Plotting with ggplot2: Part 1

Biostatistics 140.776

What is ggplot2?

- An implementation of the *Grammar of Graphics* by Leland Wilkinson
- Written by Hadley Wickham (while he was a graduate student at Iowa State)
- A “third” graphics system for R (along with **base** and **lattice**)
- Available from CRAN via `install.packages()`
- Web site: http://ggplot2.org (better documentation)

What is ggplot2?

- Grammar of graphics represents and abstraction of graphics ideas/objects
- Think “verb”, “noun”, “adjective” for graphics
- Allows for a “theory” of graphics on which to build new graphics and graphics objects
- “Shorten the distance from mind to page”

Grammar of Graphics

"…the grammar tells us that a statistical graphic is a **mapping** from data to **aesthetic** attributes (colour, shape, size) of **geometric** objects (points, lines, bars). The plot may also contain statistical transformations of the data and is drawn on a specific coordinate system"

from *ggplot2* book

Plotting Systems in R: Base

- “Artist’s palette” model
- Start with blank canvas and build up from there
- Start with `plot` function (or similar)
- Use annotation functions to add/modify (`text`, `lines`, `points`, `axis`)

Plotting Systems in R: Base

- Convenient, mirrors how we think of building plots and analyzing data
- Can’t go back once plot has started (i.e. to adjust margins); need to plan in advance
- Difficult to “translate” to others once a new plot has been created (no graphical “language”)
  - Plot is just a series of R commands

Plotting Systems in R: Lattice

- Plots are created with a single function call (`xyplot`, `bwplot`, etc.)
- Most useful for conditioning types of plots: Looking at how *y* changes with *x* across levels of *z*
- Thinks like margins/spacing set automatically because entire plot is specified at once
- Good for putting many many plots on a screen

Plotting Systems in R: Lattice

- Sometimes awkward to specify an entire plot in a single function call
- Annotation in plot is not intuitive
- Use of panel functions to annotate plots was difficult to wield and required intense preparation

Plotting Systems in R: ggplot2

- Split the difference between base and lattice
- Automatically deals with spacings, text, titles but also allows you to annotate by “adding”
- Superficial similarity to lattice but generally easier/more intuitive to use
- Default mode makes many choices for you (but you can customize)

The Basics: `qplot()`

- Looks for data in a data frame, similar to lattice, or in the parent environment
- Plots are made up of *aesthetics* (size, shape, color) and *geoms* (points, lines)
- Works much like the `plot` function in base graphics system

The Basics: `qplot()`

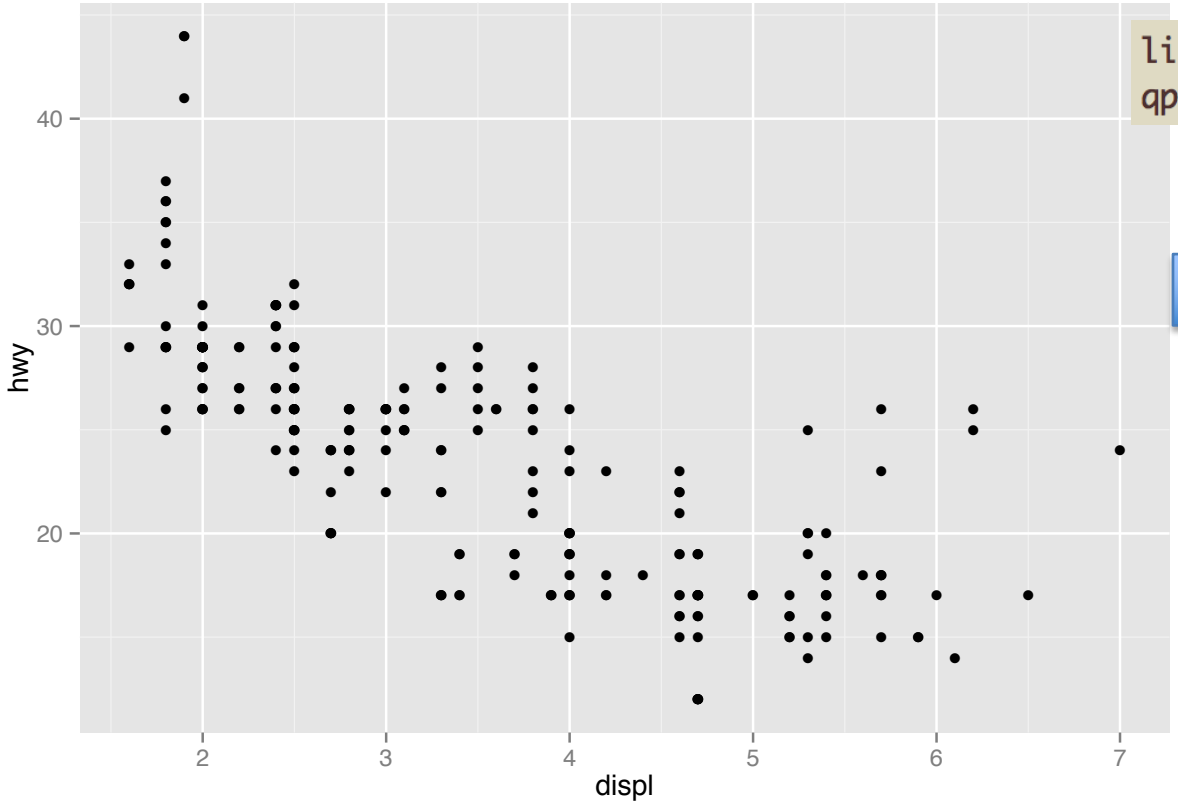
- Data need to be tidy (and usually in long format)
- Factors are important for indicating subsets of the data (if they are to have different properties) and annotating points; factors should be **labeled**
- The qplot() hides what goes on underneath, which is okay for most operations
- ggplot() is the core function and very flexible for doing things qplot() cannot do

