The Base Plotting System in R

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Plotting System

The core plotting and graphics engine in R is encapsulated in the following packages:

- *graphics*: contains plotting functions for the "base" graphing systems, including `plot`, `hist`, `boxplot` and many others.
- *grDevices*: contains all the code implementing the various graphics devices, including X11, PDF, PostScript, PNG, etc.

The lattice plotting system is implemented using the following packages:

- *lattice*: contains code for producing Trellis graphics, which are independent of the “base” graphics system; includes functions like `xyplot`, `bwplot`, `levelplot`
- *grid*: implements a different graphing system independent of the “base” system; the *lattice* package builds on top of *grid*; we seldom call functions from the *grid* package directly

The Process of Making a Plot

When making a plot one must first make a few considerations (not necessarily in this order):

- Where will the plot be made? On the screen? In a file?
- How will the plot be used?
    - Is the plot for viewing temporarily on the screen?
    - Will it be presented in a web browser?
    - Will it eventually end up in a paper that might be printed?
    - Are you using it in a presentation?
- Is there a large amount of data going into the plot? Or is it just a few points?
- Do you need to be able to dynamically resize the graphic?

The Process of Making a Plot

- What graphics system will you use: base, lattice, or ggplot2? These generally cannot be mixed.
- Base graphics are usually constructed piecemeal, with each aspect of the plot handled separately through a series of function calls; this is often conceptually simpler and allows plotting to mirror the thought process
- Lattice graphics are usually created in a single function call, so all of the graphics parameters have to specified at once; specifying everything at once allows R to automatically calculate the necessary spacings and font sizes.
- ggplot2 combines concepts from both base and lattice graphics but uses an independent implementation

We focus on using the **base plotting system** to create graphics on the **screen device**.

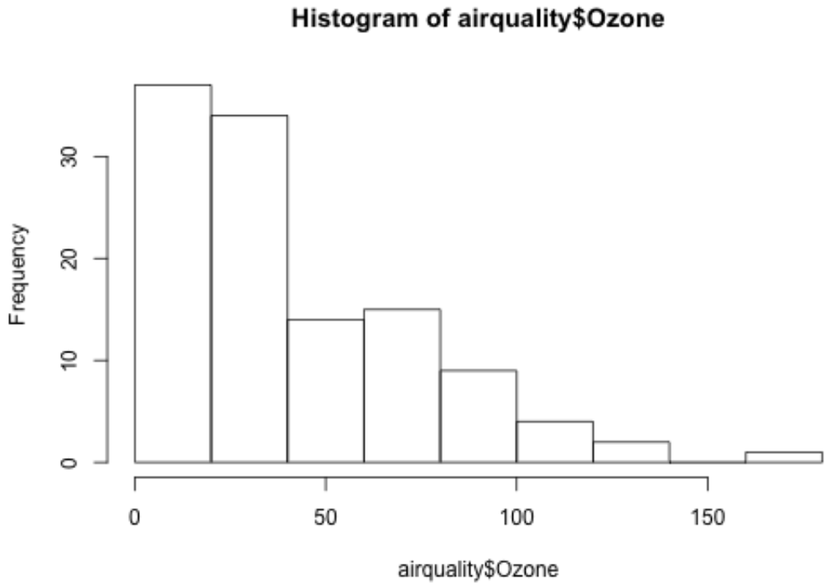
Base Graphics

Base graphics are used most commonly and are a very powerful system for creating 2-D graphics.

- There are two *phases* to creating a base plot
    - Initializing a new plot
    - Annotating (adding to) an existing plot
- Calling `plot(x, y)` or `hist(x)` will launch a graphics device (if one is not already open) and draw a new plot on the device
- If the arguments to `plot` are not of some special class, then the *default* method for `plot` is called; this function has *many* arguments, letting you set the title, x axis label, y axis label, etc.
- The base graphics system has *many* parameters that can set and tweaked; these parameters are documented in `?par`; it wouldn't hurt to try to memorize this help page!

