Data Visualization in ggplot

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August 10, 2023

https://r-graph-gallery.com/137-spring-shapes-data-art.html

What do you look for in a good plot?

What do you look for in a good plot?

Using the right kind of plot for your data

Legibility (large enough fonts)

Labeled axes (+ legends, when appropriate)

Axis scales that make sense

Colors that help the interpretation

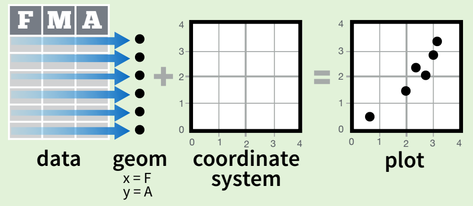
ggplot

Data Visualization
with ggplot2
Cheat Sheet

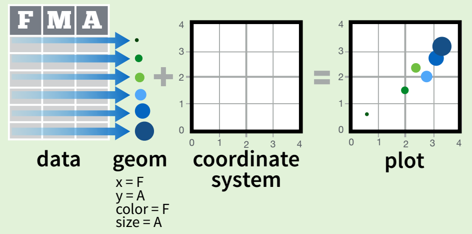
RStudio

Basics

ggplot2 is based on the **grammar of graphics**, the idea that you can build every graph from the same few components: a **data** set, a set of **geoms**—visual marks that represent data points, and a **coordinate system.**



To display data values, map variables in the data set to aesthetic properties of the geom like **size**, **color**, and **x** and **y** locations.



Build a graph with **qplot()** or **ggplot()**

aesthetic mappings · data · geom

qplot(x = cty, y = hwy, color = cyl, data = mpg, geom = "point"**)**

Creates a complete plot with given data, geom, and mappings. Supplies many useful defaults.

ggplot(data = mpg, **aes(**x = cty, y = hwy**))**

Begins a plot that you finish by adding layers to. No defaults, but provides more control than qplot().

data

```
ggplot(mpg, aes(hwy, cty)) +
 geom_point(aes(color = cyl)) +
 geom_smooth(method ="lm") +
 coord_cartesian() +
 scale_color_gradient() +
 theme_bw()
```

add layers, elements with +

layer = geom + default stat + layer specific mappings

additional elements

Add a new layer to a plot with a **geom_*()** or **stat_*()** function. Each provides a geom, a set of aesthetic mappings, and a default stat and position adjustment.

last_plot()

Returns the last plot

ggsave("plot.png", width = 5, height = 5)

Saves last plot as 5' x 5' file named "plot.png" in working directory. Matches file type to file extension.

Geoms - Use a geom to represent data points, use the geom's aesthetic properties to represent variables. Each function returns a layer.

One Variable

Continuous

a <- ggplot(mpg, aes(hwy))

a + **geom_area(stat = "bin")**
x, y, alpha, color, fill, linetype, size
b + geom_area(aes(y = ..density..), stat = "bin")

a + **geom_density(**kernel = "gaussian"**)**
x, y, alpha, color, fill, linetype, size, weight
b + geom_density(aes(y = ..county..))

a + **geom_dotplot()**
x, y, alpha, color, fill

a + **geom_freqpoly()**
x, y, alpha, color, linetype, size
b + geom_freqpoly(aes(y = ..density..))

a + **geom_histogram(**binwidth = 5**)**
x, y, alpha, color, fill, linetype, size, weight
b + geom_histogram(aes(y = ..density..))

Discrete

b <- ggplot(mpg, aes(fl))

b + **geom_bar()**
x, alpha, color, fill, linetype, size, weight

Graphical Primitives

c <- ggplot(map, aes(long, lat))

c + **geom_polygon(**aes(group = group)**)**
x, y, alpha, color, fill, linetype, size

d <- ggplot(economics, aes(date, unemploy))

d + **geom_path(**lineend="butt", linejoin="round', linemitre=1**)**
x, y, alpha, color, linetype, size

d + **geom_ribbon(**aes(ymin=unemploy - 900, ymax=unemploy + 900)**)**
x, ymax, ymin, alpha, color, fill, linetype, size

e <- ggplot(seals, aes(x = long, y = lat))

e + **geom_segment(**aes(
xend = long + delta_long,
yend = lat + delta_lat)**)**
x, xend, y, yend, alpha, color, linetype, size

e + **geom_rect(**aes(xmin = long, ymin = lat,
xmax= long + delta_long,
ymax = lat + delta_lat)**)**
xmax, xmin, ymax, ymin, alpha, color, fill, linetype, size

Two Variables

Continuous X, Continuous Y

f <- ggplot(mpg, aes(cty, hwy))

f + **geom_blank()**

f + **geom_jitter()**
x, y, alpha, color, fill, shape, size

f + **geom_point()**
x, y, alpha, color, fill, shape, size

f + **geom_quantile()**
x, y, alpha, color, linetype, size, weight

f + **geom_rug(**sides = "bl"**)**
alpha, color, linetype, size

f + **geom_smooth(**model = lm**)**
x, y, alpha, color, fill, linetype, size, weight

f + **geom_text(**aes(label = cty)**)**
x, y, label, alpha, angle, color, family, fontface, hjust, lineheight, size, vjust

