ggplot2

An implementation of the
grammar of graphics

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Outline

- Intro: installation, documentation, data and qplot
- How make to a plot
- Geoms, stats, scales, facets and coordinate systems

- Let me know if you have questions

ggplot2

- install.packages("ggplot2")
  - 0.5.7 should be available v. soon
- http://had.co.nz/ggplot2
  - documents 99 ggplot objects with over 500 examples
  - opportunities for feedback
  - link to (draft) ggplot book

Diamonds data

- ~54,000 round diamonds from http://www.diamondse.info/
- Carat, colour, clarity, cut
- Total depth, table, depth, width, height
- Price

qplot

- Wraps up all the details of ggplot with a familiar syntax borrowed from plot
- Additional features:
  - Automatically scales data
  - Can produce any type of plot
  - Facetting and margins
  - Creates objects that can be saved and modified

qplot

```
qplot(diamonds$carat, diamonds$price)
qplot(carat, price, data = diamonds)
qplot(carat, price, data = diamonds,
  colour=clarity)
qplot(carat, price, data = diamonds,
  geom=c("point", "smooth"), method=lm)

qplot(carat, data = diamonds,
  geom="histogram")
qplot(carat, data = diamonds,
  geom="histogram", binwidth = 100)
```

Defaults

- Layers of convenience functions
  - Multiple levels allow you to trade-off simplicity and control
    - qplot is the simplest to use, but gives the least control
- To understand more sophisticated levels you need a basic understanding of the grammar

How to make a plot

length	width	depth	trt
2	3	4	a
1	2	1	a
4	5	15	b
9	10	80	b

How to make a plot

- Want a scatterplot of length vs width

length	width	depth	trt
2	3	4	a
1	2	1	a
4	5	15	b
9	10	80	b

How to make a plot

- Want a scatterplot of length vs width
- What is a scatterplot?

length	width	depth	trt
2	3	4	a
1	2	1	a
4	5	15	b
9	10	80	b

How to make a plot

- Want a scatterplot of length vs width
- What is a scatterplot?

length	width	depth	trt
2	3	4	a
1	2	1	a
4	5	15	b
9	10	80	b

- Represent observations with points (geom)

How to make a plot

- Want a scatterplot of length vs width
- What is a scatterplot?

length	width	depth	trt
2	3	4	a
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- Represent observations with points (geom)
- Linear scaling of x and y axes (scales)

How to make a plot

- Want a scatterplot of length vs width
- What is a scatterplot?

length	width	depth	trt
2	3	4	a
1	2	1	a
4	5	15	b
9	10	80	b

- Represent observations with points (geom)
- Linear scaling of x and y axes (scales)
- Cartesian coordinate system

