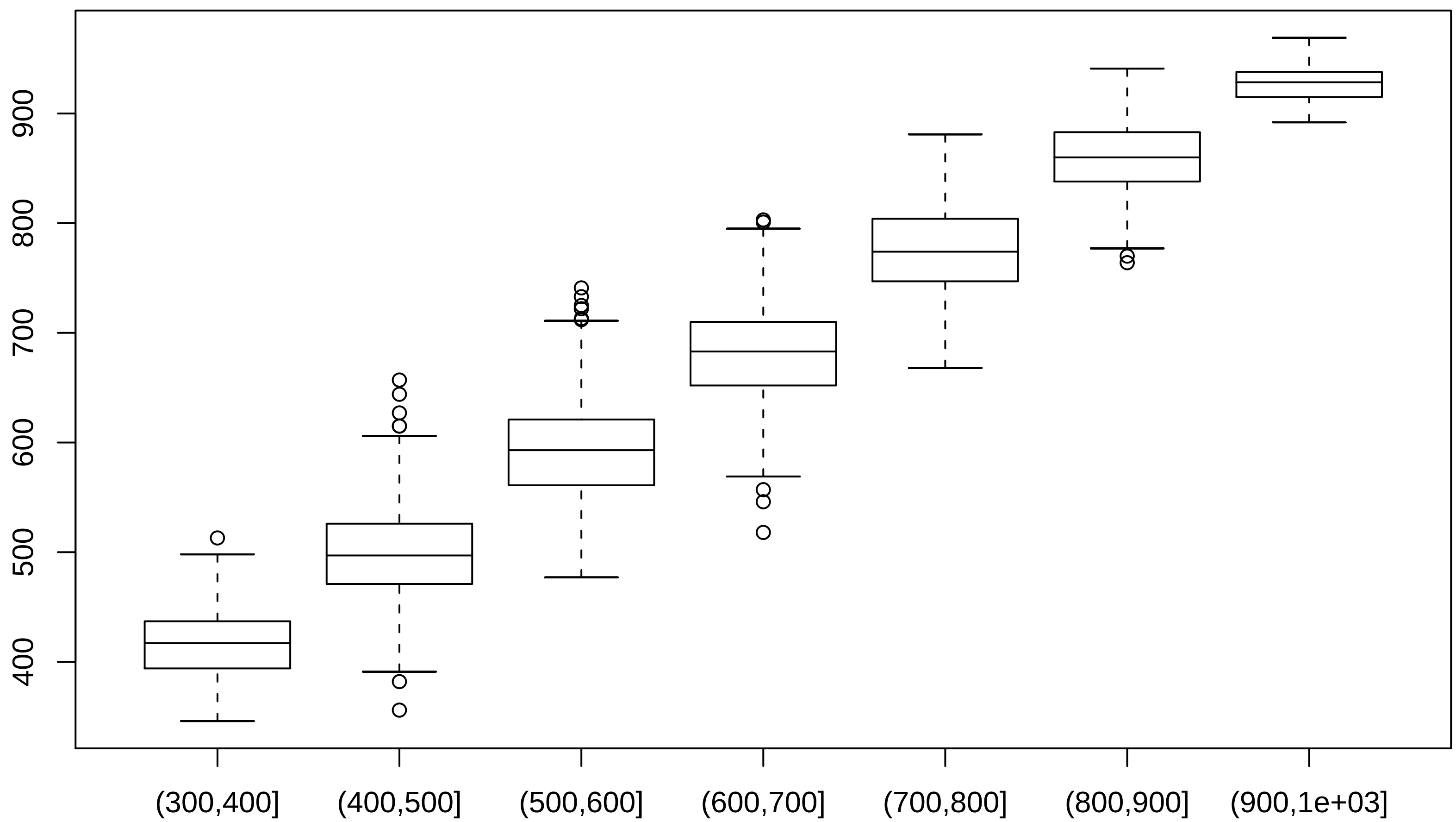


Smoothers

For showing multiple groups a scatterplot smoother or perhaps boxplots would be better.