Discrete X, Continuous Y

g <- ggplot(mpg, aes(class, hwy))

g + **geom_bar(stat = "identity")**
x, y, alpha, color, fill, linetype, size, weight

g + **geom_boxplot()**
lower, middle, upper, x, ymax, ymin, alpha, color, fill, linetype, shape, size, weight

g + **geom_dotplot(**binaxis = "y", stackdir = "center"**)**
x, y, alpha, color, fill

g + **geom_violin(**scale = "area"**)**
x, y, alpha, color, fill, linetype, size, weight

Discrete X, Discrete Y

h <- ggplot(diamonds, aes(cut, color))

h + **geom_jitter()**
x, y, alpha, color, fill, shape, size

Continuous Bivariate Distribution

i <- ggplot(movies, aes(year, rating))

i + **geom_bin2d(**binwidth = c(5, 0.5)**)**
xmax, xmin, ymax, ymin, alpha, color, fill, linetype, size, weight

i + **geom_density2d()**
x, y, alpha, colour, linetype, size

i + **geom_hex()**
x, y, alpha, colour, fill size

Continuous Function

j <- ggplot(economics, aes(date, unemploy))

j + **geom_area()**
x, y, alpha, color, fill, linetype, size

j + **geom_line()**
x, y, alpha, color, linetype, size

j + **geom_step(**direction = "hv"**)**
x, y, alpha, color, linetype, size

Visualizing error

df <- data.frame(grp = c("A", "B"), fit = 4:5, se = 1:2)
k <- ggplot(df, aes(grp, fit, ymin = fit-se, ymax = fit+se))

k + **geom_crossbar(**fatten = 2**)**
x, y, ymax, ymin, alpha, color, fill, linetype, size

k + **geom_errorbar()**
x, ymax, ymin, alpha, color, linetype, size, width (also **geom_errorbarh()**)

k + **geom_linerange()**
x, ymin, ymax, alpha, color, linetype, size

k + **geom_pointrange()**
x, y, ymin, ymax, alpha, color, fill, linetype, shape, size

Maps

data <- data.frame(murder = USArrests$Murder,
 state = tolower(rownames(USArrests)))
map <- map_data("state")
l <- ggplot(data, aes(fill = murder))

l + **geom_map(**aes(map_id = state), map = map**) +**
expand_limits(x = map$long, y = map$lat**)**
map_id, alpha, color, fill, linetype, size

Three Variables

seals$z <- with(seals, sqrt(delta_long^2 + delta_lat^2))
m <- ggplot(seals, aes(long, lat))

m + **geom_contour(**aes(z = z)**)**
x, y, z, alpha, colour, linetype, size, weight

m + **geom_raster(**aes(fill = z), hjust=0.5, vjust=0.5, interpolate=FALSE**)**
x, y, alpha, fill

m + **geom_tile(**aes(fill = z)**)**
x, y, alpha, color, fill, linetype, size

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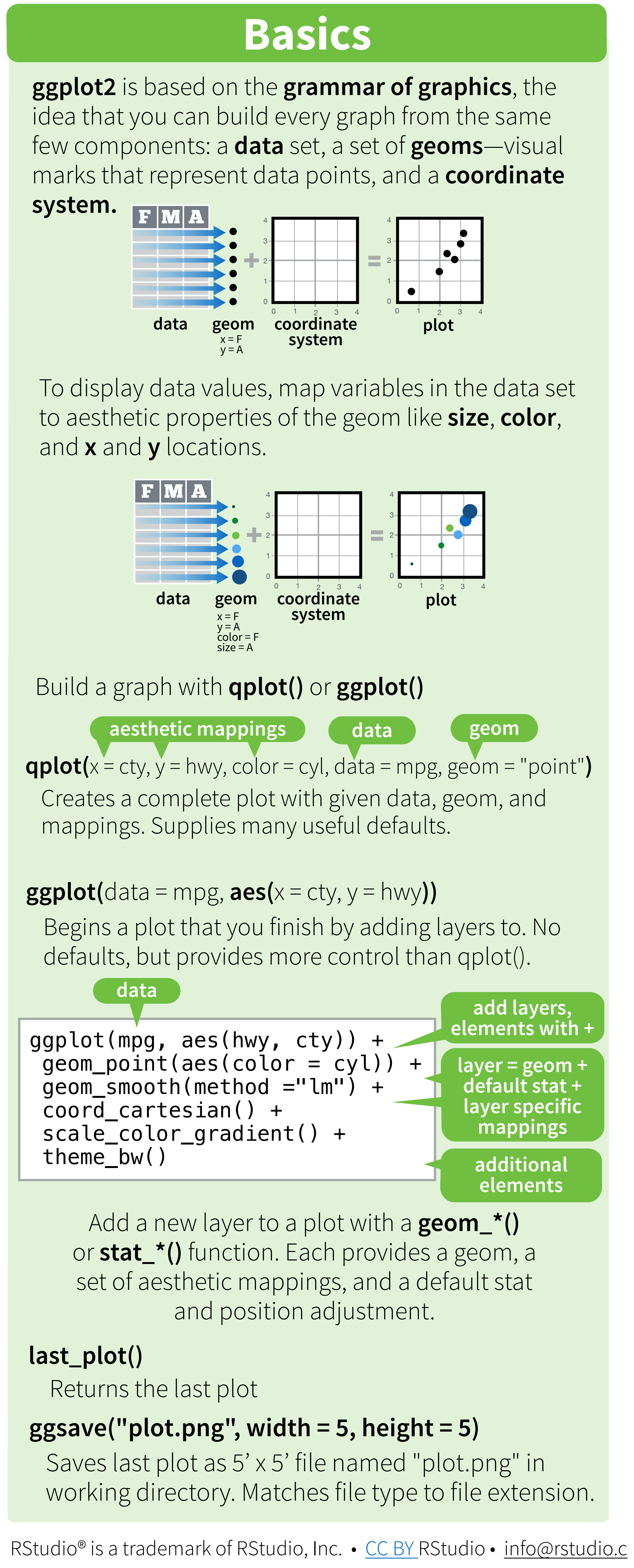
Learn more at **docs.ggplot2.org** • ggplot2 0.9.3.1 • Updated: 3/15

