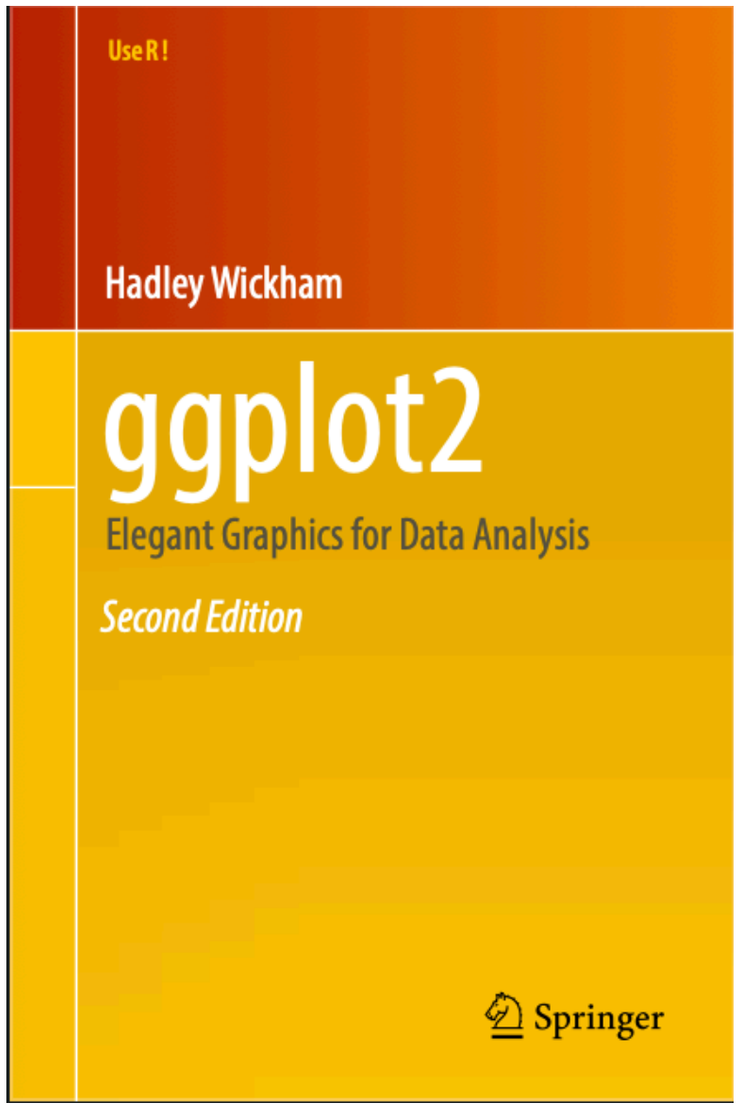
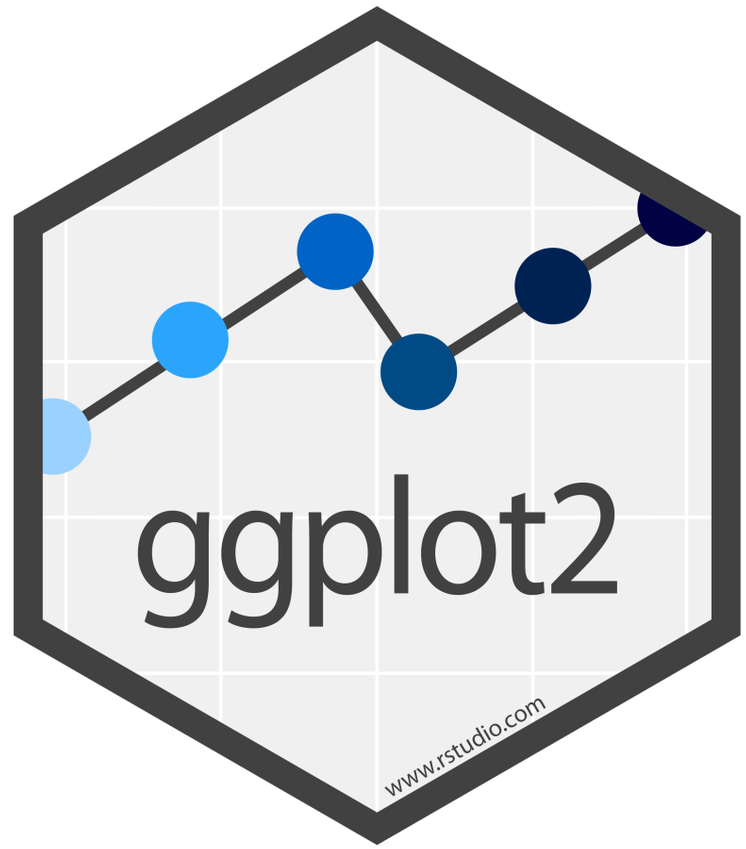
Data Visualization Basics





Outline

What is data visualization?

Outline

What is data visualization?

The Grammar of Graphics

Outline

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The Grammar of Graphics

Intro to ggplot2

Outline

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Intro to ggplot2

Aesthetics

Outline

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Scales

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Scales

Geoms

Data Visualization

> “The most important maxim for data analysis to heed, and one which many statisticians seem to have shunned, is this: “Far better an approximate answer to the right question, which is often vague, than an exact answer to the wrong question, which can always be made precise.”

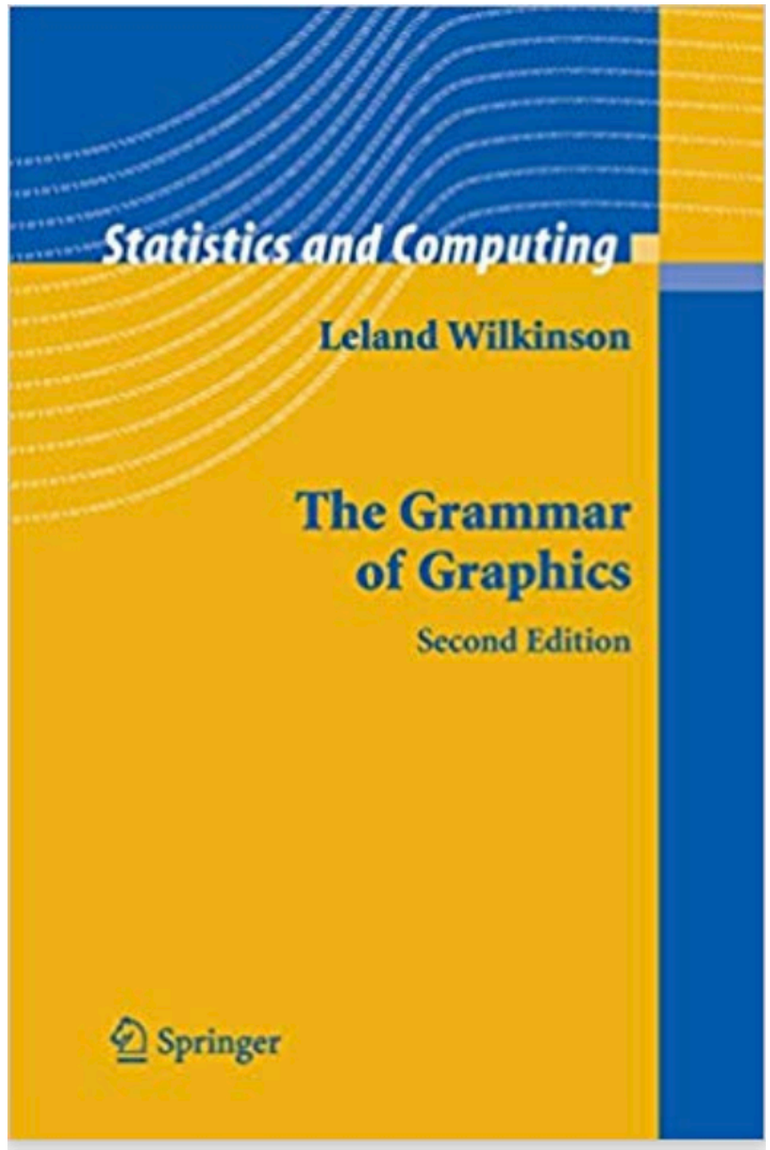
John Tukey

The Future of Data Analysis,
The Annals of Mathematical Statistics, 1-67.

Data Visualization

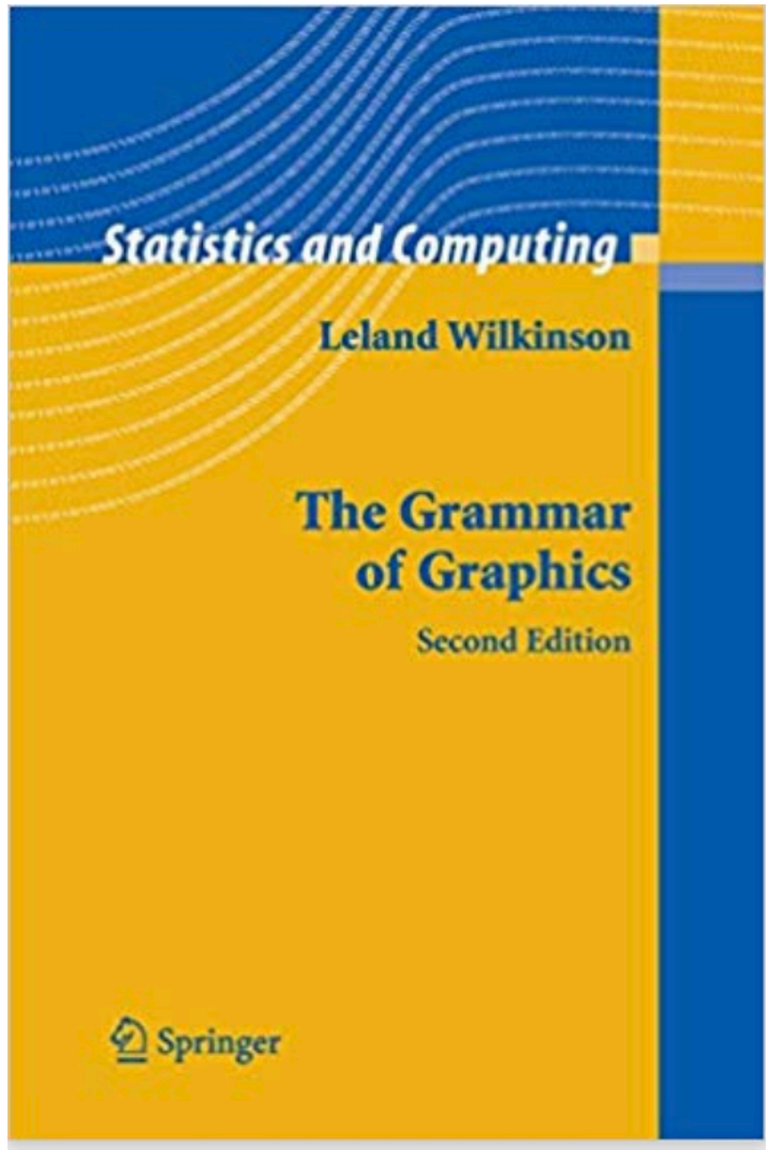
> “Modern data graphics can do much more than simply substitute for small statistical tables.
>
> At their best, graphics are **instruments for reasoning** about quantitative information.
>
> Often the most effective way to describe, explore, and summarize a set of numbers–even a very large set–is to look at pictures of those numbers.
>
> Edward Tufte
> *The Visual Display of Quantitative Information*, 2001.
>
> Emphasis added.