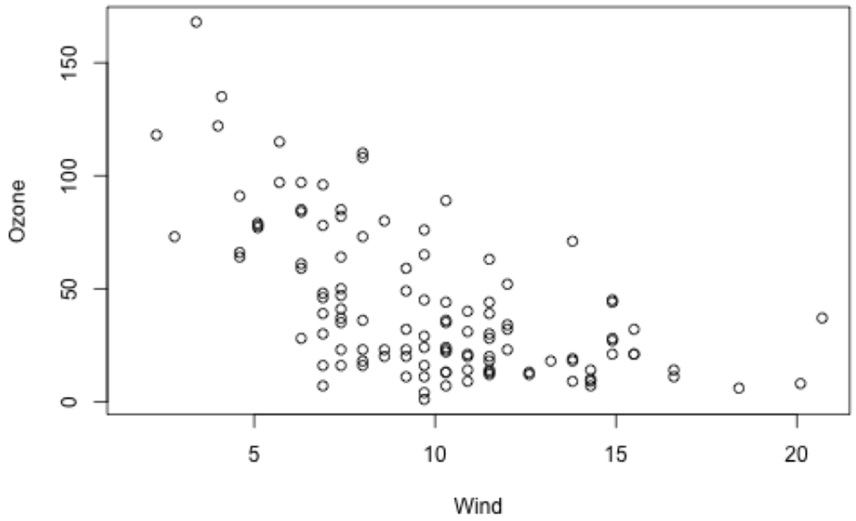
Simple Base Graphics: Histogram

```
library(datasets)
hist(airquality$Ozone)  ## Draw a new plot
```



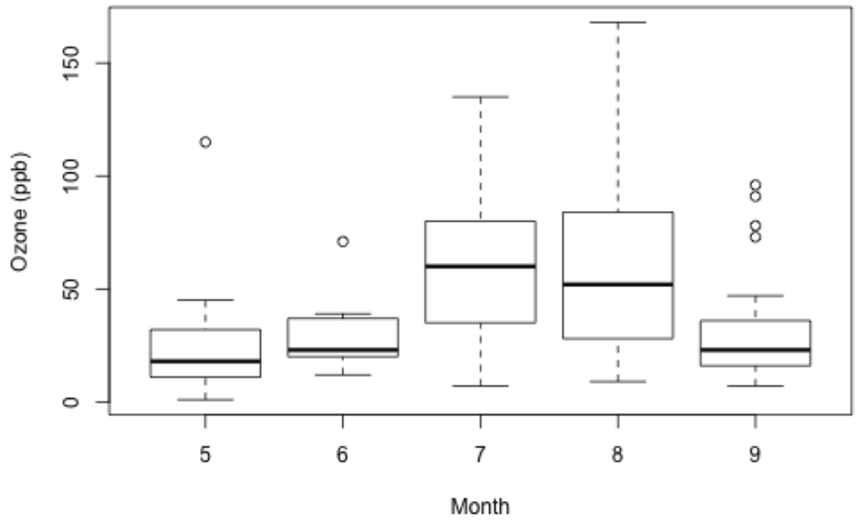
Simple Base Graphics: Scatterplot

```
library(datasets)
with(airquality, plot(Wind, Ozone))
```



Simple Base Graphics: Boxplot

```
library(datasets)
airquality <- transform(airquality, Month = factor(Month))
boxplot(Ozone ~ Month, airquality, xlab = "Month", ylab = "Ozone (ppb)")
```



Some Important Base Graphics Parameters

Many base plotting functions share a set of parameters. Here are a few key ones:

- `pch`: the plotting symbol (default is open circle)
- `lty`: the line type (default is solid line), can be dashed, dotted, etc.
- `lwd`: the line width, specified as an integer multiple
- `col`: the plotting color, specified as a number, string, or hex code; the `colors()` function gives you a vector of colors by name
- `xlab`: character string for the x-axis label
- `ylab`: character string for the y-axis label

Some Important Base Graphics Parameters

The `par()` function is used to specify *global* graphics parameters that affect all plots in an R session. These parameters can be overridden when specified as arguments to specific plotting functions.