Example Dataset

```
> library(ggplot2)
> str(mpg)
'data.frame':   234 obs. of  11 variables:
 $ manufacturer: Factor w/ 15 levels "audi","chevrolet",..: 1 1 1 1 1 1 1 1 1 1 ...
 $ model       : Factor w/ 38 levels "4runner 4wd",..: 2 2 2 2 2 2 2 3 3 3 ...
 $ displ       : num  1.8 1.8 2 2 2.8 2.8 3.1 1.8 1.8 2 ...
 $ year        : int  1999 1999 2008 2008 1999 1999 2008 1999 1999 2008 ...
 $ cyl         : int  4 4 4 4 6 6 6 4 4 4 ...
 $ trans       : Factor w/ 10 levels "auto(av)","auto(l3)",..: 4 9 10 1 4 9 1 9 4 10
...
 $ drv         : Factor w/ 3 levels "4","f","r": 2 2 2 2 2 2 2 1 1 1 ...
 $ cty         : int  18 21 20 21 16 18 18 18 16 20 ...
 $ hwy         : int  29 29 31 30 26 26 27 26 25 28 ...
 $ fl          : Factor w/ 5 levels "c","d","e","p",..: 4 4 4 4 4 4 4 4 4 4 ...
 $ class       : Factor w/ 7 levels "2seater","compact",..: 2 2 2 2 2 2 2 2 2 2 ...
```

Factor label information important for annotation

ggplot2 “Hello, world!”



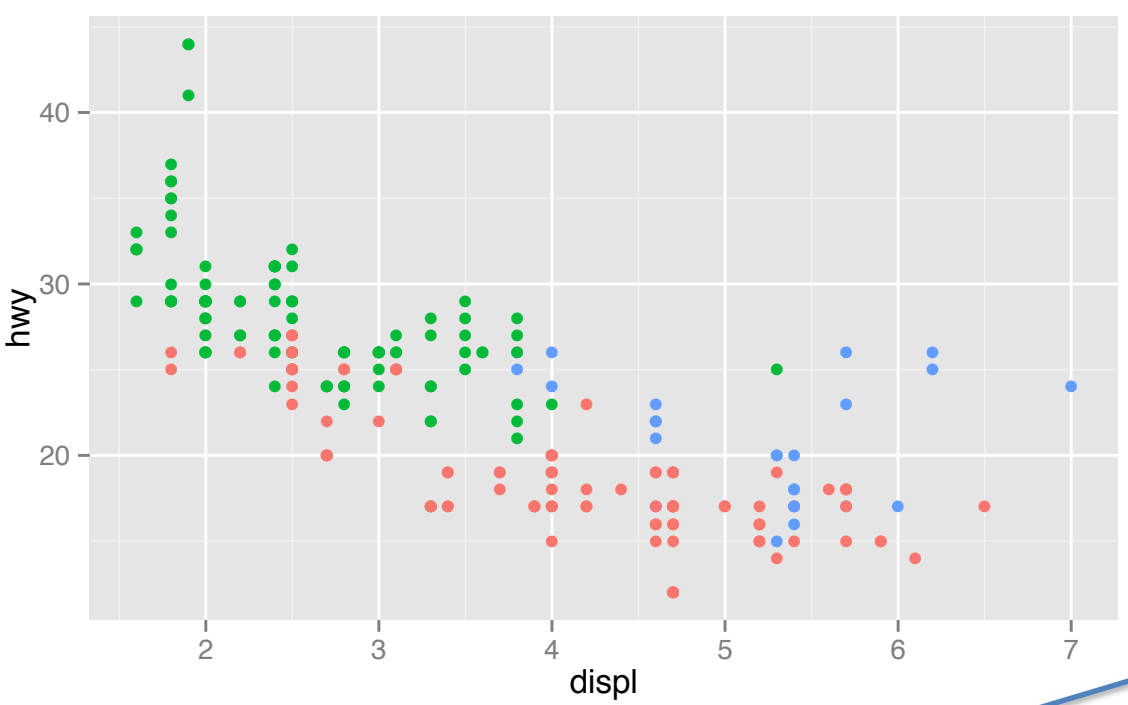

```
library(ggplot2)
qplot(displ, hwy, data = mpg)
```