Basics of ggplot syntax



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F M A
data
geom
x = F
y = A
coordinate system
plot

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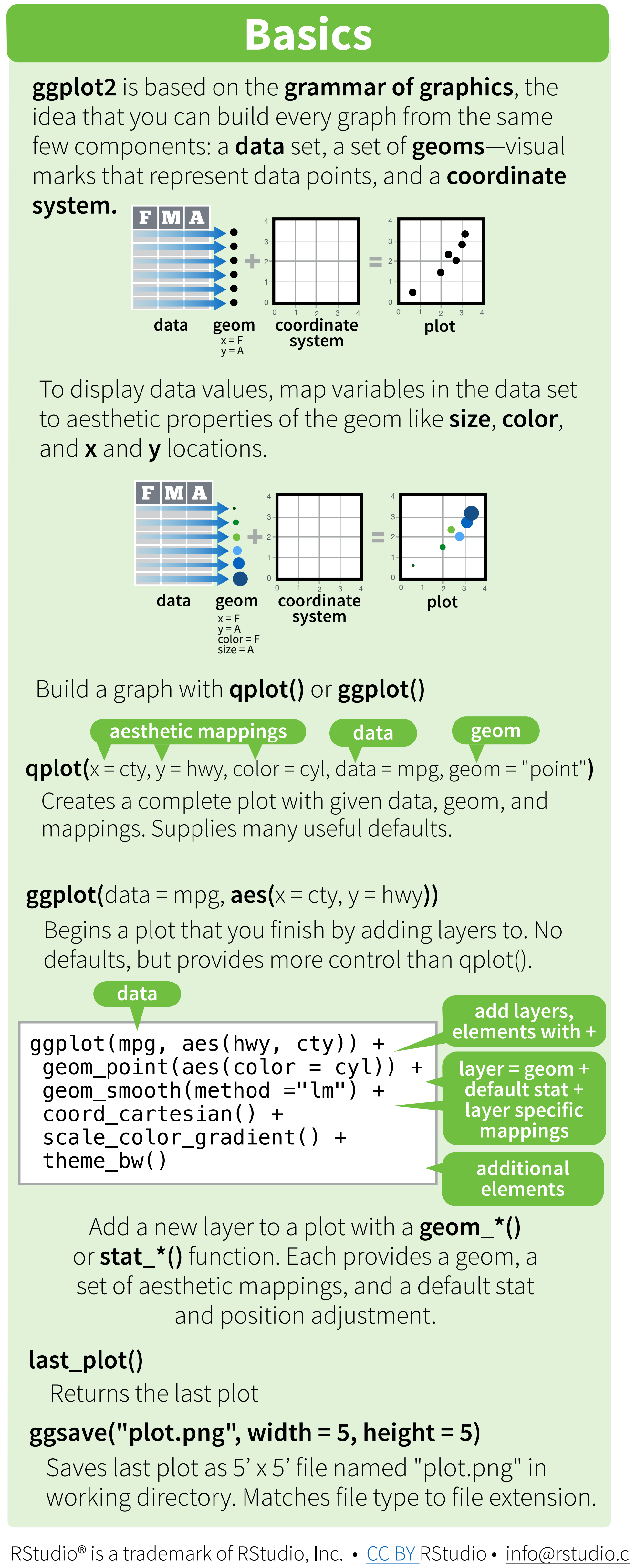
The variables in the dataframe that you want to plot

Dataframe

Setting up the axes

ggplot(data, aes(x = X, y = Y))