Data

length	width	depth	trt
2	3	4	a
1	2	1	a
4	5	15	b
9	10	80	b

Mapping

length	width	depth	trt
2	3	4	a
1	2	1	a
4	5	15	b
9	10	80	b

x	y	colour
2	3	a
1	2	a
4	5	b
9	10	b

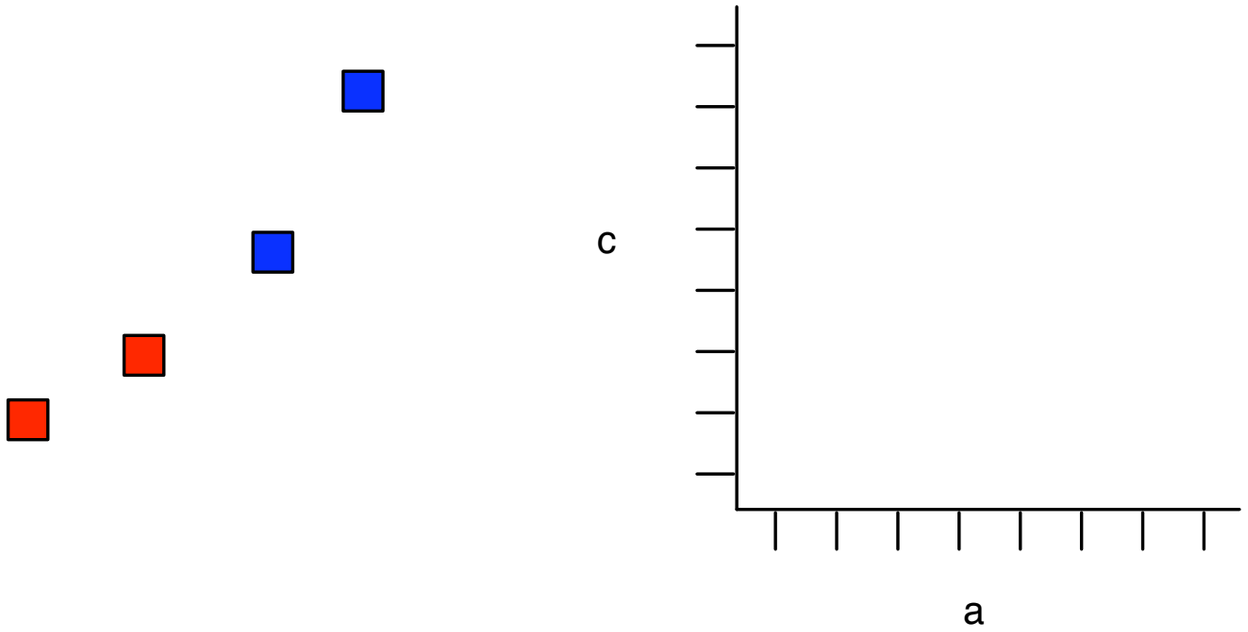
Scales

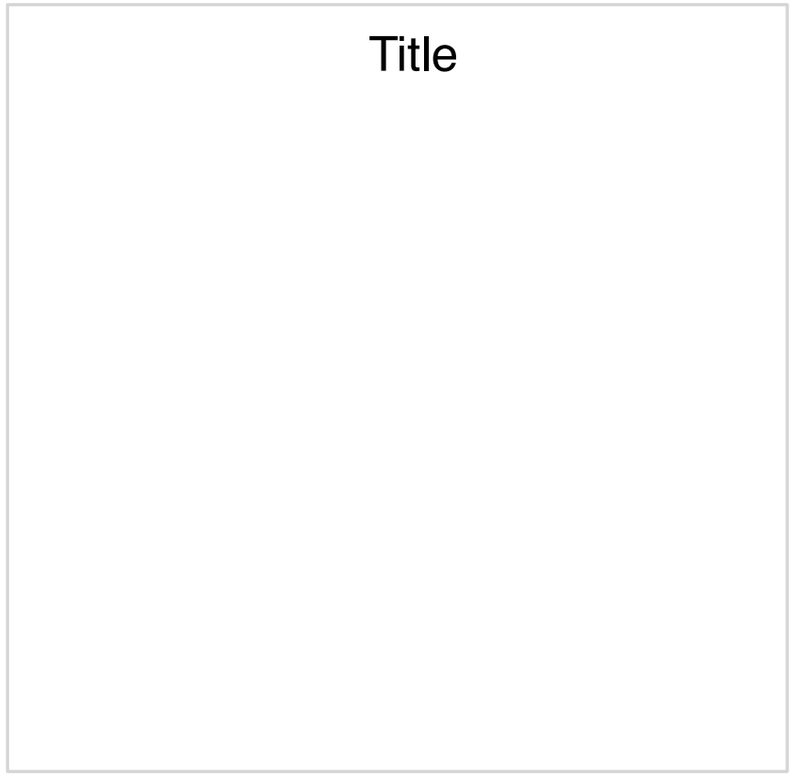
Need to convert to physical “drawing” units

x	y	colour
2	3	a
1	2	a
4	5	b
9	10	b

x	y	colour
25	11	red
0	0	red
75	53	blue
200	300	blue

(and coordinate system)