- `las`: the orientation of the axis labels on the plot
- `bg`: the background color
- `mar`: the margin size
- `oma`: the outer margin size (default is 0 for all sides)
- `mfrow`: number of plots per row, column (plots are filled row-wise)
- `mfcol`: number of plots per row, column (plots are filled column-wise)

Some Important Base Graphics Parameters

Default values for global graphics parameters

```
par("lty")
```

```
## [1] "solid"
```

```
par("col")
```

```
## [1] "black"
```

```
par("pch")
```

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

Some Important Base Graphics Parameters

Default values for global graphics parameters

```
par("bg")
```

```
## [1] "transparent"
```

```
par("mar")
```

```
## [1] 5.1 4.1 4.1 2.1
```

```
par("mfrow")
```

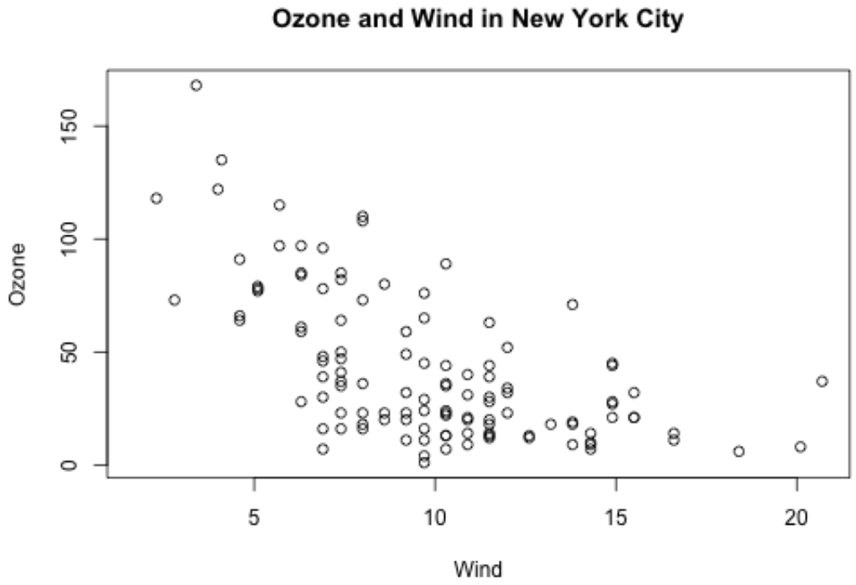
```
## [1] 1 1
```

Base Plotting Functions

- `plot`: make a scatterplot, or other type of plot depending on the class of the object being plotted
- `lines`: add lines to a plot, given a vector x values and a corresponding vector of y values (or a 2-column matrix); this function just connects the dots
- `points`: add points to a plot
- `text`: add text labels to a plot using specified x, y coordinates
- `title`: add annotations to x, y axis labels, title, subtitle, outer margin
- `mtext`: add arbitrary text to the margins (inner or outer) of the plot
- `axis`: adding axis ticks/labels