The Grammar of Graphics



The Grammar of Graphics

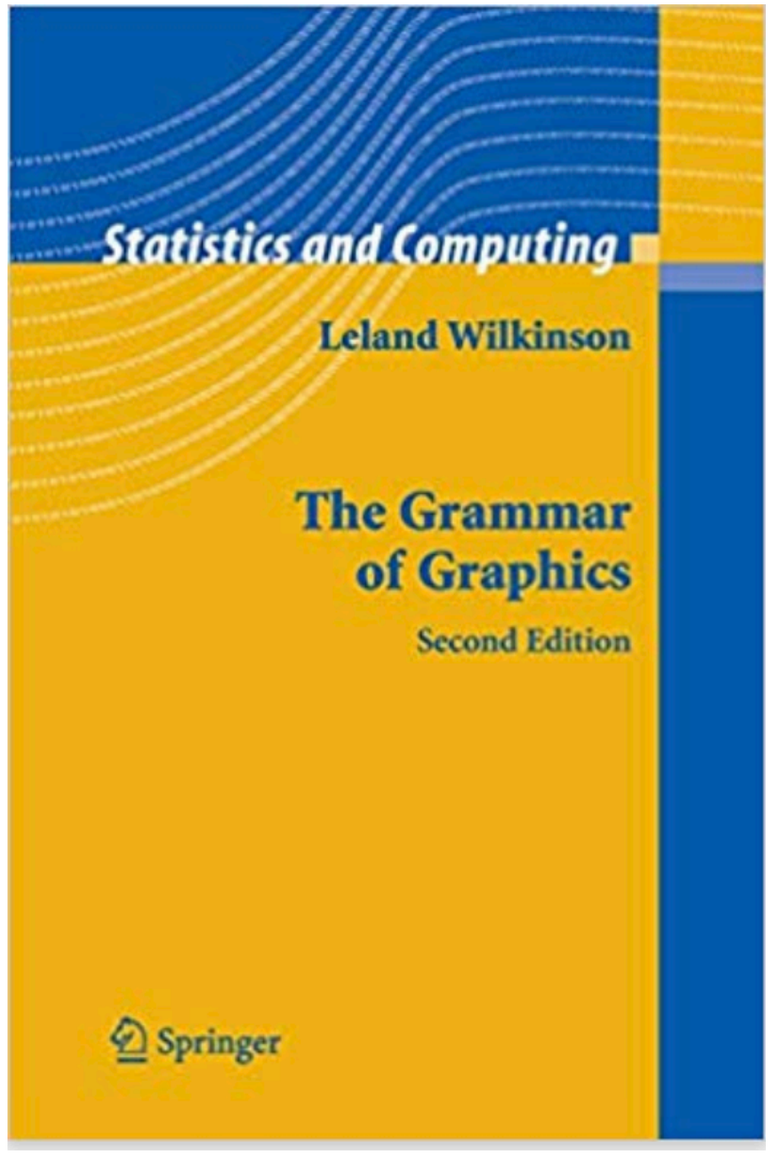
The grammar of graphics is a conceptual framework for statistical graphics



The Grammar of Graphics

The grammar of graphics is a conceptual framework for statistical graphics

Originally by Wilkinson (2005)

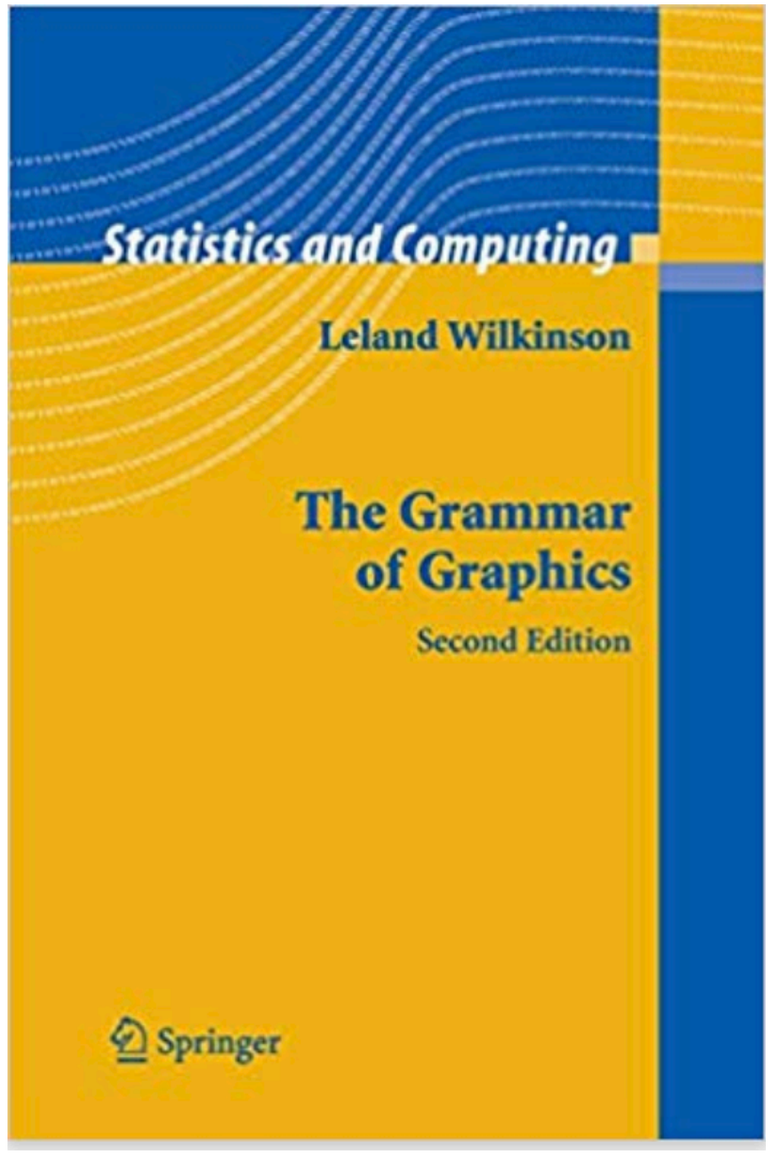


The Grammar of Graphics

The grammar of graphics is a conceptual framework for statistical graphics

Originally by Wilkinson (2005)

Wickham (2009) expanded it and implemented it in the ggplot2 R package



The Grammar of Graphics

> The grammar of graphics is an answer to the question: what is a statistical graphic? … In brief, 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).

Wickham, ggplot2, p.5

The Grammar of Graphics

Every plot needs

The Grammar of Graphics

Every plot needs

1. Data (with aesthetics)

The Grammar of Graphics

Every plot needs

1. Data (with aesthetics)
2. Layers composed of

The Grammar of Graphics

Every plot needs

1. Data (with aesthetics)
2. Layers composed of
    2.1 Geometric objects (geoms)

The Grammar of Graphics

Every plot needs

1. Data (with aesthetics)
2. Layers composed of
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    2.2 Statistical transformations

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3. Scales

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5. A facet specification (possibly none)

The Grammar of Graphics

Every plot needs

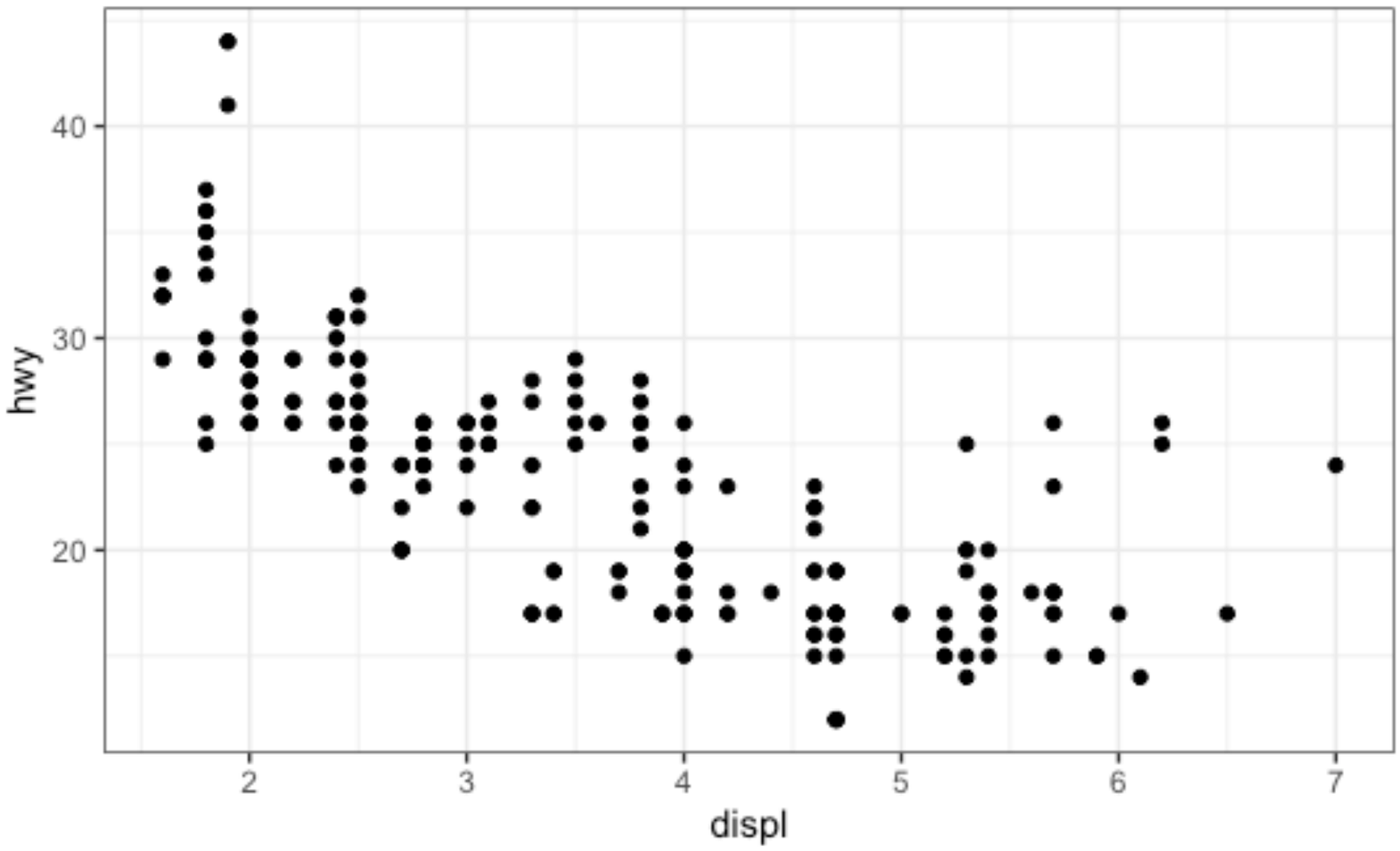
1. Data (with aesthetics)
2. Layers composed of
    2.1 Geometric objects (geoms)
    2.2 Statistical transformations
3. Scales
4. A coordinate system
5. A facet specification (possibly none)
6. A theme

The ggplot2 package

Code:

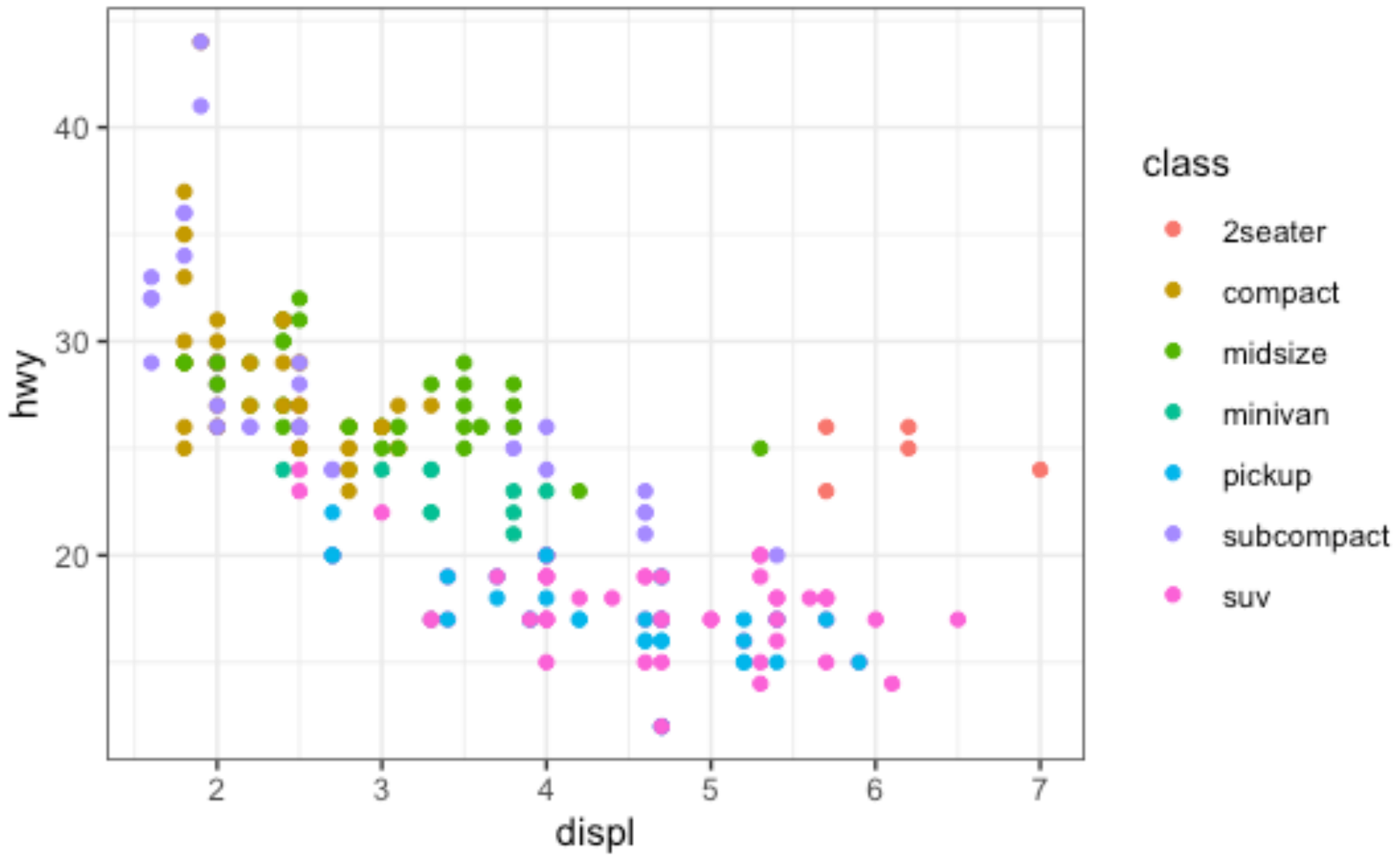
```
ggplot(data = mpg, mapping = aes(x = displ,
y = hwy)) + geom_point()
```