Basics of ggplot syntax



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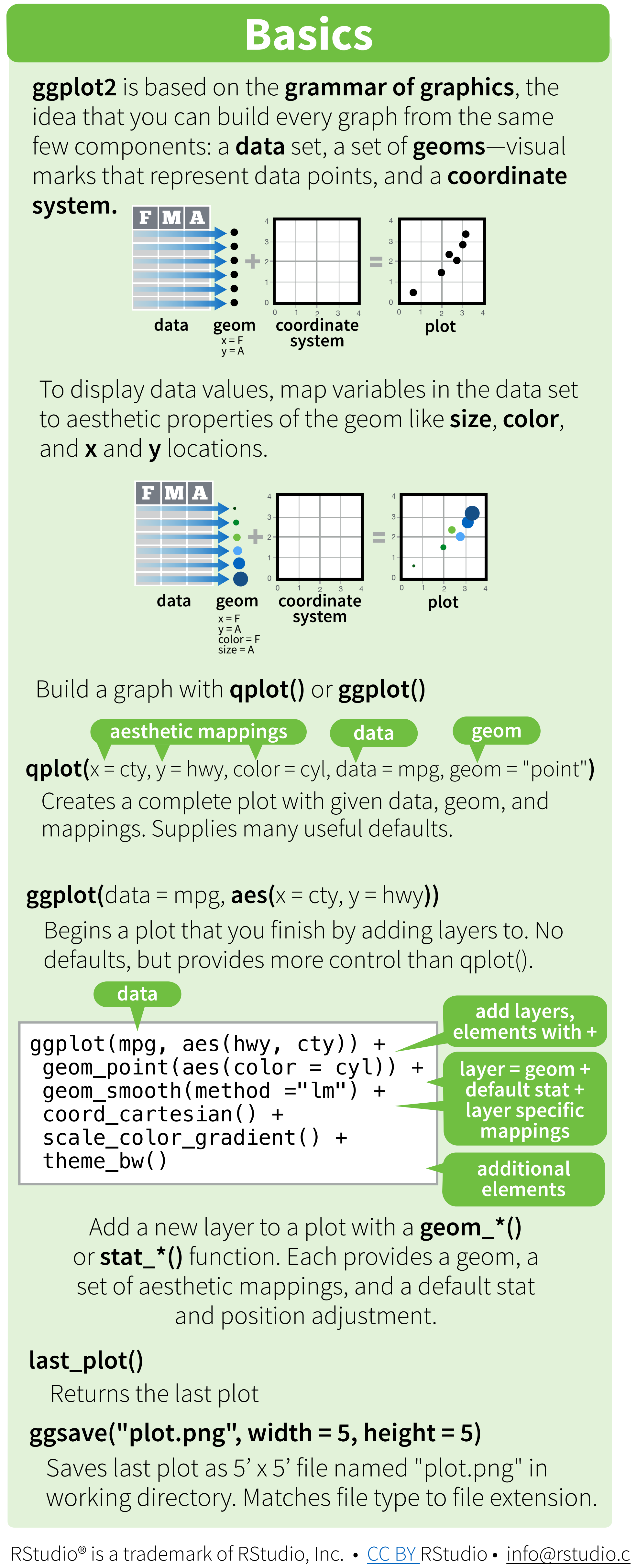
What kind of plot? geom_point() +

geom_smooth(method = “lm”) +

Basics of ggplot syntax



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Setting up the axes ggplot(data, aes(x = X, y = Y)) +

What kind of plot? geom_point() +
geom_smooth(method = “lm”) +

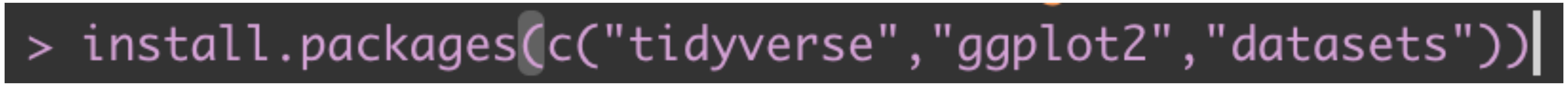
Customization xlab(‘’) + ylab(‘’) +
scale_color_manual() +
theme_classic()

Initial steps

Download R & RStudio: https://rstudio-education.github.io/hopr/starting.html

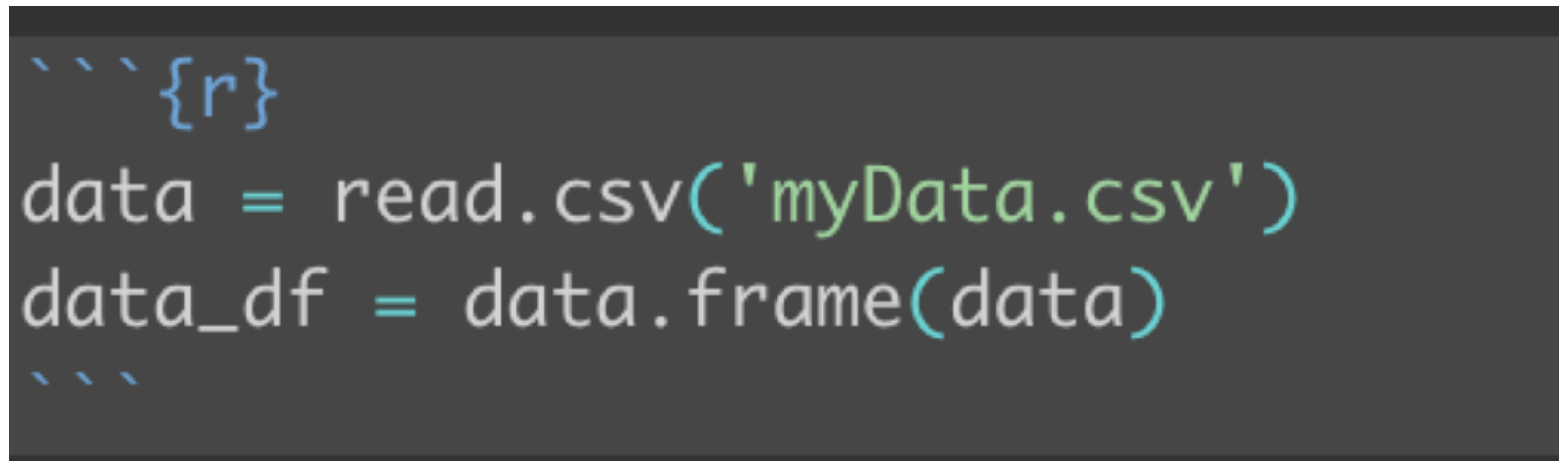
- or use Google Colab (https://colab.research.google.com/notebook#create=true&language=r)