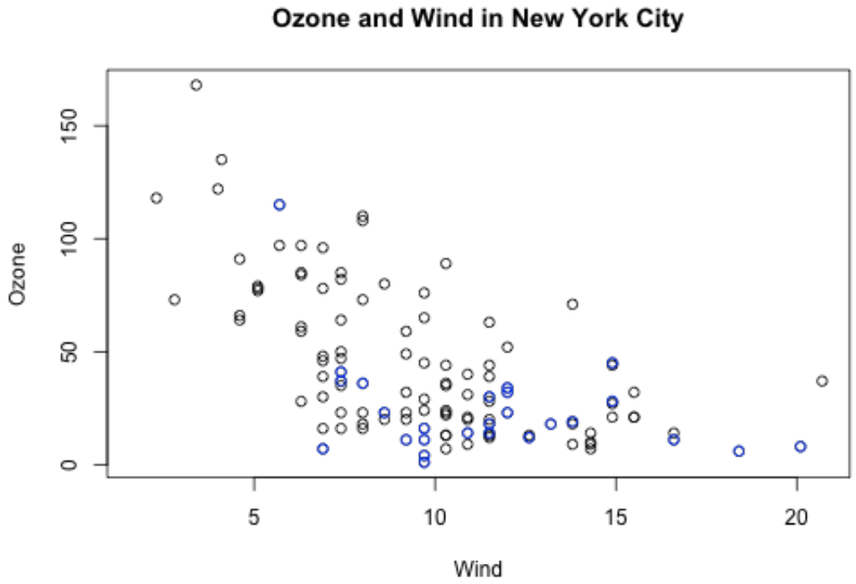
Base Plot with Annotation

```
library(datasets)
with(airquality, plot(Wind, Ozone))
title(main = "Ozone and Wind in New York City")  ## Add a title
```



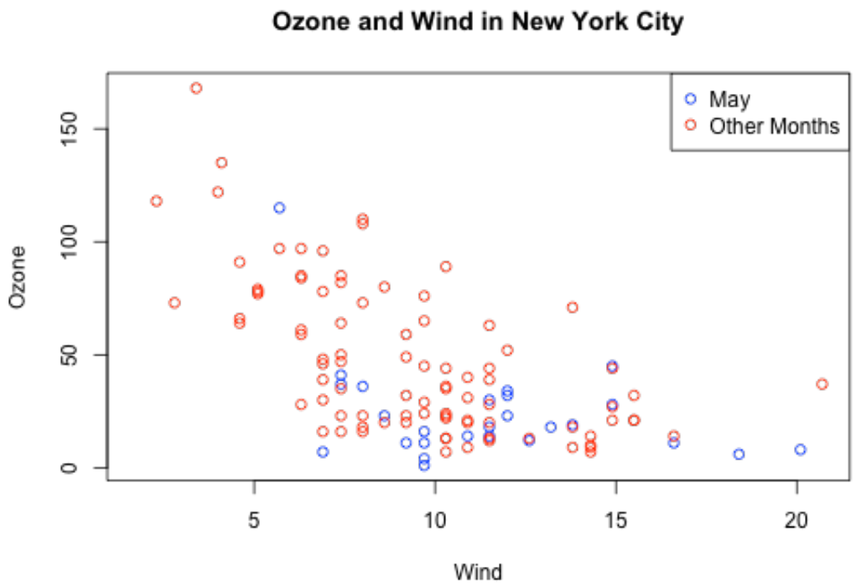
Base Plot with Annotation

```
with(airquality, plot(Wind, Ozone, main = "Ozone and Wind in New York City"))
with(subset(airquality, Month == 5), points(Wind, Ozone, col = "blue"))
```