Output:



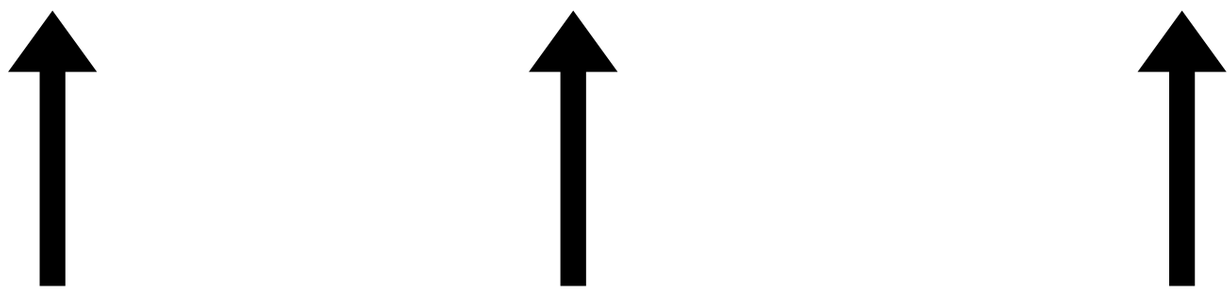
The ggplot2 package

```
ggplot(data = mpg, mapping = aes(x = displ,
y = hwy, color = class)) + geom_point()
```



The ggplot2 package

```
mapping = aes(x = displ, y = hwy, color = class))
```



x, y, and color are all **aesthetics**

Other aesthetics include shape and size

The Diamonds Dataset

Your Turn!

The ggplot2 package has a dataset called *diamonds*

Look at the variables in the dataset and determine the type of data you are working with (categorical, quantitative, etc.)

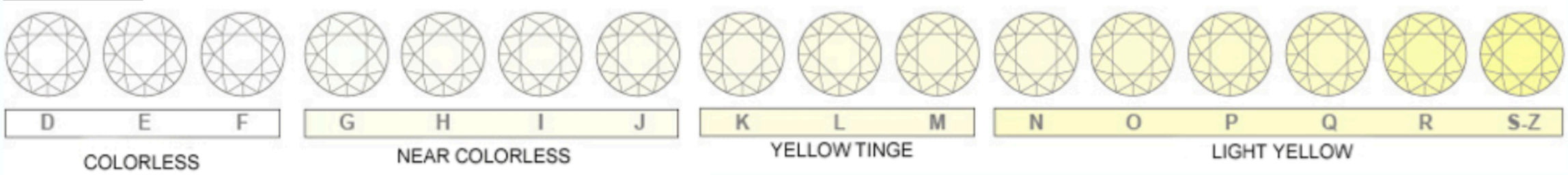
Choose one categorical and one quantitative variable to plot! (think about what plots are appropriate for the types of data)

Follow my general template in the previous slides to make the plots (changing names and the geom type)

Diamonds

Cut Ideal > Premium > Very Good > Good > Fair

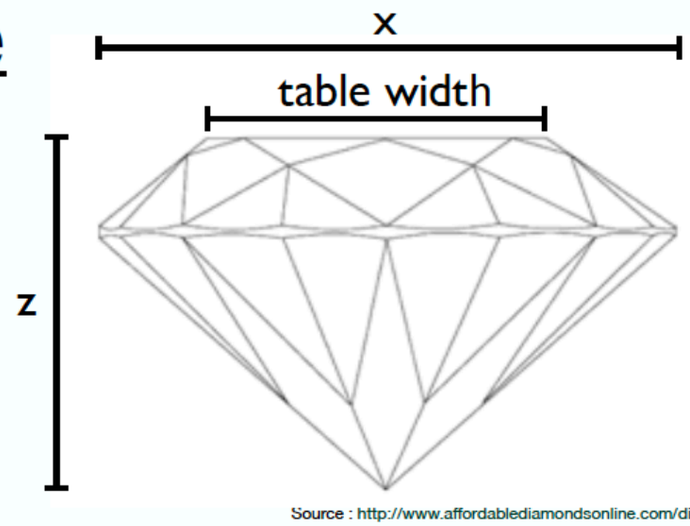
Color



Clarity

Clarity	Flawless	Internally Flawless	Very Very Slightly Included		Very Slightly Included		Slightly Included		Included		
Grade	**FL**	**IF**	**VVS1**	**VVS2**	**VS1**	**VS2**	**SI1**	**SI2**	**I1**	**I2**	**I3**

Everything else



also

y
carat
price
depth = z / diameter
table = table width / x

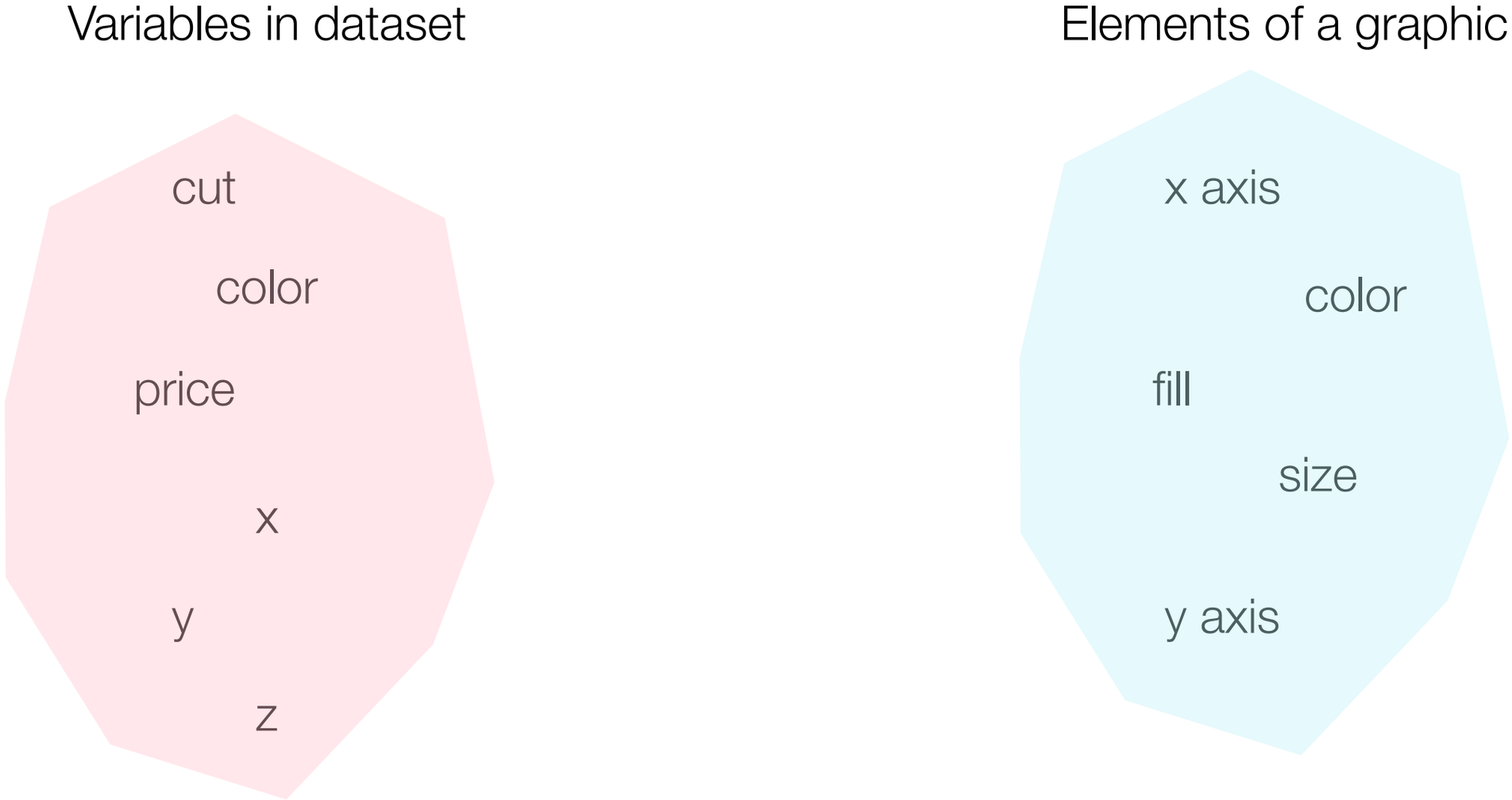
Source : http://www.affordablediamondsonline.com/diamondshapes.jpg, http://beaufortsjeweler.com/images/diamond_color_chart.gif, http://www.am-diamonds.com/images/anatomy_diamond.gif

Credit: David J Kahle

Aesthetics

Aesthetics

Aesthetics are a mapping from the variables to a part of the graph



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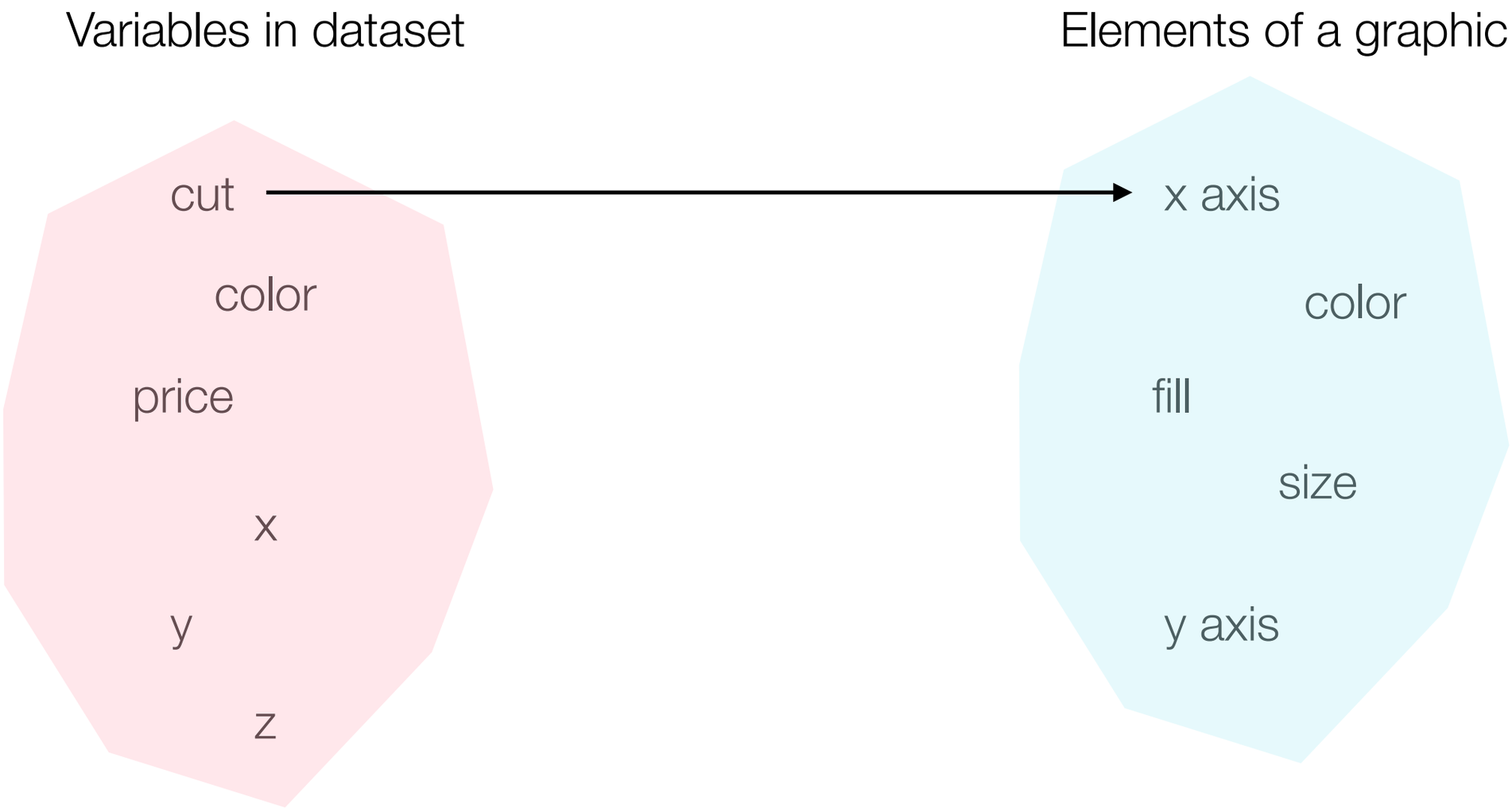