Install relevant packages (tidyverse, ggplot, datasets)



```
> install.packages(c("tidyverse","ggplot2","datasets"))
```

Load in data (if necessary)



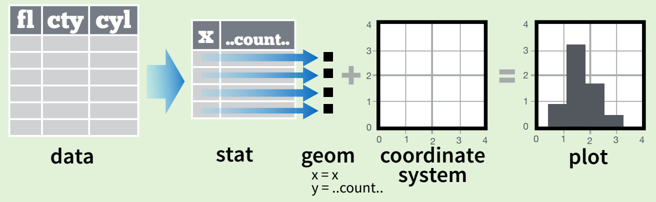
~~~
```{r}
data = read.csv('myData.csv')
data_df = data.frame(data)
```
~~~

Tutorial

Customization in ggplot

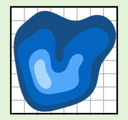
Stats - An alternative way to build a layer

Some plots visualize a **transformation** of the original data set. Use a **stat** to choose a common transformation to visualize, e.g. a + geom_bar(stat = "count")



Each stat creates additional variables to map aesthetics to. These variables use a common **..name..** syntax.

stat and geom functions both combine a stat with a geom to make a layer, i.e. **stat_count(geom="bar")** does the same as **geom_bar(stat="count")**



stat function · layer mappings

i + **stat_density2d(**aes(fill = ..level..),
geom = "polygon", n = 100**)**

geom for layer · parameters for stat · variable created by transformation

1D distributions

c + **stat_bin(**binwidth = 1, origin = 10**)**
x, y | ..count.., ..ncount.., ..density.., ..ndensity..
c + **stat_count(**width = 1**)**
x, y, | ..count.., ..prop..
c + **stat_density(**adjust = 1, kernel = "gaussian"**)**
x, y, | ..count.., ..density.., ..scaled..

2D distributions

e + **stat_bin_2d(**bins = 30, drop = TRUE**)**
x, y, fill | ..count.., ..density..
e + **stat_bin_hex(**bins = 30**)**
x, y, fill | ..count.., ..density..
e + **stat_density_2d(**contour = TRUE, n = 100**)**
x, y, color, size | ..level..
e + **stat_ellipse(**level = 0.95, segments = 51, type = "t"**)**

3 Variables

l + **stat_contour(**aes(z = z)**)**
x, y, z, order | ..level..
l + **stat_summary_hex(**aes(z = z), bins = 30, fun = mean**)**
x, y, z, fill | ..value..
l + **stat_summary_2d(**aes(z = z), bins = 30, fun = mean**)**
x, y, z, fill | ..value..

Comparisons

f + **stat_boxplot(**coef = 1.5**)**
x, y | ..lower.., ..middle.., ..upper.., ..width.. , ..ymin.., ..ymax..
f + **stat_ydensity(**adjust = 1, kernel = "gaussian", scale = "area"**)**
x, y | ..density.., ..scaled.., ..count.., ..n.., ..violinwidth.., ..width..

Functions

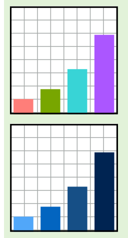
e + **stat_ecdf(**n = 40**)**
x, y | ..x.., ..y..
e + **stat_quantile(**quantiles = c(0.25, 0.5, 0.75), formula = y ~ log(x), method = "rq"**)**
x, y | ..quantile..
e + **stat_smooth(**method = "auto", formula = y ~ x, se = TRUE, n = 80, fullrange = FALSE, level = 0.95**)**
x, y | ..se.., ..x.., ..y.., ..ymin.., ..ymax..