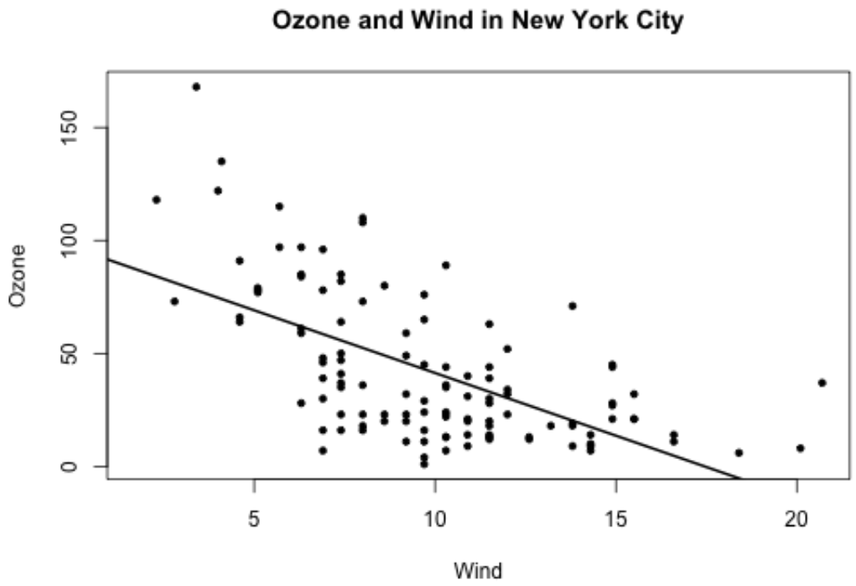
Base Plot with Annotation

```
with(airquality, plot(Wind, Ozone, main = "Ozone and Wind in New York City",
    type = "n"))
with(subset(airquality, Month == 5), points(Wind, Ozone, col = "blue"))
with(subset(airquality, Month != 5), points(Wind, Ozone, col = "red"))
legend("topright", pch = 1, col = c("blue", "red"), legend = c("May", "Other Months"))
```



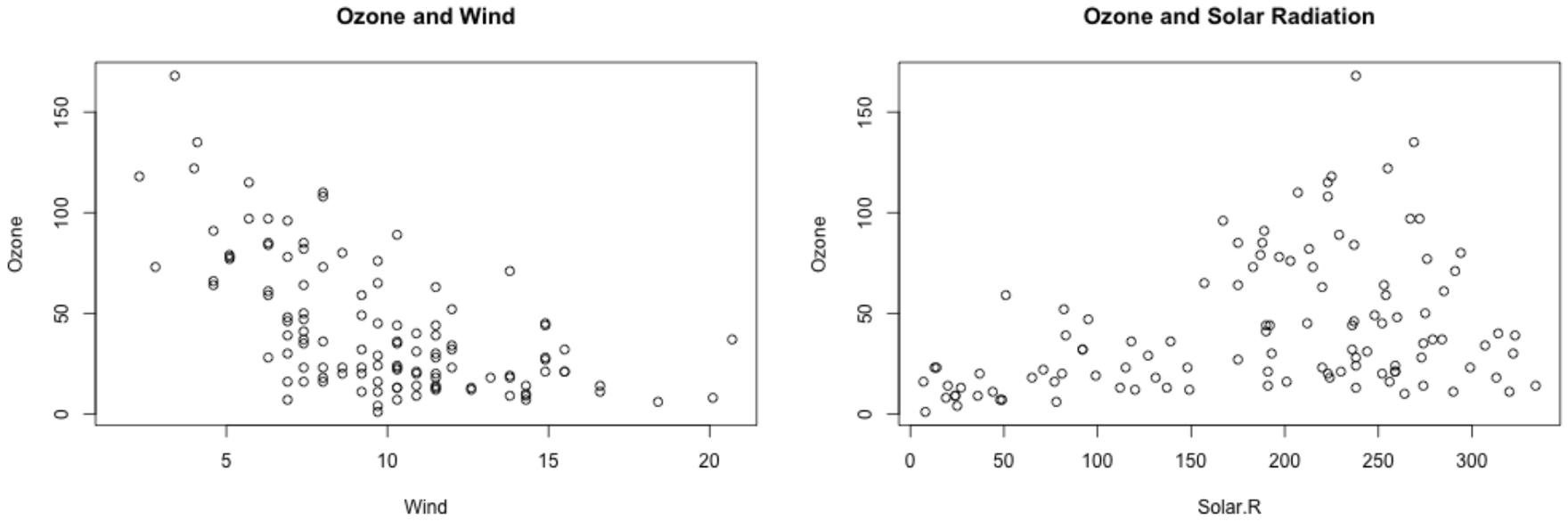
Base Plot with Regression Line

```
with(airquality, plot(Wind, Ozone, main = "Ozone and Wind in New York City",
    pch = 20))
model <- lm(Ozone ~ Wind, airquality)
abline(model, lwd = 2)
```