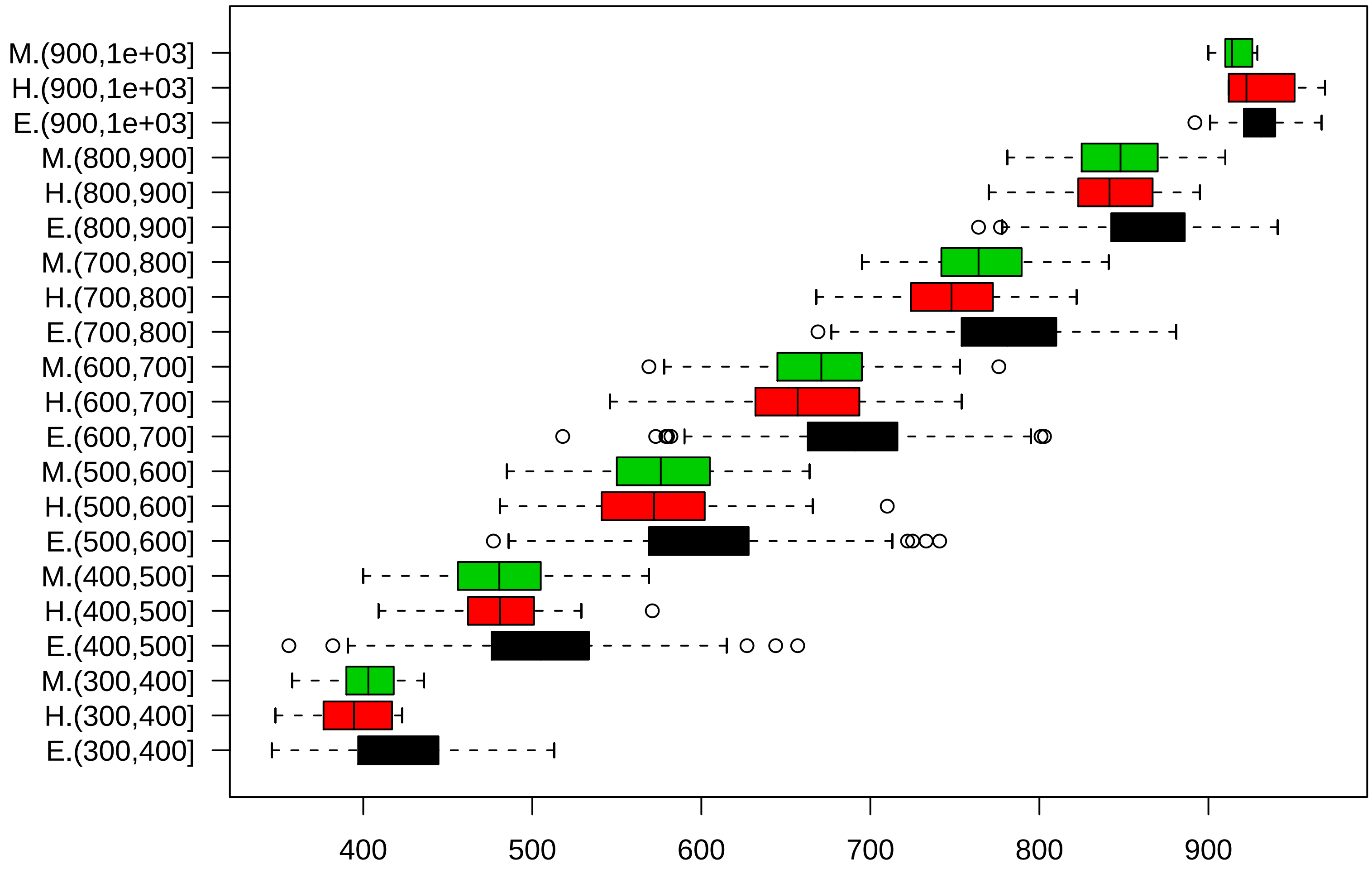
```
> boxplot(api00~cut(api99,(3:10)*100), data=apipop)
> par(las=1)
> par(mar=c(5.1,10.1,2.1,2.1))
> boxplot(api00~interaction(stype,
                                 cut(api99,(3:10)*100)),
          data=apipop, horizontal=TRUE,col=1:3)
 plot(api00~api99,data=apipop,type="n")
 with(subset(apipop, stype=="E"),
      lines(lowess(api99, api00), col="tomato"))
 with(subset(apipop, stype=="H"),
      lines(lowess(api99, api00), col="forestgreen"))
 with(subset(apipop, stype=="M"),
      lines(lowess(api99, api00), col="purple"))
```

Smoothers



400
500
600
700
800
900
(300,400]
(400,500]
(500,600]
(600,700]
(700,800]
(800,900]
(900,1e+03]