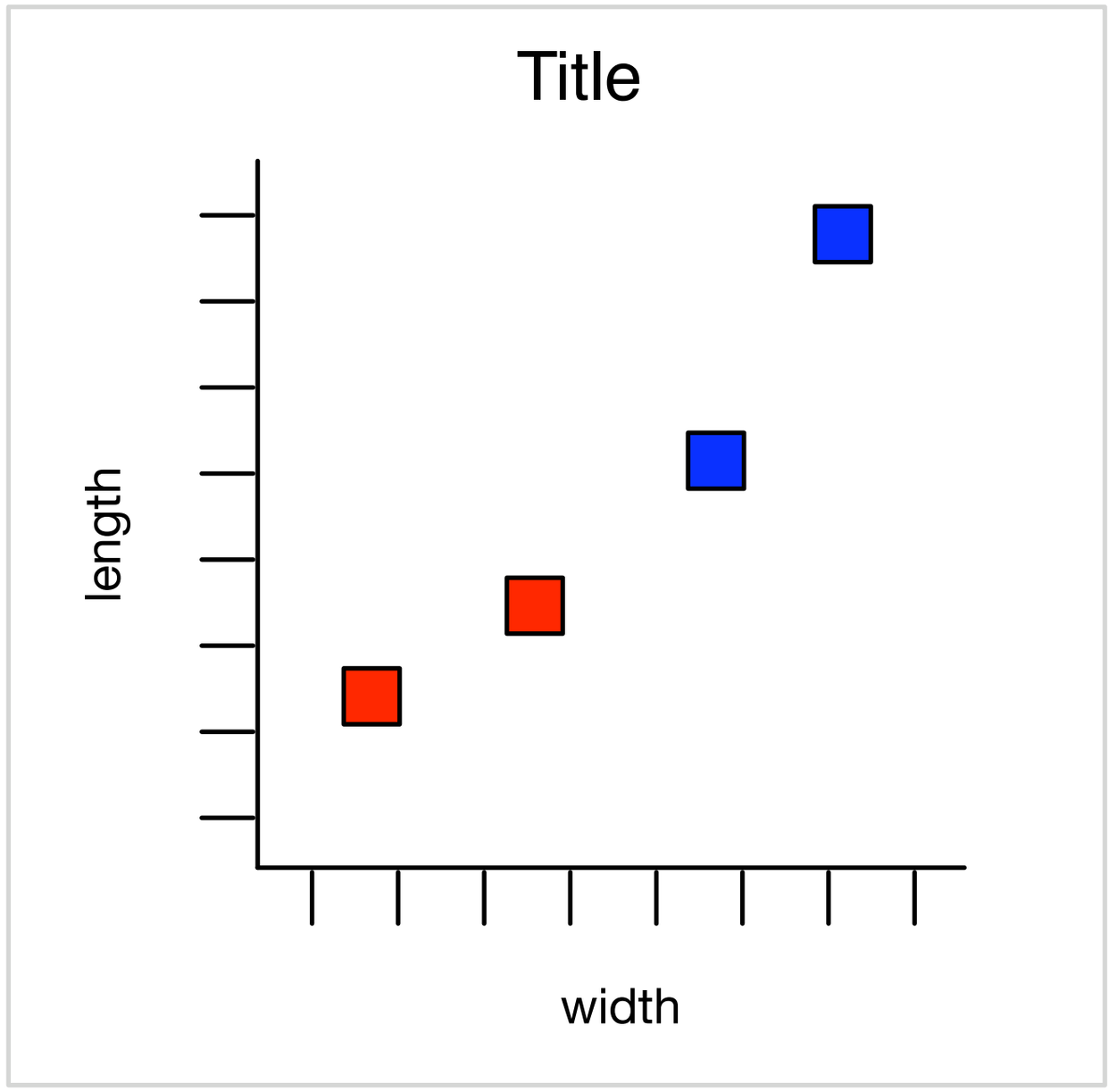


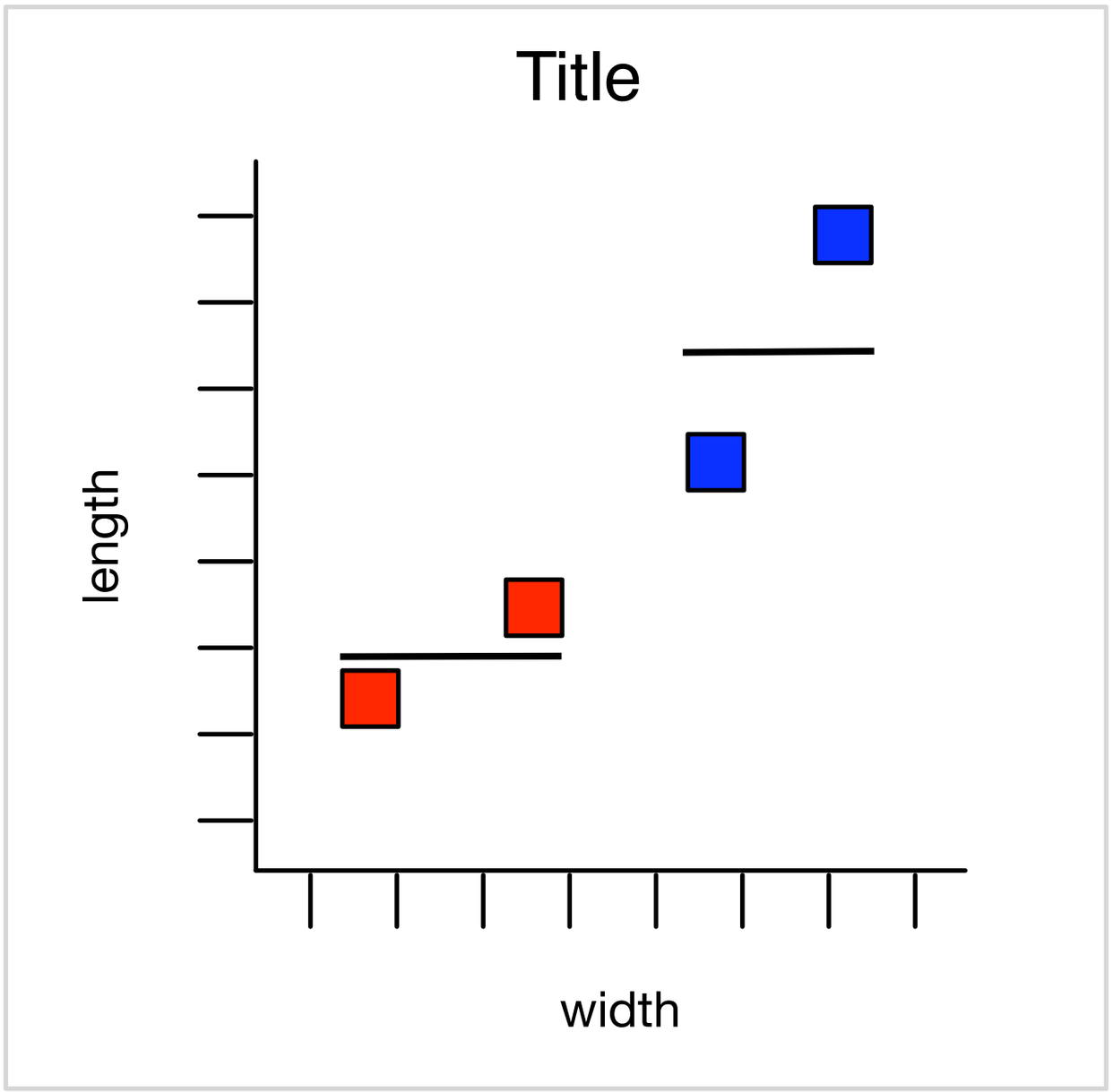
Geoms

Guides

(from scales and coordinate systems)