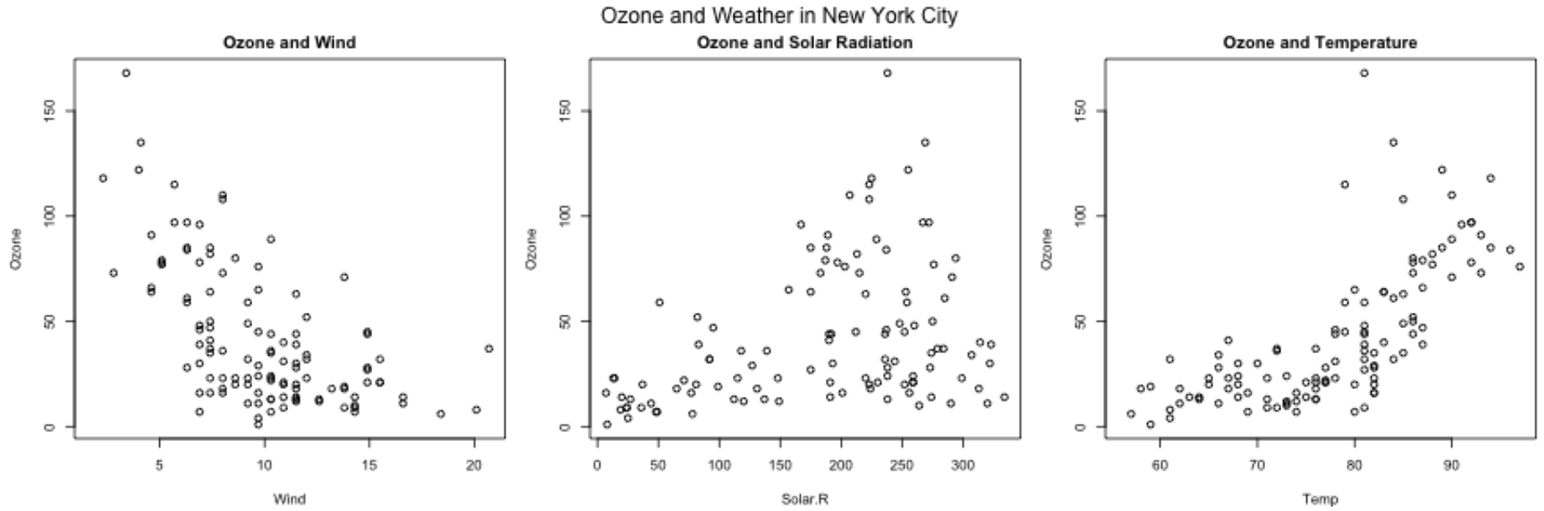
Multiple Base Plots

```
par(mfrow = c(1, 2))
with(airquality, {
    plot(Wind, Ozone, main = "Ozone and Wind")
    plot(Solar.R, Ozone, main = "Ozone and Solar Radiation")
})
```



Multiple Base Plots

```
par(mfrow = c(1, 3), mar = c(4, 4, 2, 1), oma = c(0, 0, 2, 0))
with(airquality, {
    plot(Wind, Ozone, main = "Ozone and Wind")
    plot(Solar.R, Ozone, main = "Ozone and Solar Radiation")
    plot(Temp, Ozone, main = "Ozone and Temperature")
    mtext("Ozone and Weather in New York City", outer = TRUE)
})
```



Summary

- Plots in the base plotting system are created by calling successive R functions to "build up" a plot
- Plotting occurs in two stages:
    - Creation of a plot
    - Annotation of a plot (adding lines, points, text, legends)
- The base plotting system is very flexible and offers a high degree of control over plotting