General Purpose

ggplot() + **stat_function(**aes(x = -3:3), fun = dnorm, n = 101, args = list(sd=0.5)**)**
x | ..x.., ..y..
e + **stat_identity(**na.rm = TRUE**)**
ggplot() + **stat_qq(**aes(sample=1:100), distribution = qt, dparams = list(df=5)**)**
sample, x, y | ..sample.., ..theoretical..
e + **stat_sum()**
x, y, size | ..n.., ..prop..
e + **stat_summary(**fun.data = "mean_cl_boot"**)**
h + **stat_summary_bin(**fun.y = "mean", geom = "bar"**)**
e + **stat_unique()**

Scales

Scales control how a plot maps data values to the visual values of an aesthetic. To change the mapping, add a custom scale.



n <- b + **geom_bar(**aes(fill = fl)**)**
n

scale_ · aesthetic to adjust · prepackaged scale to use · scale specific arguments

n + **scale_fill_manual(**
values = c("skyblue", "royalblue", "blue", "navy"),
limits = c("d", "e", "p", "r"), **breaks** =c("d", "e", "p", "r"),
name = "fuel", **labels** = c("D", "E", "P", "R")**)**

range of values to include in mapping · title to use in legend/axis · labels to use in legend/axis · breaks to use in legend/axis

General Purpose scales

Use with any aesthetic:
alpha, color, fill, linetype, shape, size

scale_*_continuous() - map cont' values to visual values
scale_*_discrete() - map discrete values to visual values
scale_*_identity() - use data values **as** visual values
scale_*_manual(values = c()**)** - map discrete values to manually chosen visual values

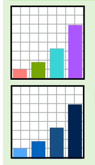
X and Y location scales

Use with x or y aesthetics (x shown here)

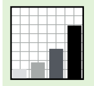
scale_x_date(date_labels = "%m/%d"), date_breaks = "2 weeks") - treat x values as dates. See ?strptime for label formats.
scale_x_datetime() - treat x values as date times. Use same arguments as scale_x_date().
scale_x_log10() - Plot x on log10 scale
scale_x_reverse() - Reverse direction of x axis
scale_x_sqrt() - Plot x on square root scale

Color and fill scales

Discrete

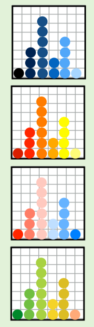


n <- d + **geom_bar(**
aes(fill = fl)**)**
n + **scale_fill_brewer(**
palette = "Blues"**)**
For palette choices:
library(RColorBrewer)
display.brewer.all()



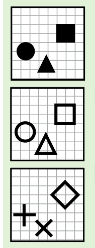
n + **scale_fill_grey(**
start = 0.2, end = 0.8,
na.value = "red"**)**

Continuous



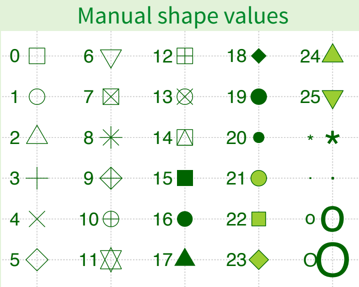
o <- c + **geom_dotplot(**
aes(fill = ..x..)**)**
o + **scale_fill_gradient(**
low = "red",
high = "yellow"**)**
o + **scale_fill_gradient2(**
low = "red", high = "blue",
mid = "white", midpoint = 25**)**
o + **scale_fill_gradientn(**
colours = terrain.colors(6)**)**
Also: rainbow(), heat.colors(), topo.colors(), cm.colors(), RColorBrewer::brewer.pal()

Shape scales

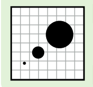


p <- e + **geom_point(**aes(
shape = fl, size = cyl)**)**
p + **scale_shape(**
solid = FALSE**)**
p + **scale_shape_manual(**
values = c(3:7)**)**
Shape values shown in chart on right

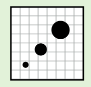
Manual shape values



Size scales



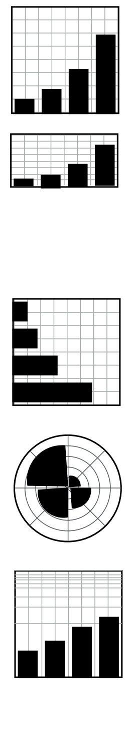
p + **scale_radius(**
range=c(1,6)**)**
p + **scale_size()**



p + **scale_size_area(**
max_scale = 6**)**
Maps to area of circle (not radius)

Coordinate Systems

r <- d + geom_bar()



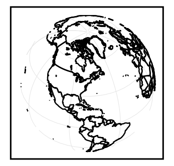
r + **coord_cartesian(**xlim = c(0, 5)**)**
xlim, ylim
The default cartesian coordinate system

r + **coord_fixed(**ratio = 1/2**)**
ratio, xlim, ylim
Cartesian coordinates with fixed aspect ratio between x and y units

r + **coord_flip()**
xlim, ylim
Flipped Cartesian coordinates

r + **coord_polar(**theta = "x", direction=1 **)**
theta, start, direction
Polar coordinates

r + **coord_trans(**ytrans = "sqrt"**)**
xtrans, ytrans, limx, limy
Transformed cartesian coordinates. Set xtrans and ytrans to the name of a window function.

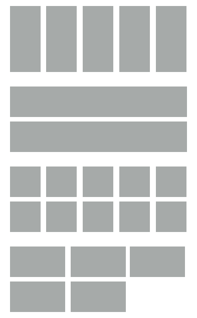


π + **coord_map(**projection = "ortho", orientation=c(41, -74, 0)**)**
projection, orientation, xlim, ylim
Map projections from the mapproj package (mercator (default), azequalarea, lagrange, etc.)