Plot


Title
length
width



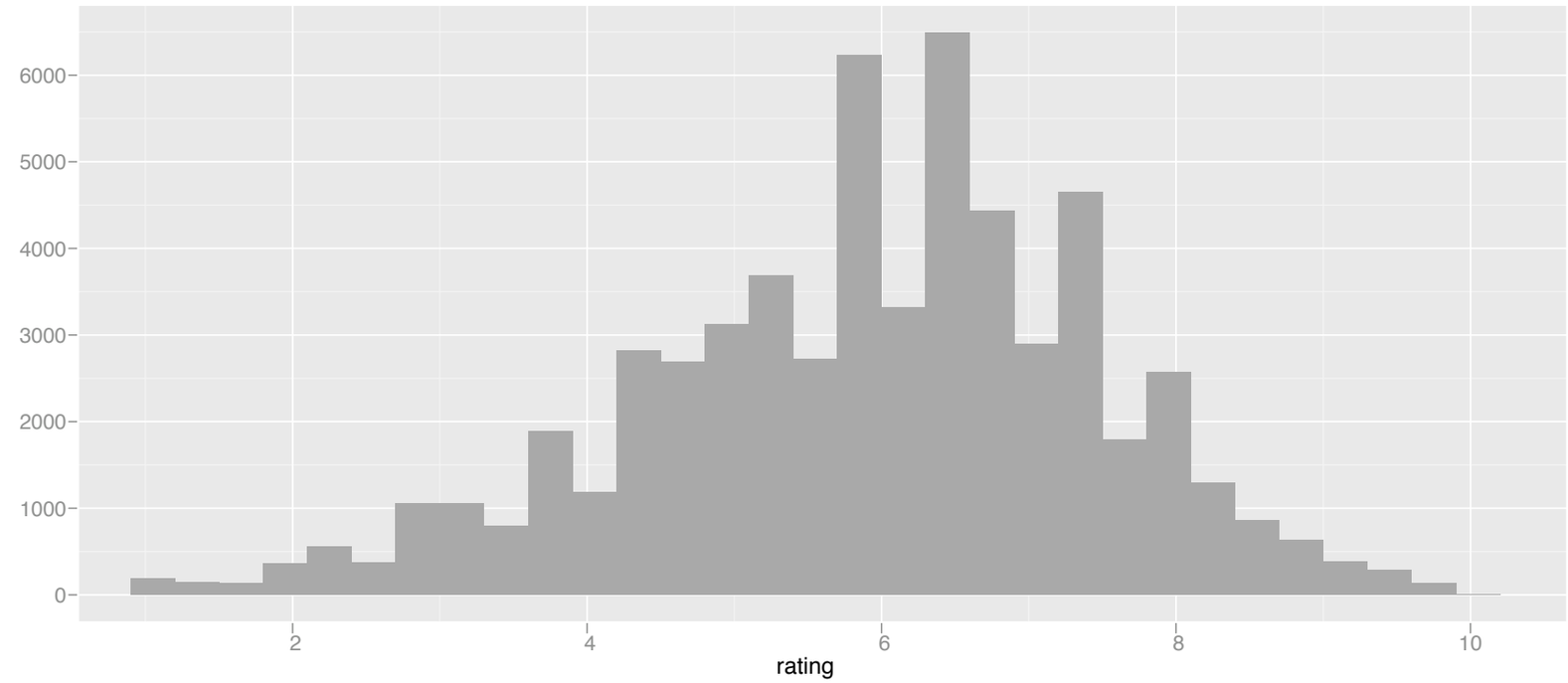
Multiple layers, statistical transformation

Components

- Data
- Geometric object (geom)
- Statistical transformation (stat)
- Scales
- Coordinate system
- (+ Position adjustment, facetting)