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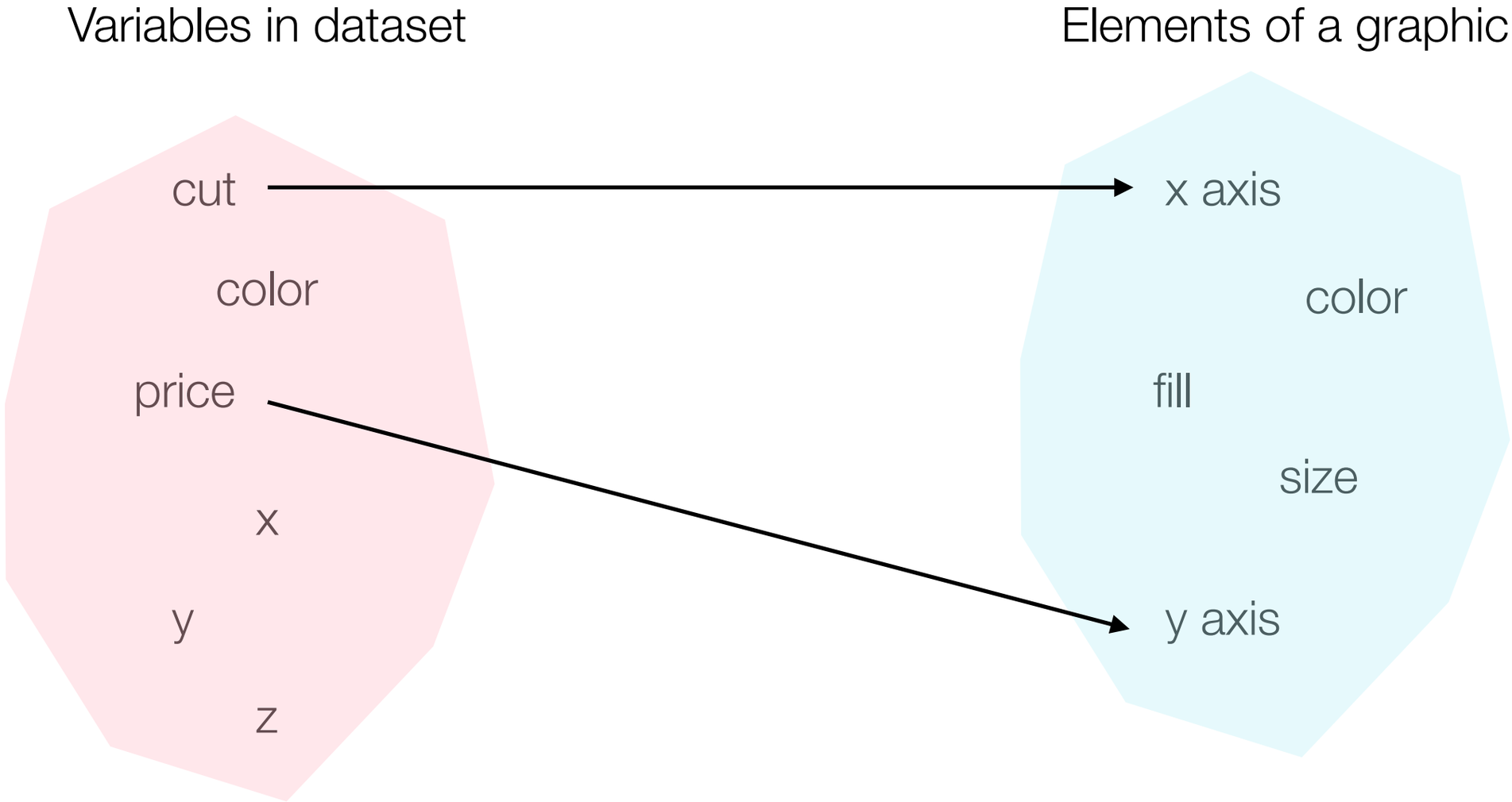

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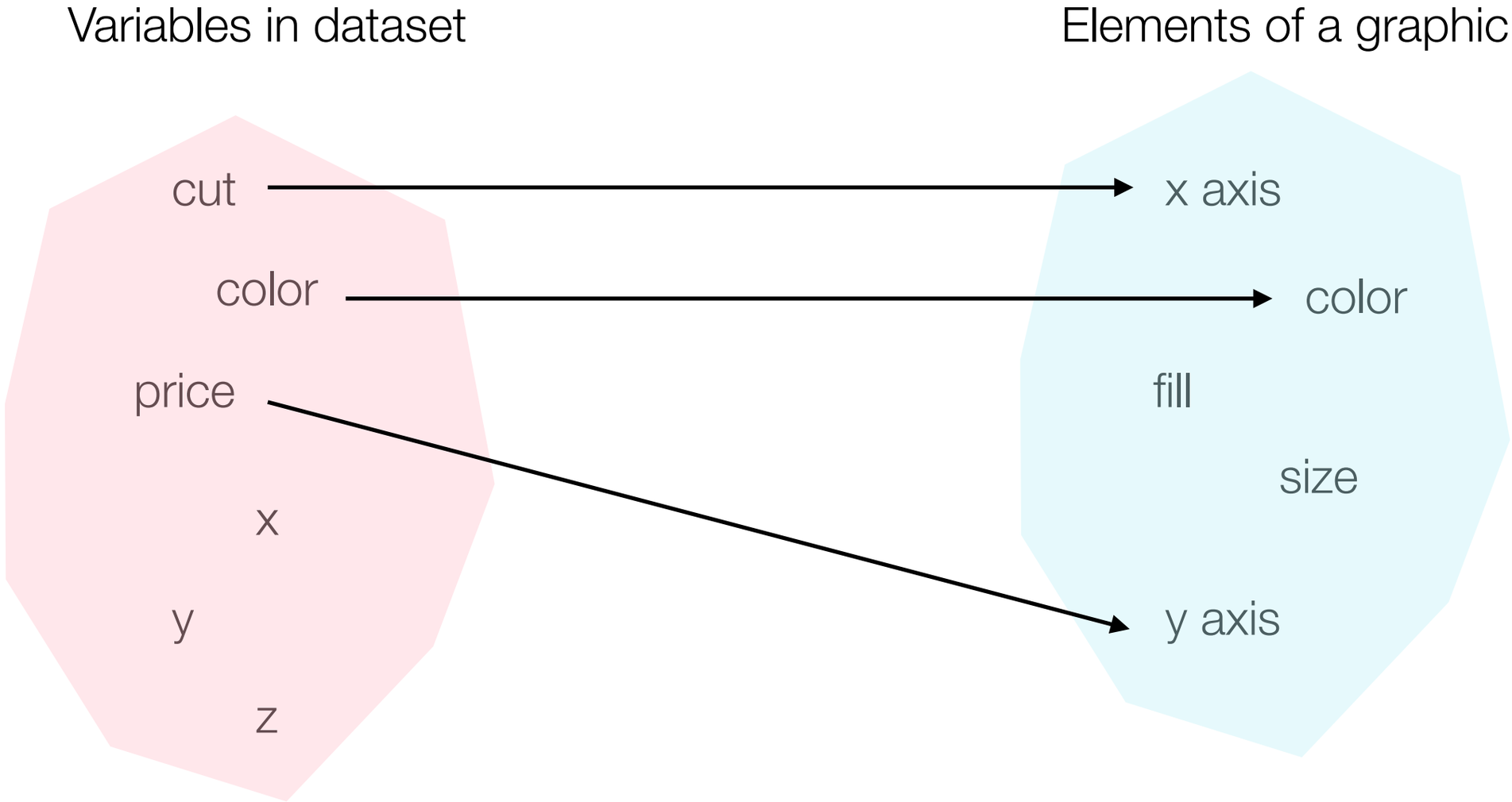

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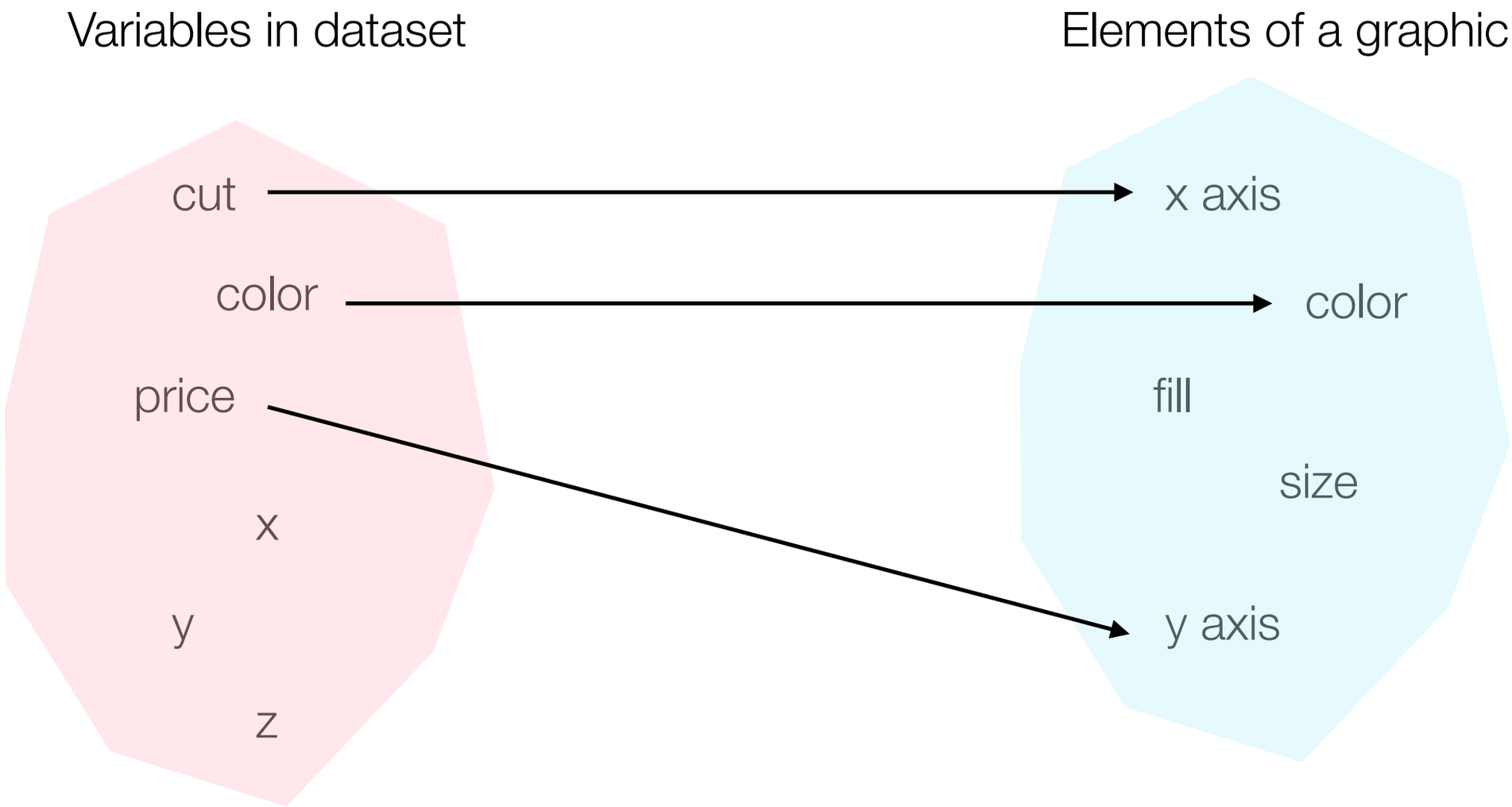
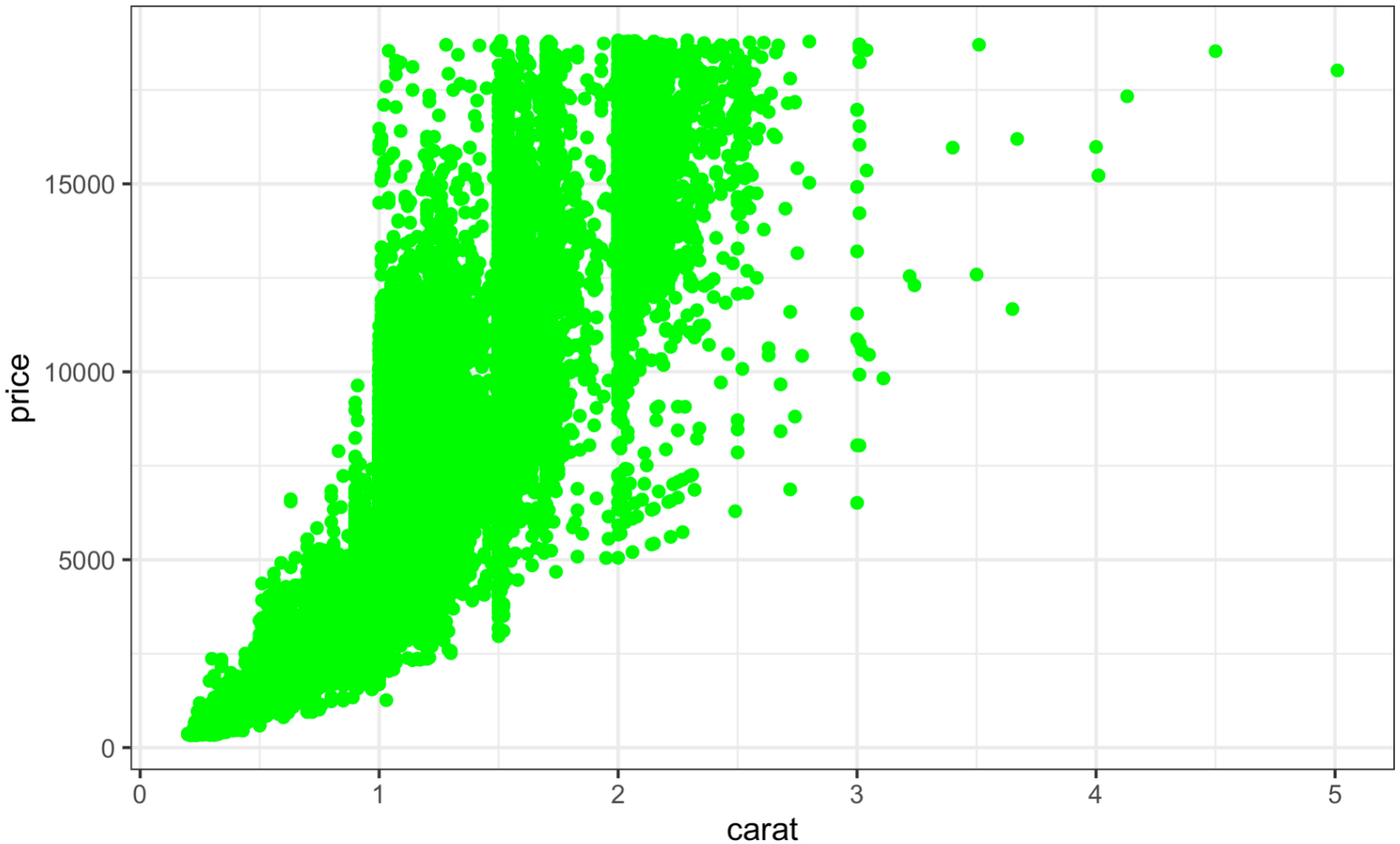