x coord

y coord

data frame

Modifying aesthetics

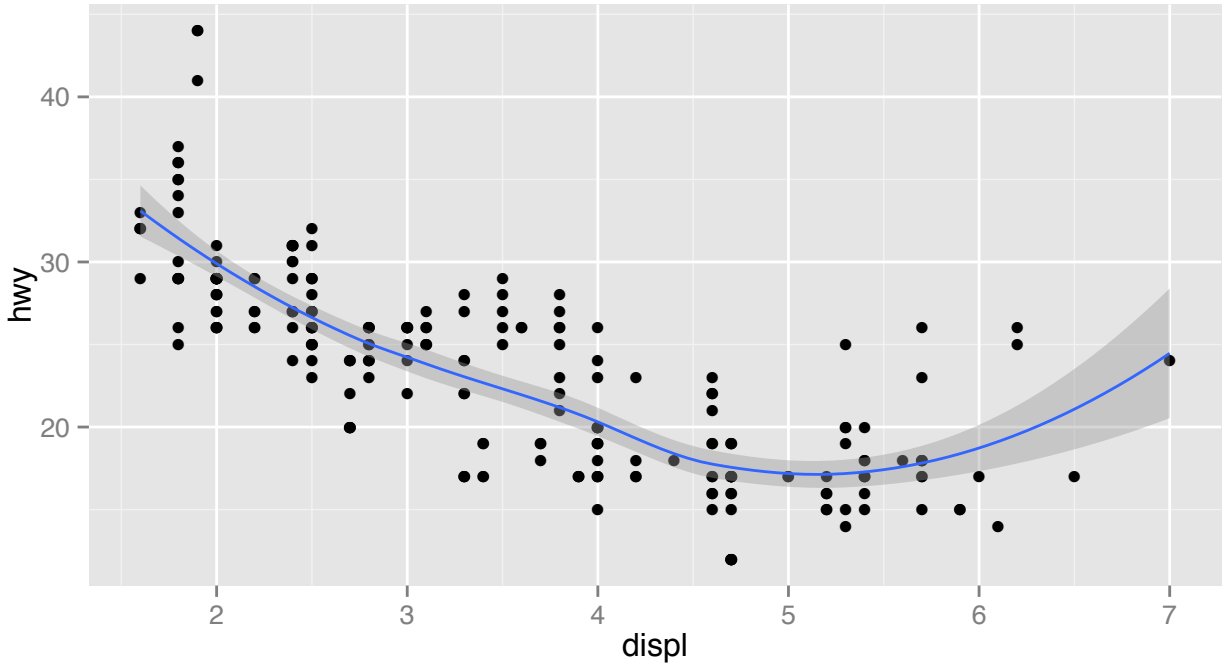


auto legend placement

color aesthetic

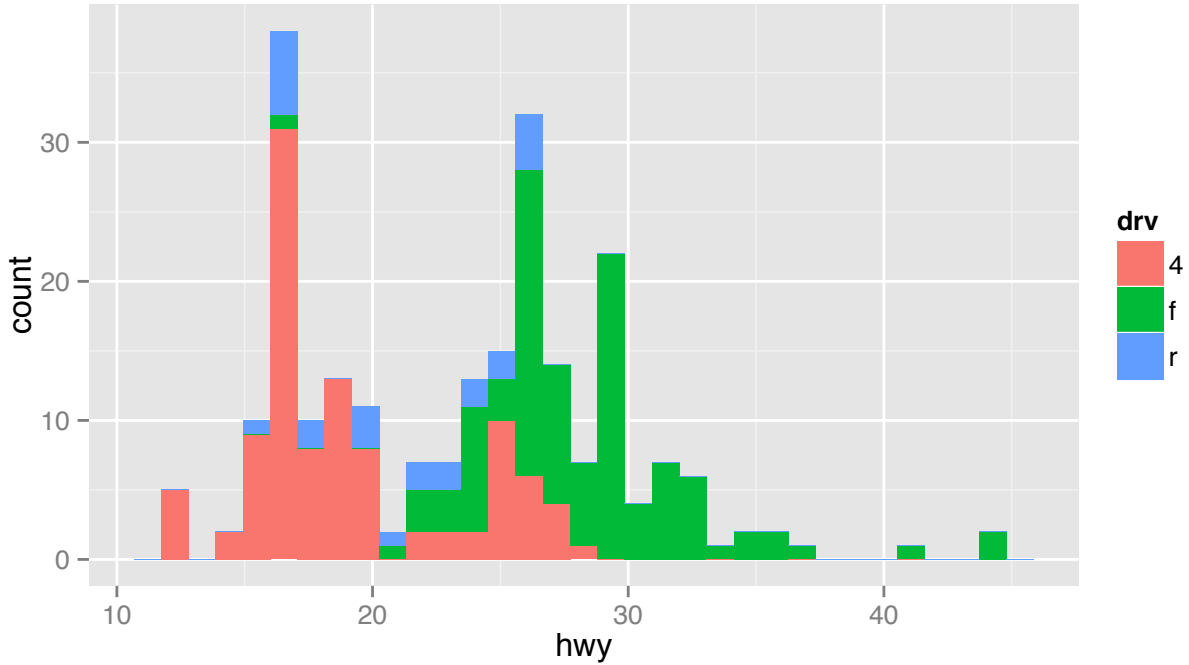
```
qplot(displ, hwy, data = mpg, color = drv)
```