Faceting

Facets divide a plot into subplots based on the values of one or more discrete variables.

t <- ggplot(mpg, aes(cty, hwy)) + geom_point()



t + **facet_grid(. ~ fl)**
facet into columns based on fl
t + **facet_grid(year ~ .)**
facet into rows based on year
t + **facet_grid(year ~ fl)**
facet into both rows and columns
t + **facet_wrap(~ fl)**
wrap facets into a rectangular layout

Set **scales** to let axis limits vary across facets

t + facet_grid(drv ~ fl, **scales = "free")**
x and y axis limits adjust to individual facets
- **"free_x"** - x axis limits adjust
- **"free_y"** - y axis limits adjust

Set **labeller** to adjust facet labels

t + facet_grid(. ~ fl, **labeller = label_both)**

fl: c	fl: d	fl: e	fl: p	fl: r

t + facet_grid(fl ~ ., **labeller = label_bquote(**alpha ^ .(fl)**))**

α^c	α^d	α^e	α^p	α^r

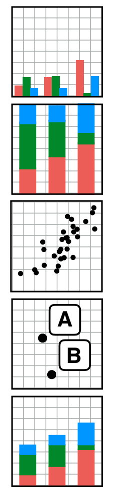
t + facet_grid(. ~ fl, **labeller = label_parsed)**

c	d	e	p	r

Position Adjustments

Position adjustments determine how to arrange geoms that would otherwise occupy the same space.

s <- ggplot(mpg, aes(fl, fill = drv))



s + geom_bar(**position = "dodge"**)
Arrange elements side by side
s + geom_bar(**position = "fill"**)
Stack elements on top of one another, normalize height
e + geom_point(**position = "jitter"**)
Add random noise to X and Y position of each element to avoid overplotting
e + geom_label(**position = "nudge"**)
Nudge labels away from points
s + geom_bar(**position = "stack"**)
Stack elements on top of one another

Each position adjustment can be recast as a function with manual **width** and **height** arguments

s + geom_bar(**position = position_dodge(width = 1)**)

Labels

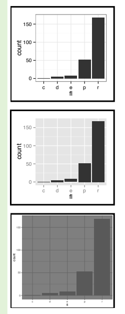
t + **ggtitle(**"New Plot Title"**)**
Add a main title above the plot
t + **xlab(**"New X label"**)**
Change the label on the X axis
t + **ylab(**"New Y label"**)**
Change the label on the Y axis
t + **labs(**title =" New title", x = "New x", y = "New y"**)**
All of the above

Use scale functions to update legend labels

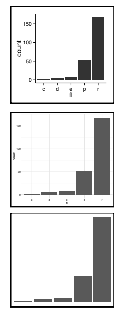
Legends

n + **theme(**legend.position = "bottom"**)**
Place legend at "bottom", "top", "left", or "right"
n + **guides(**fill = "none"**)**
Set legend type for each aesthetic: colorbar, legend, or none (no legend)
n + **scale_fill_discrete(**name = "Title", labels = c("A", "B", "C", "D", "E")**)**
Set legend title and labels with a scale function.

Themes

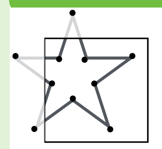


r + **theme_bw()**
White background with grid lines
r + **theme_gray()**
Grey background (default theme)
r + **theme_dark()**
dark for contrast

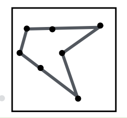


r + **theme_classic()**
r + **theme_light()**
r + **theme_linedraw()**
r + **theme_minimal()**
Minimal themes
r + **theme_void()**
Empty theme

Zooming



Without clipping (preferred)
t + **coord_cartesian(**
xlim = c(0, 100), ylim = c(10, 20)**)**



With clipping (removes unseen data points)
t + **xlim(**0, 100**)** + **ylim(**10, 20**)**
t + **scale_x_continuous(**limits = c(0, 100)**)** + **scale_y_continuous(**limits = c(0, 100)**)**

Learn more at docs.ggplot2.org • ggplot2 2.0.0 • Updated: 12/15

Customization in ggplot

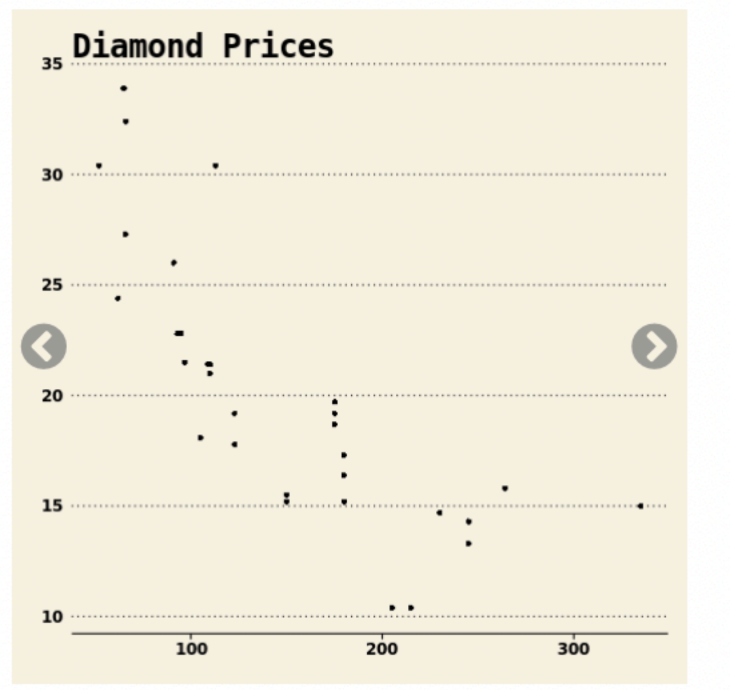
Have fun with themes and colors!