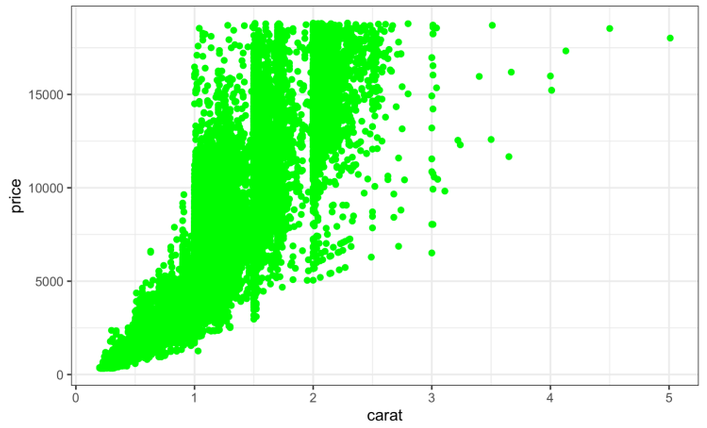
There are a lot of aesthetics (like 40!) so you can make very complex graphics! But don't abuse the power!!

Set vs. Map

How would I make the following plot?



Set vs. Map

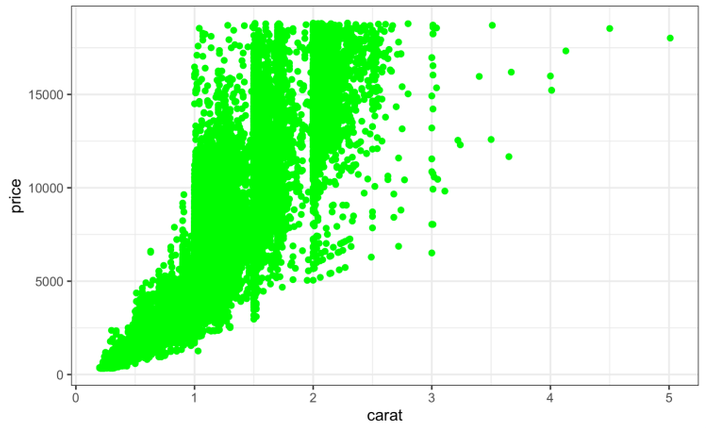


How would I make the following plot?

```
ggplot(data = diamonds, aes(carat, price, color = "green"))
 + geom_point()
```

```
ggplot(data = diamonds, aes(carat, price)) +
 geom_point(color = "green")
```

Set vs. Map



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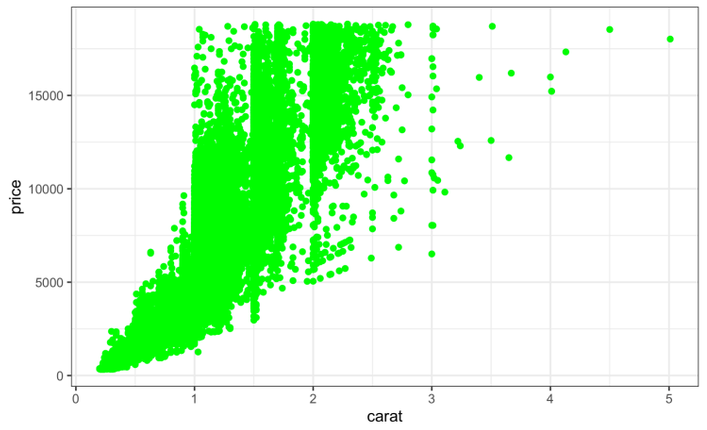

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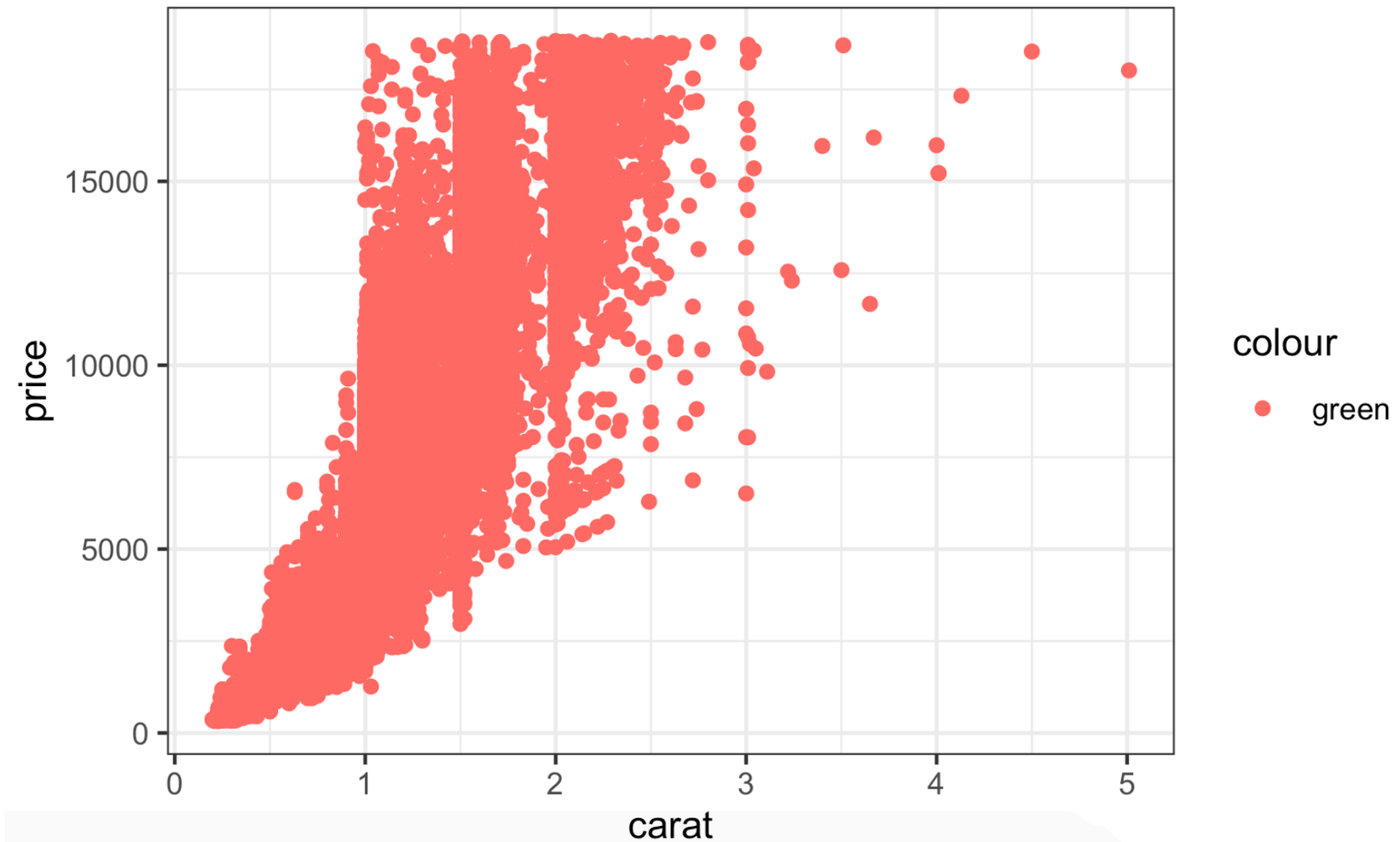
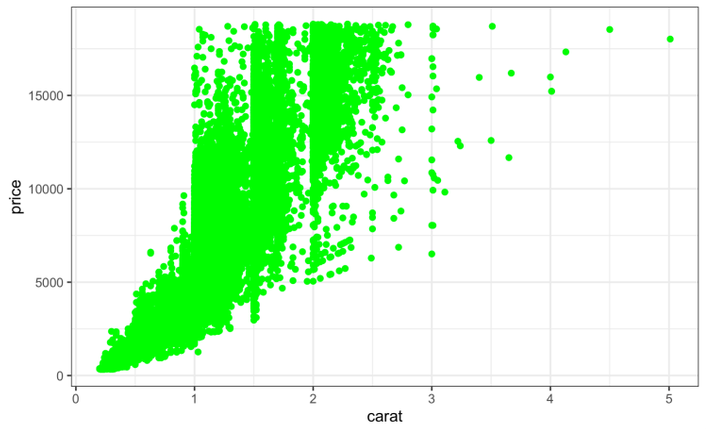