Adding a geom



qplot(displ, hwy, data = mpg, geom = c("point", "smooth"))

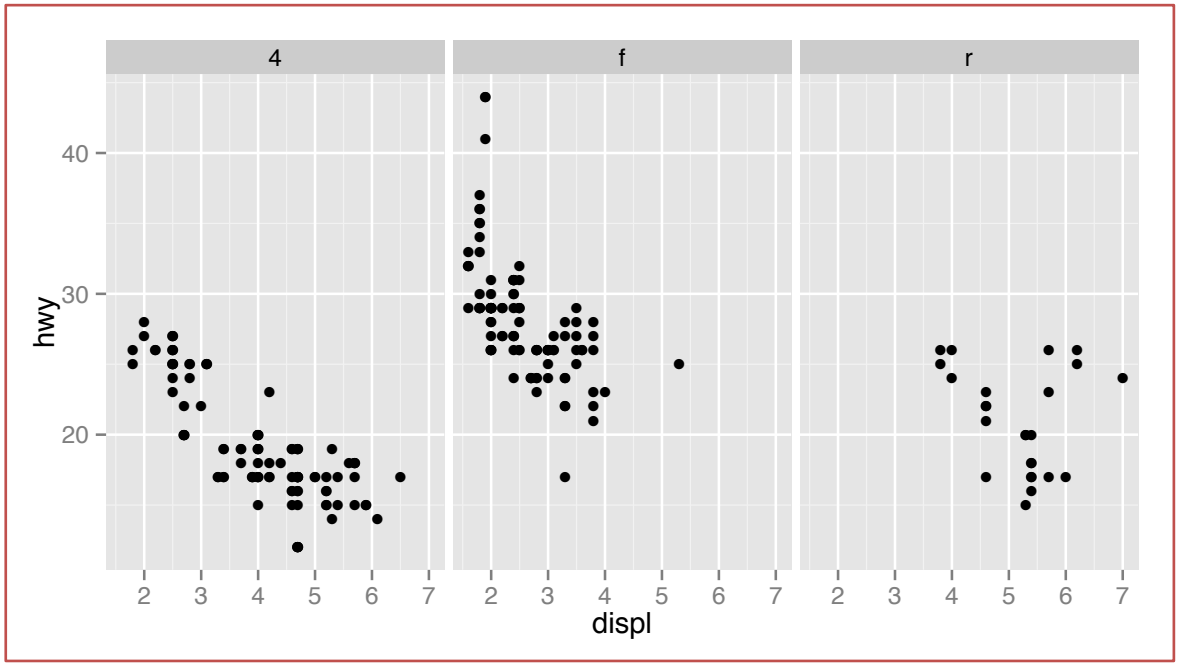
Histograms

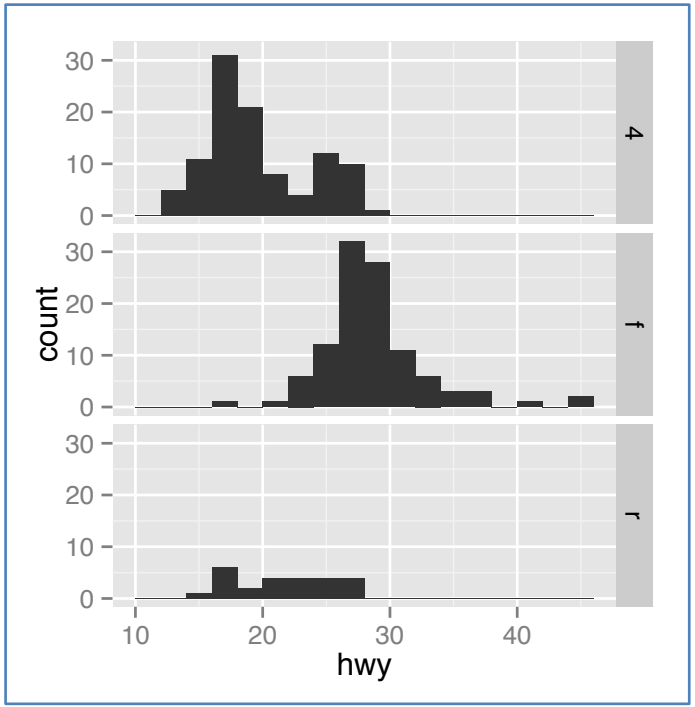


qplot(hwy, data = mpg, fill = drv)

Facets

```
qplot(displ, hwy, data = mpg, facets = . ~ drv)
```






```
qplot(hwy, data = mpg, facets = drv ~ ., binwidth = 2)
```

MAACS Cohort

- Mouse Allergen and Asthma Cohort Study
- Baltimore children (aged 5—17)
- Persistent asthma, exacerbation in past year
- Study indoor environment and its relationship with asthma morbidity
- Recent publication: http://goo.gl/WqE9j8