Smoothers



M.(900,1e+03]
H.(900,1e+03]
E.(900,1e+03]
M.(800,900]
H.(800,900]
E.(800,900]
M.(700,800]
H.(700,800]
E.(700,800]
M.(600,700]
H.(600,700]
E.(600,700]
M.(500,600]
H.(500,600]
E.(500,600]
M.(400,500]
H.(400,500]
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M.(300,400]
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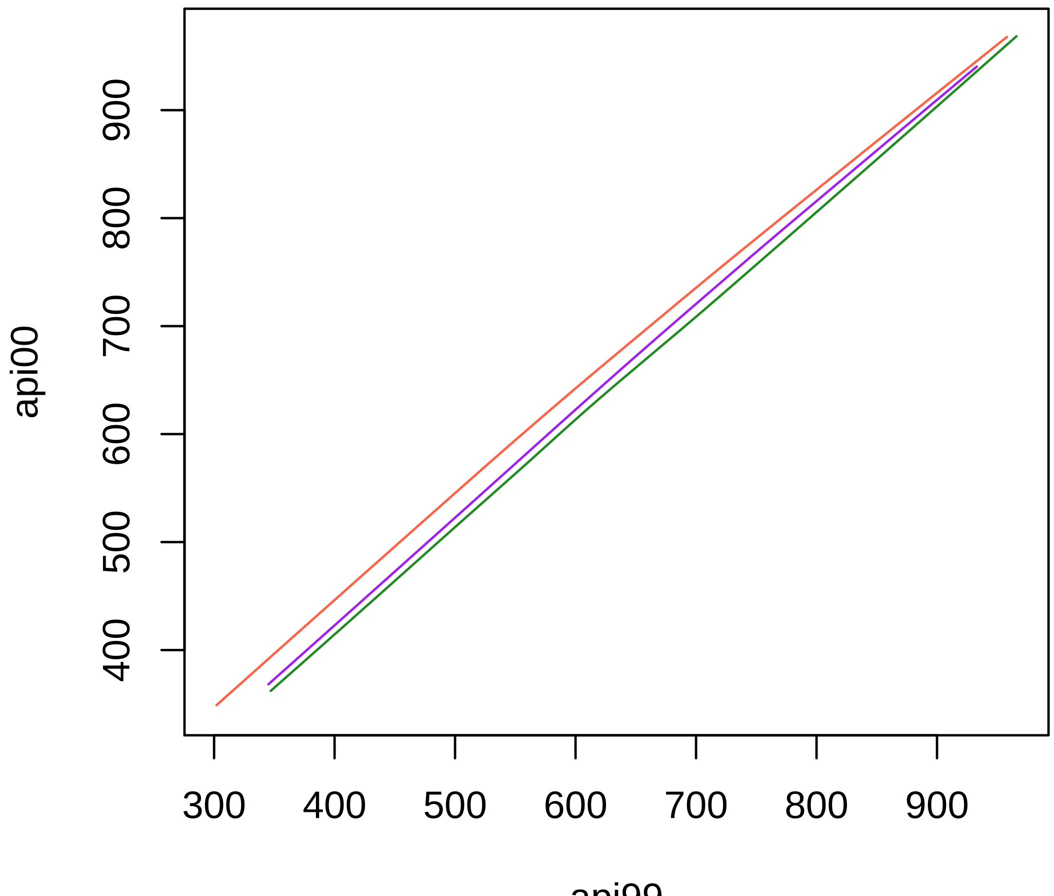
Smoothers