Set vs. Map



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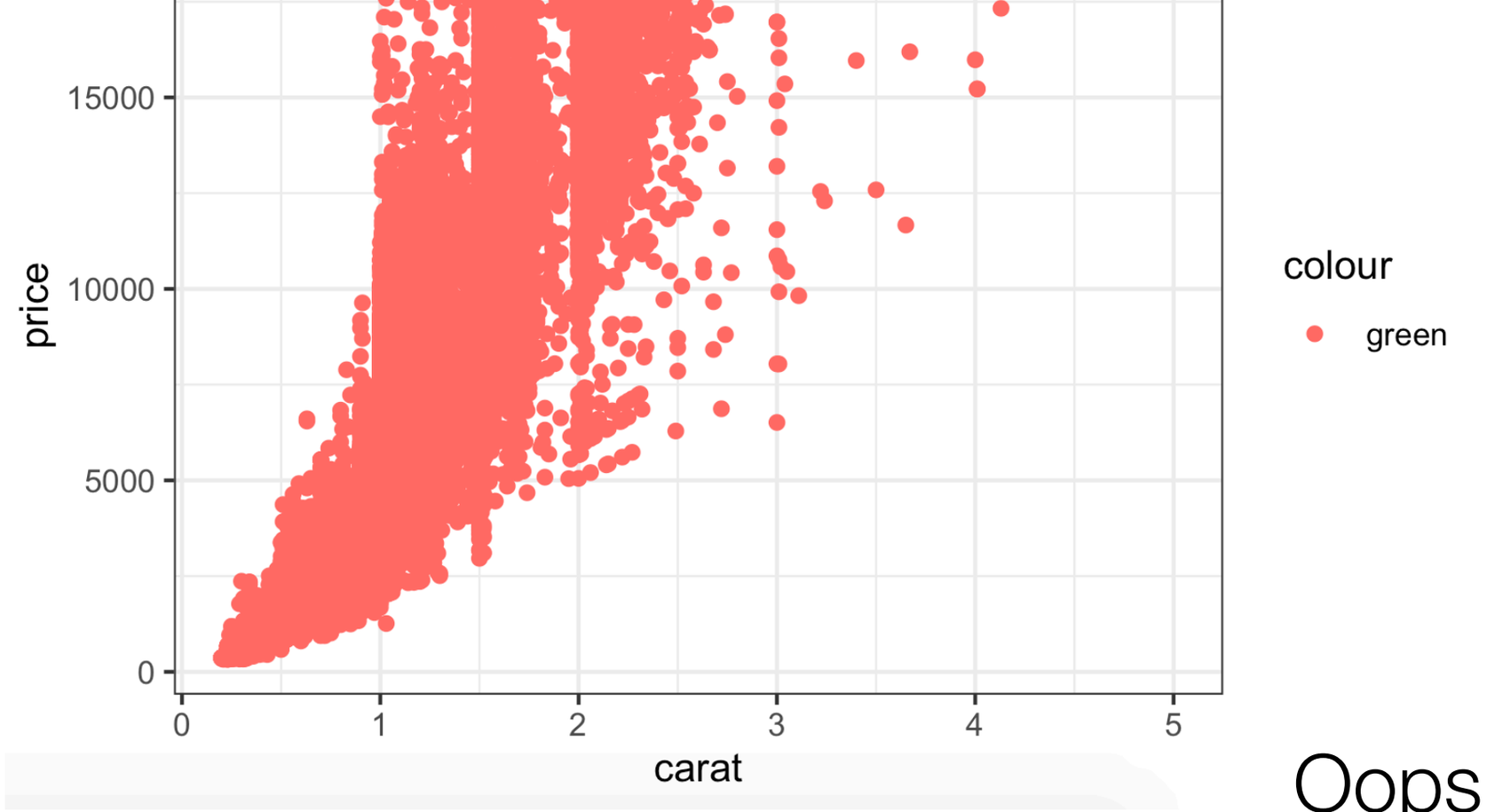
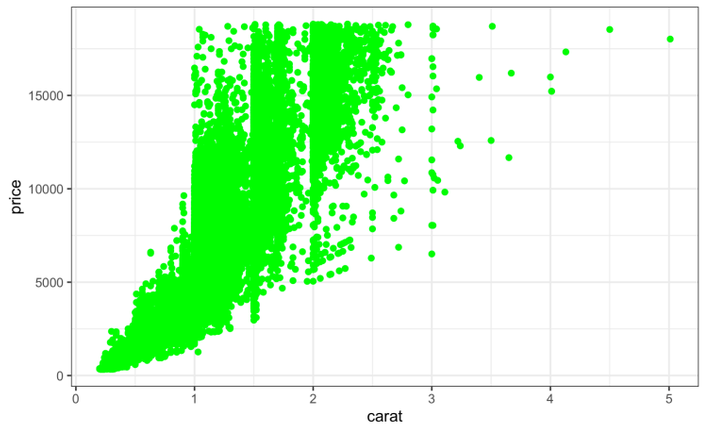


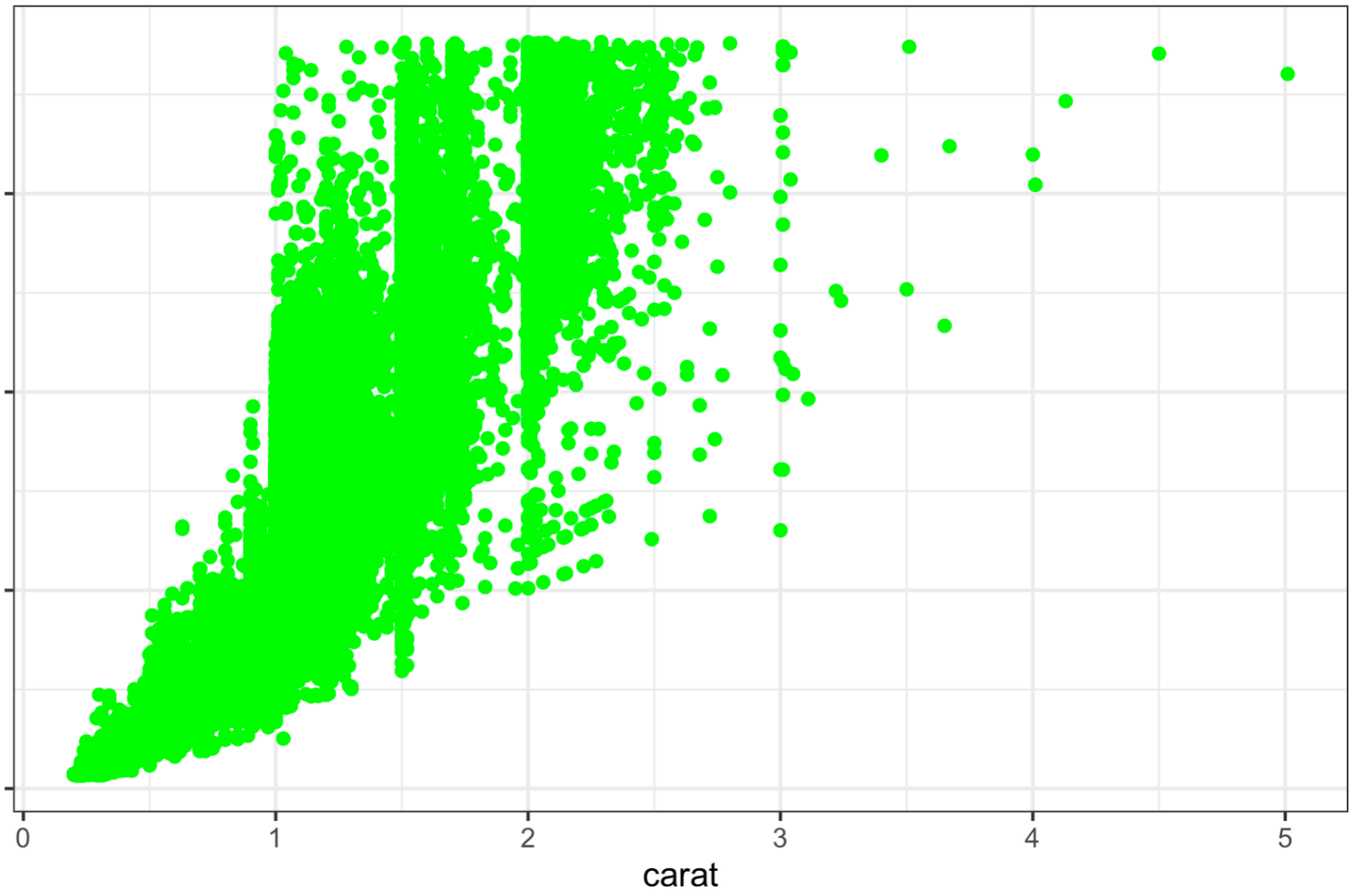
Oops!!!

Set vs. Map



How would I make the following plot?

```
ggplot(data = diamonds, aes(carat, price)) +
 geom_point(color = "green")
```

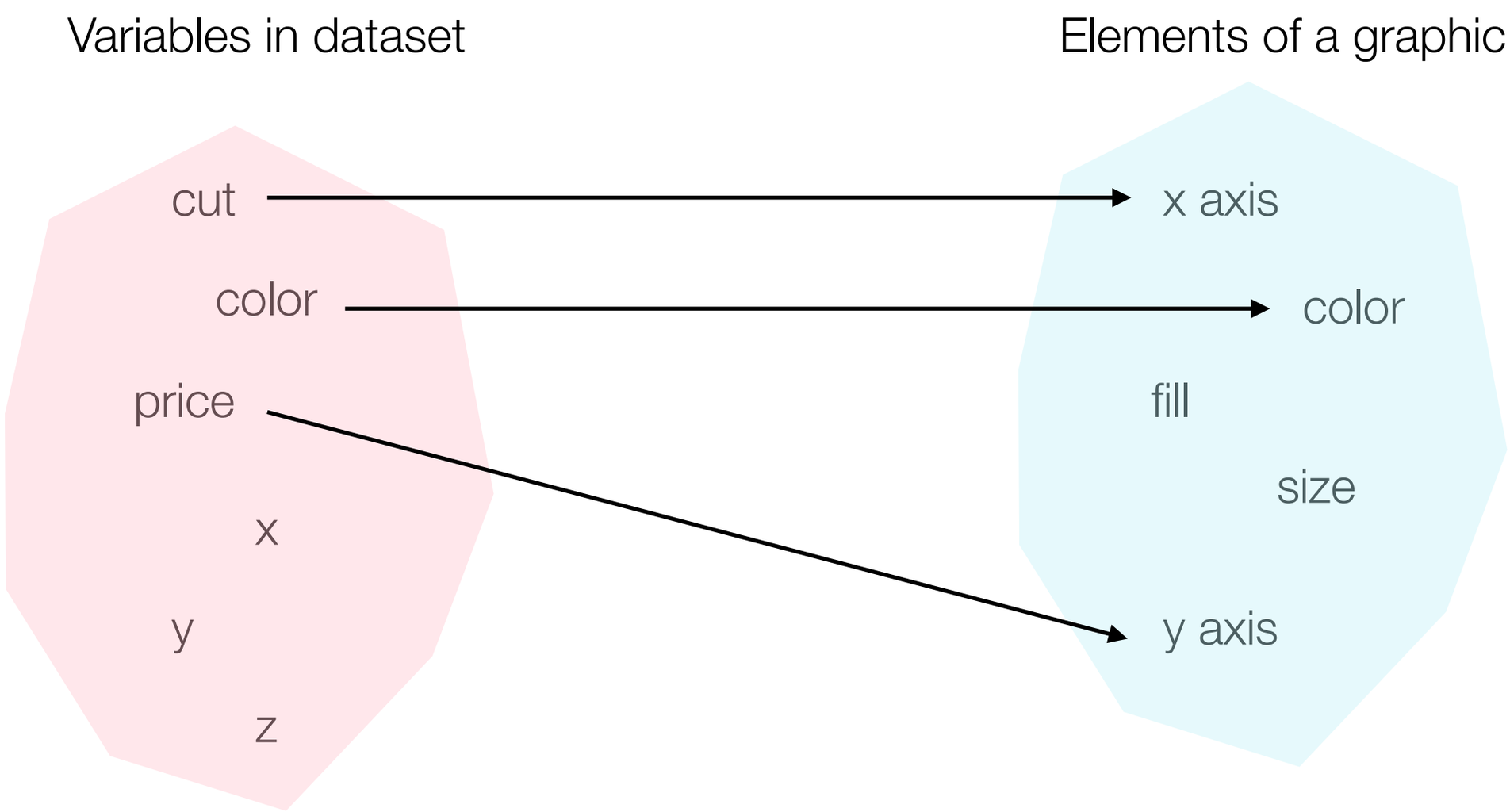


Scales

Scales

Scales are functions from the data space to the range of visual properties

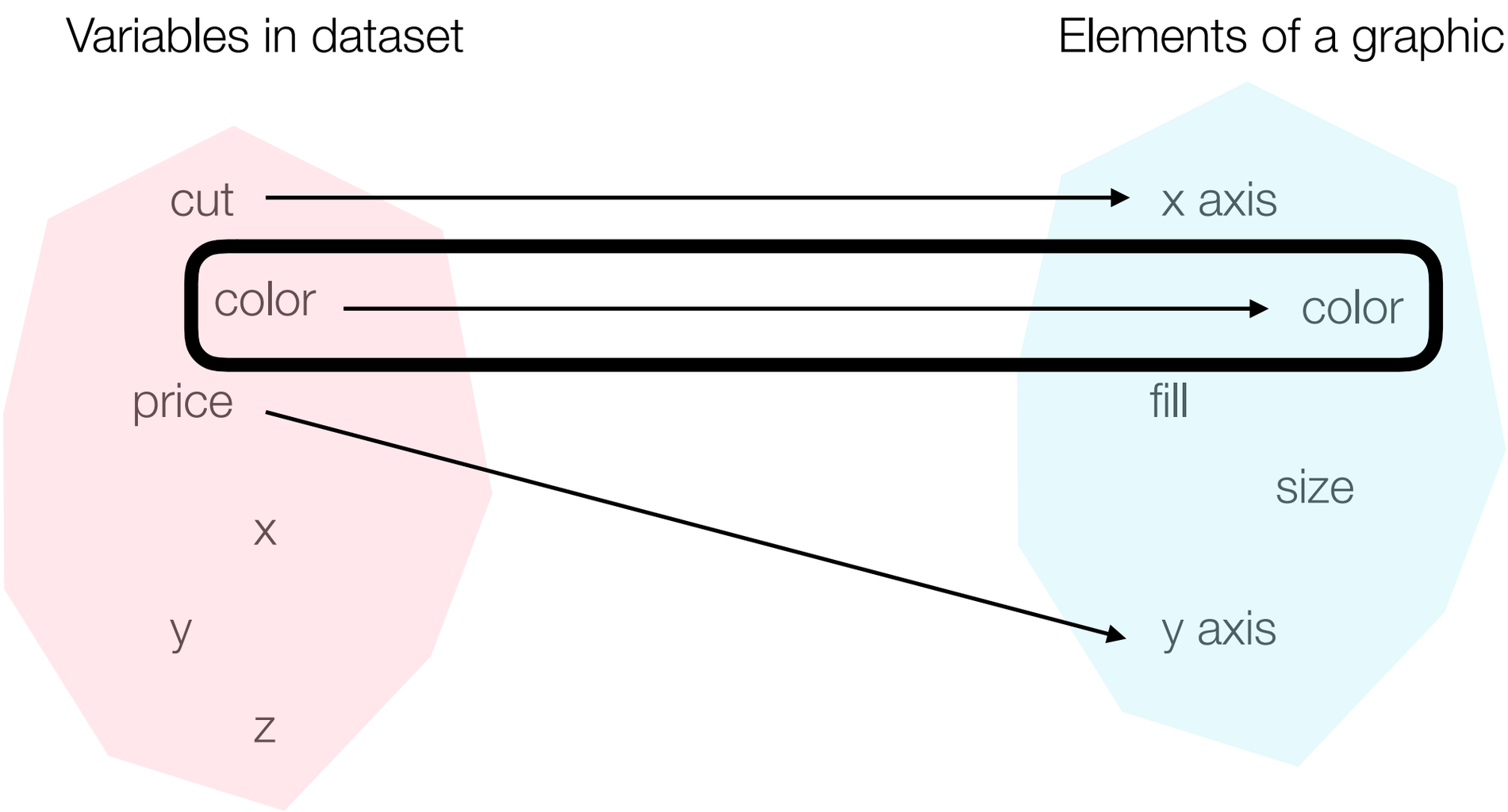
A scale is a function that maps levels of a variable to aesthetic values