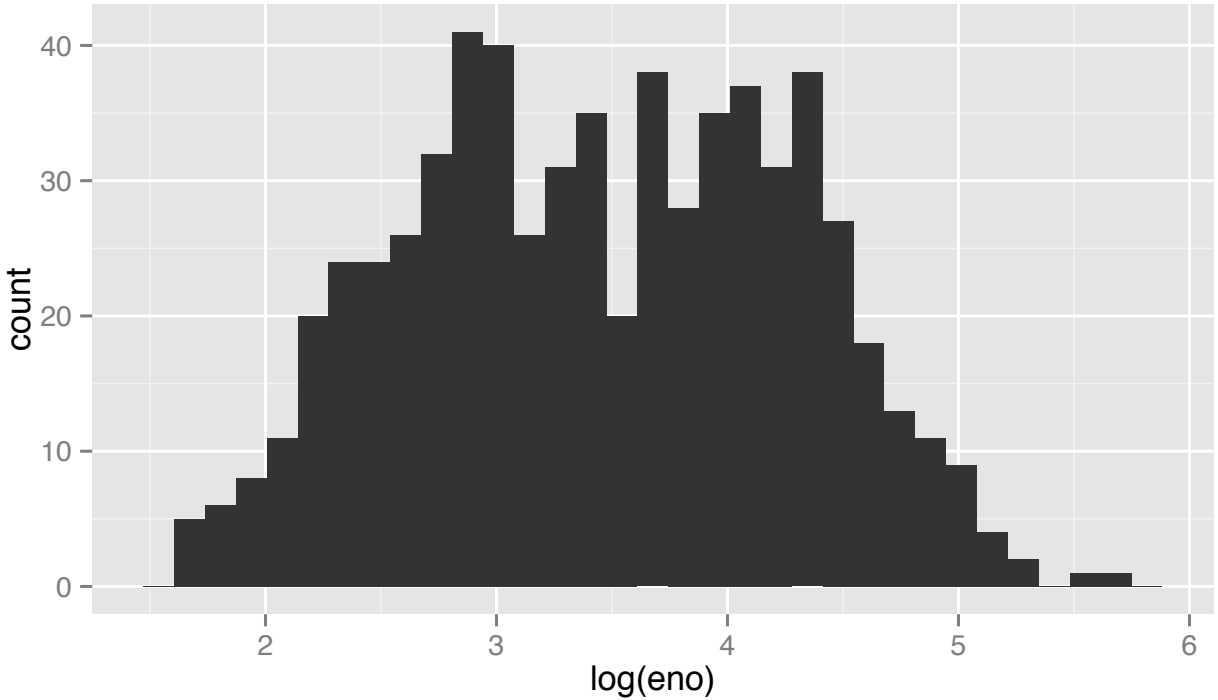
Example: MAACS

```
> str(maacs)
'data.frame':   750 obs. of  5 variables:
 $ id        : int  1 2 3 4 5 6 7 8 9 10 ...
 $ eno       : num  141 124 126 164 99 68 41 50 12 30 ...
 $ duBedMusM: num  2423 2793 3055 775 1634 ...
 $ pm25      : num  15.6 34.4 39 33.2 27.1 ...
 $ mopos     : Factor w/ 2 levels "no","yes": 2 2 2 2 2 2 2 2 2 2 ...
```

Unzip the **plotting.zip** file

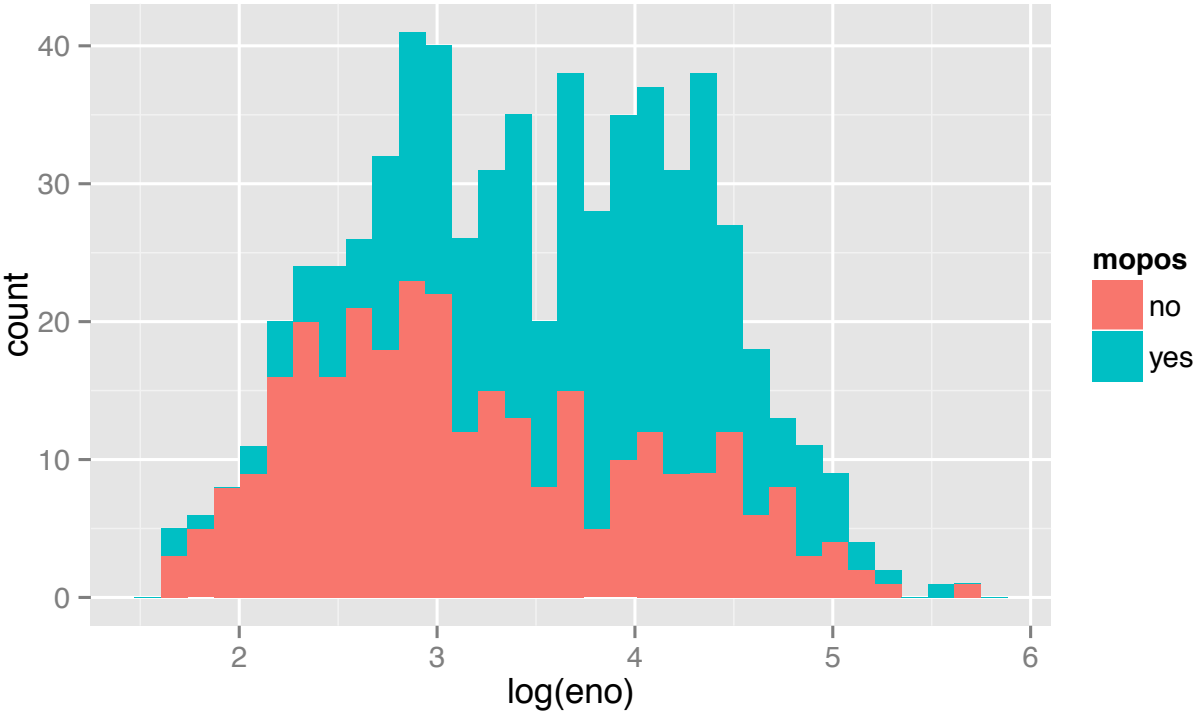
```
library(readr)
eno <- read_csv("eno.csv")
env <- read_csv("environmental.csv")
skin <- read_csv("skin.csv")
maacs <- left_join(eno, env, by = "id") %>%
                left_join(skin, by = "id")
```

Histogram of eNO



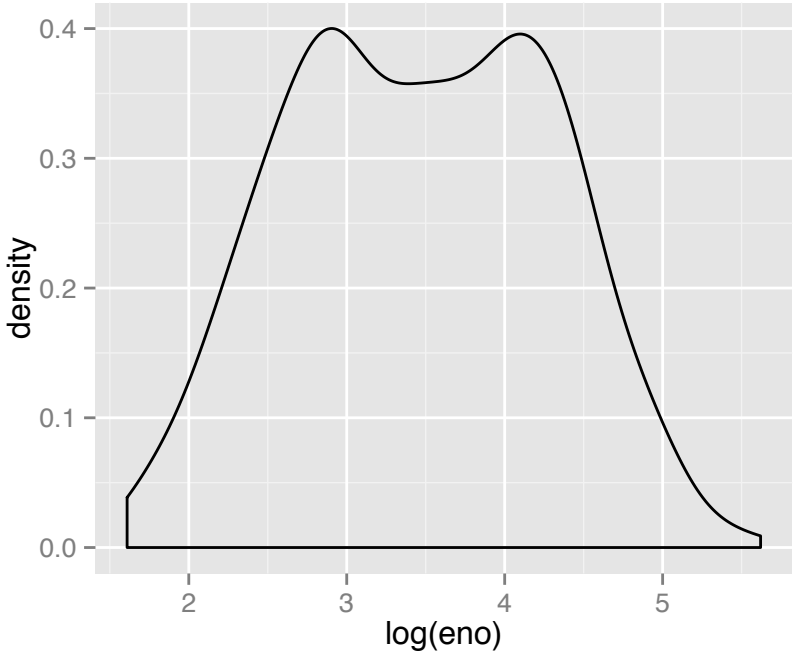
qplot(log(eno), data = maacs)

Histogram by Group

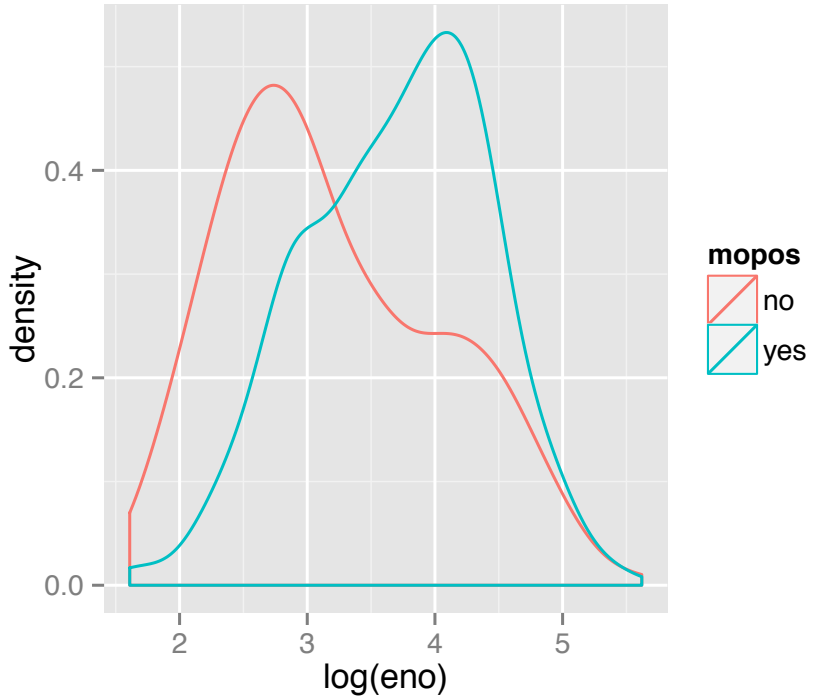


qplot(log(eno), data = maacs, fill = mopos)

Density Smooth

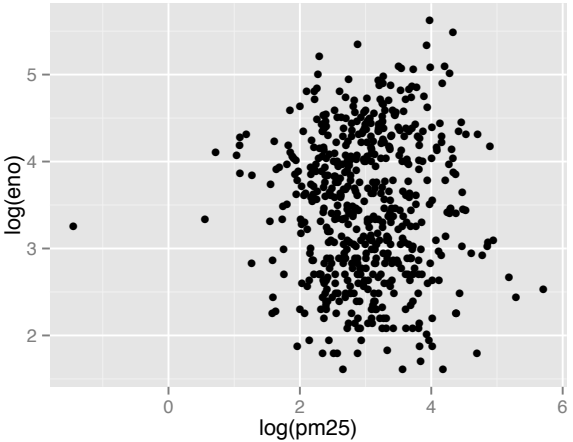


qplot(log(eno), data = maacs, geom = "density")

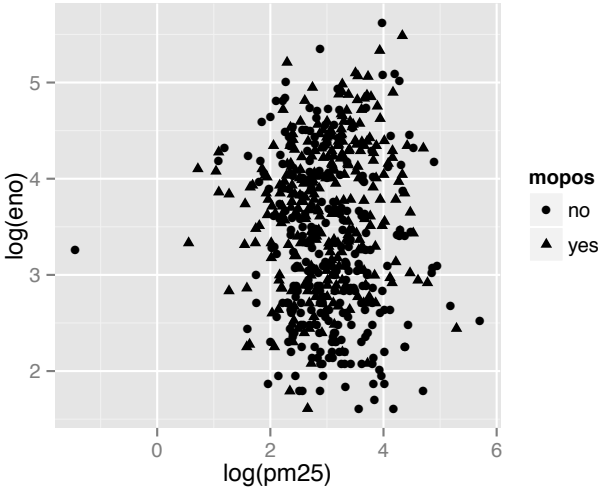


qplot(log(eno), data = maacs, geom = "density", color = mopos)

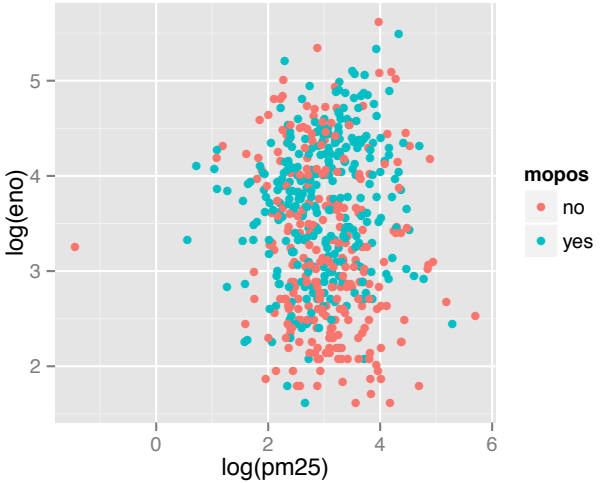
Scatterplots: eNO vs. $PM_{2.5}$



qplot(log(pm25), log(eno), data = maacs, shape = mopos)

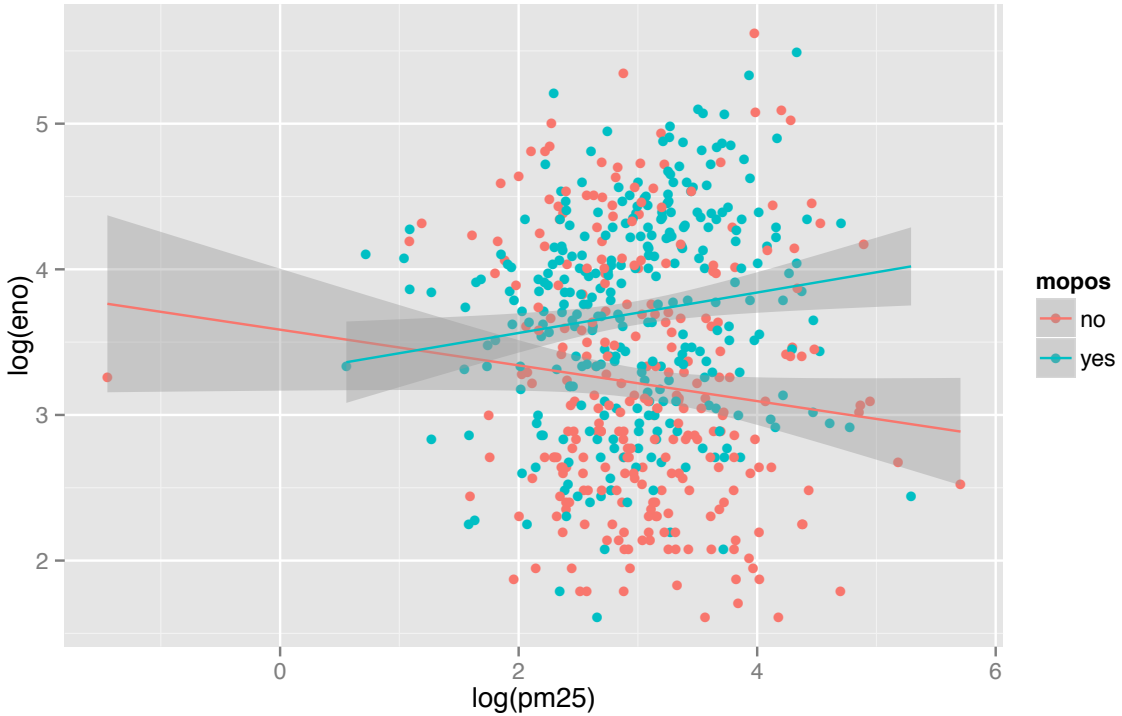


qplot(log(pm25), log(eno), data = maacs, shape = mopos)



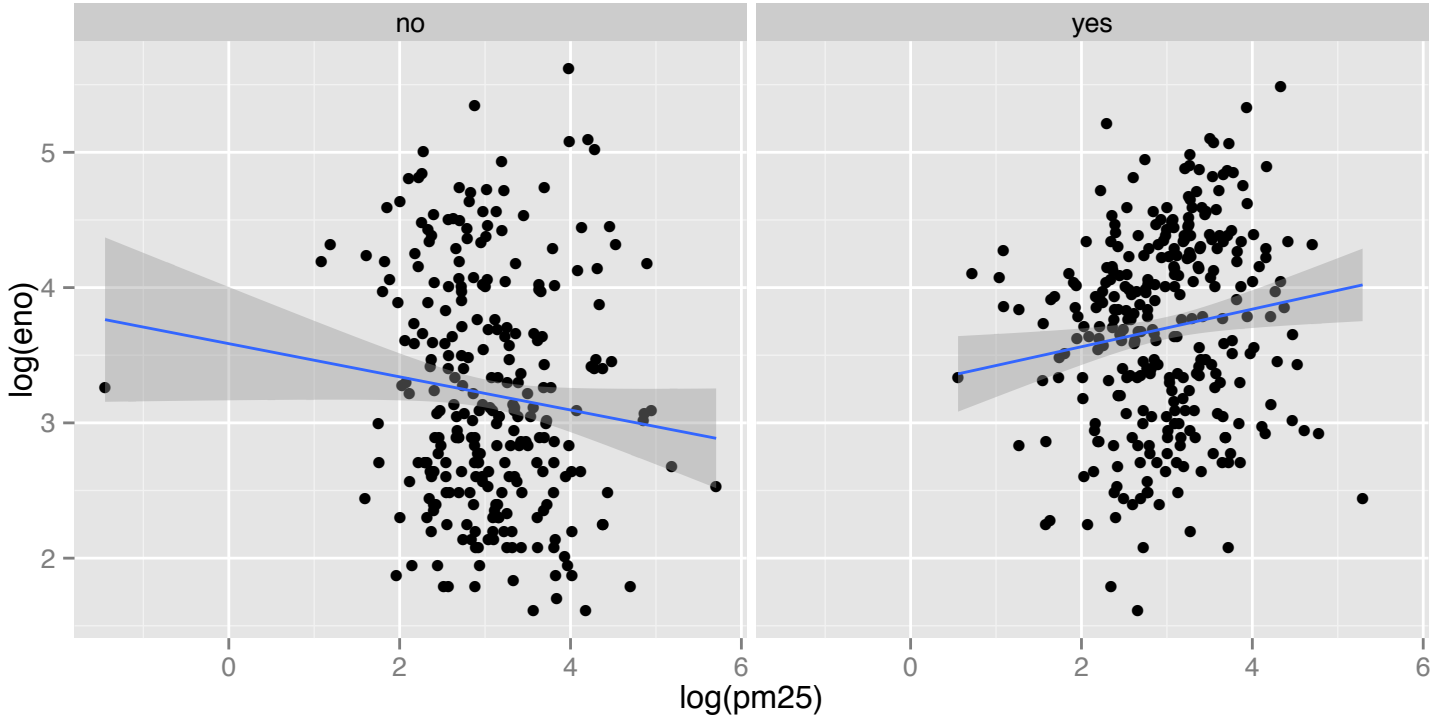
qplot(log(pm25), log(eno), data = maacs, color = mopos)

Scatterplots: eNO vs. $PM_{2.5}$



qplot(log(pm25), log(eno), data = maacs, color = mopos) + geom_smooth(method = "lm")

Scatterplots: eNO vs. $PM_{2.5}$



qplot(log(pm25), log(eno), data = maacs, facets = . ~ mopos) + geom_smooth(method = “lm”)

Basic Components of a ggplot2 Plot

- A **data frame**
- **aesthetic mappings**: how data are mapped to color, size
- **geoms**: geometric objects like points, lines, shapes.
- **facets**: for conditional plots.
- **stats**: statistical transformations like binning, quantiles, smoothing.
- **scales**: what scale an aesthetic map uses (example: male = red, female = blue).
- **coordinate system**

Summary of qplot()

- The qplot() function is the analog to plot() but with many built-in features
- Produces very nice graphics *quickly*, essentially publication ready (if you like the design)
- Difficult to go against the grain/customize (don’t bother; use full ggplot2 power in that case)

Resources

- The *ggplot2* book by Hadley Wickham
- The *R Graphics Cookbook* by Winston Chang (examples in base plots and in ggplot2)
- ggplot2 web site (https://ggplot2.tidyverse.org)
- ggplot2 mailing list (http://goo.gl/OdW3uB), primarily for developers