Notes

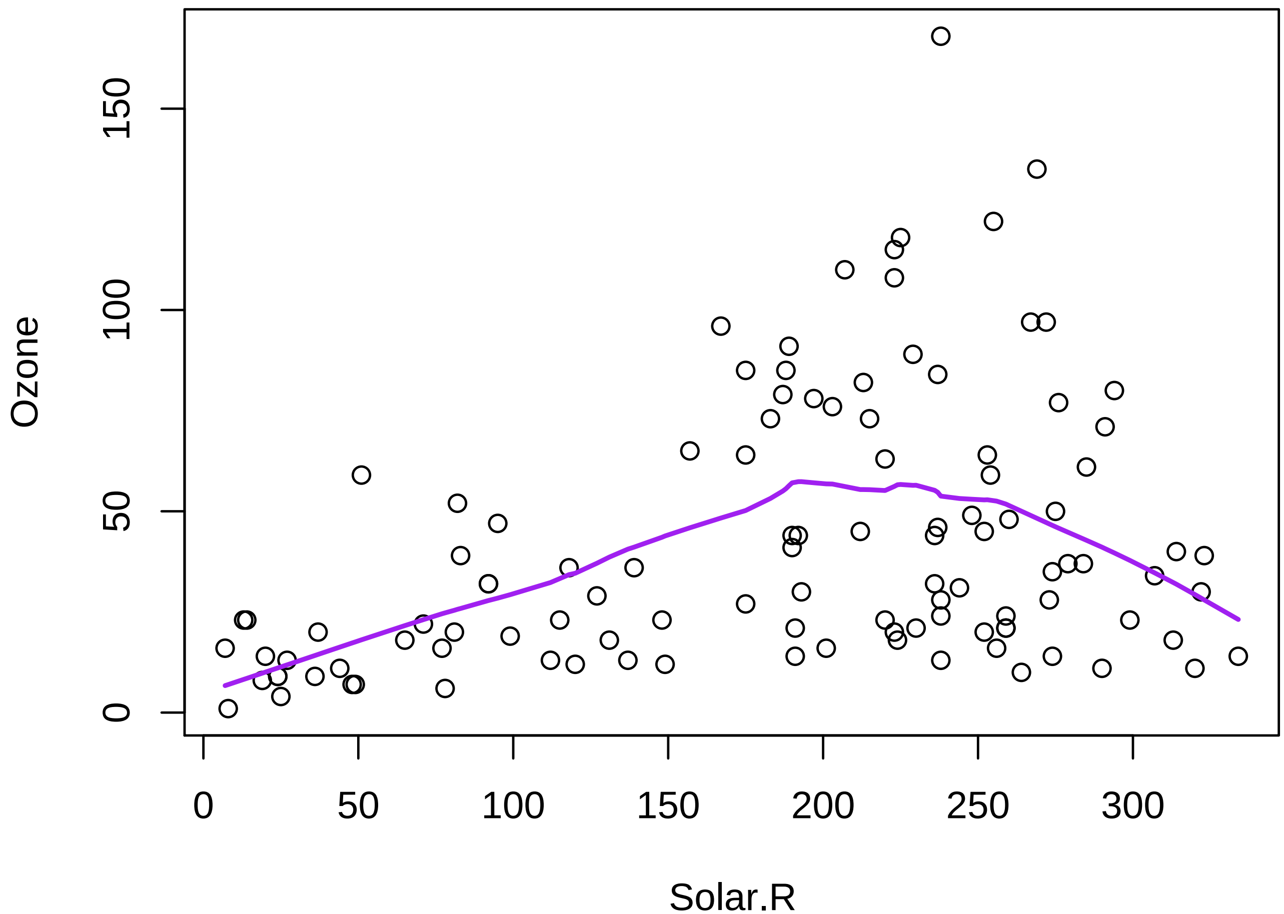
- `cut` turns a variable into a factor by cutting it at the specified points.
- Note the use of `type="n"`
- `par(mar=)` sets the margins around the plot. We need a large left margin for the labels.
- `subset` takes a subset of a data frame.

Conditioning plots

Ozone is a *secondary pollutant*, it is produced from organic compounds and atmostpheric oxygen in reactions catalyzed by nitrogen oxides and powered by su nlight.

However, looking at ozone concentrations in NY in summer we see a non-monotone relationship with sunlight

Conditioning plots

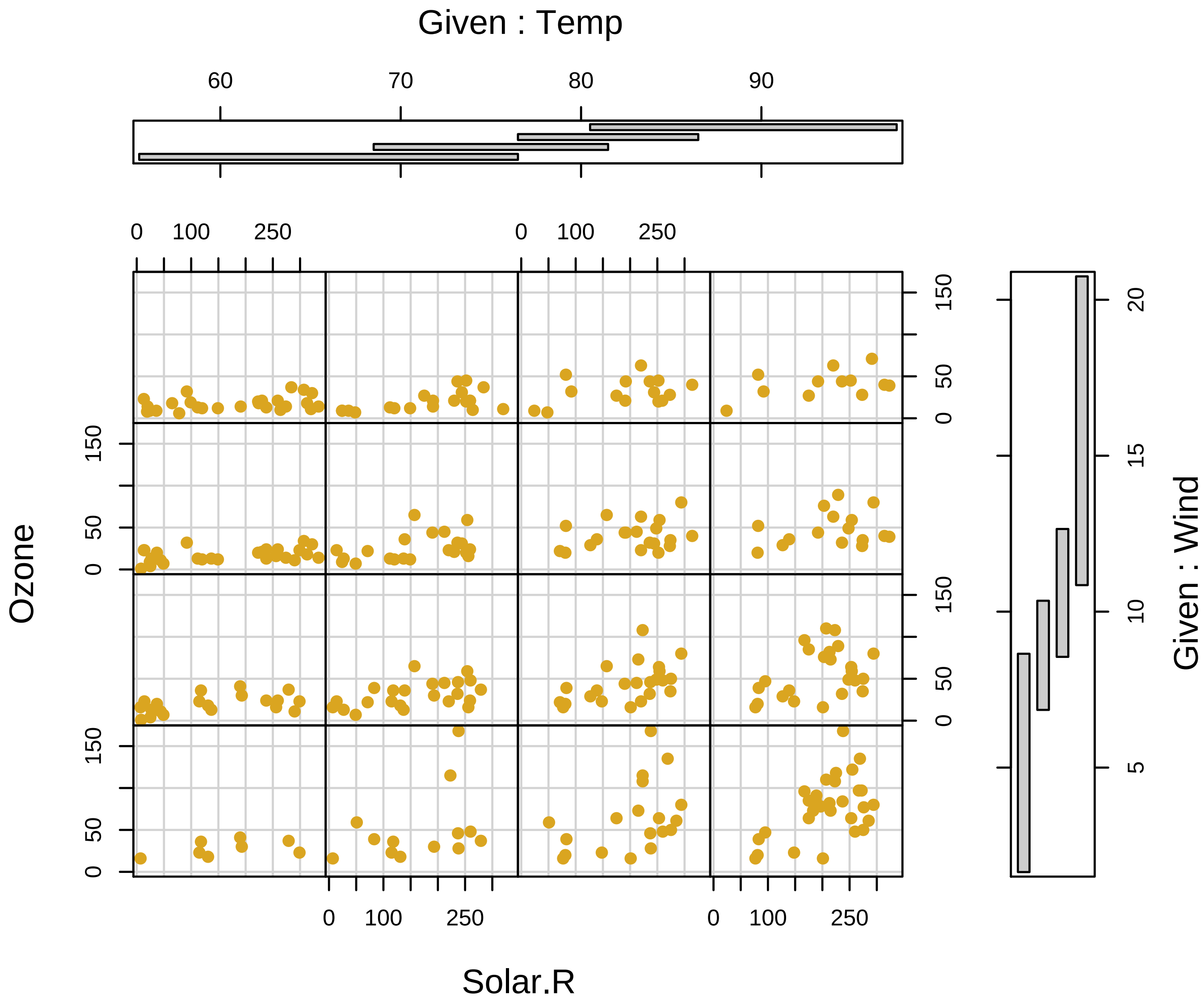


Conditioning plots

Here we draw a scatterplot of `Ozone` vs `Solar.R` for various subranges of `Temp` and `Wind`. A simple version of what is possible with the Trellis system.

```
data(airquality)
coplot(Ozone ~ Solar.R | Temp * Wind, number = c(4, 4),
     data = airquality,
    pch = 21, col = "goldenrod", bg = "goldenrod")
```

Conditioning plots



Mathematical annotation

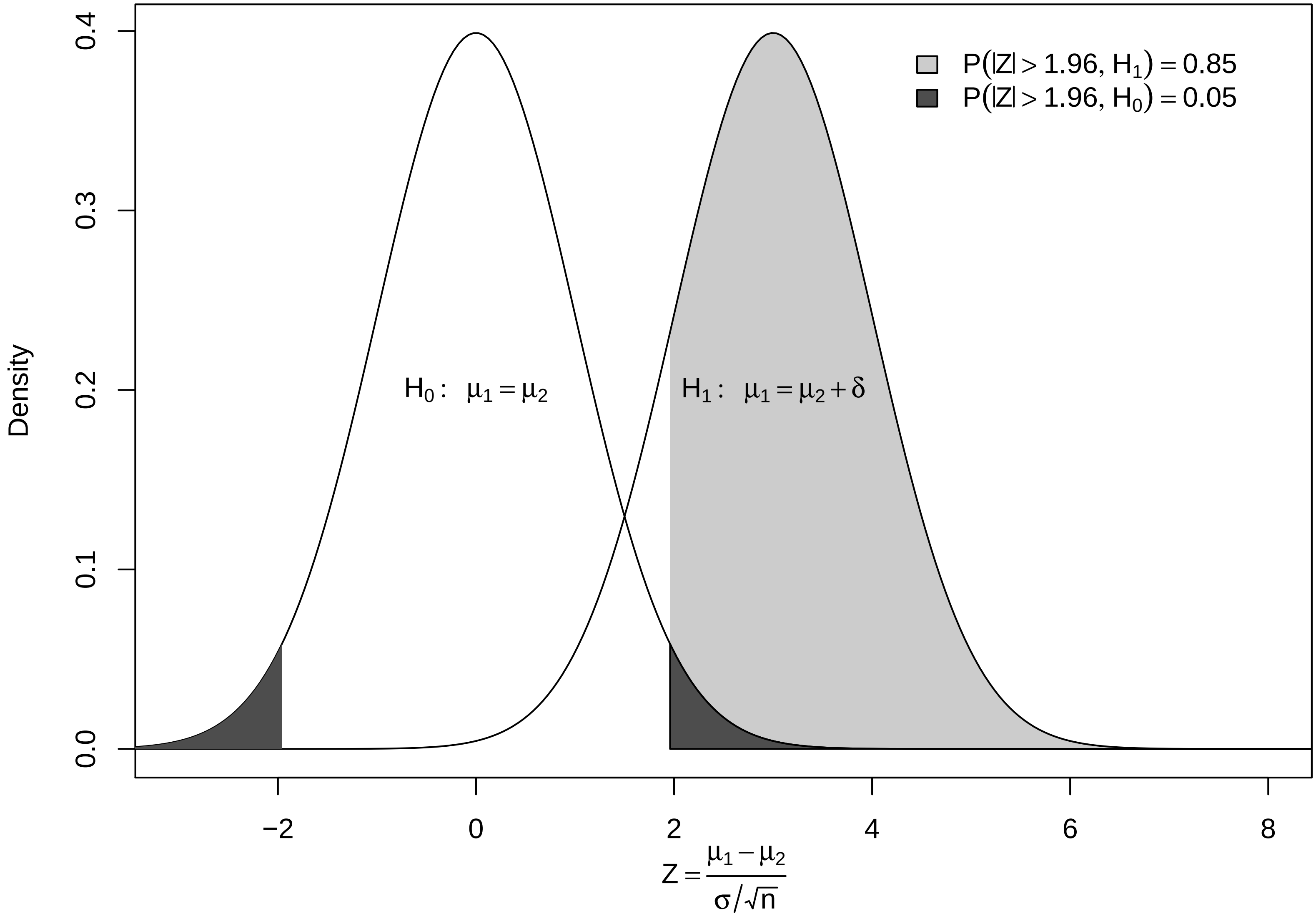
An expression can be specified in R for any text in a graph (`help(plotmath)` for details). Here we annotate a graph drawn with `polygon` .

```
x<-seq(-10,10,length=400)
y1<-dnorm(x)
y2<-dnorm(x,m=3)
par(mar=c(5,4,2,1))
plot(x,y2,xlim=c(-3,8),type="n",
    xlab=quote(Z==frac(mu[1]-mu[2],sigma/sqrt(n))),
    ylab="Density")
polygon(c(1.96,1.96,x[240:400],10),
        c(0,dnorm(1.96,m=3),y2[240:400],0),
        col="grey80",lty=0)
lines(x,y2)
lines(x,y1)
polygon(c(-1.96,-1.96,x[161:1],-10),
        c(0,dnorm(-1.96,m=0),y1[161:1],0),
        col="grey30",lty=0)
polygon(c(1.96,1.96,x[240:400],10),
        c(0,dnorm(1.96,m=0),y1[240:400],0),
        col="grey30")
```

Mathematical annotation

```
legend(4.2,.4,fill=c("grey80","grey30"),
    legend=expression(P(abs(Z)>1.96,H[1])==0.85,
         P(abs(Z)>1.96,H[0])==0.05),bty="n")
text(0,.2,quote(H[0]:~~mu[1]==mu[2]))
text(3,.2,quote(H[1]:~~mu[1]==mu[2]+delta))
```

Mathematical annotation



Maps

```
> library(maps)
> map('county', 'washington', fill = TRUE,
        col = grey(sqrt(wa[,10]/(wa[,1]))) )
> title(main="Proportion Hispanic")
```

Maps