https://yutannihilation.github.io/allYourFigureAreBelongToUs/ggthemes/

https://github.com/MatthewBJane/theme_park

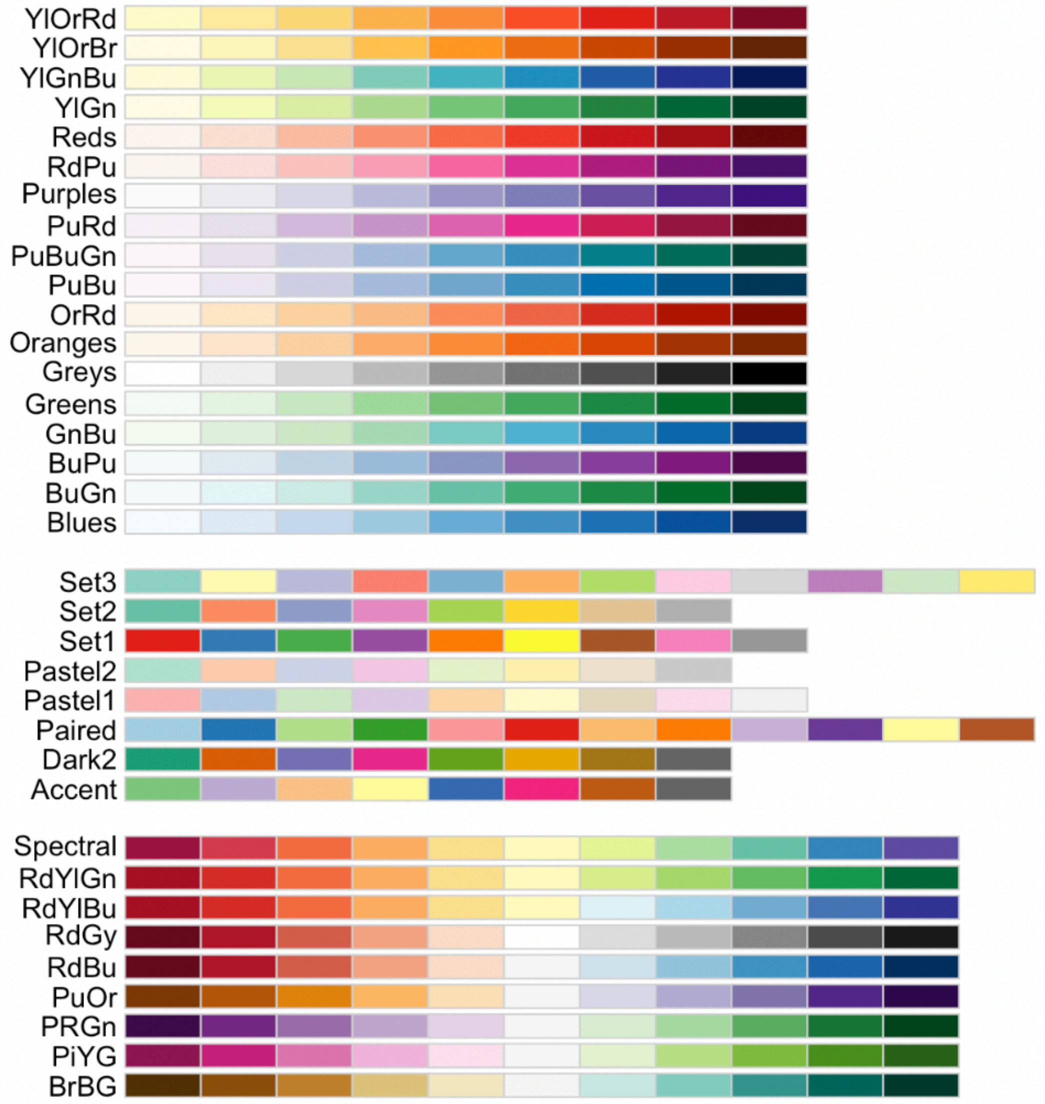
https://github.com/karthik/wesanderson

https://ggplot2.tidyverse.org/reference/scale_brewer.html



theme_wsj

Wall Street Journal theme



Sequential

(Good for continuous variables)

Qualitative

(Good for discrete variables)

Diverging

(Good for things like heat maps, correlation matrices)

Other resources

https://r-graph-gallery.com/index.html

http://r-statistics.co/Complete-Ggplot2-Tutorial-Part1-With-R-Code.html

https://lscholtus.gitlab.io/mosaicdata/ggplot2-cheatsheet-2.0.pdf

https://www.youtube.com/watch?v=qnw1xDnt_Ec