Scales

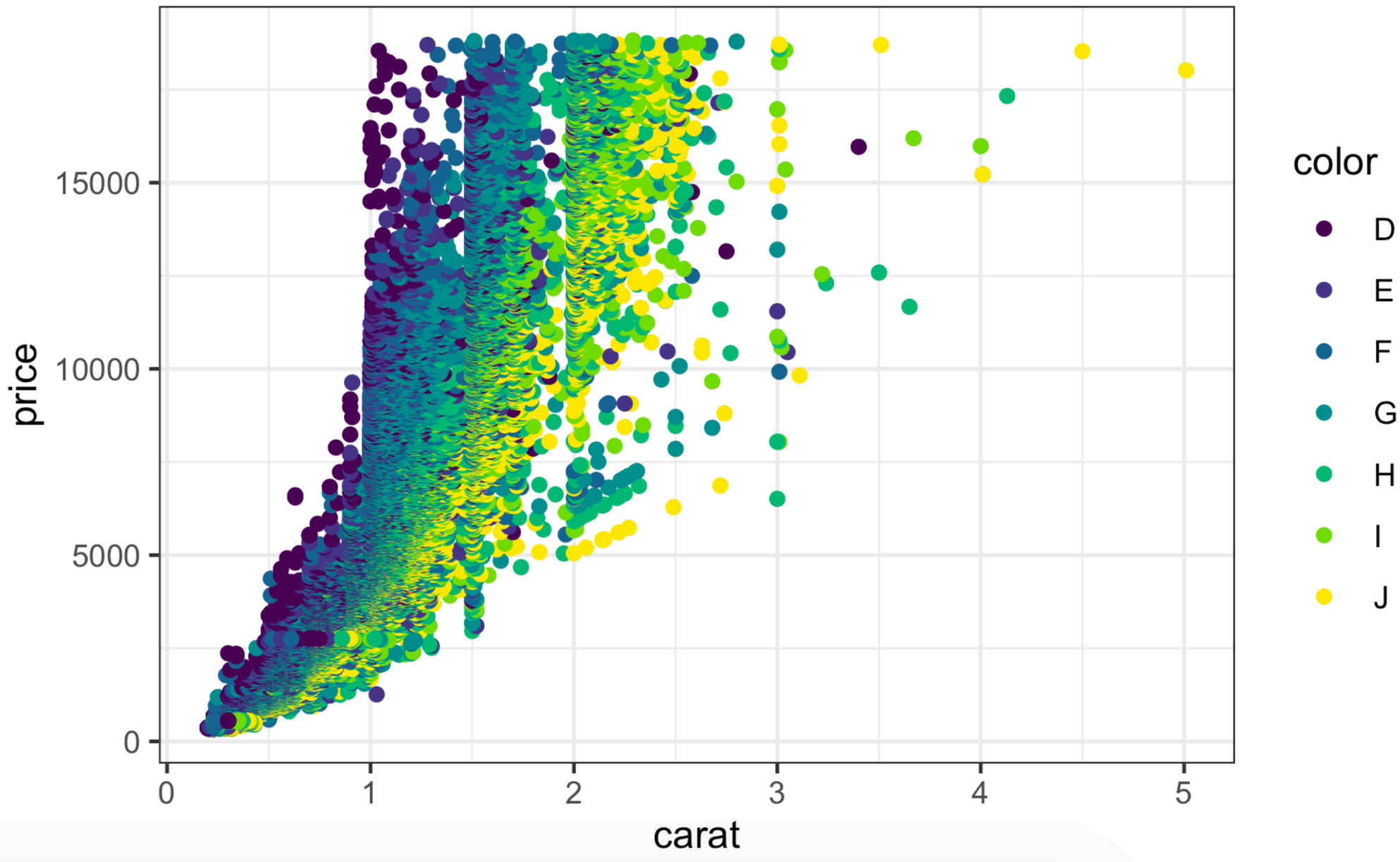
Scales are functions from the data space to the range of visual properties

A scale is a function that maps levels of a variable to aesthetic values



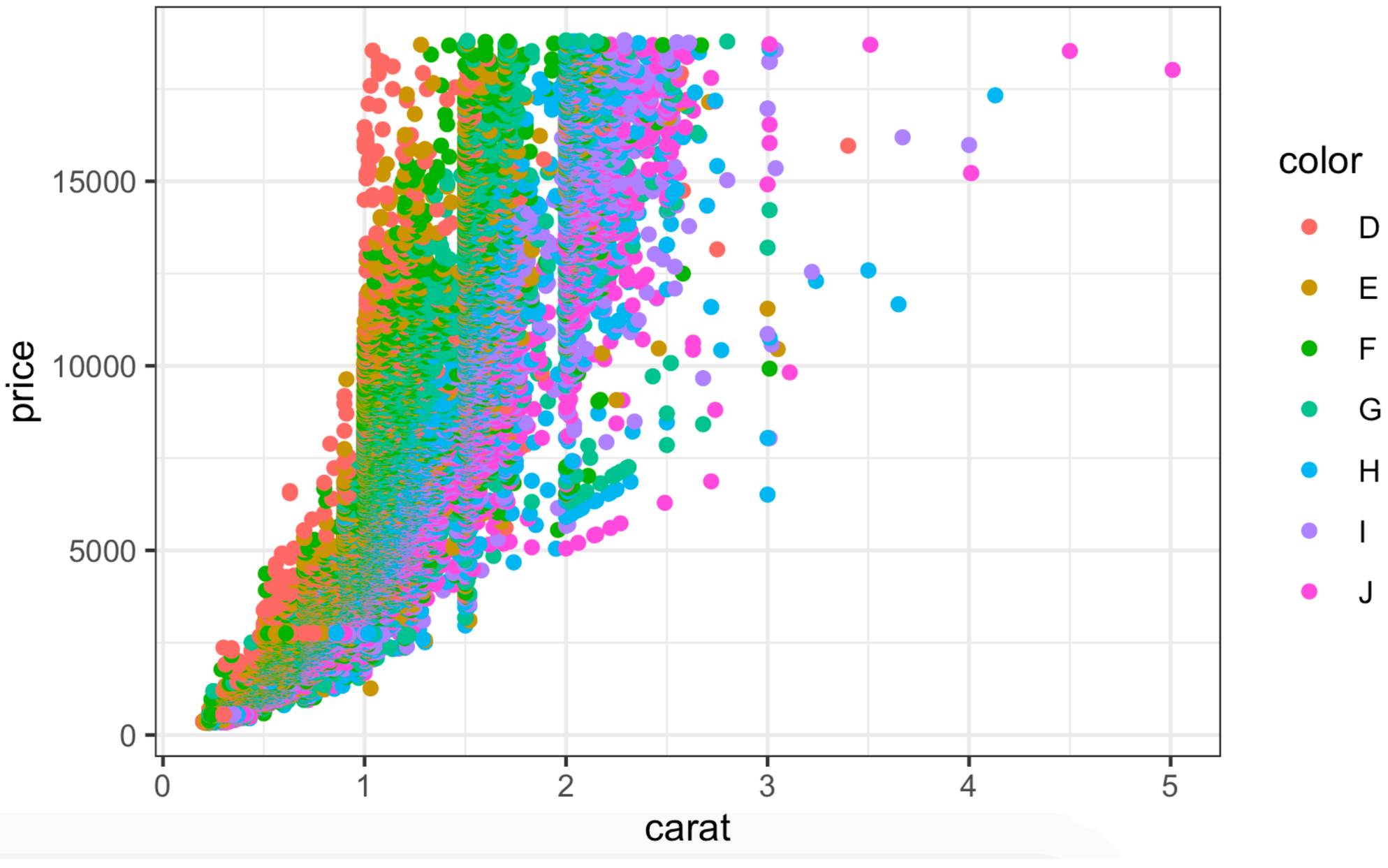
Scales

```
ggplot(data = diamonds, aes(carat, price, color = color)) +
 geom_point()
```

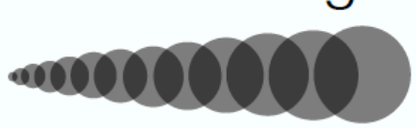
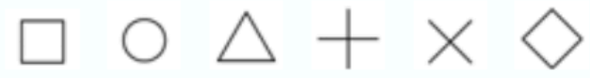
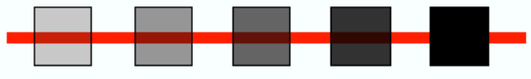


Scales

```
ggplot(data = diamonds, aes(carat, price, color = color)) +
geom_point() + scale_color_hue()
```



Scales

Aesthetic effect by variable type	Discrete	Continuous
Color	Rainbow of colors 	Color gradient 
Size Bubble Charts	Discrete size steps 	Continuous size gradient 
Shape	Different shape for points 	
Alpha	Discrete transparency steps 	Continuous transparency gradient 

Credit: David J Kahle

Geoms

Geoms

A Geom is shorthand for geometric object

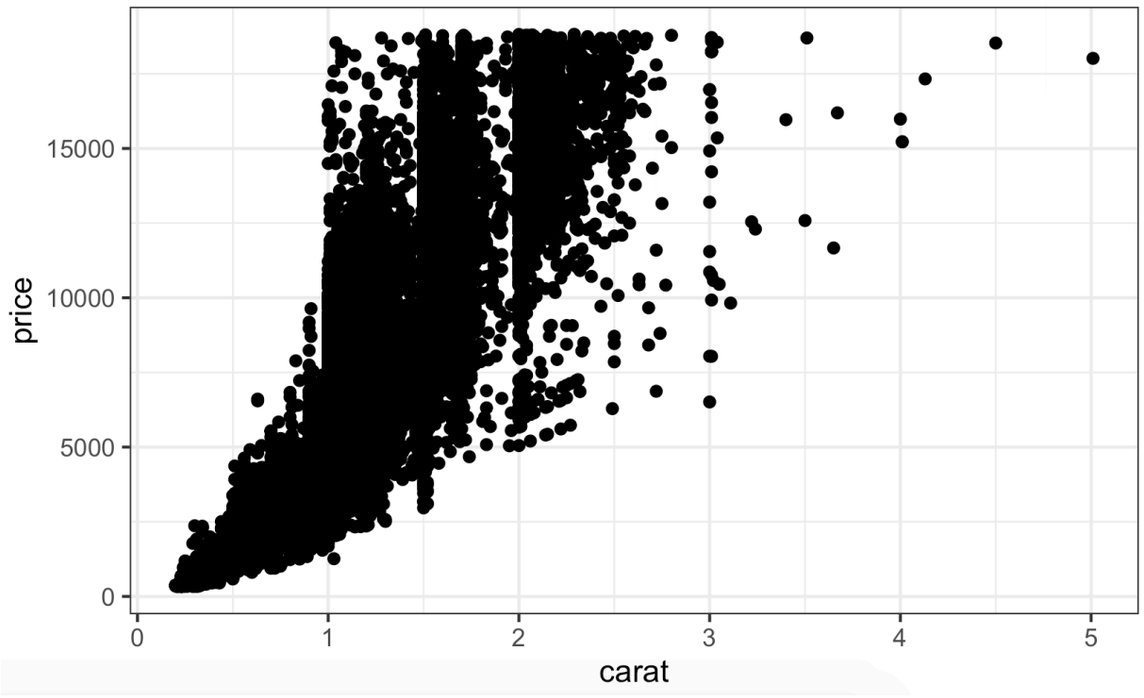
Geoms are made up of basic graphical elements