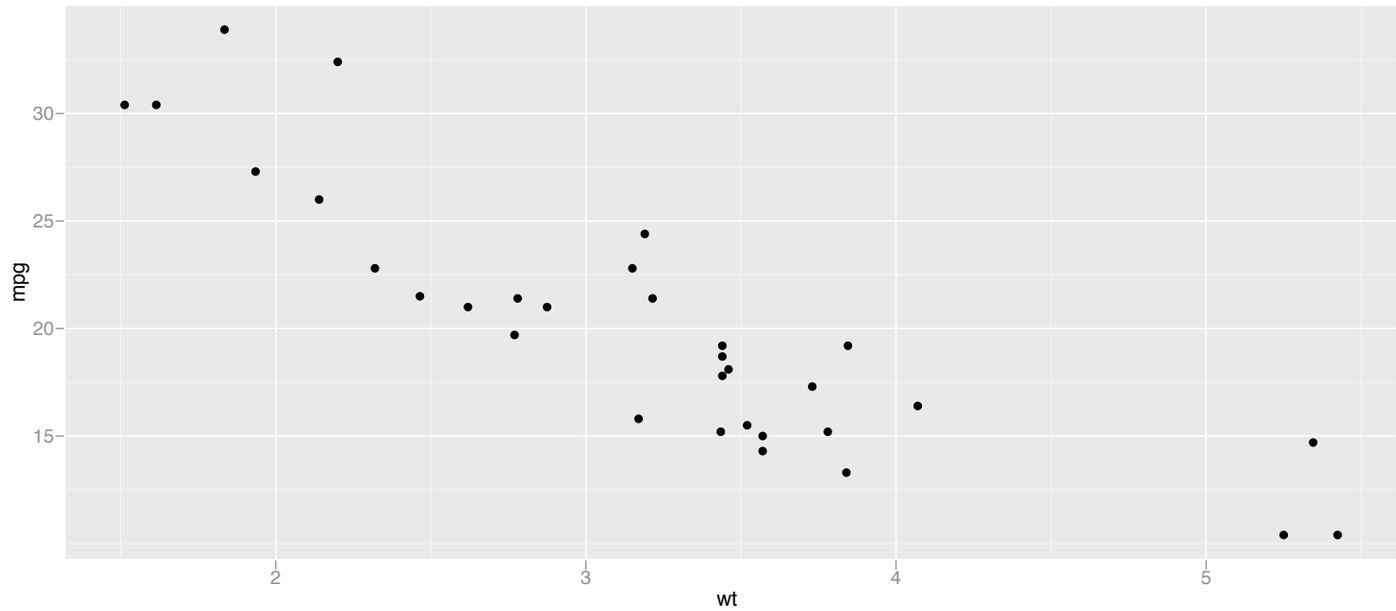
Histogram

- Geom: bar
- Stat: bin
- Scale: linear
- Coordinate system: Cartesian



Scatterplot

- Geom: point
- Stat: identity
- Scale: linear
- Coordinate system: Cartesian



Layers

- Previous description is a bit of a simplification
- Actually have: defaults + layers + scales + coordinate system
- Layer = data + mapping + geom + stat + position

Plot definition

```
ggplot(data, mapping) +
layer(
    stat = "",
    geom = "",
    position = "",
    geom_parms = list(),
    stat_params = list(),
)
```

Layers

- Usually won't write out the full specification, but use a shortcut:
  - geom_smooth()
  - stat_summary()
  - ...
- Every geom has a default statistic, every statistic a default geom (but can override)

Examples

```
d <- ggplot(diamonds,
  aes(x=carat, y=price))
d + geom_point()
d + geom_point(aes(colour = carat))
d + geom_point(aes(colour = carat))
  + scale_colour_brewer()

ggplot(diamonds) +
geom_histogram(aes(x=price))
```

Data + mapping

- Data and mappings usually stay the same on a plot, so they are stored as defaults:
- ggplot(data, mapping = aes(x=x, y=y))
- aes function describes relationship, doesn't supply data

Geoms

- Geoms define the basic "shape" of the elements on the plot
- Basics: point, line, polygon, bar, text
- Composite: boxplot, pointrange
- Statistic: histogram, smooth, density

- Documentation

Statistics

- We haven't used explicitly, but they underlie many of the layers we have been creating - some geoms are really statistics in disguise:
  - geom_histogram = stat_bin + geom_bar
  - geom_smooth = stat_smooth + geom_ribbon
  - geom_density = stat_density + geom_ribbon
- Separate transformation of data from its graphical representation

Variations on a histogram

```
p <- ggplot(diamonds, aes(x=price))

p + geom_histogram()
p + stat_bin(geom="area")
p + stat_bin(geom="point")
p + stat_bin(geom="line")

p + geom_histogram(aes(fill = clarity))
p + geom_histogram(aes(y = ..density..))
```

New variables

- Some statistics produce new variables in the data (see docs for details)
  - stat_bin produces count and density
- If you want to map an aesthetic to one of these new variables, surround it with ..
  - `ggplot(diamonds, aes(x=price))`
    `+ geom_histogram(aes(y = ..density..))`
  - `+ geom_histogram(aes(colour = ..count..))`

Parameters

- Parameters modify appearance of geoms and operation of statistics
  - + geom_smooth(method=lm)
  - + stat_bin(binwidth = 100)
  - + stat_summary(fun="mean_cl_boot")
  - + geom_boxplot(outlier.colour = "red")
- Any aesthetic can also be used as a parameter
  - + geom_point(colour = "red", size = 5)
  - + geom_line(linetype = 3)

Setting vs mapping

```
p <- ggplot(diamonds, aes(x=carat,y=price))

# What will this do?
p + geom_point(aes(colour = "green"))
p + geom_point(colour = "green")
p + geom_point(colour = colour)
```

Writing your own

- Fairly easy to write your own
- But not documented yet
- Don't be afraid of looking at the source

Your turn

- Look at the examples for stat_summary (http://had.co.nz/ggplot2/)
- Try them out
- How could you use them to better understand the diamonds data?

Scales

- Scales control the mapping between data and aesthetics, and control the display of the matching guide (axis or legend)
- ggplot automatically adds default scales as we need them, but we will often need to customise

Basics

- Change name and range or limits
- All scales take name as first argument
  - axis or legend name
  - can be an expression
- All position scales also take limits argument
  - Any data outside of limits is not plotted (but is still used for computation)

Position scales

- Can be used to plot on non-linear scales
  - scale_x_log10, scale_x_sqrt, ...
  - Can also control exactly where breaks occur (with breaks argument) and the amount of extra space on the borders (with the expand argument)

Scales

- Colour/fill probably most commonly manipulated
  - discrete: *hue*, brewer, grey, manual
  - continuous: *gradient*, gradient2
  - identity
- Also see:
  - scale_size, scale_area
  - scale_linetype

Your turn

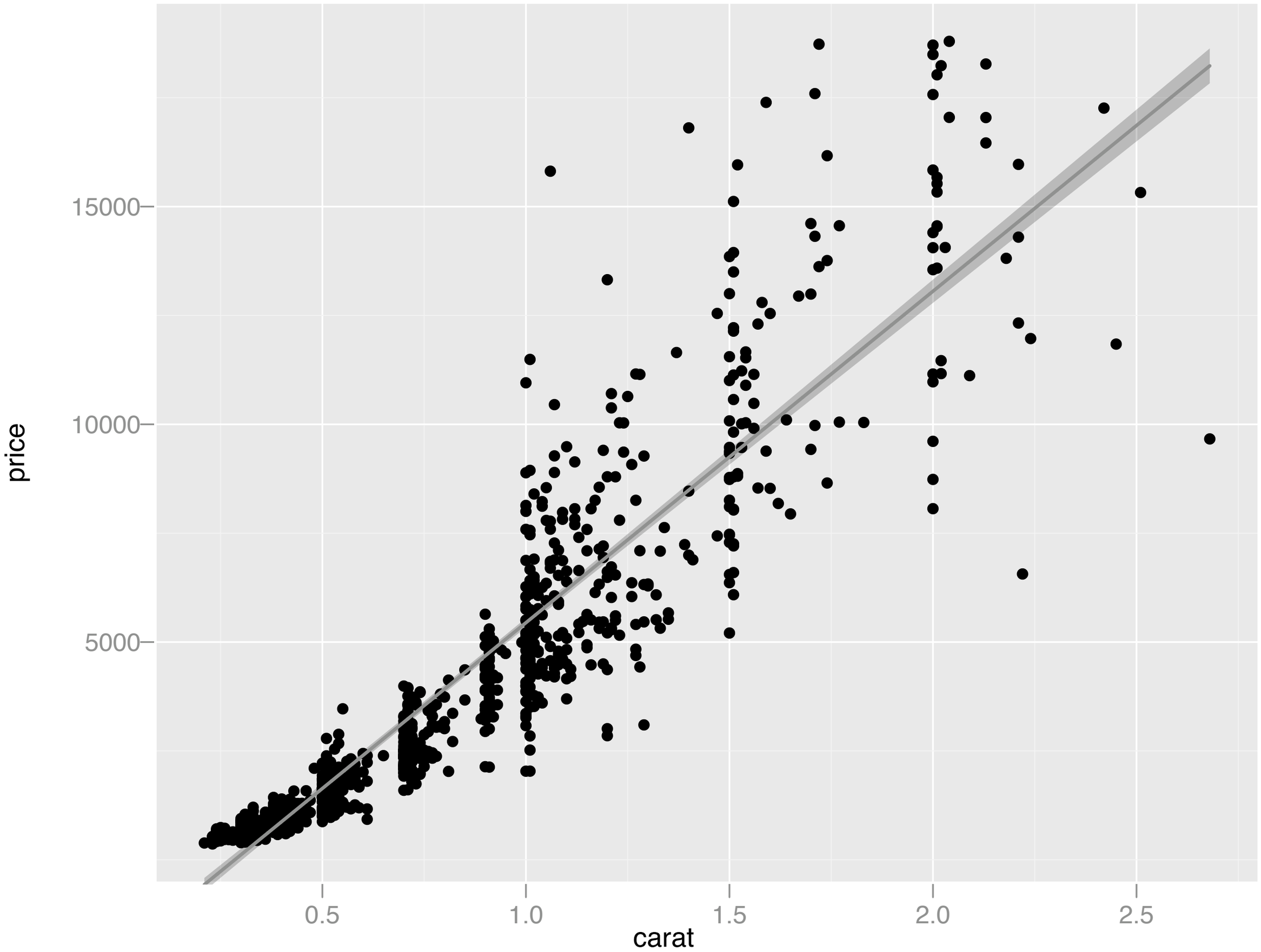
- qplot(carat, data=diamonds, geom="histogram", fill=clarity)
- qplot(carat, cut, data=diamonds, geom="jitter", colour=price)
- Look up the different colour scales in the documentation and try them out

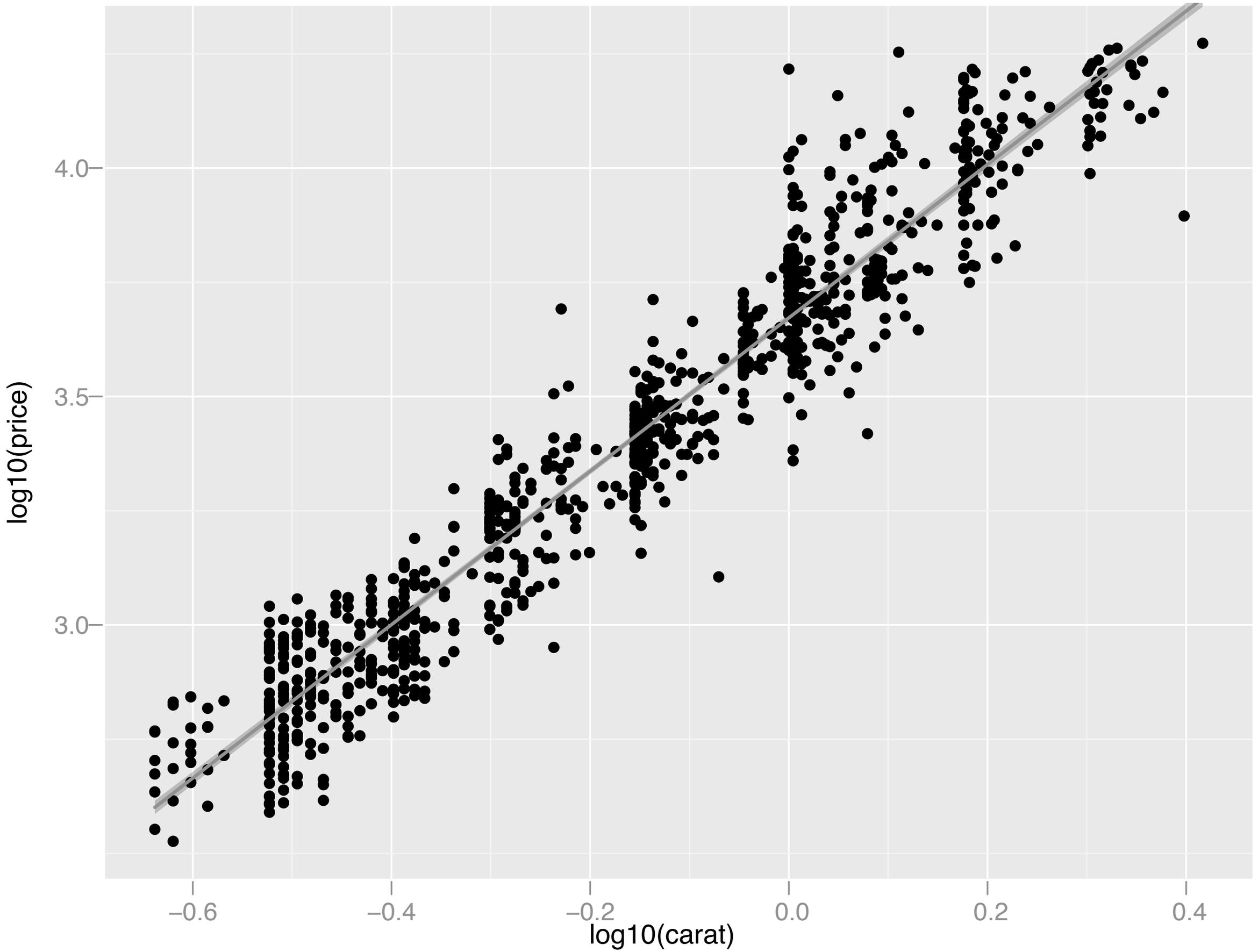
Facetting

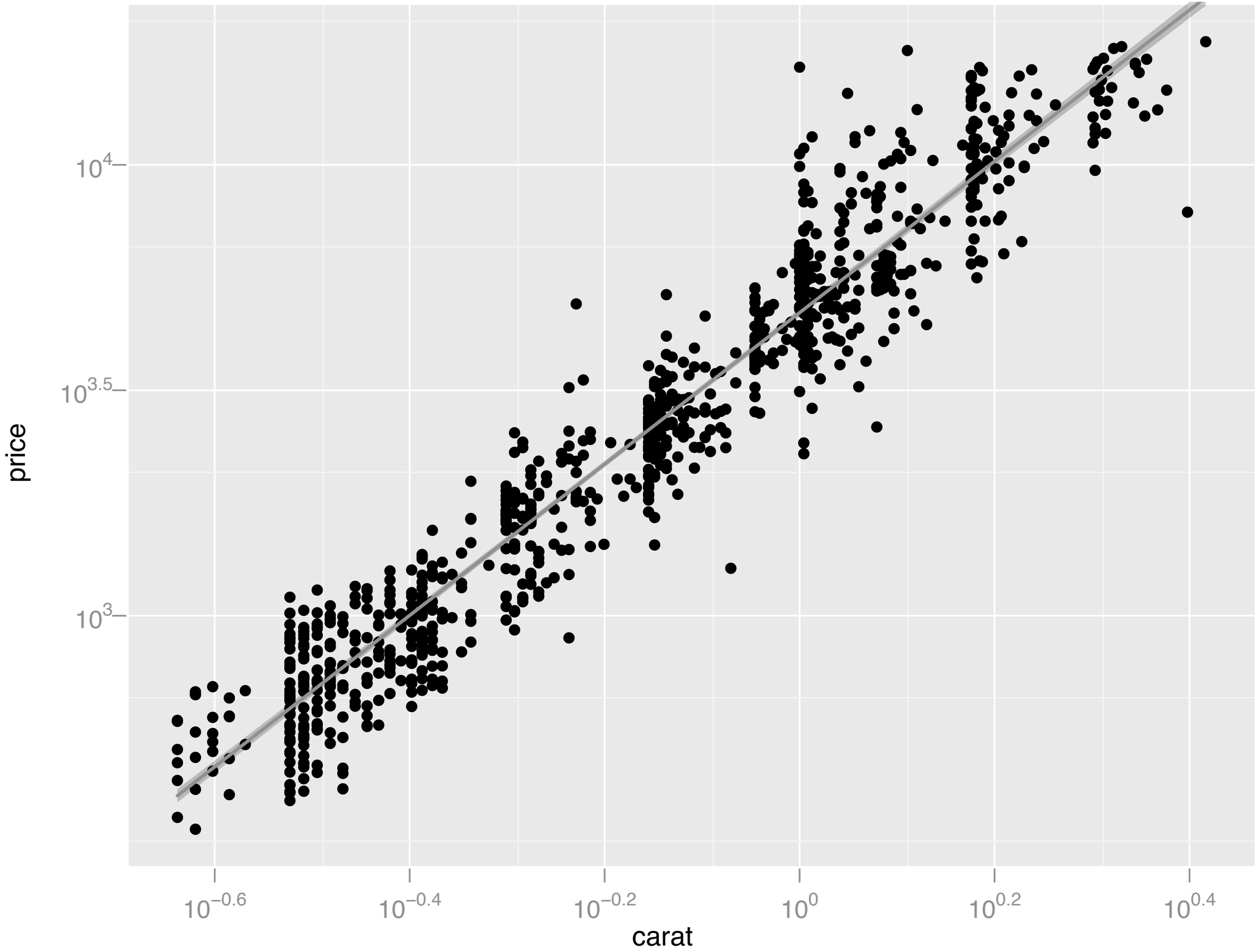
- It's often useful to draw small multiple of subsets of your data
- Currently, there is only one way to do this:
  - + facet_grid(row ~ col, margins = TRUE)
  - (just like in qplot)
- In the future there will be more

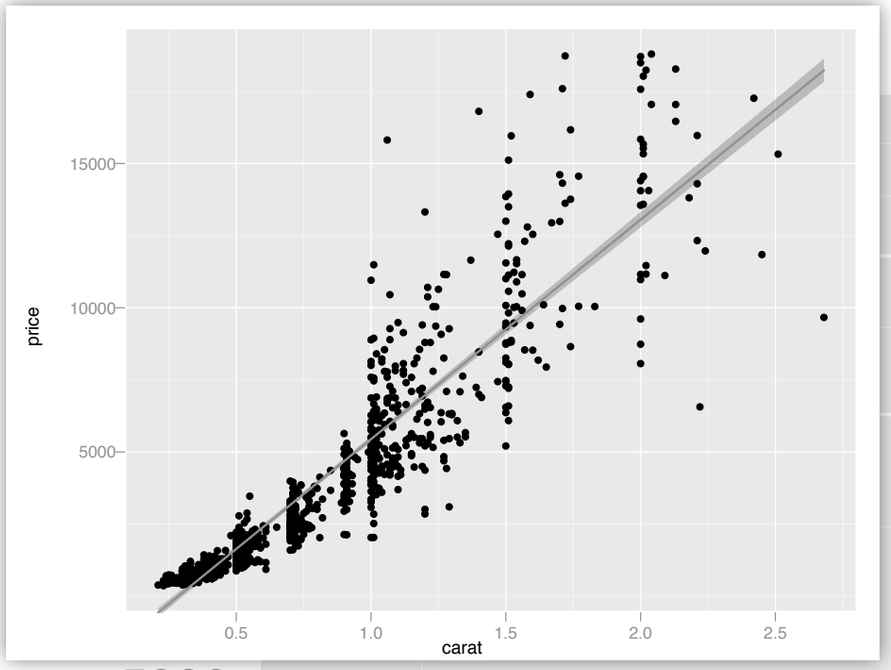
Coordinate systems

- Control how the two positions aesthetics work together (default: Cartesian)
- Others of note:
  - coord_flip()
  - coord_map()
  - coord_polar()
- Occur after statistics and affect the appearance of geoms


price
15000
10000
5000
0.5
1.0
1.5
2.0
2.5
carat


4.0
3.5
3.0
log10(price)
−0.6
−0.4
−0.2
0.0
0.2
0.4
log10(carat)


price
10^4
$10^{3.5}$
10^3
$10^{-0.6}$
$10^{-0.4}$
$10^{-0.2}$
10^0
$10^{0.2}$
$10^{0.4}$
carat



5000

price

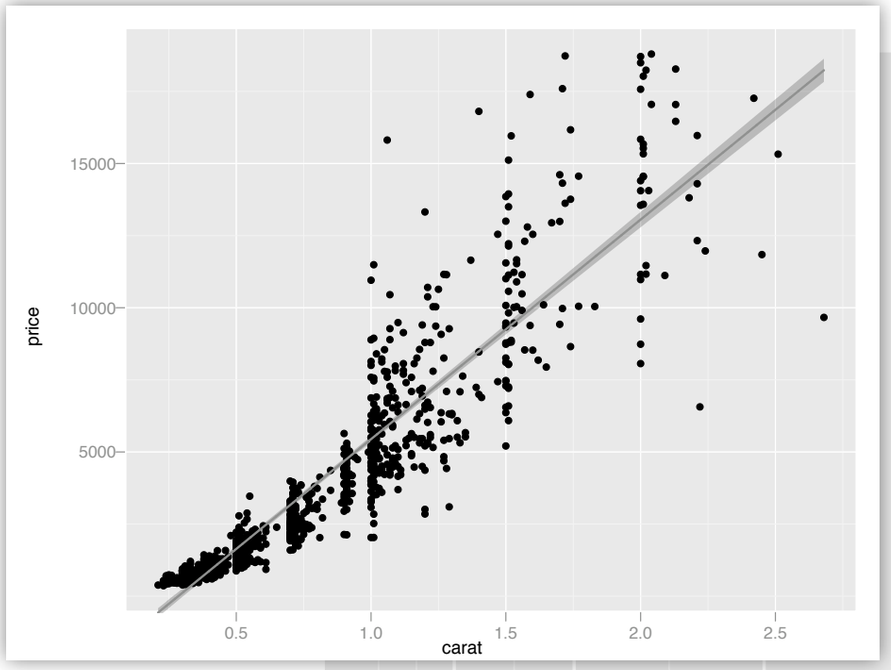
0.5

1.0

1.5

2.0

2.5



10^4
$10^{3.5}$
10^3
$10^{-0.6}$
$10^{-0.4}$
$10^{-0.2}$
10^0
$10^{0.2}$
$10^{0.4}$

Your turn

What's the difference?

```
qplot(log10(length), data=movies,
geom="histogram", binwidth=0.1)
```

```
qplot(length, data=movies,
geom="histogram", binwidth=0.1, log="x")
```

```
qplot(length, data=movies,
geom="histogram", binwidth=10) +
coord_trans(x="log10")
```