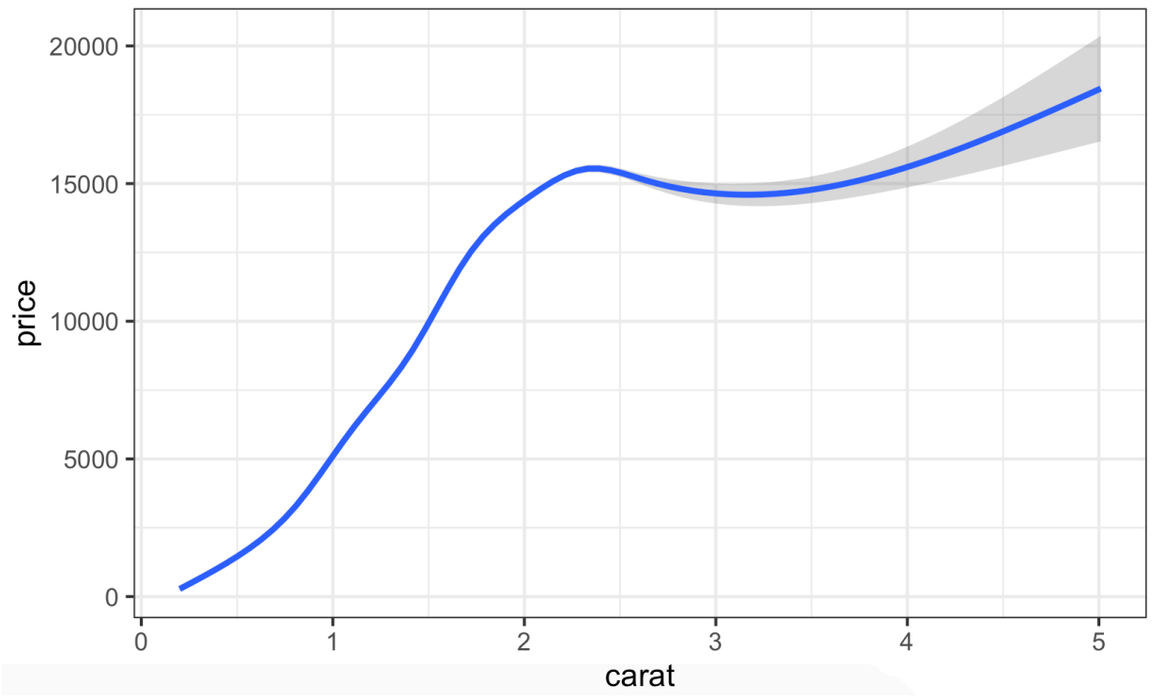
There are a lot of geoms as well!!!

For details on geoms, scales, aesthetics, etc. go to the ggplot2 reference guide

Geoms

What is the difference between these two plots?





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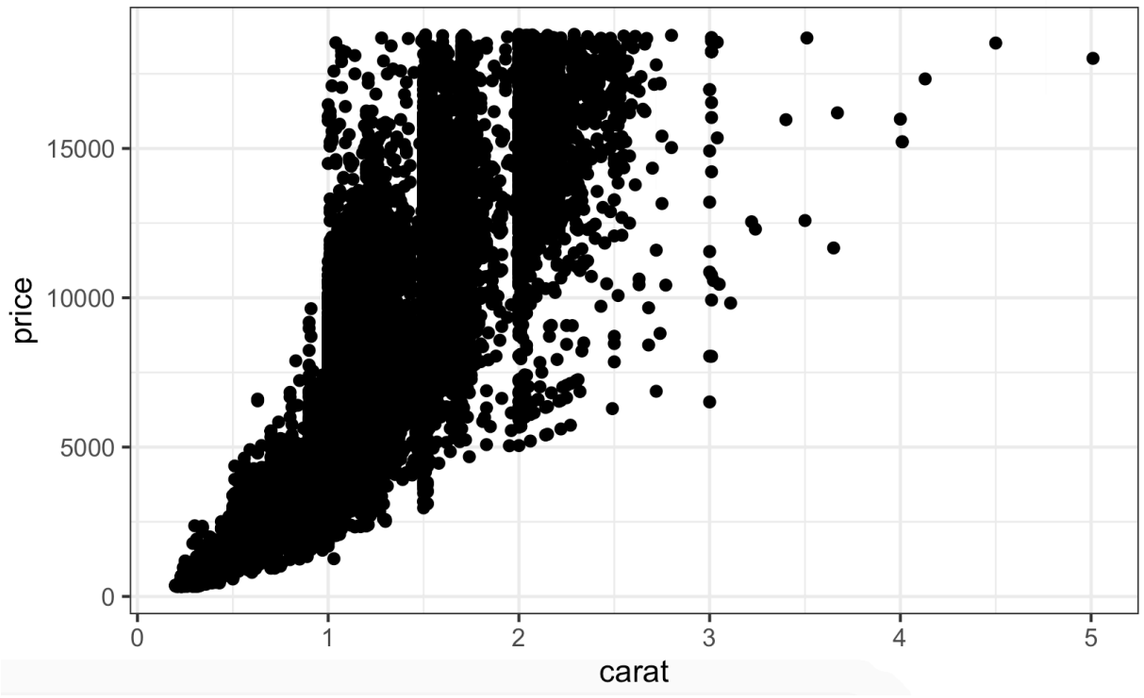

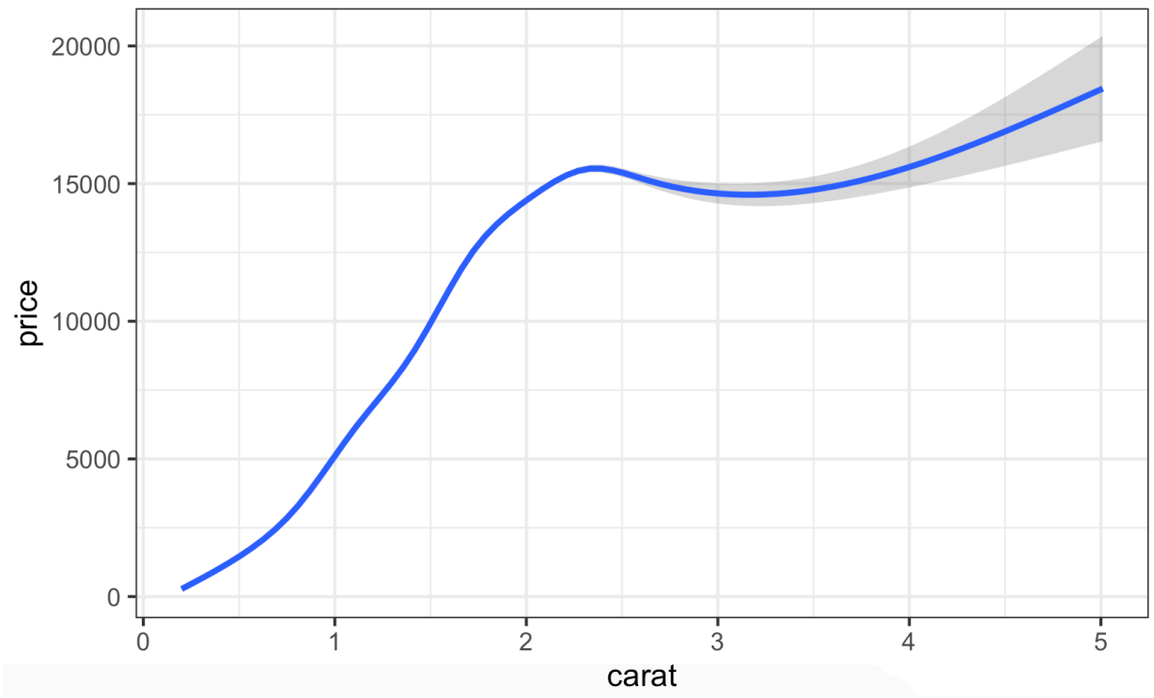

They both have the same axes and the same data!

Geoms

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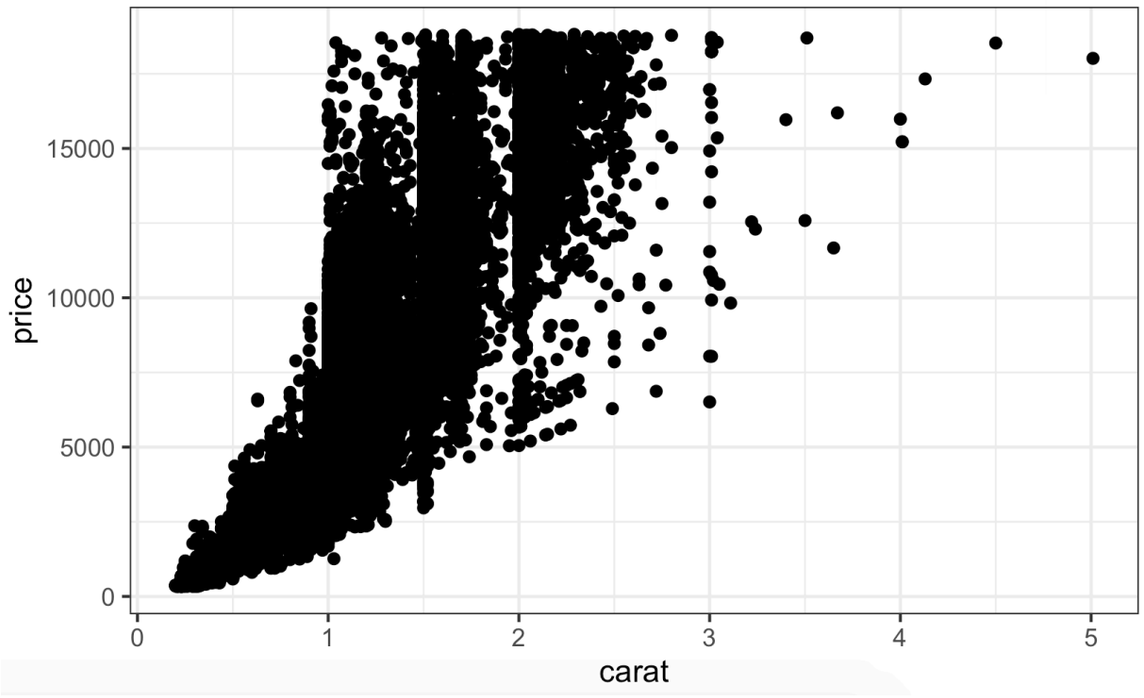

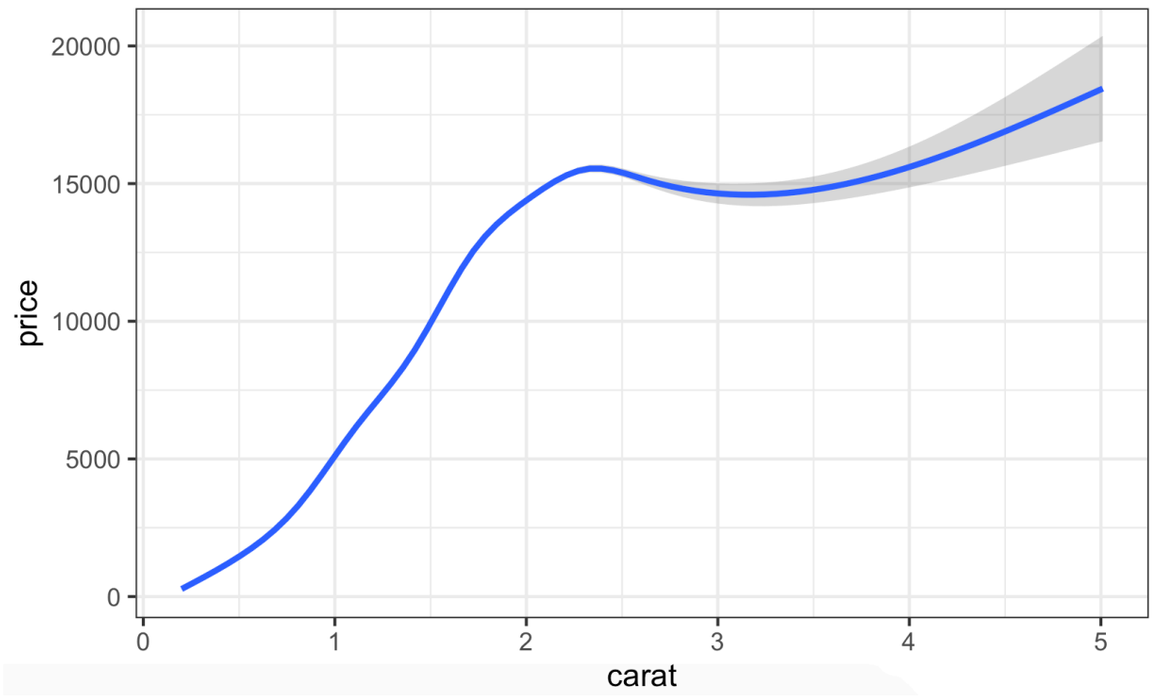

They both have the same axes and the same data!

The difference is the geometric object that represents the data!

Your Turn!

With those around you, discuss how you would make the following plots: